INTRODUCTION

se and Limitations

The ROOTS® Meter is a positive displacement, rotary type gas meter designed for continuously measuring and indicating the accurate measurement of gas flow in a pipeline.

ROOTS® Meters are suitable for handling most types of clean, dry, common gases at either constant or varying flow rates. The meter is not suitable for handling liquids. Measurement accuracy and life expectancy can be impeded by excessive deposits of dirt or other types of foreign material present in the gas stream.

Meters of standard construction are not directly suitable for handling acetylene, biogas or sewage gas. Specially constructed meters made of materials directly compatible with these and other gases are available. Please contact the Factory for details and to request publication S: SSM.

Operating Principle

As shown in Figure 1, two contra-rotating impellers of two-lobe or "figure 8" contour are encased within a rigid measuring chamber, with inlet and outlet connections on opposite sides. Precision machined timing gears keep the impellers in correct relative position. Optimal operating clearances between the impellers, cylinder, and headplates provide a continuous, non-contacting seal.

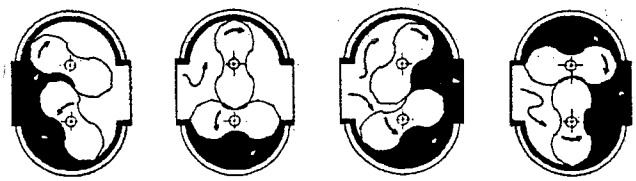


Figure 1

Because of this unique design, the gas at the meter inlet is always effectively isolated from the gas at the outlet. Consequently, a very small pressure drop across the meter will cause the impellers to rotate. During impeller rotation, the precisely machined measuring chamber traps a known volume between the impeller and the adjacent cylinder wall. With one complete revolution of both impellers, the meter will measure and pass four equal gas volumes. The sum total of these volumes is the Displacement of the meter per revolution. The displaced volume of gas is indicated in Engineering units represented in cubic feet (or cubic meters).

Volumetric accuracy of the ROOTS® Meter is permanent and non-adjustable. Measuring characteristics are established by the dimensions and precision machined contours of non-wearing fixed and rotating parts.

Meter rated capacity is the maximum flow rate at which the meter may be operated and is determined by the dynamic loads acting on the rotating parts of the meter. These loads are primarily related to meter RPM, and secondarily to the metering pressure. With few exceptions, the standard volume capacity of a rotary meter increases directly with changes in absolute line pressure and inversely with changes in absolute line temperature.

GENERAL DESCRIPTION

ROOTS® Meters are manufactured in accordance with the American National Standard specification ANSI/ASC-B109.3 for Rotary Type Gas Displacement Meter. ROOTS® Meter Series B3 sizes 8C-56M have flanged inlet and outlet connections conforming dimensionally with ANSI/ASME standards. Sizes 8C-2M are available with 1-½" NPT connections, upon special request. The meter operating temperature range is from -40°F to +140° F (-40° C to +60° C).

ROOTS® Meters Series B have a Maximum Allowable Operating Pressure (MAOP) rating of 175 psig (1200 kPa). Every meter is static pressure tested at the factory at twice its MAOP (350 psig/2400 kPa) and leak tested at 125 percent of MAOP (220 psig/1380 kPa) in accordance with ASME Boiler Pressure Vessel Codes. Upon special request, meter sizes 8C-15C are available with a MAOP rating of 200 PSIG. **IMPORTANT:** The maximum working pressure of a rotary meter is limited by casing design. Meters should *not* be installed where line pressure can exceed the Maximum Allowable Operating Pressure. Refer to the basic meter body nameplate for the MAOP.

Meter accuracy is not affected by low or varying line pressures. Series B meters may be used satisfactorily for pressures ranging from a few ounces to full MAOP. The meter base rating is expressed in hundreds (C) or thousands (M) of Actual Cubic Feet per Hour (ACFH), or in Cubic Meters per Hour (m^3H).

Displaced volume measurement is completely independent of the gas specific gravity, temperature, and pressure. Displaced volume can be easily converted to volume at Standard conditions for elevated pressure and varying temperature by application of the Basic or Ideal Gas Laws. Refer to a meter sizing chart for capacity ratings at elevated line pressures.

Major components of the meter are machined or cast from aluminum for a combination of strength and weight reduction. All aluminum parts are anodized, and the measuring chamber and impellers are hard-coat anodized for added corrosion and abrasion resistance.

Cleansing and lubrication for the main bearings and timing gears is provided by a "splash" lubrication system. The two meter end covers on Series B meters serve as oil reservoirs. Oil slingers located within the meter end covers distribute oil for lubrication.

ACCESSORY UNIT

Series 3 (Life-Lubed) Versions

Totalization of the displaced gas volume is performed by a magnetically coupled, spur gear reduction unit. The modular design of the Series 3 accessory unit allows for complete inter-changeability of accessory units on Series B basic meter bodies of the same size. Meter size and gear ratio is imprinted on the accessory unit nameplate. **IMPORTANT: Do not install an accessory unit on a meter of differing size.**

The CTR and TC cover is manufactured of Lexan®. [Lexan® is a registered trademark of the General Electric Company]. Series 3 (Life-Lubed) Accessory Units are permanently lubricated for a long life and virtually maintenance-free operation. The accessory unit utilizes a unique method of shielding specific odometer digits. Translucent shields tint but do not completely shield the digits to be viewed, while opaque (dark) masks completely cover the digits. These shields simply snap into place over the desired digits. Special configurations are available, upon request.

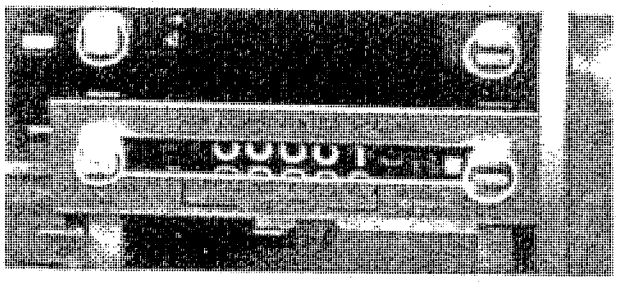
Counter (CTR) Version

The Counter Unit (CTR) gear reduction assembly is housed in a cylindrical Lexan cover as previously described. An 8-digit non-compensated index (odometer) registers displaced volume in actual cubic feet (ACF) or actual cubic meters (m^3). All numbered index wheels on the odometer have 10 divisions marked with the characters 0 through 9.

The 8C through 11M odometers with Imperial numerals have five exposed digits. The first digit on the left of the odometer is concealed. The translucent or opaque masks cover the two right most digits. For the 16M through 56M odometers with Imperial units, six digits are exposed. Only the first and last digits are covered.

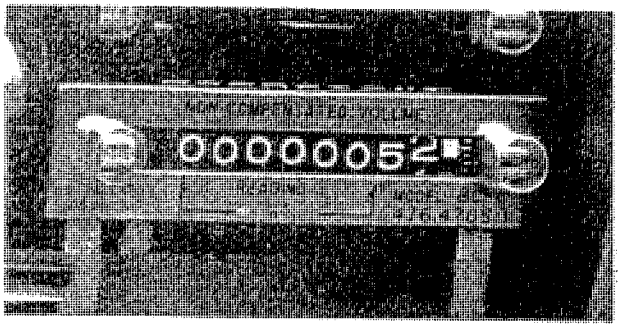
To read the odometer, the nameplate markings indicate "Reading X 100 = Cubic Feet." The last two digits to the right of the index may be read by viewing through the translucent mask, but instead of multiplying the reading by 100 (excluding the graduated increments), the readings for the 8C - 11M are multiplied by one and the readings for the 16M - 56M are multiplied by ten.

A test wheel is located on the right side of the odometer. The graduated increments on the test wheel represent 0.2 cubic feet for the 8C through 11M meters and 2 cubic feet for the 16M through 56M meters. This allows estimated readings of 0.1 cubic feet and 1 cubic foot, respectively. White reflective marks are located to the left of the graduated increments for prover testing with an optical photo-sensor.



Series B3 Imperial Odometer

CTR Units with metric readout have all 8 digits on the odometer exposed. On the 8C through 3M meters, the last two digits to the right are masked with a decimal point shown just before the masking. The unmasked area is designated as "READING = m^3" and the smallest increment on the test wheel is 0.002 m^3. On the 5M through 56M meters, only the last digit is masked. Again, a decimal point is shown just before the mask and the unmasked digits are read as cubic meters. However, the smallest increment on the test wheel is now 0.02 m^3. The scale factor also indicates "Reading = m^3."



Series B3 Metric Odometer

NOTE: The high speed, black-and-white proving wheel attached to the end of the RPM drive shaft is visible either from the front or the end of the accessory and can be used for verification of unit operation and meter testing. Refer to "Proving Operations."

Counter with Instrument Drive Unit (CD) Version

The CD Unit utilizes the CTR gear reduction assembly, a specially designed Lexan cover, and an Instrument Drive support assembly. The Instrument Drive (ID) support is mechanically linked to the gear reduction of the CTR Unit and drives the instrument drive dog at the ID output. One revolution of the instrument drive dog represents a specific displaced volume measured by the meter, depending upon meter size.

Permanent lubrication is featured with the Series 3 accessory unit. Lubrication is not required for the CTR Unit or the ID support housing.

The instrument mounting section of the Instrument Drive (ID) housing can be easily relocated 90° to an upward position when changing the meter from Top to Side inlet or vice versa. (Refer to "CONVERSION PROCEDURES, Instrument Drive Assembly Positioning"). A cover plate on the Instrument Drive support housing allows access to bevel gears for directional change of rotation of the drive dog - from clockwise to counterclockwise rotation, or vice versa. A decal located on the ID housing indicates output drive volume. A universal instrument mounting plate is installed on the ID support.

Instrument Drive Rates (CD)

Imperial	8C thru 11M	10 cu. ft./ rev.
	16M thru 56M	100 cu. ft./ rev.
Metric	8C thru 3M	0.1 m^3/ rev.
	5M thru 38M	1.0 m^3/ rev.
	56M	10.0 m^3/ rev.

Temperature Compensated (TC) Version

Temperature compensation is accomplished by a mechanical computer with a spiral bi-metallic thermocouple (probe) located in a sealed temperature well at the meter inlet. This system allows Series 3 TC Units to provide corrected gas volume readings in SCF between line gas temperatures of -20° F and + 120° F (-29° C and +49° C). Metric TC Units are also available.

All Series B basic meter bodies are shipped with a temperature probe well. This, plus other benefits of the mag-coupled accessory unit, allows for an easy and low cost alternative to convert a non-compensated meter to temperature compensated.

The Temperature Compensated (TC) Unit has two digital odometers. All numbered index wheels on the odometer have 10 divisions marked with the characters 0 through 9. The top odometer (highlighted in red) represents the Temperature Compensated volume, or the displaced gas volume corrected to Standard conditions (SCF) with respect to a contract Base temperature of 60° F (15° C). During the compensation cycle, and due to its intermittent nature of operation, directional changes in linkage loading result in a visual change in rotational velocity. This has no effect on accuracy, performance, or reliability.

The bottom odometer is Non-Compensated and is fully covered with a translucent mask to reduce readability or prevent misreading. An optional black (opaque) mask can be specified to completely prevent viewing of the non-compensated odometer. Other configurations are available upon special request.

A test wheel is located on the right side of each odometer. The graduated increments on the test wheels represent 0.2 cubic feet for the 8C through 11M meters and 2 cubic feet for the 16M meter. This allows estimated readings of 0.1 cubic feet and 1 cubic foot, respectively. White reflective marks are located to the left of the graduated increments for prover testing with an optical photo-sensor.

To check the condition of the TC Unit, refer to "TC Unit Operational Check."

Temperature Compensated with Instrument Drive (TD) Version

As the name implies, the Temperature Compensated with Instrument Drive (TD) accessory unit uses a standard TC Unit along with an Instrument Drive (ID) support as described in the CD section. However, one revolution of the ID drive dog now represents gas volume corrected to Standard conditions with respect to a contract Base temperature of 60° F (15° C). Metric TD Units are also available.

All other features and functions described under the heading "TC Version" are applicable to the TD Version.

Instrument Drive Rates (TD)		
Imperial	8C thru 11M	100 cu. ft./ rev.
	16M	1,000 cu. ft./ rev.

Solid State Pulser

The ROOTS® Solid State Pulser generates low frequency pulses representing volumetric information for remote data collection. The solid state construction eliminates mechanical switches and ensures maximum reliability. No battery or maintenance is required. Pulsers are available with Single or Dual amphenol connectors. Conduit connections are available upon request.

The CTR Unit's pulse output represents Non-Compensated volume, only. The TC Unit provides two pulse outputs, one representing Non-Compensated volume, the second representing Temperature Compensated volume. The pulse rates can be found on the decal and/or tag provided with the pulser, as well as indicated below. Wiring diagrams are available, upon request.

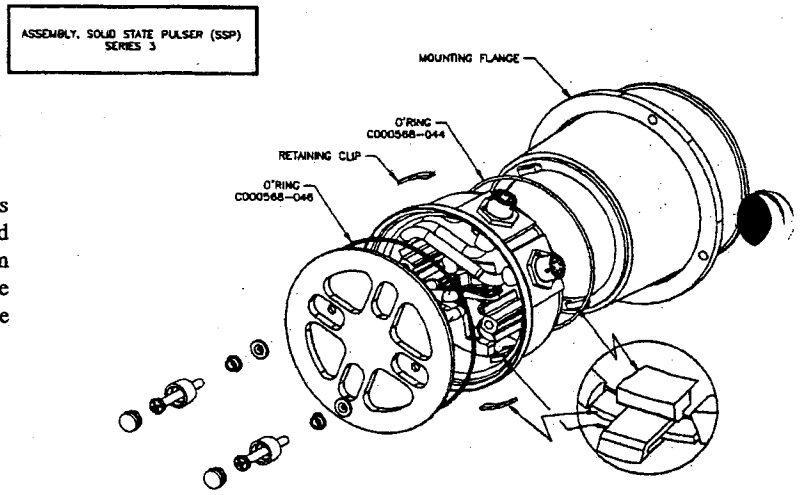
Types

Counter Version with Pulse Output, Single Connector (CPS)
Counter Version with Pulse Output, Dual Connector (CPD)
Temperature Compensated with Pulse Output, Single Connector (TPS)
Temperature Compensated with Pulse Output, Dual Connector (TPD)

Maintenance for the Series 3 Accessory

The CTR, CD, TC, TD and Solid State Pulser requires no scheduled maintenance.

To clean the Lexan cover, use hot water and soap, mineral spirits, Isopropyl alcohol, or cleaning products approved for use on Lexan. Important: Aromatics, Ketones, and Chlorinated hydrocarbons will damage the plastic cover. Do not use acetone, carbon tetrachloride, etc.



Pulse Rates

Series B Meter Size	Series 3 (Life-Lubed Type	Imperial (Cubic Feet) Non-Comp.	Imperial (Cubic Feet) Comp.	Metric (Cubic Meters) Non-Comp.	Non-Compensated Wiring Connection	Compensated Wiring Connection
8C-3M	CTR	10 cf		0.1 m3	ABC	
5M-11M	CTR	10 cf		0.1 m3	ABC	
16M-38M	CTR	100 cf		1.0 m3	ABC	
56M	CTR	100 cf		10.0 m3	ABC	
8C-11M	TC	10 cf	50 cf *		ABC	DEF
16M	TC	100 cf	500 cf **		ABC	DEF

* Planned option is 10 cf. Contact Factory for availability.
** Planned option is 100 cf. Contact Factory for availability.
For additional information, request specification sheet S: SSP.

METER INSTALLATION

Piping Configurations

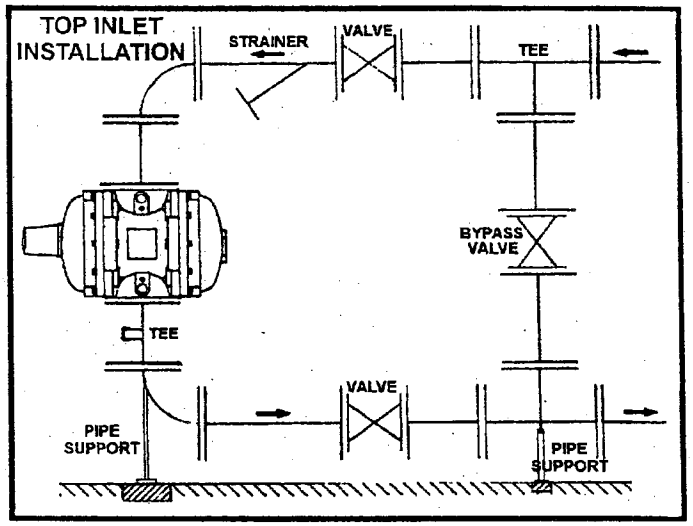
Line mounted ROOTS® Meters Series B3 may be installed in either a Top Inlet (vertical) or a Side Inlet (horizontal) configuration. The preferred or recommended installation is top inlet in a vertical pipe line with gas flow downward. Although the design of the impellers tends to make the meter inherently self-cleaning, the top inlet mounting allows gravity to pass dirt, pipe scale, or other debris through the meter.

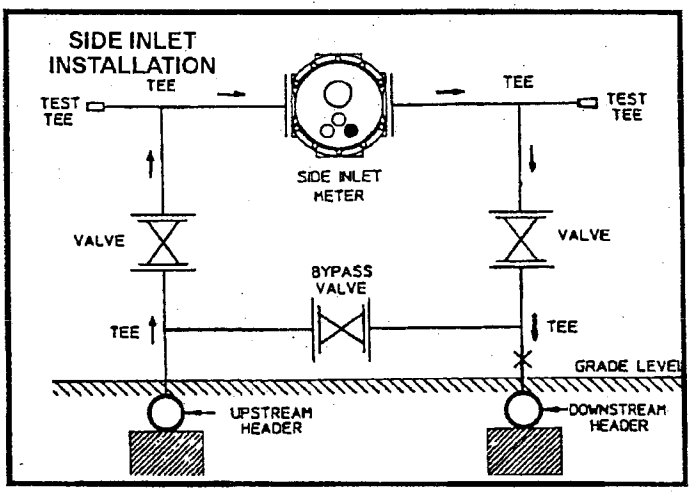
An additional recommendation is to install the meter in a side loop with a bypass adjacent to the main line. Piping should be solid and properly aligned. Eliminate piping strains on the meter body. The installation of tees will allow the meter to be tested while mounted in line using a transfer prover, facilitating the testing process.

Do not install the meter lower than the discharge pipe run to avoid accumulation of condensate and foreign materials in the metering chamber. Use a Dresser ROOTS® Gasket Strainer, Dresser ROOTS® Pipeline Strainer, or other Y-type strainer upstream of the meter to remove liquids and foreign matter (pipe sealant, tape, weld slag, etc.) from the gas stream. A 100 Mesh screen is recommended.

Do not install a lubricated gas valve directly before a meter, as excess valve lubricant or other foreign material can stop impeller rotation. Dresser ROOTS® Style 350 ULTRASEAL permanently-lubricated gas valves are designed and recommended for use in all ROOTS® Meter installations.

If over-speed conditions occur, a restricting flow orifice plate should be installed 2 to 4 pipe diameters downstream of the meter outlet. Contact DMD Dresser Measurement Operation for sizing, pricing and availability. Warranty does not cover over-speed conditions.

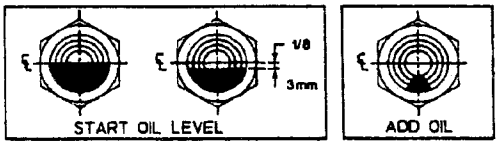




Placing Meter In Line

IMPORTANT: Remove the plastic protective caps from both meter flanges prior to meter installation.

1. Before installing a meter:
   - Make sure the upstream piping is clean by partially opening the valve to let a sufficient amount of gas blow to atmosphere.
   - Insure the impellers turn freely and no objects or contaminants are in the measuring chamber. Depending upon meter condition, it may be necessary to flush the meter with an approved solvent. After flushing, drain all solvent from both end covers. Make sure the measuring chamber is clean and dry and the impellers turn freely. Refer to Refer to "INSPECTION AND MAINTENANCE, Meter Testing, Cleaning."
2. Meter Orientation:
   - Connect meter inlet to the gas supply side of the line, insuring the gas flow will be in the same direction as the arrow on the meter body nameplate (i.e., arrow pointing downward for Top Inlet).
   - In a correct installation, both meter oil level gauges are parallel to the ground.
3. Install the meter without piping strain to prevent a binding of the impellers. Use pipe supports, as required. Level all 8C-56M line mount Series B3 meters to within 1/16" per running foot (5 mm/m), side-to-side and front-to-back.
4. Tighten flange bolts evenly in a cross-pattern. The maximum torque on a lubricated 5/8-11 cap screw is approximately 55 foot-pounds, and approximately 60 ft. lb. for non-lubricated bolts.
5. **CAUTION: The meter must NOT be under pressure for this procedure.** After the meter is installed, remove the 9/16" socket head plug in the timing gear end cover using a 1/4" Allen wrench. Insert a 3/8" Allen driver into the socket head gear clamp and slowly turn the impellers, checking for free rotation. If binding is present, do not attempt to disengage the impellers. Remove the meter from the set and clear all obstructions or piping strain prior to reinstallation. Replace the plug after verifying free impeller rotation.
6. There are only two oil reservoirs in the ROOTS® Meter Series B basic body. Oil is shipped with each new meter in a quantity sufficient to fill both reservoirs in either a Top Inlet or a Side Inlet configuration.
   a) Remove the 9/16" pipe plugs in the two meter end covers. Slowly add oil to each end cover reservoir until the oil level is to the center of the oil gauge (sight glass). DO NOT OVERFILL. See "Oil Capacities," below.



   b) **IMPORTANT**: DO NOT add oil to the permanently lubricated Series 3 accessory unit. DO NOT drill and tap the Lexan cover.

Oil Capacities

Lubricating oil capacities for the two end covers in ROOTS® Meters Series basic bodies are listed for both Top and Side Inlet mounting configurations in Imperial and Metric equivalents.

Meter Size	Top Inlet		Side Inlet	
8C175	3.0 oz.	89 ml	0.8 oz.	24 ml
11C175	3.0 oz.	89 ml	0.8 oz.	24 ml
15C175	3.0 oz.	89 ml	0.8 oz.	24 ml
2M175	7.6 oz.	226 ml	1.6 oz.	47 ml
3M175	7.6 oz.	226 ml	1.6 oz.	47 ml
5M175	7.6 oz.	226 ml	1.6 oz.	47 ml
7M175	21.8 oz.	644 ml	3.4 oz.	100.5 ml
11M175	21.8 oz.	644 ml	3.4 oz.	100.5 ml
16M175	21.8 oz.	644 ml	3.4 oz.	100.5 ml
23M175	9.6 US Pints	4.6 Liter	40.2 oz.	1.2 Liter
38M175	9.6 US Pints	4.6 Liter	40.2 oz.	1.2 Liter
56M175	9.6 US Pints	4.6 Liter	40.2 oz.	1.2 Liter

ROOTS® Meter Series B3 only require oil in two reservoirs (the Timing end cover and the Mag-Drive end cover).

Meter Start-Up

1. Slowly pressurize the meter in accordance with the following recommendations:

   IMPORTANT: Do not exceed 5 psig/second (35 kPa/second) maximum when pressurizing. Rapid pressurization can cause an over-speed condition which may damage the meter. Resulting damage is not covered by warranty.

   a) Open the bypass and outlet (downstream of meter) gas valves.

   b) Partially open the meter inlet gas valve until the meter starts operating at low speed. Throttling of the bypass valve may be necessary to initiate gas flow through the meter. Verify gas is flowing through the meter by watching for movement of the black-and-white RPM wheel on the accessory unit. If movement is present, go to step c). If the RPM dial is not turning, verify gas is being delivered to the meter. If gas is flowing to the meter inlet and the RPM wheel is not moving, go to step e).

   c) Let the meter operate at low speed for several minutes. Listen closely for unusual scraping or knocking sounds.

   d) If operation is satisfactory, go directly to step f).

   e) If unusual sounds are present or the accessory unit's RPM wheel is not turning, place the meter in bypass. Slowly depressurize and vent all pressure from the meter set before checking for piping misalignment, piping strain, torsion, or other related problems. Once the problem has been resolved, repeat the start-up procedure beginning with step a).

DANGER: Slowly depressurize and vent all pressure from the meter set before working on meter.

   f) Gradually open the inlet valve until full line flow is passing through the meter and the inlet valve is fully open.

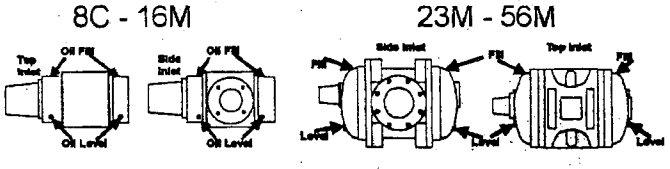
   g) Slowly close the bypass valve.

   h) Follow your company authorized procedure or common practice to leak test the meter and all connections. Soapy water, Snoop® and gas analyzers are commonly used for this procedure.

INSPECTION AND MAINTENANCE

Lubrication

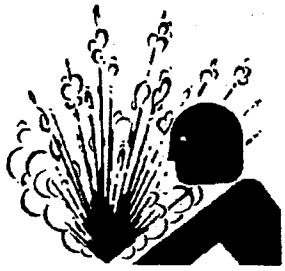
Meters installed and maintained in accordance with factory recommendations can be expected to operate dependably for many years. Proper oil level and cleanliness have the greatest effect on meter life expectancy. The two oil reservoirs in the meter end covers should be visually inspected for proper mid-gauge oil levels once a month until a practical interval is determined. Add oil as necessary.



Use only ROOTS® Versi-Temp 2 Meter Oil or other instrument grade oils approved for service by the manufacturer.

DO NOT add oil to the Series 3 Accessory Unit.
No scheduled lubrication maintenance is required.

Oil change frequency will depend upon the cleanliness of the gas being measured. Change oil when the color darkens or when the level increases, indicating an accumulation of moisture. Under favorable conditions, these periods may be from 3 to 5 years, or longer.



CAUTION: THE METER END COVER IS PRESSURIZED. Bleed off the line pressure before removing the oil fill or drain plug from the meter.

The permanently lubricated Series 3 accessory unit is sealed-off from the meter body and is not pressurized.

Meter Level

Since the meter is supported entirely by the gas pipe line, movement of the piping through accident, settling of the ground or other causes can impede meter operation and accuracy. Refer to "INSTALLATION" procedures. Make sure the meter remains level within 1/16" per foot (5 mm/m) in any direction, side to side, front to back.

Meter Testing

The Differential Rate Test is an accurate and convenient method of comparing a rotary meter's performance at any time with its original performance. This and other commonly used test methods are covered later in this manual under "TESTING."

Cleaning - If there is any evidence of dirt or dust in the meter, a suggested method for removal is to windmill the impellers (at a speed less than maximum capacity) by injecting controlled compressed air from a nozzle into the meter inlet. Flush approximately 5 ounces (150 ml) of an approved non-toxic, non-flammable solvent through the meter. Use the compressed air to completely dry the meter.

Note: Before performing this procedure, drain all oil from the meter end covers. After the meter has been replaced in the meter set, add oil.

ACCESSORY UNIT REMOVAL & CONVERSION PROCEDURES

NOTE: Refer to Drawings at the end of this manual.

The following section covers procedures for installing the Instrument Drive Assembly and the Solid State Pulser options, each developed exclusively for the Series 3 Accessory. Tools necessary for these procedures include a 5/32" and 9/64" Allen® wrench, a light grade of machine oil (for lubricating the O-ring) and Needle-Nose Pliers for gripping wiring connections and small parts.

Removing the Accessory Unit from the Meter

1. Remove the four #10-24 screws holding the slip flange on the meter end cover. Loosen the screws in a cross or star-like pattern to avoid stressing the cover.
2. Slide the slip flange off the accessory unit.
3. Remove the accessory unit by *carefully* pulling the complete assembly directly away from the meter body, taking care not to damage the male driving magnet and O-ring seal. IMPORTANT: If the accessory unit is temperature compensating, slide the assembly directly away from the meter end cover until the temperature probe has cleared the end of the meter. Make sure the thermocouple (bi-metallic probe) does not bind in the probe well during the removal process. Shock and/or damage will result in a loss of compensating accuracy.
4. Remove the O-ring seal.

Removing the Gear Reduction Assembly from the Lexan Cover

1. Using a 9/64" Allen wrench, remove the screw holding the accessory in its housing. The screw can be accessed through the Tool Access Port.
2. Slide the gear reduction unit out of Lexan cover.

Replacing the Gear Reduction Unit in Lexan Cover

1. Slide the gear reduction unit into the Lexan cover. Align the odometer(s) with the large, clear window on the cover. When the gear unit is properly installed, the pin that is molded into the bottom of the Lexan cover will engage a hole in the bottom of the plate.
2. Using a 9/64" Allen wrench, insert the screw into the threaded boss on the Lexan cover and torque to 20-25 in.-lb. Do not over tighten to avoid damage to the threaded boss.

Installing a Complete Accessory Unit to the Meter

1. Before installing a new O-ring onto the meter end cover, apply a thin film of grease to the O-ring. Position the O-ring onto the end cover.
2. Properly align the magnetic coupling with the magnet cup in the meter body. If a TC Accessory, align the temperature probe with the probe well. *Carefully* slide the accessory onto the meter end cover and hold in place.
3. Slide the slip flange over the unit housing with the counter-bored side facing the meter.
4. Rotate the slip flange until all four holes in the slip flange are aligned with the four screw holes in the meter end cover. A dimple in the slip flange should be aligned with the odometer(s).
5. While holding the slip flange to the meter end cover, insert the four screws into position and tighten in a cross or star-like pattern to 6-9 ft. lb. When properly installed, the slip flange will be in continuous contact with the meter end cover.

Converting a Counter (CTR or TC) Version to Counter with ...ument Drive (CD or TD)

...nstrument Drive (ID) assembly for the Series 3 Accessory offers a simple solution for adding an Automated Meter Reading (AMR) device, chart recorder, or other instrumentation.

Follow all procedures outlined above under "Removing the Accessory Unit from the Meter," and "Removing the Gear Reduction Assembly from the Lexan Cover."

1. Replace the original CTR or TC cover with the new cover supplied with the Instrument Drive conversion kit (cover with hole a hole in the opposite end). Slide the gear reduction unit into the Lexan cover. Align the odometers with the large, clear window on the cover.
2. Using a 9/64" Allen wrench, insert the screw into the threaded boss on the Lexan cover and torque to 20-25 in.-lb.
3. Lubricate the new ID/Lexan Cover O-ring with a thin film grease. Place O-ring around the recessed area of at the end of the Lexan cover.
4. Slide the aluminum ID housing over the Lexan cover. The "paddle" on the instrument drive will fit through the hole in the cover and engage with the 72-Tooth drive gear on the gear reduction unit.
5. Apply a thin film of grease to the *new* O-ring (#408) and position the O-ring onto the meter end cover. DO NOT use the O-ring for the CTR Unit.
6. Properly align the male drive magnet on the accessory unit with the magnet cup in the meter body. If a TC Accessory, align the temperature probe with the probe well. *Carefully* slide the accessory onto the meter end cover and hold in place.
7. Align the mounting ring of the instrument drive assembly until all four holes in the ring are aligned with the four screw holes in the meter end cover for the preferred installation configuration (Top or Side inlet).
8. While holding the instrument drive assembly to the meter end cover, insert the four screws into position and tighten in a cross or star-like pattern. Using a 5/32" Allen wrench, torque to approximately 30 to 40 in.-lb. When properly installed, the mounting ring is in continuous contact with the meter end cover.

Changing the Rotational Direction of the Instrument Drive

1. Unless otherwise specified, all meters with an instrument drive are shipped from the Factory where the "drive dog" will turn in a Clockwise (CW-B). To change to Counter-Clockwise (CCW-A), use the following procedure:
   A. Remove the two cap screws holding the front cover plate of the ID unit.
   B. Using a 5/32" Allen wrench, remove the two screws holding the modular, bevel gear train assembly in position. Insure O-ring is removed during assembly removal.
   C. Rotate the modular drive assembly 180° so that the pinion gear is towards the top of the instrument drive. Reposition the assembly into the housing and replace the two screws and tighten. Insure O-ring is in place. Windmill the meter or rotate the drive dog a minimum of one revolution to ensure proper rotation.
   D. Replace the front cover plate, screws, and tamper devices - if applicable. Follow company procedures for tamper-evident security.

   Install instrumentation or other mechanically drive device to the instrument adapter plate, making certain that the center of the drive circle for the instrument meets the drive dog of the ID Unit. The Instrument Drive assembly requires no maintenance.

NOTE: To change bevel gear rotation, follow Step 1 (above) and set-up as required per the following desired rotation.

Counter-Clockwise (CCW-A) rotation of the Drive Dog = Vertical shaft miter gear is positioned below the horizontal shaft

Clockwise rotation (CW-B) rotation of the Drive Dog = Vertical shaft miter gear is positioned above the horizontal shaft

Side Inlet to Top Inlet Conversion

ROOTS® Meters Series B3 may be installed in either a Side or Top inlet configuration. However, oil capacities differ between configurations. Refer to "Oil Capacities."

No changes are required for meters with CTR or TC accessories. If a CD or TD version, the following procedures are required to change the position of the instrument drive assembly.

1. Using a 5/32" Allen wrench, remove the two #10-24 screws holding the Side Cover Plate onto the aluminum housing. Remove the cover plate.
2. Use a flat blade screwdriver to remove the two screws holding the universal adapter plate to the ID Support assembly.
3. Remove the two screws holding the modular, bevel gear train assembly (per instructions under "Converting a CD Assembly from CW to CCW Rotation").
4. Using the 5/32" Allen wrench, remove the two #10-24 screws holding the neck of the ID Support assembly to the aluminum housing.
5. Install the ID Support to the desired mounting position (or where the cover plate was removed).
6. Re-install the bevel gear train. See instructions referenced under Step 3. Insure rotation is set as desired.
7. Re-install the cover plate to the position from where the ID Support was removed.
8. Re-install the adapter plate onto the ID Support housing.

Adding a Solid State Pulser to a CTR or TC Accessory

Installing the solid state pulser kit consists of two basic steps. The first step is to install the pulser magnet kit. The magnet kit consists of the magnet(s) that go on the gear reduction unit inside the CTR or TC Lexan cover. As the magnet(s) rotate, a sensor within the solid state pulser housing senses a change in the magnetic field. The next step is to snap the Solid State Pulser into position on the CTR or TC Lexan cover. This aligns the magnet(s) inside the cover with the sensing unit within the pulser housing. Refer to the following directions:

Installing the Magnet Kit

Note: A magnet kit can be ordered pre-installed onto the CTR or TC Unit direct from the factory. To determine whether the magnet kit has been installed, place a small magnet over the end of the Lexan cover and slowly move the magnet over the flat surface. If the magnet is attracted to the gear reduction unit inside the cover, then magnet(s) have already been installed.

If the magnet kit has been pre-installed, skip the remainder of this section and continue with the next section - "Mounting the Solid State Pulser Kit." If the magnet kit has not been pre-installed, proceed as follows:

1. Remove the CTR or TC Unit from the Lexan cover by using an Allen-head wrench to remove the #8-32 mounting screw by way of the Tool Access Port.
2. Remove and discard the retaining ring holding the 72-tooth gear. Make sure the washer under this retaining ring remains in place. If the unit is temperature compensated (TC), also remove and discard the retaining ring holding the 36-tooth gear. Do not reuse the retaining ring; extra retaining rings are supplied in the kit.
3. Place the metallic spacer over the shaft with the 72-tooth gear. The washer (see Step 2) should be positioned between the spacer and the 72-tooth gear.
4. Install a retaining ring on the shaft over the metallic spacer. The far

end of the shaft should be supported while using the retaining ring pliers to install the ring, being careful not to deform the retaining ring.

5. Pull *gently* on the 72-tooth gear to check for proper installation of the retaining ring. The ring should not slide on the shaft; however, the gear should have about 1/32" axial movement (1 mm) between the washer and the accessory unit end plate.
6. Place a magnet over the shaft and on top of the retaining ring installed in the Step 5. The magnet is retained by the magnet attraction to the retaining ring and shaft.

NOTE: If the accessory unit is a CTR Version, proceed to step 12. If a TC Version, continue with Step 7.

7. Install the plastic spacer over the shaft with the 36-tooth gear. The plastic spacer is a little larger than the metallic spacer used earlier.
8. Place two small washers over the shaft, on top of the plastic spacer.
9. Install a retaining ring onto the shaft over the two small washers. The far end of the shaft should be supported while using the retaining ring pliers to install the ring. Be careful not to deform the retaining ring.
10. Pace a magnet over the shaft, on top of the retaining ring installed in the previous step. The magnet is retained by the magnet attraction to the retaining ring.
11. *Gently* pull on the 72-tooth gear to check for proper installation of the retaining ring. The ring should not slide on the shaft. The gear should have about 1/32" axial movement (1 mm) between the washer and the accessory unit end plate.
12. Place a magnet over the shaft and on top of the retaining ring installed in the Step 5. The magnet is retained by the magnet attraction to the retaining ring and shaft.
13. Install the CTR or TC unit into the Lexan cover following the directions under "Replacing the Gear Reduction Unit in Lexan Cover."

Mounting the Solid State Pulser Kit to the Lexan Cover

1. Before mounting the pulser housing to the end of the Lexan cover, place the mounting flange over the cover with the counterbored side facing the open end of the cover. **IMPORTANT**: After the plastic pulser housing is mounted, the mounting flange can not be installed over the Lexan cover.
2. Place the smaller of the two O-rings provided in the kit over the closed end of the exterior of the CTR/TC Lexan cover. Place a light coating of grease on the O-ring prior to installation. Without this grease, the pulser housing can not be mounted due to the close fit of the parts.
3. Mount the pulser housing to the CTR/TC cover by snapping it in place over the O-ring previously installed in Step 2. Orient the pulser housing to the alignment boss of the cover (with the hole in the bottom of the pulser housing). Next, while depressing the flexible mounting tabs located inside the pulser housing, firmly push the pulser housing onto the Lexan cover. Continue to push the pulser housing until it is completely over the greased O-ring seal, and the flexible mounting tabs are engaged with the snap catch feature of the Lexan cover.
4. The pulser housing must be secured by installing the two curved, rectangular, metallic retaining devices behind the flexible mounting tabs molded to the inside of the pulser housing. Wedge the devices behind the flexible mounting tabs with a flat bladed screwdriver. After wedging the retaining devices in place, push them down into their final location to properly secure the pulser housing. The top edge of both retaining devices should be approximately level with the inside bottom surface of the pulser housing. The retaining devices prevent the flexible mounting tabs from releasing.

IMPORTANT: The O-ring installed between the Lexan cover and the pulser housing should not be visible from the outside of the housing. If it is visible, the pulser housing should be pushed further over the O-ring. Additional grease on the O-ring may be required.

5. On conduit versions with a single plug in the side of the pulser housing, remove the plug, install the conduit and wire the circuitry per drawing included with the kit. If the pulser has amphenol connectors, continue with Step 6.
6. Assemble each of the two #10-24 mounting screws with the seal washer, shoulder washer, and tamper device housing as illustrated in the reference drawing. Be certain to place these parts in the proper order and with the shoulder washer oriented properly (flanged end facing the seal washer).
7. Place a light coat of grease on the remaining O-ring (the larger of the two in the kit). Place the O-ring onto the bottom of the lid.
8. Place the lid onto the end of the pulser housing. Install the two mounting screws into the threaded bosses inside the housing. When assembled properly, the seal washer will seal between the top of the lid, the screw and the shoulder washer. When the lid is tight, the O-ring should not be visible. Security caps can then be installed, if desired.
9. Wire the connectors. (Refer to the appropriate drawing included with the kit).
10. Install the CTR or TC accessory onto the meter body, following the directions under "Installing a Complete Accessory Unit to the Meter."

Removal

1. To remove the pulser from the CTR/TC Lexan cover, first remove the two mounting screws holding the lid in position. If the mounting screws are contained in a tamper device, the caps must be broken.
2. Remove the two curved, metallic, rectangular retaining devices using a flat bladed screwdriver.
3. Remove the pulser housing from the Lexan cover by depressing both flexible mounting tabs while firmly pulling the pulser housing straight away from the cover.

TESTING

General

Rotary meters can be tested for accuracy by several industry accepted methods. These test methods include, but are not limited to: bell or piston prover, transfer prover, sonic nozzle prover, and critical flow proving. The Differential Rate Test is unique to rotary meters and is an accurate and convenient method of comparing a meter's performance to previous or original performance records. It is accepted by many State Utility Commissions as a means of periodically substantiating that the original accuracy of a meter has remained unchanged.

Differential Rate Test

A change in the meter's internal resistance can affect rotary meter accuracy. Any significant increase on the meter's internal resistance to flow will increase the pressure drop between the inlet and outlet of the meter, thus increasing the differential. Therefore, the meter differential pressure appears as a prime indicator of meter condition.

A test under actual operating conditions will provide the most reliable data for future checks of a meter's operating condition. Although accuracy cannot be directly determined by a differential test, results have shown that an increase of up to 50 percent in differential pressure can be tolerated without affecting meter accuracy at the higher flow rates (25% and above) by more than 1 percent. Supportive technical data is available, upon request.

A differential rate test consists of a series of differential pressure readings taken across the meter at several gas flow rates within the meter's capacity range. Ideally, testing should be performed when the meter is first installed and under the actual conditions of gas line pressure and specific gravity that will exist in service. This is particularly important when line pressure is higher than 15 PSIG (100 kPa Gauge). Multiple curves may be necessary for meters under varying pressure conditions.

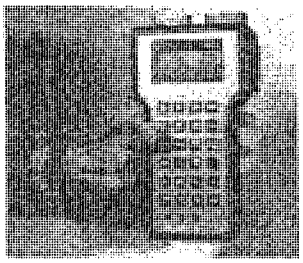
When less than 15 PSIG (100 kPa Gauge), the meter differential can, for practical purposes, be compared directly with Factory curves or specific test results. The factory Test Data Sheet lists actual meter test results of accuracy and differential obtained from a bell or piston prover test on air at atmospheric pressure. Comparisons can also be made against Factory published Characteristic Accuracy curves which are based on an average of 25 to 30 individual Prover Tests. Published data is representative of typical product production.

Establishing Base Line Curves - Developing an original differential or baseline curve is recommended at the time of meter initial installation. At least three (3) test points are required at gas flow rates from 25% to 100% of meter capacity. Plot the points on a graph and then connect the points to form a curve. This provides an accurate baseline for comparison to later tests.

The gas line pressure, specific gravity of the gas, and line temperature should also be recorded. If the application is under varying pressure conditions, plot multiple curves for various pressure ranges (i.e., 15, 45 and 60 psig). An increase in flow rate, line pressure or specific gravity will cause an increase in the differential. Normally, a simple meter flushing will eliminate a high pressure differential due to increased internal friction.

After developing a base-line curve, meter condition and performance can be checked periodically by running a similar differential rate test at a single selected point. This does not give the overall characteristics for the meter, but does provide a quick reference check. Differentials taken at varying flow rates are needed to give an overall picture. If the differential pressure increases by more than 50 percent of the original value, inspect the meter for causes of increased resistance. Principal causes are binding of impellers, worn bearings, contaminates such as dirt or valve grease in the metering chamber, and too heavy or excess oil. Refer to "INSPECTION AND MAINTENANCE. Meter Testing, Cleaning" for information on how to flush a meter.

Test Procedure - The test is performed using a ROOTS® Versi-Test Calibrator, manometer, or other differential pressure test equipment with an indicating scale range of about 6" H_2O (150 mm). The testing device should have inlet, outlet, and bypass valving, and must be pressure rated for the maximum metering pressure for the test. Pressure lines should be connected to the 1/4" meter inlet and outlet pressure taps located on the meter body. (The pressure taps are just above and below the meter nameplate). Test plugs can be permanently installed in the pressure taps to facilitate testing.



A pressure gauge is used to verify pressure readings. A stop watch is used to "clock" the meter RPM for calculating gas flow rate.

Follow all manufacturer's and company recommended operating procedures.

CAUTION: When the meter is on line pressure, follow applicable safety rules and wear appropriate protective apparatus.

Install the pressure differential indicating device into the meter inlet and outlet differential taps. Follow the manufacturer's instructions for proper installation and operating procedures. Install a pressure gauge or other pressure standard if not a component of the test equipment.

2. Adjust the meter bypass and the meter inlet valves until the meter is operating at a predetermined or selected flow rate in the lower capacity range, or approximately 25 percent of meter rated capacity. Let the flow rate stabilize.

3. Time or "clock" the passage of a predetermined volume of gas as registered on the odometer or instrument to determine the Index or Flow Rate in Actual Cubic Feet per Hour (or m^3/h):

$$\text{Index Rate} = \frac{\text{Cu. Ft. x 3600}}{\text{Test Time (sec.)}}$$

Convert the calculated flow rate to a percentage of meter rated capacity:

$$\%\ \text{Meter Capacity} = \frac{\text{Index Rate}}{\text{Meter Base Rating}}$$

4. Record the pressure differential, line pressure, and gas specific gravity. Repeat the test to obtain an accurate average reading.

NOTE: At the time of meter start-up in a new installation, repeat Steps 2 - 3 at a minimum of three different flow rates, each between 25% and 100% of meter capacity. The original base line curve should be drawn using data at a constant pressure for all three tests.

5. Remove the differential test equipment and pressure standard.

6. If the pressure differential is within acceptable limits, return the meter to full service. If the pressure differential is higher than recommended, remove the meter for inspection and service. For Factory assistance regarding meter inspection and/or repair, please call the Product Services Department, your Customer Service Representative or local Sales Representative or Distributor and request a Return Material Authorization (RMA).

Proving Operations

Conventional scanning methods may be used with the Series 3 Accessory in meter proving. There are two sources for volume scanning. The first method is to focus a photocell or scanner on the exposed portion of the right-most odometer wheel (the large white, square "tick-mark). Each tick-mark represents 1 cubic foot (0.02832 cubic meters) of volume. The Non-Compensated odometer is used for an Uncorrected test. The Temperature Compensated odometer is used for a combined (TC) test.

The other source of volume scanning is the round proving wheel attached to the end of the high-speed drive shaft. This wheel is visible either from the front or the end of the accessory. When using the ROOTS® RS-45 Scanner from the front, the scanner must be focused on the edge of this wheel. When scanning from the end of the accessory housing, the scanner must be focused on the face of the proving wheel. Each revolution of the proving wheel will provide one scan pulse and represents one revolution of the meter impellers. The volume of gas per revolution varies with the size of the meter. Test results are Uncorrected.

A special rubber collar and bracket to ease the task of focusing the RS-45 Scanner on the Series 3 Accessory is included with the RS-45 Scanner Assembly. These items may also be purchased separately.

Test Volumes required for accurate resolution using the Automated Prover Test using a photocell focused on the graduated mark of the Temperature Compensated volume odometer test wheel:

Size	ROOTS® Model 4 Prover	TQM ROOTS® Model 5 Prover
8C - 11M	1,000 cf	200 cf
16M - 56M	10,000 cf	2,000 cf

DIFFERENTIAL - RATE TEST DATA

Meter Model _____ ROOTS® Serial No. _____ Utility Serial No. _____

Location _____ Date Installed _____ Register Reading _____

Line Press.	Gas Temp.	Sp. Grav	Volume Meas.	Run Time	Rate CFH (m³/h)	Differential Pressure Inches W.C. (mm W.C.)	Differential Pressure % Change	Date	Tester
INITIAL TESTS - NEW METER									
PERIODIC CHECK TESTS									

TC Unit Operational Check

This procedure may be used to verify the overall accuracy of the TC Unit, independent of the basic meter body measurement accuracy. The designed accuracy for the TC Unit is to within ± 0.5% of the theoretical correction for gas temperatures between -20°F to +120°F (-29°C and +49°C) and compensated to a 60° F (15° C) Base Temperature.

The TC Unit Operational Check is based upon Calculated Measurement Counts (actual measurement) versus Theoretical Counts, using the industry standard 10 cycle count of the compensation cycle. This is the recommended test for field checking the TC Unit calibration.

A ROOTS® Transfer Prover is a commonly used device for conducting a TC Unit Operation Check in the shop or when the meter is not in service. The prover is used for flow rate control and indication of temperature during the test procedure. The prover may also be used during this time to test the accuracy of the basic meter body using the non-compensated odometer or the RPM test wheel (See: "Proving Operations,"). The information derived from the TC Unit Operation Check is then combined with the meter's uncorrected accuracy to determine the meter's overall accuracy, including temperature compensation. An optional motor driven device is available from Dresser for test and calibration in a temperature bath.

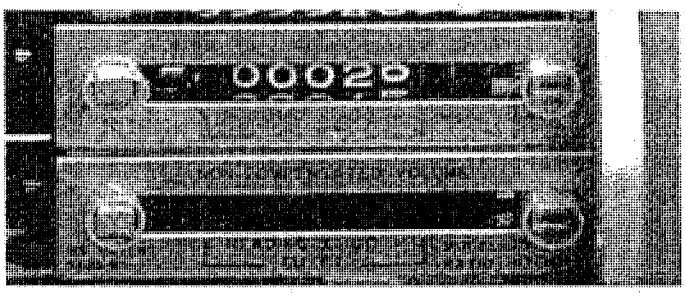
Calibration will not be covered in this manual other than to state that during the calibration procedure, the TC probe should be immersed into a solution with a controlled temperature within the unit's temperature compensating range. Calibration of the TC Unit should *not* be performed while the accessory is installed on the meter.

Procedure for the TC Unit Operational Check -

1. Measure and record stabilized gas (or air) temperature directly at the meter inlet using a certified temperature standard.

2. Record the temperature displayed by the accessory's temperature probe. The probe is visible from the outside top of the accessory housing. Compare to the readings taken in step 1. Both values should agree within ± 4 °F.

3. Observe the Temperature Compensated volume odometer. When the odometer stops turning after an intermittent compensating cycle, record the last 3-digit reading (Ci) indicated on the odometer, PLUS the value indicated by the graduated marks on the least significant test wheel (viewed through the translucent mask). Read as a whole number. See Sample Counter Reading, below:



In the above example, a reading of "2594" should be recorded.

4. After the Compensated Volume odometer has cycled 10 times and stopped, record the reading of the Temperature Compensated odometer (Cf), PLUS the graduated wheel estimation as you did in Step #3 above.

5. Record the theoretical number of divisions for indicated temperature from Chart No. 1.

6. Calculate the percent accuracy with the following equation, or using the information on the following page:

$$\text{Percent Accuracy} = \frac{Cf - Ci}{T} \times 100\%$$

Where T = the temperature recorded in Step 2, or the flowing temperature measured at the meter inlet using a certified test thermometer.

ROOTS METER TC UNIT OPERATIONAL CHECK

CHART NO. 1

THEORETICAL NUMBER OF COUNTS (T) VERSUS TEMPERATURE [1]

°F	°C	Counts	°F	°C	Counts	°F	°C	Counts	°F	°C	Counts
-20	-28.9	1181.8	10	-12.2	1106.4	40	4.4	1040.0	70	21.1	981.1
-18	-27.8	1176.5	12	-11.1	1101.7	42	5.6	1035.9	72	22.2	977.4
-16	-26.7	1171.2	14	-10.0	1097.0	44	6.7	1031.7	74	23.3	973.8
-14	-25.6	1165.9	16	-8.9	1092.4	46	7.8	1027.7	76	24.4	970.1
-12	-24.4	1160.7	18	-7.8	1087.9	48	8.9	1023.6	78	25.6	966.5
-10	-23.3	1155.6	20	-6.7	1083.3	50	10.0	1019.6	80	26.7	963.0
-8	-22.2	1150.4	22	-5.6	1078.8	52	11.1	1015.6	82	27.8	959.4
-6	-21.1	1145.4	24	-4.4	1074.4	54	12.2	1011.7	84	28.9	955.9
-4	-20.0	1140.4	26	-3.3	1070.0	56	13.3	1007.7	86	30.0	952.4
-2	-18.9	1135.4	28	-2.2	1065.6	58	14.4	1003.9	88	31.1	948.9
0	-17.8	1130.4	30	-1.1	1061.2	60	15.6	1000.0	90	32.2	945.5
2	-16.7	1125.5	32	0.0	1056.9	62	16.7	996.2	92	33.3	942.0
4	-15.6	1120.7	34	1.1	1052.6	64	17.8	992.4	94	34.4	938.6
6	-14.4	1115.9	36	2.2	1048.4	66	18.9	988.6	96	35.6	935.3
8	-13.3	1111.1	38	3.3	1044.2	68	20.0	984.8	98	36.7	931.9
									100	37.8	928.6

[1] Chart based upon 60° F (15.56° C) Base Temperature.

NOTE:

The number of theoretical counts (T) can be calculated as follows:

Let Tb = Base Temperature
Ta = Actual Gas Temperature

Therefore:

$$\text{Number of Counts (T)} = \frac{460°F + Tb}{460°F + Ta} \times 1000 \text{ or } \frac{273°C + Tb}{273°C + Ta} \times 1000$$

For example, the number of theoretical counts (T) with a gas temperature of 40° F. would be calculated as follows:

$$\text{Number of Counts (T)} = \frac{460°F + Tb}{460°F + Ta} \times 1000 = \frac{460°F + 60°F}{460°F + 40°F} \times 1000 = \frac{520}{500} \times 1000 = \underline{\underline{1040.0}}$$

II. SAMPLE DATA SHEET FOR TC UNIT OPERATIONAL CHECK:

1. Stabilized gas (or air) temperature ..... ____ °F./°C.

	Digits	Grad		Symbol
2. Final Compensated Counter Reading (Cf)	____ ____ ____	____	=	Cf
3. Initial Compensated Counter Reading (Ci)	____ ____ ____	____	=	Ci
4. Calculated Measured Counts (Cm) = Cf - Ci	____ ____ ____	____	=	Cm
5. Record the theoretical counts (T) from Chart No. 1	____ ____ ____	____	=	T

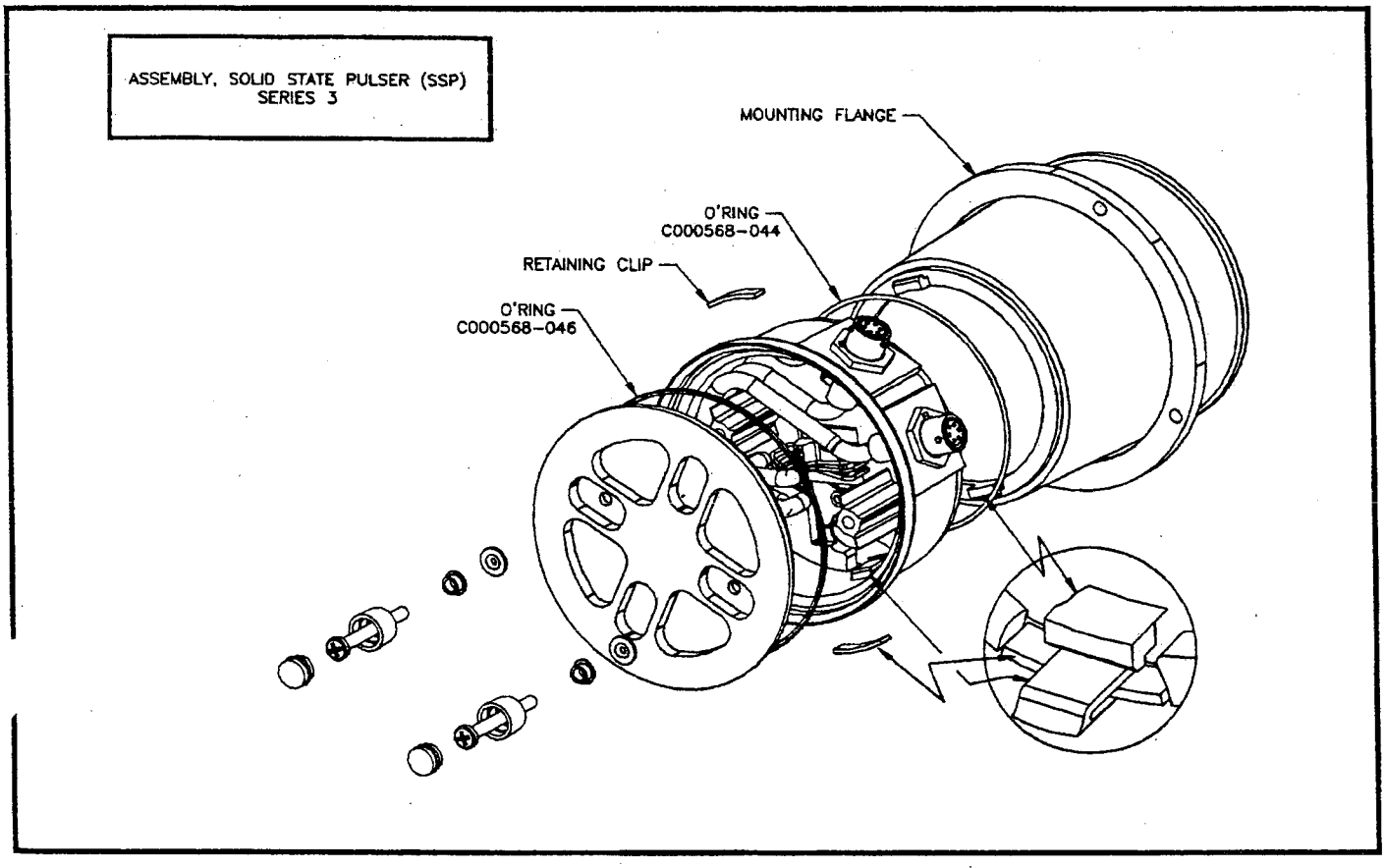
6. Calculate operational check accuracy as follows:

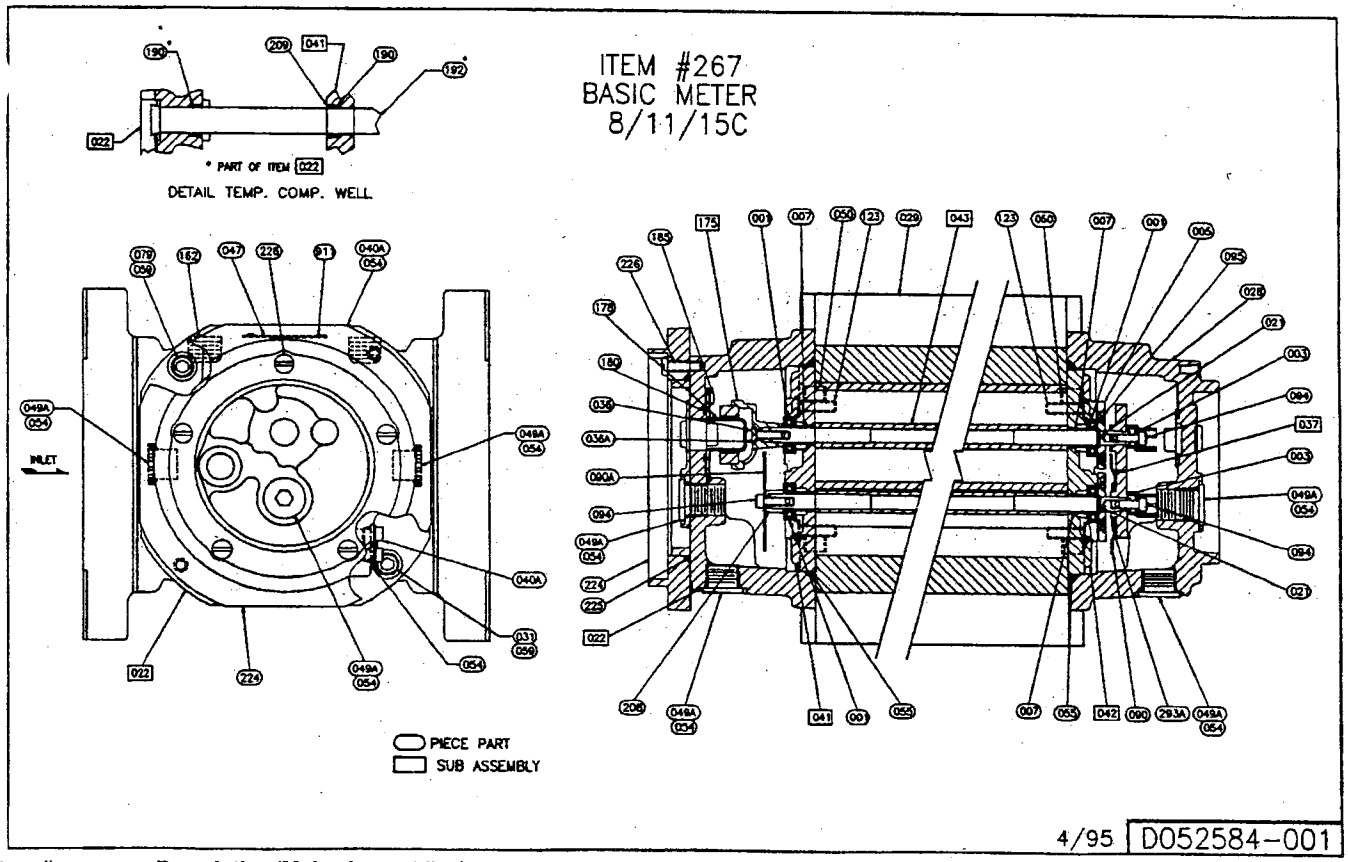
$$\% \text{ Accuracy} = \frac{\text{Measured Counts}}{\text{Theoretical Counts}} \times 100\%$$

$$\% \text{ Accuracy} = \frac{Cm}{T} \times 100\% = \frac{\_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_}{\_\_\_\_ \_\_\_\_ \_\_\_\_ \_\_\_\_} \times 100\% = \_\_\_\_\%$$

Trouble	Item	Possible Cause	Remedy
No Flow Registered	1	Obstruction in piping or meter.	Check piping and valves to assure an open flow path. Check for impeller rotation. Refer to "Placing Meter in Line" Step #5.
	2	Index or RPM wheel does not turn.	No gas flow. Open valve or remove obstruction per Item 1.
Low Volume Registration	3	Meter oversized for load.	Use proper meter size.
	4	Leak at meter bypass	Check bypass and valves.
	5	Meter internal friction	See High Differential, Item #6
High Differential	6	Build-up of deposits in measuring chamber.	Flush meter.
	7	Worn bearings or gears.	Replace or Return to Dresser's Product Services Department.
	8	High oil level or heavy oil	Check oil level and cleanliness.
	9	Impellers rubbing cylinder or headplates, or meter out of time.	Rotate impellers manually to check for binding or rubbing. Remove obstructions and/or time the meter. Check the meter level.
Vibration / Noise	10	Piping misalignment or strain	Remove piping strain. Level meter.
	11	Impellers rubbing casing.	See Items #7 & #9.
	12	Contaminants in measuring chamber	See Item #6.

Note: Also refer to Installation, Operation and Maintenance procedures within this manual for possible solutions.





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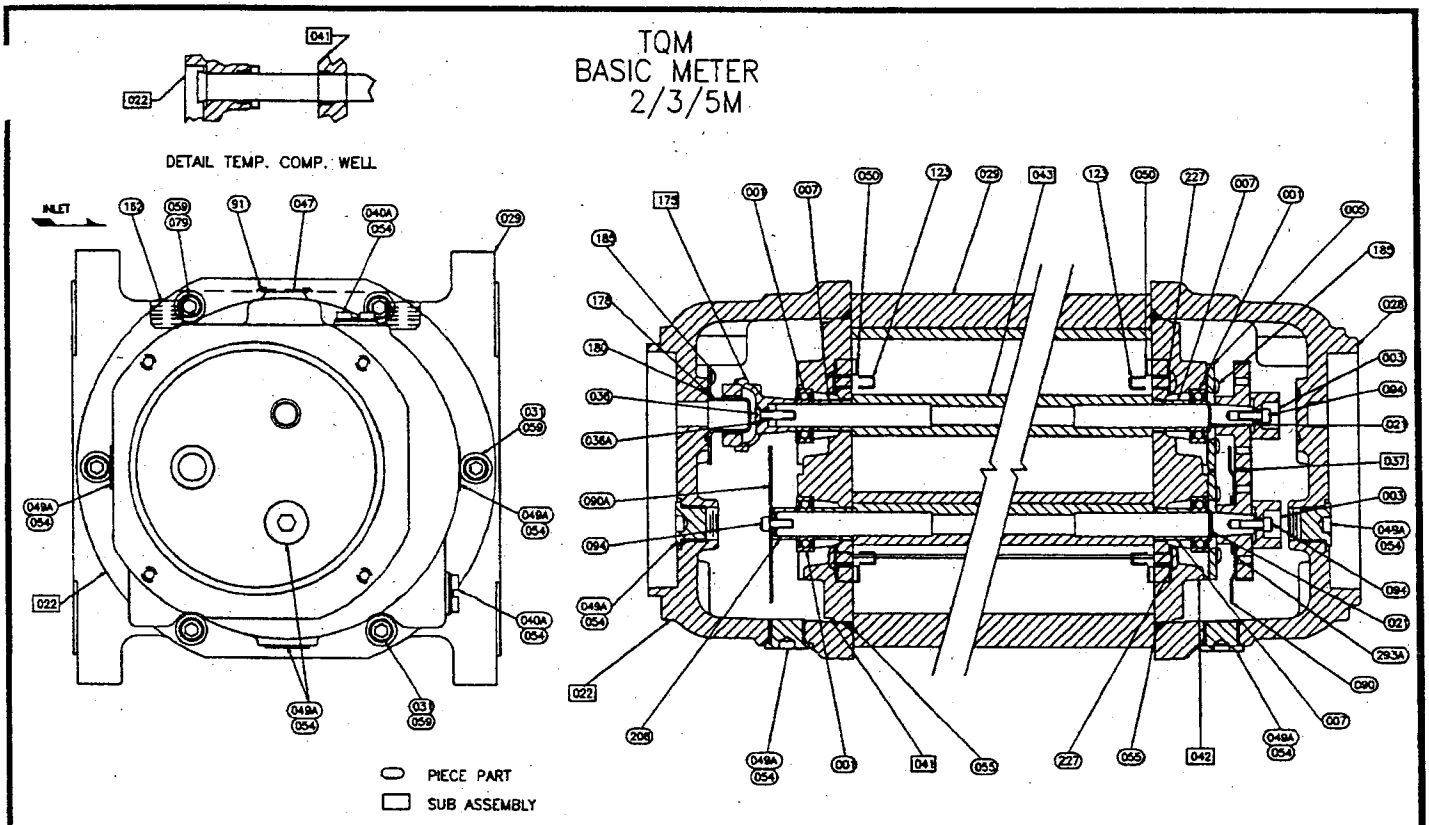
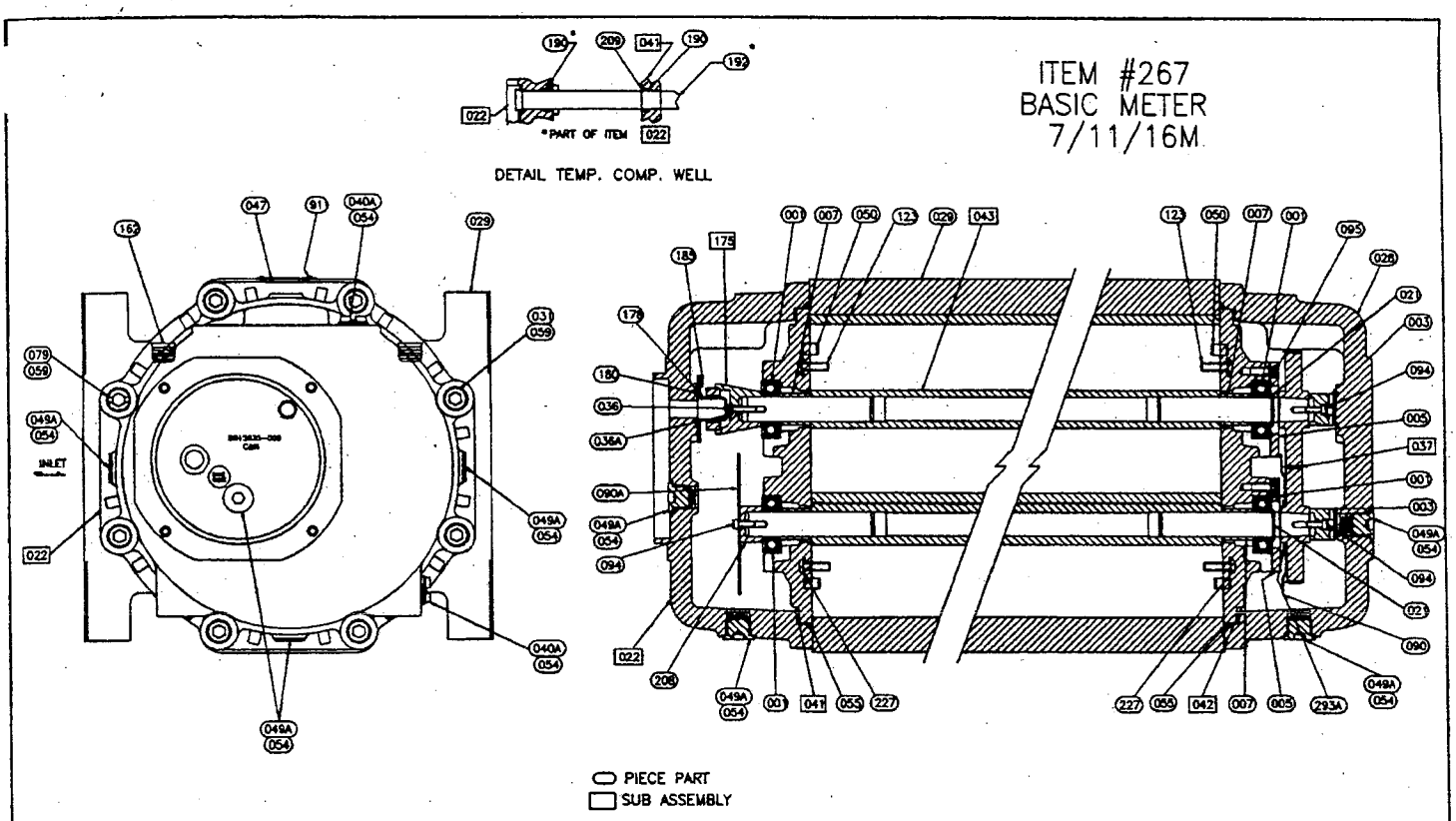
Item #	Description (Major Assemblies)	Part Number	Qty/ Meter	Repair Class
001	Bearing, Main Shaft	012676-000	4	B
003	Clamp, Gear	053378-000	2	C
005	Bearing Clamp	012665-000	2	C
007	Sleeve, Bearing Placement	051621-000	4	B
021	Retaining Ring	011823-005	2	C
022	Cover Assembly - Magnet Drive End	053055-000	1	C
028	Cover Assembly - Gear End	051609-000	1	C
029	Cylinder			
	8C	*	1	B
	11C	*	1	B
	15C	*	1	B
031	Cap Screw (1/4 - 20 NC3 X 1)	010055-004	7	C
036	Screw, Flat, Hex Head, Self Locking (6 - 32 NC2 X 5/8)	012675-003	1	C
036A	Washer, Locking	012684-001	1	C
037	Timing Gears (sets only)	051640-000	1set	C
040A	Sight Gauge, Oil Level (see #54)	051671-000	4	C
041	Headplate, Magnet Drive End	051679-001	1	B
042	Headplate, Gear End	051680-001	1	B
043	Impeller and Shaft Assembly			
	8C	*	2	B
	11C	*	2	B
	15C	*	2	B
047	Nameplate	*	1	C
049A	Plug, Hex (9/16-18 NF2) (see #54)	012261-005	8	C
054	Seal, O-Ring for #40A or #49A (.468 X .624 X .078)	000568-906	12	C
055	Seal, O-Ring Headlate (3 1/2 X 3 3/4 X 1/8)	000568-238	2	C
059	Washer, Flat, (9/32 X 1/2 X 1/16)	010181-020	8	C
079	Cap Screw, Drilled (1/4-20 NC3 X 1)	011863-004	1	C
090	Oil Slinger, Gear End	012667-000	1	B
090a	Oil Slinger, Counter End	012668-000	1	B
094	Cap Screw, Socket Head, Locking (6-32 NC3 X 1/2)	000145-238	3	C
095	Cap Screw, Hex Head, (6-32NC X 5/16)	011858-004	4	C
123	Cap Screw, Socket Head (10-24NC X 5/8)	000644-035	8	C
162	Pipe Plug, Dry Seal (1/4 NPFT)	010506-002	2	C
175	Magnet Wheel Assembly	051607-000	1	C
178	Magnet Cup	012666-000	1	C
180	O-Ring, Magnet Cup (11/16 X 13/16 X 1/16)	000568-017	1	C
185	Cap Screw, Socket Head (6-32NC2 X 1/4)	011925-031	3	C
208	Clamp, Bearing Shaft	051637-000	1	C
224	Ring, Mounting Machined	051697-000	1	C
225	Seal, O-Ring (3 X 3/16 X 3/32)	000568-151	1	C
226	Screw, (8-32NC2 X 9/16)	000644-026	5	C
293A	Retaining Ring (7/16)	012659-011	1	C



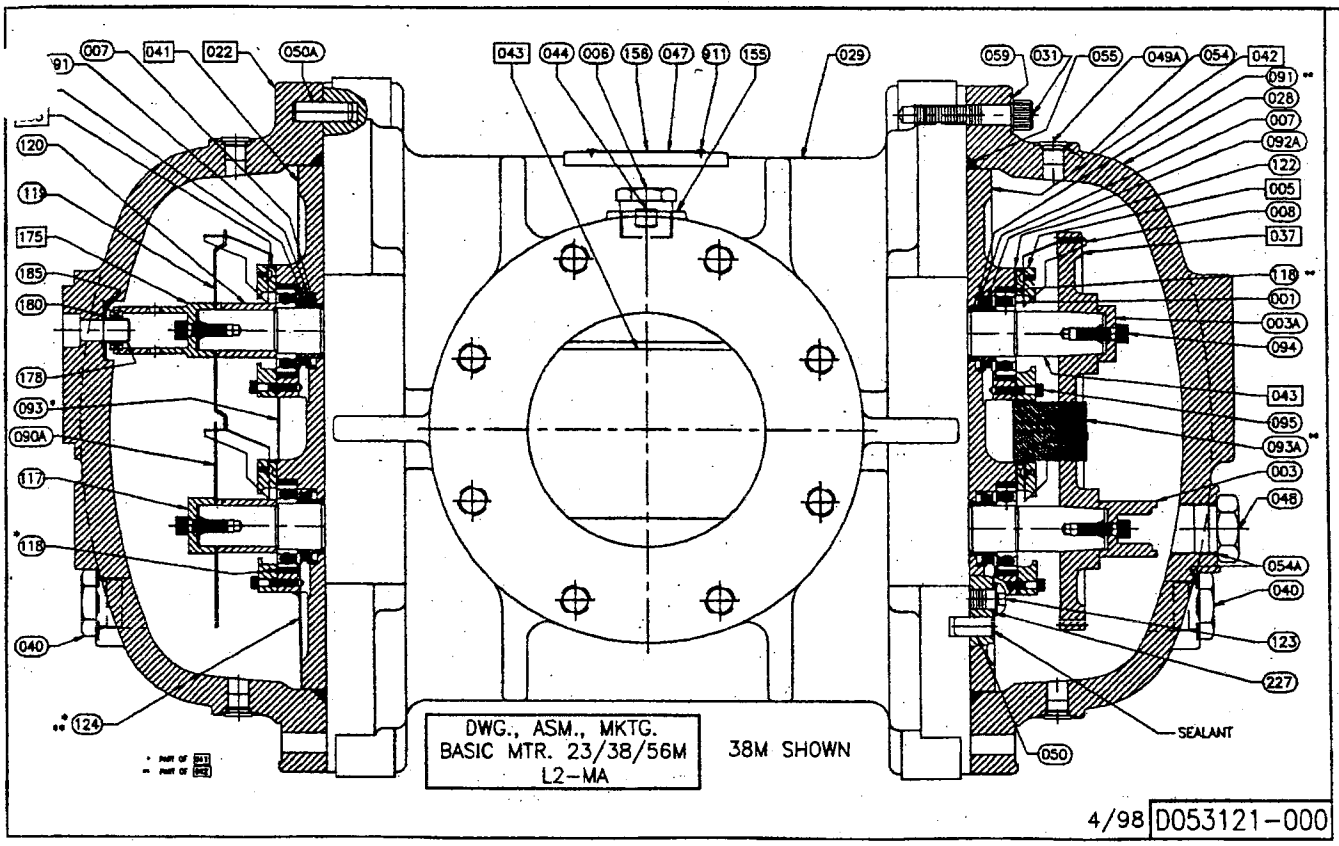
6/95 D052585-001

Item #	Description (Major Assemblies)	Part Number	Qty/ Meter	Repair Class
001	Bearing, Main Shaft	012677-000	4	B
003	Clamp, Gear	012703-000	2	C
005	Bearing Clamp	012679-000	2	C
007	Sleeve, Bearing Placement	051669-000	4	B
021	Retaining Ring	011823-011	2	C
022	Cover Assembly - Magnet Drive End	053056-000	1	C
028	Cover Assembly - Gear End	051677-000	1	C
029	Cylinder			
	2M	*	1	B
	3M	*	1	B
	5M	*	1	B
031	Cap Screw (1/4 - 20 NC3 X 1 1/4)	010055-005	11	C
036	Screw, Flat, Hex Head, Self Locking (10-32NF X 7/8)	011858-006	1	C
036A	Washer, Locking	012684-003	1	C
037	Timing Gears (sets only)	044330-000	1set	C
040A	Sight Gauge, Oil Level (see #54)	051671-000	4	C
041	Headplate, Magnet Drive End	051921-001	1	B
042	Headplate, Gear End	051922-001	1	B
043	Impeller and Shaft Assembly			
	2M	*	2	B
	3M	*	2	B
	5M	*	2	B
047	Nameplate	*	1	C
049A	Plug, Hex 9/16-18 NF2 (see #54)	012261-005	8	C
054	Seal, O-Ring for #40A or #49A (.468 X .624 X .078)	000568-906	12	C
055	Seal, O-Ring Headlate (5 1/8 X 4 7/8 X 1/8)	000568-249	2	C
059	Washer, Flat, (9/32 X 1/2 X 1/16)	010181-020	12	C
079	Cap Screw, Drilled (1/2-20NC3 X 1 1/4)	011863-005	1	C
090	Oil Slinger, Gear End	012685-000	1	B
090a	Oil Slinger, Counter End	012673-000	1	B
094	Cap Screw, Socket Head, Locking (10-32NF3 X 3/4)	000141-069	3	C
[illegible]3	Cap Screw, Socket Head (1/4-20NC X 3/4)	011935-055	8	C
[illegible]2	Pipe Plug, Dry Seal (1/4 NPFT)	010506-002	2	C
[illegible]5	Magnet Wheel Assembly	051684-000	1	C
178	Magnet Cup	012666-000	1	C
180	O-Ring, Magnet Cup (11/16 X 13/16 X 1/16)	000568-017	2	C
185	Cap Screw, Socket Head (6-32NC2 X 1/4)	011925-031	7	C
208	Clamp, Bearing Shaft	051670-000	1	C
227	Washer, Seal (1/4)	012283-001	8	C
293A	Retaining Ring (5/8)	012659-014	1	C

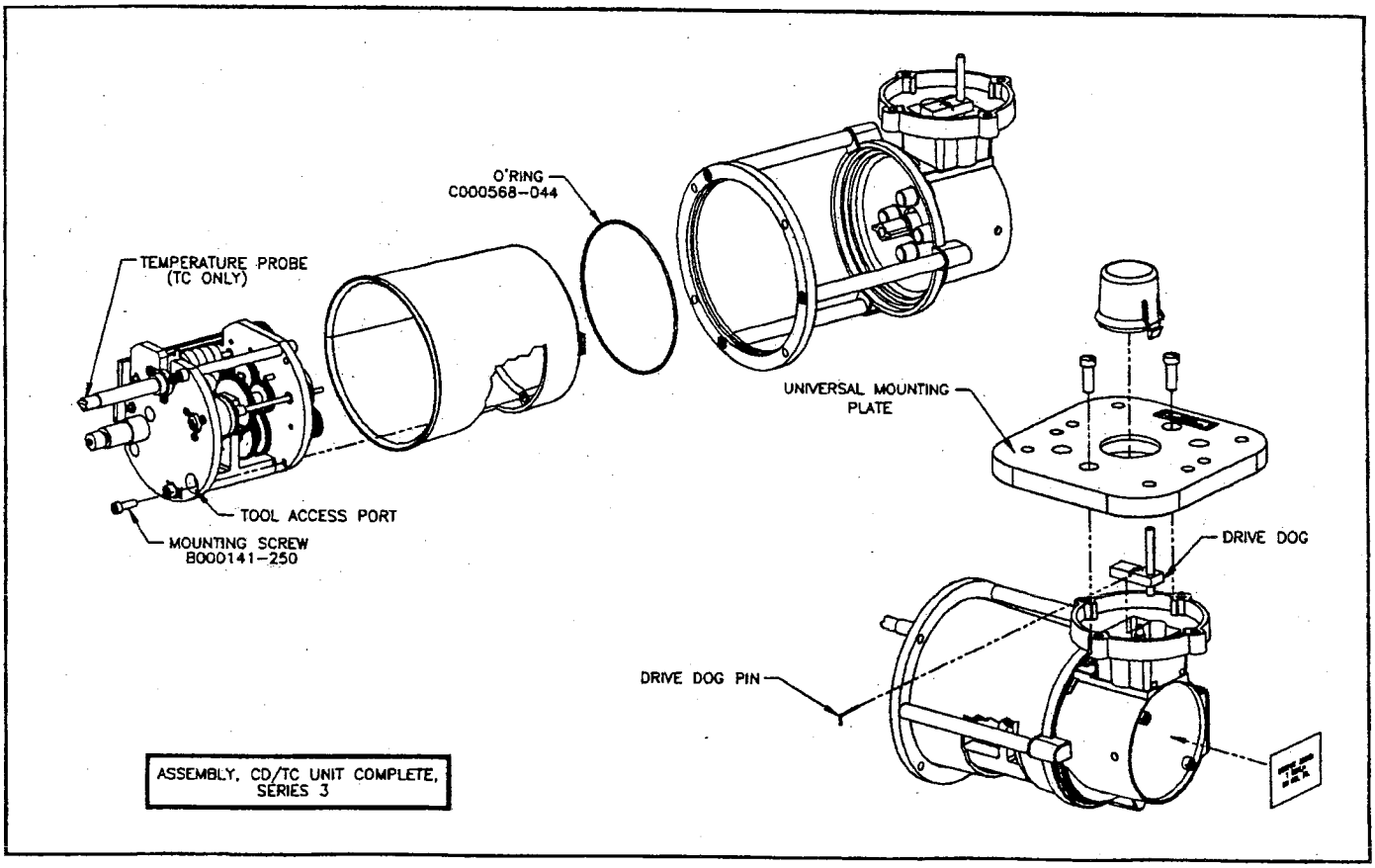


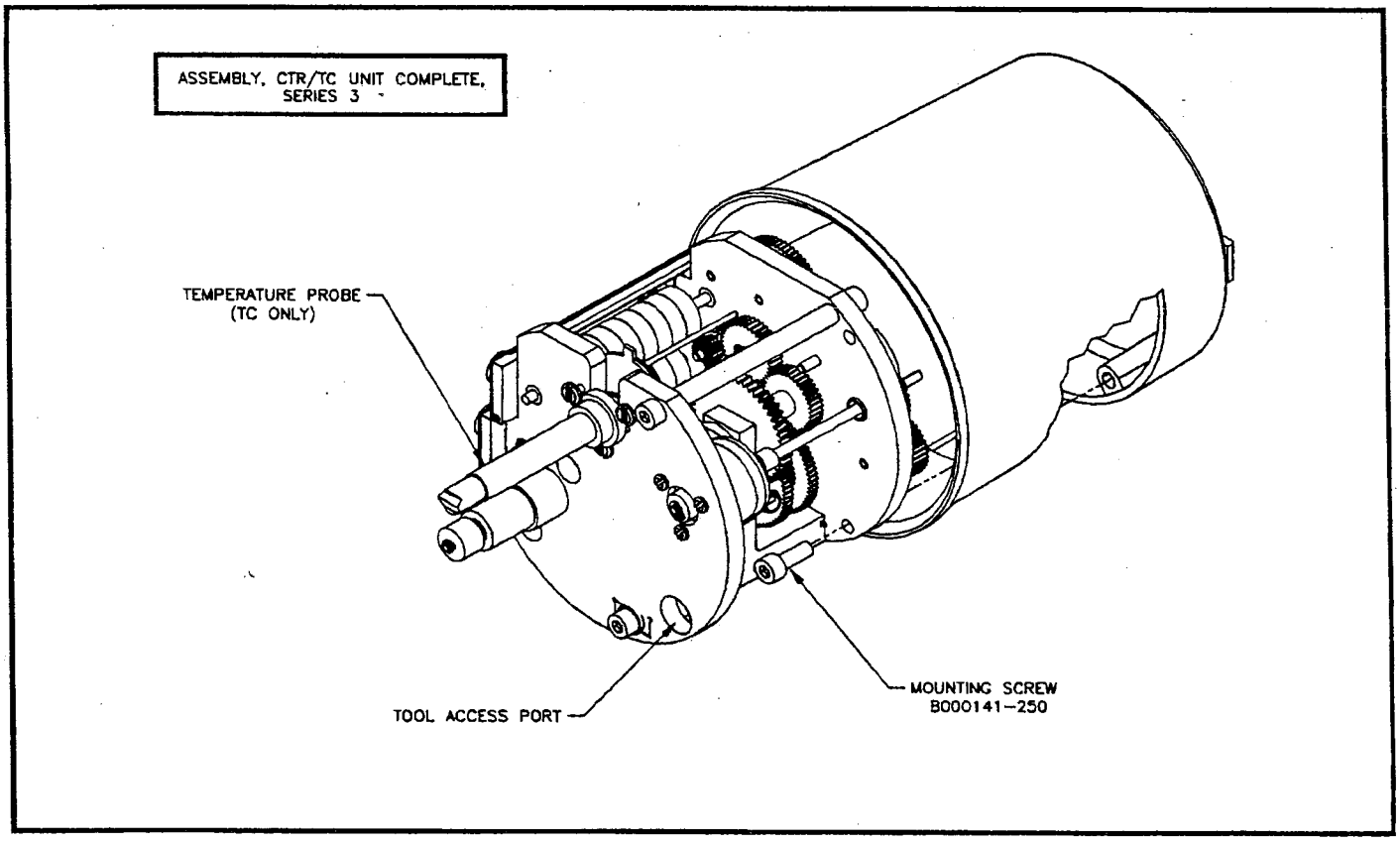
3/94 D052586-001

Item #	Description (Major Assemblies)	Part Number	Qty/ Meter	Repair Class
001	Bearing, Main Shaft	012671-001	4	B
003	Clamp, Gear	012703-000	2	C
005	Bearing Clamp	049264-000	2	C
007	Sleeve, Bearing Placement	051722-000	4	B
021	Retaining Ring	011823-019	2	C
022	Cover Assembly - Magnet Drive End	053057-000	1	C
028	Cover Assembly - Gear End	051675-000	1	C
029	Cylinder			
	7M	*	1	B
	11M	*	1	B
	16M	*	1	B
031	Cap Screw (3/8 - 16 NC3 X 1 1/2)	010065-008	15	C
036	Screw, Flat, Hex Head, Self Locking (10-32NF X 7/8)	011858-006	1	C
036A	Washer, Locking	012684-003	1	C
037	Timing Gears (sets only)	051858-000	1set	C
040A	Sight Gauge, Oil Level (see #54)	051671-000	4	C
041	Headplate, Magnet Drive End	051923-001	1	B
042	Headplate, Gear End	051924-001	1	B
043	Impeller and Shaft Assembly			
	7M	*	2	B
	11M	*	2	B
	16M	*	2	B
047	Nameplate	*	1	C
049A	Plug, Hex 9/16-18 NF2 (see #54)	012261-005	8	C
054	Seal, O-Ring for #40A or #49A (.468 X .624 X .078)	000568-906	12	C
055	Seal, O-Ring Headlate (7 1/2 X 7 3/4 X 1/8)	000568-264	2	C
059	Washer, Flat, (13/32 X 47/64 X 1/16)	010181-022	16	C
079	Cap Screw, Drilled (3/8-16NC3 X 1 1/2)	011971-007	1	C
090	Oil Slinger, Gear End	012701-000	1	B
090a	Oil Slinger, Counter End	012702-000	1	B
094	Cap Screw, Socket Head, Locking (10-32NF3 X 3/4)	000141-069	3	C
095	Cap Screw (10-24NC X 1/2)	011858-005	6	C
123	Cap Screw, Socket Head (3/8-16NC X 1)	011925-064	8	C
162	Pipe Plug, Dry Seal (1/4 NPFT)	010506-002	2	C
175	Magnet Wheel Assembly	051672-000	1	C
178	Magnet Cup	012666-000	1	C
180	O-Ring, Magnet Cup (11/16 X 13/16 X 1/16)	000568-017	2	C
185	Cap Screw, Socket Head (6-32NC2 X 1/4)	011925-031	7	C
208	Clamp, Bearing Shaft	051721-000	1	C
227	Washer, Seal (3/8)	011974-001	8	C
293A	Retaining Ring (7/16)	012867-017	1	C



#	Description (Major Assemblies)	Part Number	Qty/ Meter	Repair Class
	Bearing, Main Shaft	012932-000	4	B
	Clamp, Gear	052605-000	1	C
003A	Clamp, Gear & Crank	052606-000	1	C
005	Clamp, Bearing -Oil Leader Assembly	052680-000	4	A
006	Plug, Pipe Hex Head (1 X 15/16)	010505-106	2	C
007	Sleeve, Bearing Placement	012929-000	4	B
022	Cover Assembly - Magnet Drive End	052684-000	1	C
028	Cover Assembly - Gear End	052296-000	1	C
029	Cylinder			
	23M	*	1	B
	38M	*	1	B
	56M	*	1	B
031	Cap Screw (1/2 - 13 NC3 X 2 1/4)	010080-007	20	C
037	Timing Gears (sets only)	052522-000	1set	C
040	Sight Glass, Oil Level	012916-000	2	C
041	Headplate, Magnet Drive End	052683-000	1	A
042	Headplate, Gear End	052683-100	1	A
043	Impeller and Shaft Assembly			
	23M	*	2	B
	38M	*	2	B
	56M	*	2	B
044	Plug, Pipe (1/4)	010506-002	2	C
047	Nameplate	*	1	C
048	Plug, Hex Head (1 5/16 NF2)	012914-001	1	C
049A	Plug, Hex 9/16-18 NF2 (see #54)	012261-005	8	C
054	Seal, O-Ring for #49A (.468 X .624 X .078)	000568-906	12	C
054A	Seal, O-Ring for #40 and #48 (1.171 X 1.403 X .116)	000568-916	3	C
055	Seal, O-Ring Headlate (13 1/2 X 14 X 1/4)	000568-456	2	C
059	Washer, Flat, Special for #31 (.532 X .872 X .062)	012984-001	20	C
090a	Oil Slinger, Flat, Counter End	012895-000	1	C
092	Oil Slinger, Counter End Shaft	053003-000	2	B
092A	Oil Slinger, Gear End Shaft	053002-000	2	B
094	Cap Screw, Socket Head, Locking (5/16-18NC X 1)	012935-000	4	C
095	Cap Screw (10-24NC X 7/8)	000141-271	12	C
117	Clamp, Flat Oil Slinger, Counter End	052664-000	1	C
119	Oil Slinger, Disher, Counter End	012896-000	1	C
120	Spacer, Oil Slinger, Counter End	052665-000	2	C
122	Spacer-Shim, Bearing Clamp, Gear End .020	052678-001	2	C
122A	Spacer-Shim, Bearing Clamp, Gear End .025	052678-002	2	C
	Cap Screw, Socket Head (1 1/2-13NC3 X 1 1/2)	013018-000	8	C
	Nameplate, "Inlet"	052681-000	1	C
	Nameplate, "Warning"	052682-000	1	C
175	Magnet Wheel Assembly	052654-000	1	C
178	Magnet Cup	012666-000	1	C
180	O-Ring, Magnet Cup (5/8 X 3/4 X 1/16)	000568-016	1	C
185	Cap Screw, Socket Head (6-32NC2 X 1/4)	011925-031	3	C
227	Washer, Seal (1/2)			
	23M and 38M	011974-001	8	C
	56M	011974-005	8	C
911	Grip Nail, Metal Tack	012319-006	8	C


O'RING
C000568-044
TEMPERATURE PROBE
(TC ONLY)
TOOL ACCESS PORT
MOUNTING SCREW
B000141-250
UNIVERSAL MOUNTING
PLATE
DRIVE DOG
DRIVE DOG PIN
ASSEMBLY, CD/TC UNIT COMPLETE,
SERIES 3


ASSEMBLY, CTR/TC UNIT COMPLETE,
SERIES 3
TEMPERATURE PROBE
(TC ONLY)
TOOL ACCESS PORT
MOUNTING SCREW
B000141-250

Description	CTR	CD	TC	TD	CTR or TC w/Pulser
Assembly #400, Complete Gear Reduction Unit with Lexan® Cover	Varies	Varies	Varies	Varies	Varies
Assembly #400, Complete Gear Reduction Unit, with Lexan® Cover and Instrument Drive support housing.	Varies	Varies	Varies	Varies	Varies
Assembly, #409, Cover w/ Hardware	054678-000	See ID Asm.	054678-000	See ID Asm.	See: CTR & TC
Kit, Mounting Hardware - includes:	053858-000	053858-100	053858-000	053858-100	
Flange, Slip (Mounting)	053780-900	See: ID Asm.	053780-900	See: ID Asm.	See: CTR & TC
Seal, O-Ring - Meter End Cover	000568-155	000568-155	000568-155	000568-155	
Screw (3), #10-24 x 5/8"	000141-267	000141-267	000141-267	000141-267	
Screw (1), Drilled Head, #10-24x5/8"	011951-004	011951-004	011951-004	011951-004	
Assembly, ID - includes misc. parts, plus:		054186-000		054186-000	
Gear Reduction Assembly	N/A	Varies	N/A	Varies	N/A
Cover, Lexan		054090-001		054090-001	
O-Ring, 3-3/4 " x 3-7/8" x 1/16"		000568-044		000568-044	
Screw, #8-32x1/2"		000141-250		000141-250	
Screw (3), #10-24 x 5/8"		000141-267		000141-267	
Screw (1), Drilled Head, #10-24x5/8"		000143-267		000143-267	
Assembly, Instrument Plate (included in ID Asm.) - includes:		047269-000		047269-000	
Assembly, Drive Dog (includes drive dog and shear pin)	N/A	047249-000	N/A	047249-000	N/A
Plate, Universal Instrument Mounting		031972-000		031972-000	
Screw (2), #1/4-20x3/4"		010104-003		010104-003	
Protective Cap Plug		052698-000		052698-000	
Kit, Solid State Pulser - includes misc. parts and following major parts:	Varies		Varies		See: CTR & TC
Pulser Housing Asm.	Varies		Varies		Varies
Magnet Kit	054190-003		054190-003		See: CTR & TC
- Ring, Retaining	011813-001		011813-001		
- Magnet, Male	012663-001	N/A	012663-001	N/A	
- Spacer, Metal	053678-000		053678-000		
- Washer, M.C. Accy Unit	009990-001		009990-001		
- Spacer, Plastic (TC, only	N/A		013114-001		
O-Ring (Housing), 4-1/4"x4-3/8"x1/16"	000568-046		000568-046		
Clip, Retaining	054214-000		054214-000		
O-Ring (Lid), 3-3/4"x3-7/8"x1/16"	000568-044		000568-044		

SERIES B3	Units	8C175	11C175	15C175	2M175	3M175	5M175	7M175	11M175	16M175	23M175	38M175	56M175
Base Rating	acfh	800	1100	1500	2000	3000	5000	7000	11000	16000	23000	38000	56000
Max. Operating Press.	psig	175	175	175	175	175	175	175	175	175	175	175	175
Rangeability +/- 1%		26:1	31:1	40:1	68:1	76:1	120:1	67:1	124:1	116:1	40:1	90:1	53:1
Rangeability +/- 2%		46:1	58:1	78:1	126:1	139:1	215:1	115:1	227:1	223:1	60:1	110:1	109:1
Start Rate	cfh	2.79	2.3	1.94	1.9	2.1	1.2	5.33	3.88	3.24	23	27	40
Stop Rate	cfh	2.03	1.74	1.57	1.1	1.8	0.80	3.39	3.23	1.89	18	20	29
Flow Rate, 0.5" w.c., Gas	cfh	800	1100	1500	2000	2580	3975	5400	7300	9950	14800	20600	23000
Differential, 100% Flow	in. w.c.	0.26	0.356	0.459	0.495	0.64	0.733	0.984	1.07	1.27	1.0	1.5	1.8
Drive Rate, CD/TD	cf/rev	10 / 100	10 / 100	10 / 100	10 / 100	10 / 100	10 / 100	10 / 100	10 / 100	100 / 1,000	100	100	100
Min. CTR Reading	cf	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	2.0	2.0	2.0	2.0
Nominal Pipe Size	in.	2	2	2	2	2	3	3	4	4	6	6	8
Flange/Flange Dim.	in.	6-3/4	6-3/4	6-3/4	6-3/4	6-3/4	6-3/4	9-1/2	9-1/2	9-1/2	16	18	21
Oil Capacity: Side Inlet	oz.	0.8	0.8	0.8	1.6	1.6	1.6	3.4	3.4	3.4	40.2	40.2	40.2
Oil Capacity: Top Inlet	oz.	3	3	3	7.6	7.6	7.6	21.8	21.8	21.8	154	154	154
CTR Version													
Net Weight	lbs.	18	22	24	26.5	29	35	48	62	83	202	244	284
Shipping Weight	lbs.	20	24	26	28.5	31	38	51	65	86	232	274	314
Carton Size	in.	20x12x10	20x12x10	20x12x10	20x12x10	20x12x10	24x12x10	30x13x12	34x14x12	34x14x12	44x24x24	44x24x24	44x24x24
CD Version													
Net Weight	lbs.	21	22	24	29.5	31	38	51	65	86	205	247	287
Shipping Weight	lbs.	23	24	26	31.5	34	41	54	68	89	235	277	317
Carton Size	in.	24x12x10	24x12x10	24x12x10	24x12x10	24x12x10	24x12x10	30x13x12	34x14x12	34x14x12	44x24x24	44x24x24	44x24x24
MODEL		8C175*	11C175*	15C175*	2M175	3M175	5M175	7M175	11M175	16M175	23M175	38M175	56M175
BASE RATING		800	1100	1500	2000	3000	5000	7000	11000	16000	23000	38000	56000
Metering Pressure: PSIG													
1		0.8	1.2	1.6	2.1	3.1	5.2	7.3	11.5	16.7	24.0	39.7	58.5
5		1.1	1.5	2.0	2.6	4.0	6.6	9.2	14.5	21.1	30.3	50.0	73.8
25		2.1	2.9	4.0	5.4	8.0	13.4	18.7	29.4	42.8	61.5	101.7	149.8
60		4.0	5.6	7.6	10.1	15.2	25.3	35.4	55.6	80.8	116.2	191.9	282.9
100		6.2	8.5	11.7	15.5	23.3	38.8	54.4	85.4	124.3	178.6	295.1	434.9
150		8.9	12.3	17.0	22.3	33.0	56.0	78.0	123.0	179.0	256.7	424.1	625.0
175		10.3	14.1	19.0	25.7	39.0	64.0	90.0	141.0	206.0	295.7	488.6	721.5
200		11.7	16.0	21.9									

* Series B3 ROOTS® Meter models 8C175, 11C175 and 15C175 are available in 200 PSIG MAOP