Glossary of Terms

Hydra-Cell® METERING SOLUTIONS™

Note: Terms in ***bold italics*** within the following definitions are defined separately within this document.

Accuracy: The degree of precision, usually expressed in terms of error, as a percentage of the specified value, or as a percentage of a range. See separate definition for ***Steady State Accuracy***, ***per API Standard 675***.

Absolute Pressure (PSIA): The total force per unit area exerted by a fluid. It is the sum of ***Atmospheric Pressure and Gauge Pressure***.

API Standard 674: This standard covers the minimum requirements for reciprocating positive displacement pumps for use in service in the petroleum, chemical, and gas industries. Both direct-acting and power-frame types are included. There are no test requirements defined within API Standard 674 for ***Steady-State Accuracy***, ***Flow Repeatability***, or ***Linearity***.

API Standard 675: This standard covers the minimum requirements for controlled volume positive displacement pumps for use in service in the petroleum, chemical, and gas industries. Both packed-plunger and diaphragm types are included. Diaphragm pumps that use direct mechanical actuation are excluded. Hydra-Cell Metering Solutions P-Series pumps meet and exceed the performance test requirements of API Standard 675 for ***Steady-State Accuracy***, ***Flow Repeatability***, and ***Linearity*** (as defined in section 4.3.3). They do not, however, meet all design requirements defined in section 2 of the standard. (See Exceptions to API 675 document in this binder section)

API Standard 676: This standard covers the minimum requirements for rotary positive displacement pumps for use in service in the petroleum, chemical, and gas industries. There are no test requirements defined within API Standard 676 for ***Steady-State Accuracy***, ***Flow Repeatability***, or ***Linearity***.

Atmospheric Pressure: The force exerted on a unit area by the weight of the atmosphere; the higher the elevation above sea level, the lower the atmospheric pressure, Patm. See chart at right for Patm shown as pressure head, both in feet of water and centimeters of water.

Back Pressure Valve (BPV): Ensures a constant pressure for the discharge check assemblies and hydraulic driven diaphragm to work against, thus allowing the metering pump to provide accurate and predictable flow. See typical installation drawing under ***Hydra-Cell Metering Solutions*** definition for where to install the BPV.

Bypass Valve: Internal to some pump heads or pump hydraulic ends; allow fluid to be re-circulated if a given pressure limit is exceeded. Alternatively, an external ***Pressure Relief Valve*** is used in the discharge line to protect the pump, piping and system accessories.

Calibrated: Describes any gauge, meter, pump, etc. that has been systematically checked and adjusted to a known, certified standard.

Calibration Cylinder: Used to check performance and accuracy of an individual metering pump system. See typical installation drawing under ***Hydra-Cell Metering Solutions*** definition for where to install the Calibration Cylinder.

Capacity: The quantity of fluid actually delivered per unit of time at the stated operating conditions. This quantity can be expressed in units of volume or mass. It includes liquid and any dissolved or entrained gases or solids, and is based on suction conditions. See separate definition for ***Rated Capacity***.

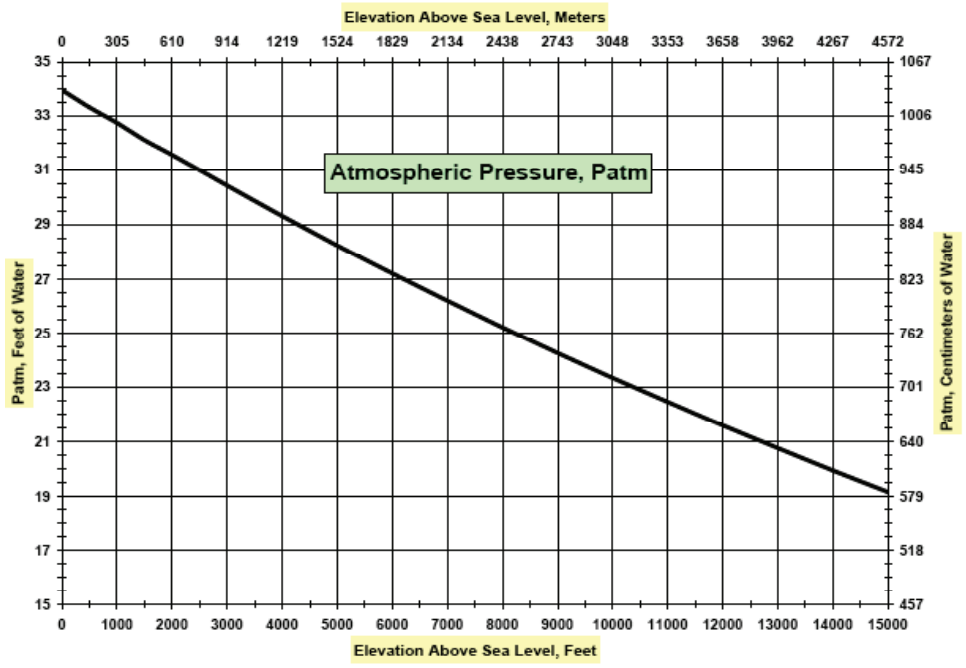
Cavitation: Process in which small bubbles are formed and implode violently; occurs instantaneously when NPSHa < NPSHr.

Check Valve: Allows liquid to flow in one direction only; used in pairs in hydraulic-driven diaphragm metering pumps. As an accessory, may be used in discharge line to prevent reverse flow.

Chemical Compatibility: It is the responsibility of the user to determine suitable materials of construction for the pump and other liquid system components.

Dead Volume: Liquid occupying areas within the system which is not replaced during each cycle or removed during a purge.

Degassing: Generally, referring to the evacuation of free gasses from the application liquid.



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Density (specific weight of a fluid): Weight per unit volume, often expressed as pounds per cubic foot or grams per cubic centimeter.

Explosion-proof (XPRF) Motor: A totally enclosed motor that will withstand an explosion of a specific vapor or gas within its housing, or will prevent sparks or flashes generated within its housing from igniting surrounding vapor or gas.

Flooded Suction: Liquid flows to pump inlet from an elevated source by means of gravity; recommended for metering pump installations.

Flow: A measure of the liquid volume capacity of a pump. Given in gallons per hour (GPH), gallons per minute (GPM), liters per minute (L/min), or milliliters per minute (mL/min).

Flow Repeatability: Describes the reproducibility of pump flow rate under a given set of conditions when capacity setting is varied and then returned to the set point being tested; expressed as a percent (+/-) of rated capacity. ***API Standard 675*** standard stipulates that repeatability must remain within ±3%. Flow Repeatability of ±3% or better can be achieved with HCMS P-Series Metering Pumps; it is a function of rated speed, turndown ratio, and system operating temp. & pressure ranges. See graphical representation at right.

Fluids: Include liquids, gases, and mixtures of liquids, solids and gases. In this catalog, the terms fluid and liquid are both used to mean a pure liquid or a liquid mixed with gases or solids that acts essentially like a liquid in pumping applications.

Fluid Slip: Commonly used to describe the migration of liquid around the internal moving parts of a pump. It is the volumetric difference between physical component displacement and liquid throughput of a pump system.

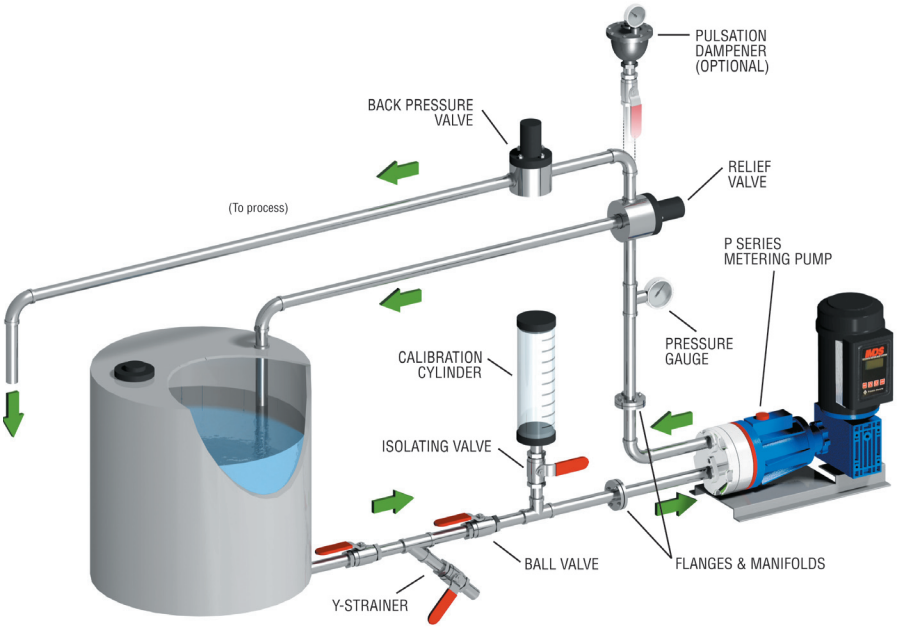
Fluid Slip Loss: Refers to the liquid which passes through the clearance space, (~.00005") between the piston and the cylinder wall. The clearance between the piston and cylinder wall must be optimized for the liquid being pumped in order to minimize the loss due to fluid slip.

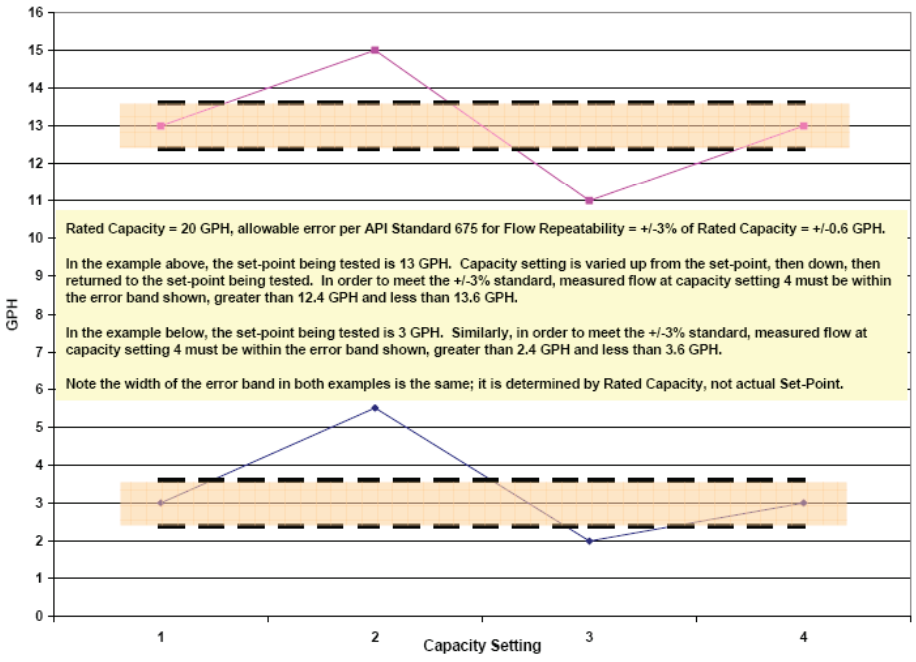
Foot Valve: A check-valve used in suction lift applications; prevents loss of prime when liquid source is lower than the pump. Installed at the point of liquid intake near/at the bottom of a drum - may contain a built-in strainer.

Gauge Pressure (PSIG): A measure of the force per area exerted by a fluid using ***Atmospheric Pressure*** as a zero reference.

Head: A measure of pressure expressed in feet of head for centrifugal pumps; indicates the height of a column of water being moved by the pump (without friction losses).

Hydra-Cell Metering Solutions (HCMS): Wanner Engineering solution for precision pumping applications, based on field proven Hydra-Cell hydraulic driven diaphragm technology. A typical installation is illustrated below:





Injection Valve: Ensures chemical is fully dispersed into the center of the process line for even mixing.

Isolating Ball Valves: Allow for ease of maintenance and repair of various system components.

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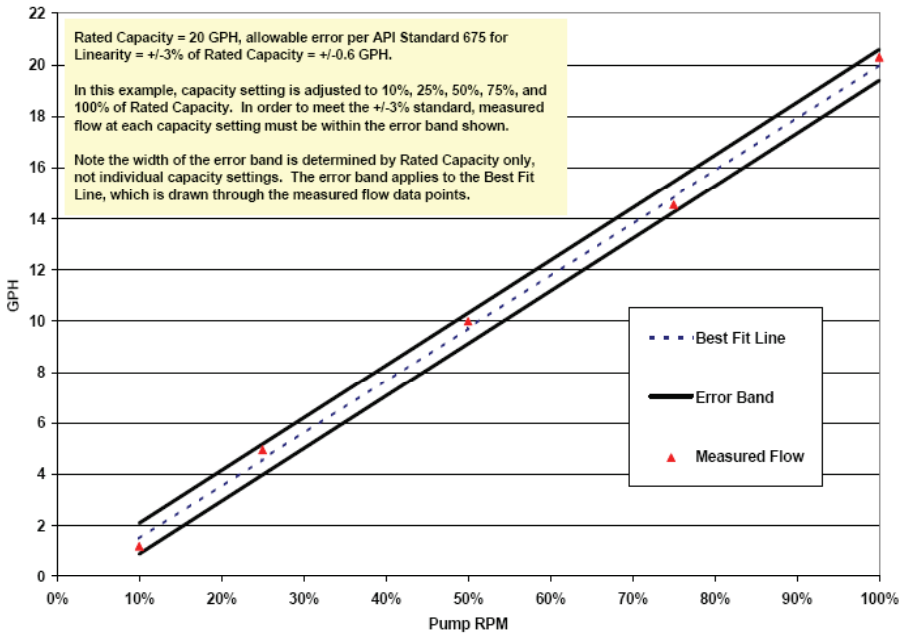
Linearity: The degree to which performance or response approaches the condition of being linear; the maximum deviation from the ideal straight line that can be drawn through plotted calibration test points describing how flow varies with capacity setting - expressed as percent (+/-) of the rated capacity of the pump. ***API Standard 675*** stipulates that Linearity must remain within ±3%. Linearity of ±3% or better can be achieved with HCMS P-Series Metering Pumps; it is a function of rated speed, turndown ratio, and system operating temperature and pressure ranges. See graphical representation at right:



Lost Motion: A means of changing displacement of a constant stroke pump by altering the effective stroke length during each cycle; accomplished either mechanically or hydraulically. HCMS P-Series Metering Pumps do not employ lost motion technology; therefore, simplicity is maintained, efficiency is maximized and consistent performance is delivered via the use of electronic precision control.

Maximum Allowable Speed: The highest speed (in strokes per minute, or pump shaft RPM) at which the manufacturers design will permit continuous operation. HCMS P-Series Metering Pumps have the highest speed ratings in the industry for hydraulic actuated diaphragm metering pumps, by a factor of 2 to 3 times or more.

Maximum Operating Speed: The highest speed (in strokes per minute, or pump shaft RPM) at which the end-user will operate the metering pump. This may be less than or equal to the ***Maximum Allowable Speed*** defined above. Maximum Operating Speed defines the **Rated Capacity** for a metering pump, upon which several performance characteristics are dependent upon.

Mechanical Valving: Valve ports are opened and closed via mechanical actuation. This is in contrast to check valves which open and close as a result of fluid pressure/flow.

Multiplexing: The combination of two or more pumping elements with a common driver to deliver smoother flows and more capacity. HCMS P-Series Metering Pumps employ a form of multiplexing within a single pumping head as standard design practice (with the exception of the P-100, which is a simplex design). Typical hydraulic actuated metering pumps require separate pumping heads with complex manifold piping to achieve multiplexing. This type of solution is very large and costly as compared to multiplexing within a common pumping head.

Net Positive Suction Head Available (NPSHa): The total suction head (in feet absolute) present at the pump suction connection, less the vapor pressure of the pumped liquid (in feet absolute). NPSHa is a function of the system in which the pump operates everything on the suction side of the pump up to the suction port. The formula below is commonly used to determine system NPSHa:

NPSHa = Pt + Hz - Hf - Ha - Pvp

where:

Pt = Atmospheric pressure

Hz = Vertical distance from surface liquid to pump centerline (if liquid is below pump centerline, the Hz is negative)

Hf = Friction losses in suction piping

Ha = Acceleration head at pump suction

Pvp = Absolute vapor pressure of liquid at pumping temperature

Note: *It is important to correct for the specific gravity of the liquid and to convert all terms to units of "feet absolute" in using this formula.*

In metering pump applications, flooded suction is required for most reliable and consistent performance. Also, fluid velocity in metering system suction piping is generally low (Hf = negligible) and pump RPM is generally slow enough such that acceleration head losses (Ha) are also negligible. HCMS P-Series Metering Pumps are designed with suction ports rated for more than 2 times the maximum published capacity; therefore, velocities are low in the suction piping. Also, HCMS P-Series Metering Pumps employ multiplexing within a single pumping head (all except P-100); therefore, acceleration head losses are minimal even at the maximum allowable speed.

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Net Positive Suction Head Required (NPSHr): The positive pressure (in feet absolute) required at the pump suction port to overcome pressure losses that occur as the fluid travels from the suction port to the point(s) inside the pump where the pressure starts to increase. NPSHr is a function of the pump design, size (capacity), and operating speed. It is measured at the suction port of the pump and typically provided by the pump manufacturer in the form of a curve or set of curves.

Note: *Testing in water is standard practice; therefore, NPSHr data is generally provided in units of "feet of water". This must be taken into consideration and converted to "feet of pumped liquid" when comparing to the calculated value of NPSHa.*

For general pumping it is wise to have NPSHa greater than NPSHr by at least 2 feet (of pumped fluid). For metering applications, with flooded suction NPSHa will generally exceed NPSHr by 10 or more feet (of pumped fluid) – this is why NPSHa is normally not a consideration in metering applications, unless the pumped fluid is very volatile (high vapor pressure). Stabile inlet conditions with ample NPSHa are a necessity for accurate and reliable fluid metering, regardless of the pump being used.

Open Drip-Proof (ODP) Motor: An open motor with ventilator openings that will prevent liquids and solids, dropped from an angle of 0° to 15° from vertical, from interfering with its operation.

pH: An indication of the acidity or alkalinity of a solution; units range from 0 (most acidic), to 7 (neutral), to 14 (most alkaline).

Pressure: The force exerted on the walls of a tank, pipe, etc. Force exerted per unit area - normally measured in pounds per square inch (psi).

Pressure Relief Valve (PRV): Protects metering pump, discharge line, and accessories from over-pressurization. See typical installation drawing under ***Hydra-Cell Metering Solutions*** definition for where to install the PRV.

Prime: Charge of liquid required to begin pumping action when liquid source is lower than pump; held in pump by a ***Foot Valve*** on the intake line or by a valve or chamber within the pump.

Priming Valve: A valve, either manually operated or automatically acting, used to discharge air from the pump and/or discharge line, thus preventing or eliminating an air-lock in the system. Wanner HCMS Back Pressure Valves include an integral Priming Valve (manually operated) to allow the pump and discharge piping system to easily prime upon system start-up.

Proportional Control: Control in which the amount of corrective action is proportional to the amount of error.

Pulsations: Cyclical fluctuations of liquid flow; most severe with simplex pumps.

Pulsation Dampener: Mechanical device inserted into the outlet tubing of the liquid circuit to dampen liquid pulsations. See typical installation drawing under ***Hydra-Cell Metering Solutions*** definition for where to install the Pulsation Dampener.

Rated Capacity: The quantity of fluid actually delivered per unit of time at the maximum operating speed. This quantity can be expressed in units of volume or mass; it includes liquid and any dissolved or entrained gases or solids, and is based on suction conditions.

Sanitary Pump: Pump designed to conform to the cleansing standards of the US Food and Drug Administration.

Seals: Devices mounted in the pump housing and/or on the pump shaft that prevent leakage of liquid from the pump.

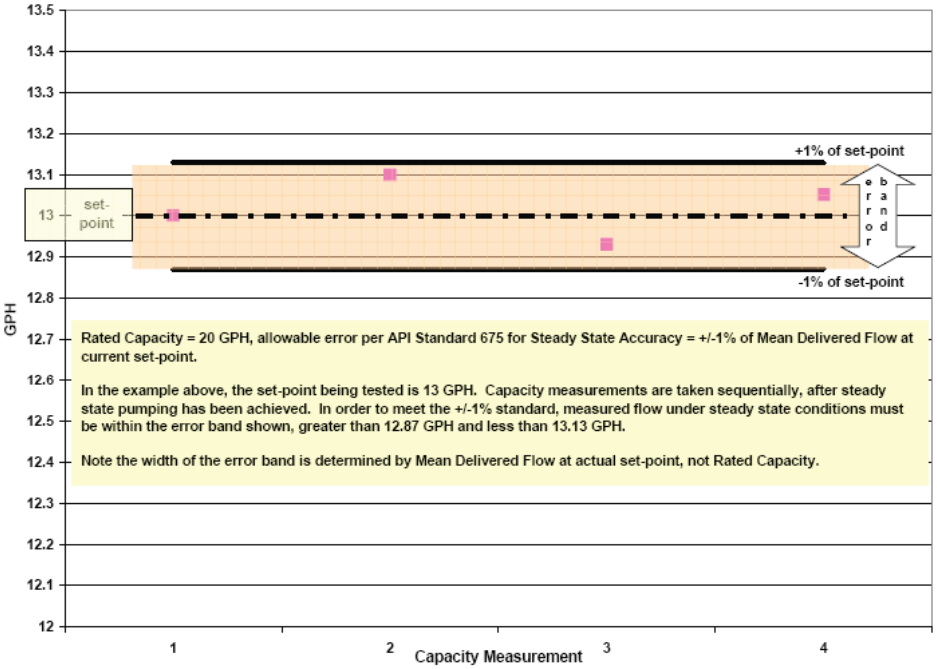
Self-Priming: Pumps that draw liquid up from below pump inlet (suction lift), as opposed to pumps requiring flooded suction. Any pump which does not require pre-wetting or pressurization in order to produce liquid flow.

Single-Phase Motor: Any motor energized by a single alternation voltage.

Specific Gravity: The ratio of the weight of a given volume of liquid to pure water. Pumping heavy liquids (specific gravity greater than 1.0) will require more drive horsepower.

Static Discharge Head: Maximum vertical distance (in feet) from pump to point of discharge with no flow.

Steady State Accuracy: Flow variation expressed as a percentage of Mean Delivered Flow under fixed system conditions; applies over the turndown ratio. ***API Standard 675*** standard stipulates that S.S. Accuracy must remain within ±1%. S.S. Accuracy of ±1% for HCMS P-Series Metering Pumps reflects continuous run, injection-mode metering. See graphical representation below:



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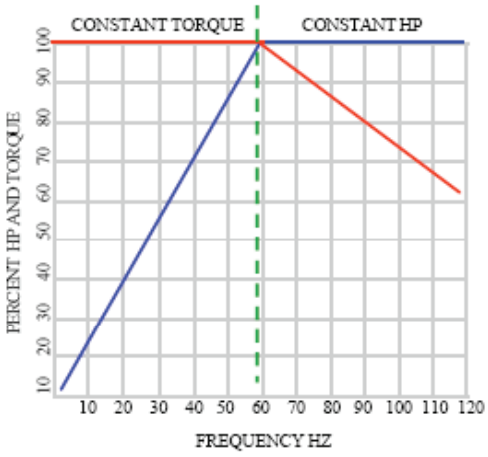
Strainer: A device installed in the inlet of a pump to prevent foreign particles from damaging the internal parts; Y-strainer configuration typically used in metering installations.

Standard Operating Conditions (Standard Temperature and Pressure - STP): Defined temperature and pressure to which all values are referenced for comparison; generally 760 mm Hg (1 atm), 25°C.

Sump: A well or pit in which liquids collect below floor level; sometimes refers to an oil or water reservoir.

Temperature Compensation: Correction for the influence of temperature on a measurement.



VFD Speed Torque Characteristics

Blue = Horsepower
Red = Torque
Green = Motor Nameplate Frequency (60 Hz)

In Constant Torque Area - VFD supplies rated motor nameplate voltage and motor develops full horsepower at 60 hertz base frequency.

In Constant Horsepower Area - VFD delivers motor nameplate rated voltage from 60 Hertz to 120 hertz (or drive maximum). Motor horsepower is constant in this range but motor torque is reduced as frequency increases.
Note: Motor HP = Torque x RPM

Three-Phase Motor: A relatively inexpensive, self-starting motor (no starting winding or capacitor); can start heavy loads. The motor requires a three-phase AC power supply.

Tolerance: The maximum allowable deviation from a specified standard, as the range of variation permitted, expressed in actual values or more often as a percentage of the nominal value.

Total Head: Sum of discharge head, suction lift, and friction loss.

Totally-Enclosed (TE) Motor: Motors that prevent the free flow of air from the inside of the motor enclosure to the outside.

Totally-Enclosed, Non-Ventilated (TENV) Motor: A motor in a totally enclosed housing that is not equipped with an external cooling device.

Totally-Enclosed, Fan-Cooled (TEFC) Motor: A motor in a totally enclosed housing that is equipped with a separate external blower.

Transducer: Any device which generates an electrical signal from real world physical measurements.

Transmitter: A device which translates the low-level output of a sensor or transducer to a higher level signal suitable for transmission to a site where it can be further processed.

Turndown Ratio: The ***Rated Capacity*** divided by the minimum capacity that can be obtained while maintaining specified steady state accuracy, flow repeatability, and linearity. A 10:1 Turndown Ratio capability is industry standard for metering applications. Use of sophisticated motor controls allows speed Turndown Ratios of 1000:1 and greater if required. The mechanical response of the metering pump over these extremely high Turndown Ratios may or may not meet ***API Standard 675*** testing requirements.

Variable Displacement: Capability of changing the volume of liquid moved by the piston for each stroke through either electrical or mechanical means.

Variable Frequency Drive (VFD): An electronic controller that adjusts the speed of an electric motor by modulating the power being delivered. A constant volts/Hz relationship is maintained from 0-60 Hz, while voltage is typically held constant above 60 Hz. See chart above for implications on motor torque and horsepower output:

HCMS P-Series Metering Pump systems employ VFD technology along with suitable motors in order to accomplish precision control of fluid delivery. Various levels of control are available to meet the needs of each precision metering application:

- Open-loop control, or inverter drives can generally provide speed regulation to within only 2% of base motor speed for a standard AC induction motor, with low-end controllable speed starting at about 300 RPM. This method provides speed control only, it offers no torque control or high torque values at low speeds.
- Sensor-less vector control is effective down to about 3 Hz and can provide improved speed regulation to within 0.5%. Torque control to +/-5% and starting torques up to 250% can be delivered depending on the specific drive and motor.
- Closed-loop vector control uses encoder feedback and sophisticated control algorithms to deliver very precise torque and speed from the motor shaft. Separate speed and torque loops are employed to allow high torque near 0 RPM as well as speed regulation to within 0.001% over a range greater than 1000:1. Torque control to +/-2% and starting torques up to 400% are possible.

Viscosity: The resistance of a fluid to flow when subjected to shear stress (the "thickness" of a liquid). Most liquids decrease in viscosity and flow more easily as they get warmer. Absolute viscosity is measured in centipoise. Kinematic viscosity includes the influence of the specific gravity of the fluid and is measured in centistokes.

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