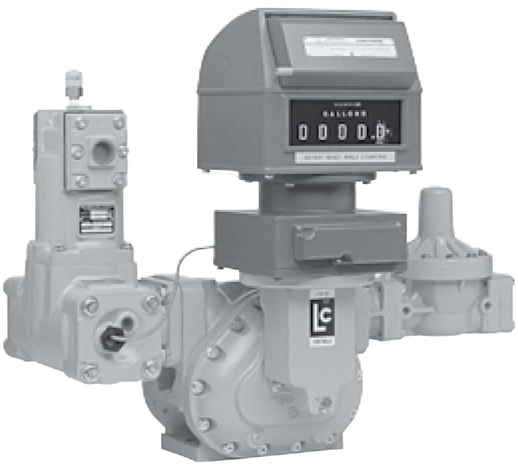
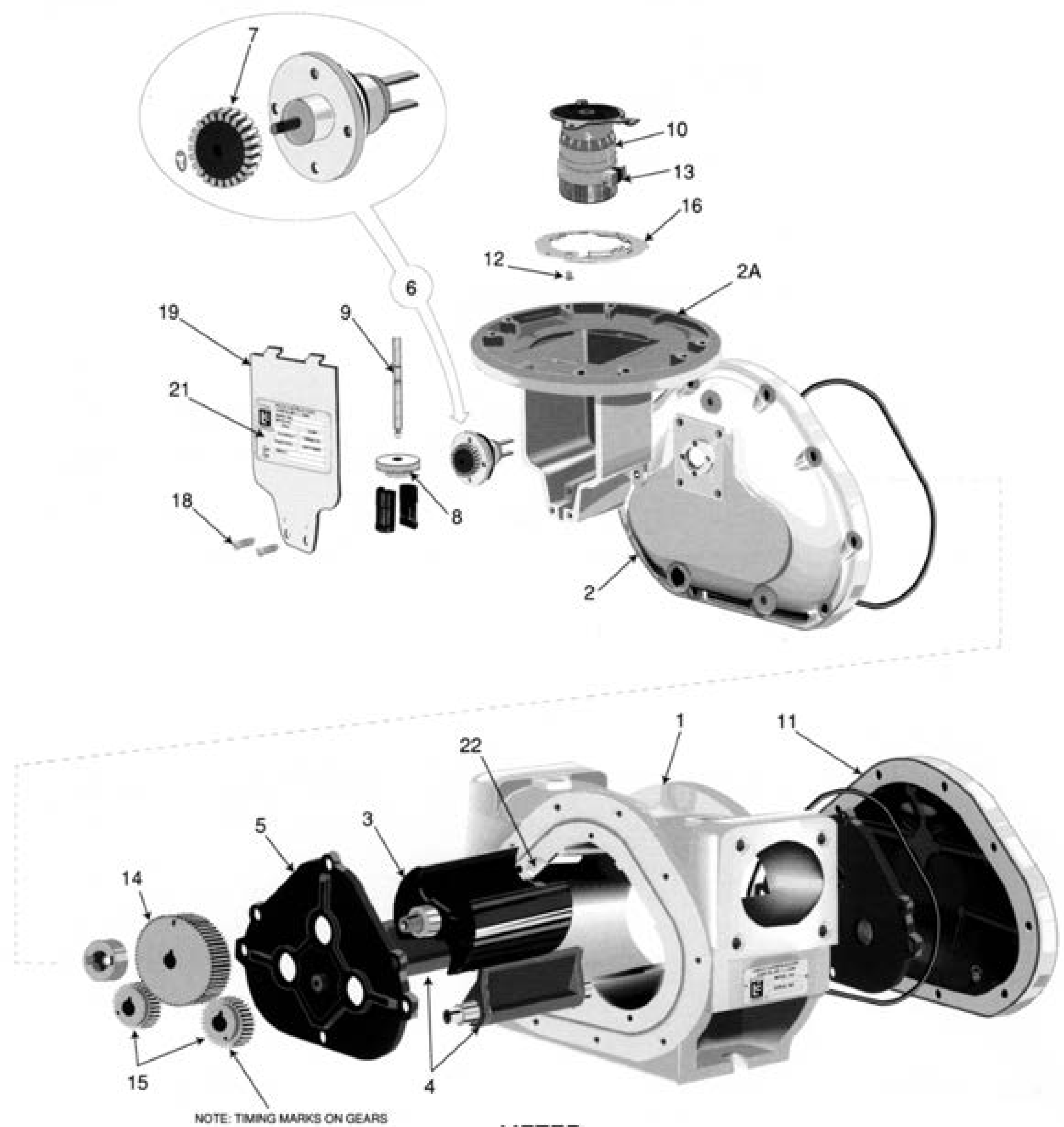
Principles of Design
PD Flowmeter & Accessories

Engineering Data



The Liquid Controls meter is a positive displacement meter designed to meet the wide range of metering applications encountered in the petroleum production, pipeline, refining and marketing, chemical processing, pharmaceutical, paint, solvent, food processing, aircraft fueling, military fuel servicing and agricultural fields.

The LC meter consists of a housing in which three rotors turn in synchronized relationship within three cylindrical bores with no metal-to-metal contact in the metering element. No contact means no wear, no wear means no increase in clearances, no increase in clearances means no increase in slippage, no increase in slippage means no deterioration in accuracy. Optional accessories include strainers, air eliminators, preset counters, valves, temperature volume compensators, large numeral counters and ticket printers.



METER

1. Meter Body
2. Counter End Cover
2a. Register Mounting Adapter
3. Blocking Rotor
4. Displacement Rotor
5. Bearing Plate
6. Packing Gland
7. Packing Gland Pinion
8. Adjuster Drive Shaft Gear
9. Adjuster Drive Shaft
10. Adjuster
11. Rear Cover
12. Adjuster Mounting Screw
13. Adjuster Locking Screw
14. Blocking Rotor Gear
15. Displacement Rotor Gear
16. Adjuster Mounting Plate
18. Adjuster Cover Screws
19. Adjuster Cover
21. Specification Plate
22. Bleed Hole

The meter body (1), the counter end cover (2) and the rear cover (11) form the pressure containing vessel. The meter body (1) and the two bearing plates (5) form the housing of the metering chamber (element). The bleed holes (22) in the meter body (1) permits filling of the cover cavities, providing hydraulic balance and preventing deflection of the bearing plates which might cause inaccuracies due to clearance changes or binding in running fits.

The blocking rotor (3) and the two displacement rotors (4) are journaled at either end and supported by the bearing plates (5) through which the rotor shafts protude. At one end of the blocking rotor is a timing gear (14). At one end of each of the displacement rotors is a pinion (15). The displacement rotor pinions have half the number of teeth of the blocking rotor gear. The blocking rotor (3) and the displacement rotors (4) are locked in timed relation so that the displacement rotors (4) make two revolutions for each single revolution of the blocking rotor (3). The displacement per revolution of the device is equivalent to the volume of the semi-circular bores of the measuring chamber being swept twice by each displacement rotor. At any position in the cycle the meter body (1), the blocking rotor (3) and at least one of the displacement rotors (4) form a continuous capillary seal between the unmetered upstream product and the metered downstream product.

The hydraulically balanced blocking rotor (3) is exposed to inlet pressure on one side and outlet pressure on the other side, producing no resultant force to cause rotation. The active displacement rotor (4) is exposed to the same differential in liquid pressure and produces torque about its axis driving the blocking rotor (3) and the inactive displacement rotor (4). This true rotary motion is transmitted through the packing gland (6), the face gear (8), the adjuster drive shaft (9) and the non-cyclic adjuster (10) to the register stack. This non-cyclic output means consistent accuracy, since the register indication is in precise agreement with the actual volume throughput at any given instant.

Throughout the metering element the mating surfaces are either flat surfaces or cylindrical faces and sections that are most accurately machined. These relatively simple machining operations, plus the fact that there is no oscillating or reciprocating motion within the device, permits extremely close and consistent tolerances within the LC meter.

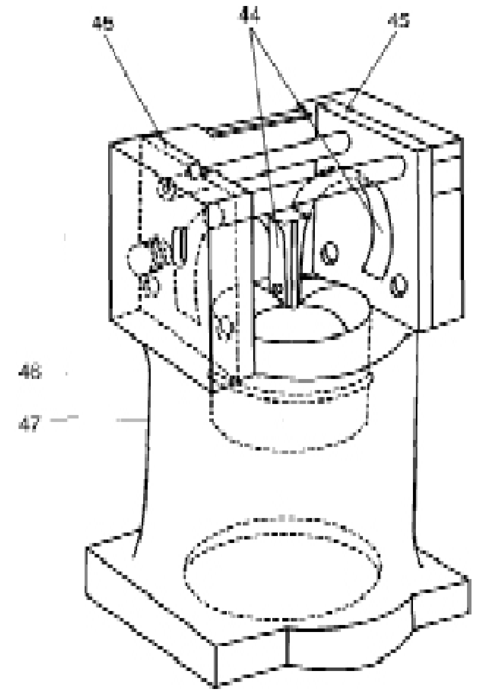
Because the dynamic force exerted by the product flowing through the meter is at right angles to the faces of the displacement rotors, and because the meter is designed so that the rotor shafts are always in a horizontal plane, there is no axial thrust. Therefore, with no need for thrust washers or thrust bearings, the rotors automatically seek the center of the stream between the two bearing plates eliminating wear between the ends of the rotors and the bearing plates. The clearance between the rotor journals and the bearings is about 0.0005” (0.0127 mm) and the clearance between the rotors and the bores within which they turn is about 0.002” (0.0508 mm). It is not possible for the rotors to contact or rub against the metering element bores until bearing/journals have worn another .0005”. The oversize design of the sleeve bearings, as well as the specially selected materials from which they are made, assure maximum throughput before wear takes place. No metal-to-metal contact within the metering element means no wear, no wear means no increase in slippage, and no increase in slippage means no deterioration in accuracy.

As a result the LC meter provides unequalled accuracy, long operating life, and unusual dependability.

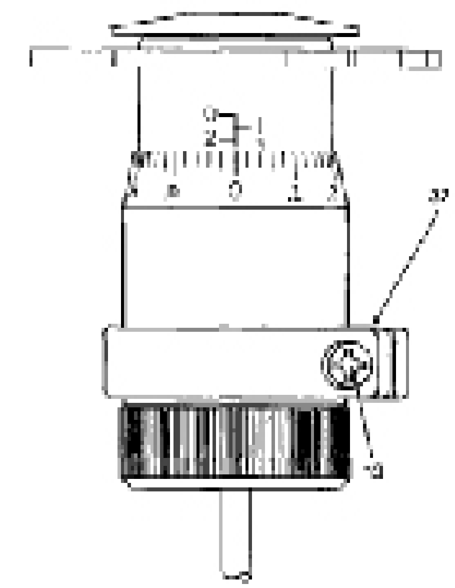
Air Eliminator

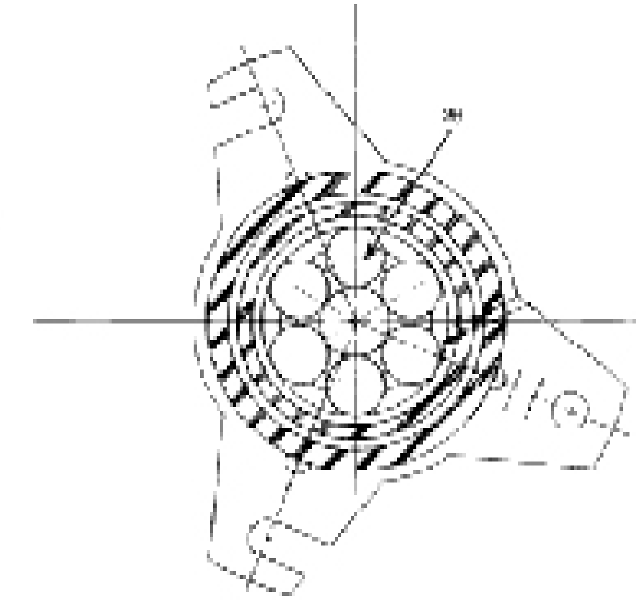
The Air Eliminator mechanism is a reed curtain valve consisting of two stainless steel strips (44) operating in conjuction with synthetic rubber-covered orifice plates (45). One end of each reed is connected to the float (46) while the other end is attached to the housing (47), creating opposing arched stress of the reeds, which balances float action for maximum sensitivity in responding to the presence of air or vapor. As the float rises or drops, the point of arched stress is transferred along the length of the reeds, thereby creating no metal fatigue. As air accumulates in the housing (47) the liquid level recedes, dropping the float (46) revealing only a minute portion of the orifice plate (45) initially with the wider orifice opened as the reeds are progressively peeled away. The design of the float and valve plates is such that the valve will open against 150 psi or no head and will maintain a positive seal under no pressure or 150 psi when closed. Due to the inherent design the energy required to flex the reeds is balanced. Energy used to flex the reeds at one point is recovered when the flexing is removed from the second point.

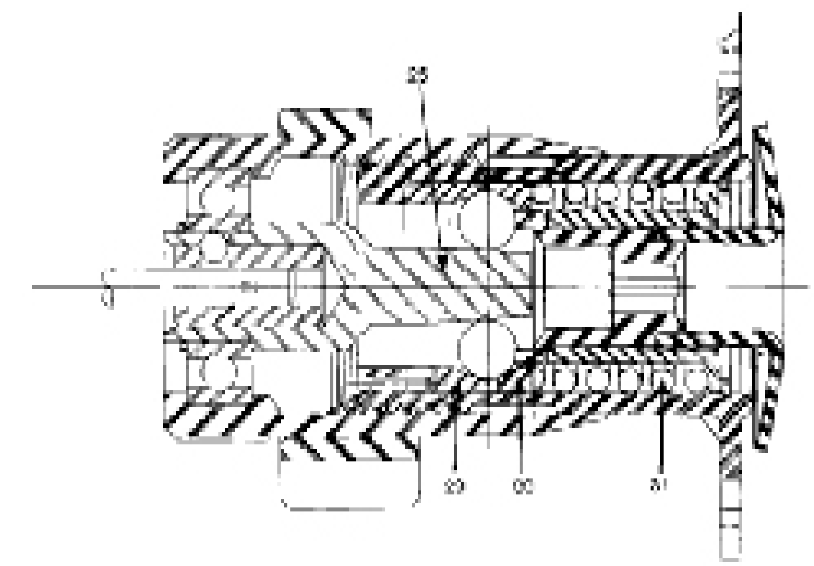
The seal between the Air Eliminator and the main vessel is made with an “O” Ring.



Adjuster Detail







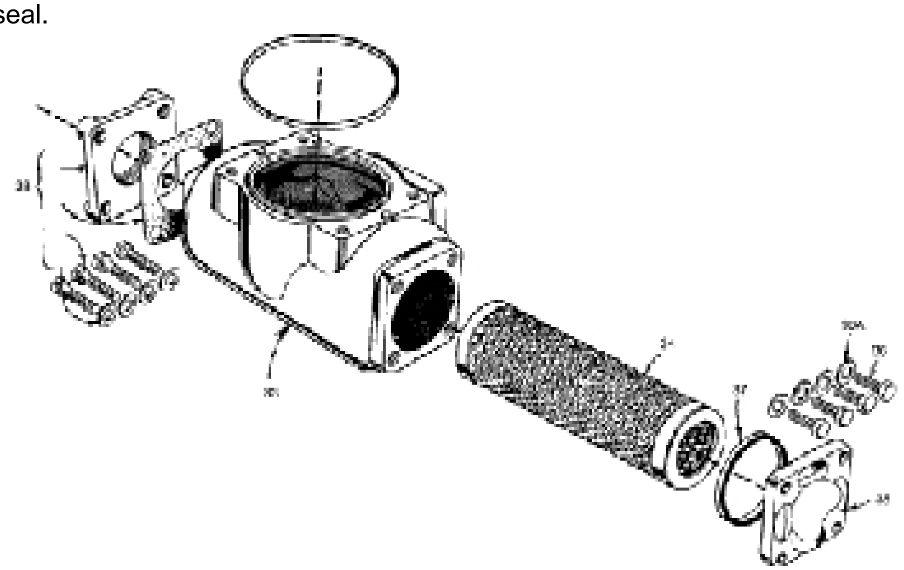
The adjuster is the variable transmission between the meter element and the register. It is adjustable so that drive between meter and register indication are synchronized for accurate recording of liquid flow by volume. For easy access the adjuster is located directly behind the sealable LC emblem face plate (adjuster cover plate 19).

The adjuster drive shaft (8) is driven directly off the blocking rotor and, in turn, drives a hardened, ground tapered plug (25). The plug has a circumferential differential from one end to the other of 5%. The plug (25), drives within a nest of six balls. The balls, in turn, are held in place between the tapered plug and a split race (29 & 30). The bottom half of the race is the changing plug circumference introduced within the nest of balls (26) as the adjuster setting is changed. The balls are contained within a ball cage, which, in turn, becomes the output drive to the counter. As the adjuster is turned to the right (to a lower number setting), the plug circumference within the nest of balls is increased. Therefore, for one revolution of the plug under these circumstances the balls travel further, thus speeding up the output, i.e., counter rotation thereby reducing the volume of a recorded gallon. Introducing a smaller circumference (turning to a higher number) increases the volume of a recorded gallon. The locking clamp (32) is secured with the screw (13) to avoid inadvertently changing the setting. Adjustment is linear, non-cyclical and infinitely variable over a 5% range for precise control.

Strainer Detail

The strainer housing (33) is fitted with a cylindrical open ended basket (34). The effective screening area of a 40 mesh basket is equal to approximately a 6” pipe diameter. One end of the basket is used as the inlet and sealed by the flange assembly (38). The other end is sealed with the strainer cover (35) and secured with four screws (36) and washers (36A). Tightening the screws to a snug fit applies pressure to the O-Ring (37) providing an effective seal.

Strainer basket cover and flange assembly are interchangeable to allow maximum mounting flexibility. The strainer must always be located on the INLET side of the meter. A strainer is intended to prevent foreign material from damaging the measuring chamber of the meter. however, it should not be construed as a filter.

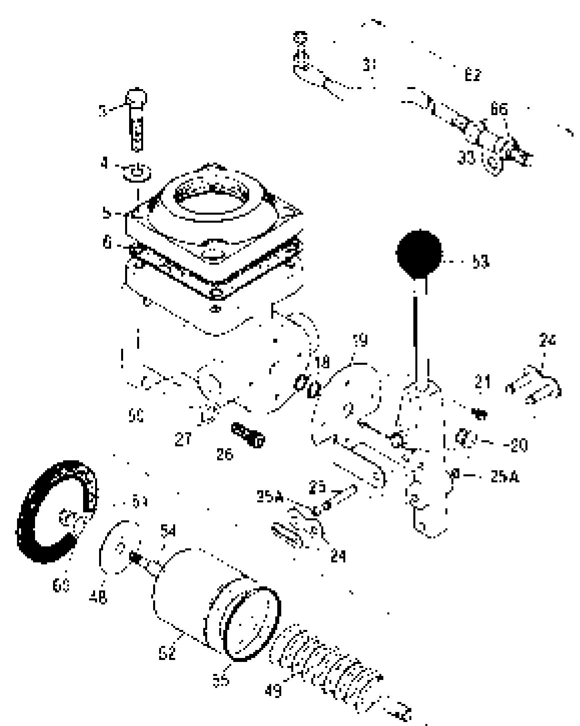


Valve Detail

The LC valve provides the important advantages of being hydraulically balanced which assures easy opening regardless of system pressure and a dashpot design assuring soft closure (not hydraulic shock) at shut-off.

The housing (50) contains the moveable cylindrical piston (52), which is moved from a closed to open position by the handle (53) through the linked shaft (54). The piston is fitted with a seal (55) in a machined groove on its outer diameter. The dashpot washer (48) is close fitting at the base of the piston (52). The piston is spring (49) loaded biased closed. The lower end of the shaft (54) is fitted with a washer (60) held in place by locknut (61).

In operation, overcoming the pressure of the spring is the only effort required to open the valve. At a predetermined “dwell” period the preset while retrograding to “0” triggers its latch mechanism releasing the trip ring and mechanical linkage assembly (62). The valve closes slowly to approximately 10% of full flow. This results in a rate of valve closure that prevents hydraulic shock while permitting the preset counter to engage its second notch stage on the trip ring reintroducing a holding force on the linkage assembly (62). The initial downward motion of the piston (52) compresses the liquid flow causing it to pass through the bleed hole in the dashpot washer. When the preset counter reaches zero, it again releases the linkage (62), permitting the piston (52) to complete its closure abruptly.



Summary

1) The basic design of the Liquid Controls meter entails machining operations limited to cylindrical turning, grinding and/or boring. These machining operations are generally considered more simple and accurate than form cutting. This means the liquid capillary seals representing the minute spaced relation between rotating parts are more uniform and smaller than in meter principles involving form cutting. This smaller total clearance produces better accuracy over a wider range of flow. Liquid Controls meters meet the requirements of the National Bureau of Standards as well as other applicable standards over a range of flow from full flow to 5% of full flow.

2) As a consequence of paragraph 1, the LC meter’s accuracy is affected very little by changes in viscosity. Even highly refined petrols have sufficient viscosity to maintain a liquid capillary seal in the small clearances between rotating members of the LC meter.

3) The LC meter has a shorter seal length. Seal length is defined as the sum total of the clearances in a meter. With other factors equal, it follows that a meter with the shortest seal length is the most accurate.

4) Therefore with other factors being equal, the meter design having the lowest pressure loss at its maximum rate of flow will be the most accurate over the full flow range. The liquid capillary seal between the rotating elements of a meter have a certain strength for a given viscosity product. As long as the pressure differential over this capillary seal does not exceed a value representing the strength of this seal, there will be no more slippage at high rates of flow than at low rates of flow.

The pressure loss is the sum total of the mechanical loss and the fluid hydraulic loss including compression and/or vacuum of the liquid in a cavity of diminishing or increasing volume during a meter cycle. In liquid capillary seal meters the mechanical loss at normal rates of flow is negligible. The fluid hydraulic loss is the major portion of the total loss and is materially effected by the compression of liquid trapped in pockets and/or vacuum drawn upon pockets of increasing volume in a meter cycle.

The LC meter does not at any point in its cycle produce a pocket of decreasing or increasing volume. Pressure losses due to compression and/or vacuum are therefore avoided, putting the LC meter in the category of low pressure loss meters.

5) The Liquid Controls meter is relatively unaffected by “clingage” and “carryover” which affects all meter principles, some to a considerable degree.

“Clingage” is defined as the reduced displacement of liquid per revolution, resulting from build up in a meter upon unswept surfaces. The only unswept surfaces in the LC design are the unmachined surfaces of the displacement rotors. Build up of paraffin or residue on these surfaces does not affect the volumetric displacement of the meter.

The volumetric displacement of the meter is governed solely by the volume of each of the semi-circular bores. If a deposit of ¼” thick occurs on the side of the displacement rotors, it simply means that the blade enters its displacement bore earlier but still sweeps just 180 degrees.

6) The output shaft of the LC meter, which actuates the counter, moves at a uniform or non-cyclical speed of rotation. This gives a consistent means of checking meter accuracy against a volumetric prover.

7) The direct reading LC Adjuster is graduated in divisions of 1%, 0.1% and 0.02%. Since the adjuster is graduated in percent, any size prover can be used with equal ease and simplicity of adjustment. Adjustment is linear, non-cyclical, and is infinitely variable over a 5% range for precise control.

8) Maintenance:

(a) There is no hand fitting, scraping, filing or adjustment necessary in assembling the LC meter.

(b) Because of Liquid Controls exclusive design, LC meters provide accurate, effective performance with a minimum number of parts per assembly. This simplicity in design contributes to minimum maintenance cost...along with easy, fast disassembly and assembly.

(c) The simple design of the LC meter allows any mechanic to maintain it without special tools.

9) Meters and accessories are available in a complete selection of materials for maximum compatibility with liquids to be metered. Materials for housings and covers include aluminum, steel, cast iron, brass and stainless steel. Bearing plates, bearing plate inserts, rotors, gears and seals are also offered in a variety of materials to meet many different system requirements.

10) All LC meters can be operated in either direction with equal accuracy.

11) Standard LC meters, except the M-10, M-25, M-40 and M-80, as stocked are suitable for operation on products with viscosities up to 1,000,000 Saybolt Seconds Universal.

Due to the common coefficients of expansion of the critical parts of the LC meter element, products can be metered accurately from cryogenic temperatures up to 450°F. (232°C). When metering products with temperatures above 180°F (82°C) it is recommended that the register stack be raised off the meter by means of a 12” counter extension to prevent damage to plastic totalizer wheels and discoloration of enameled reset wheels.

LIQUID CONTROLS

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