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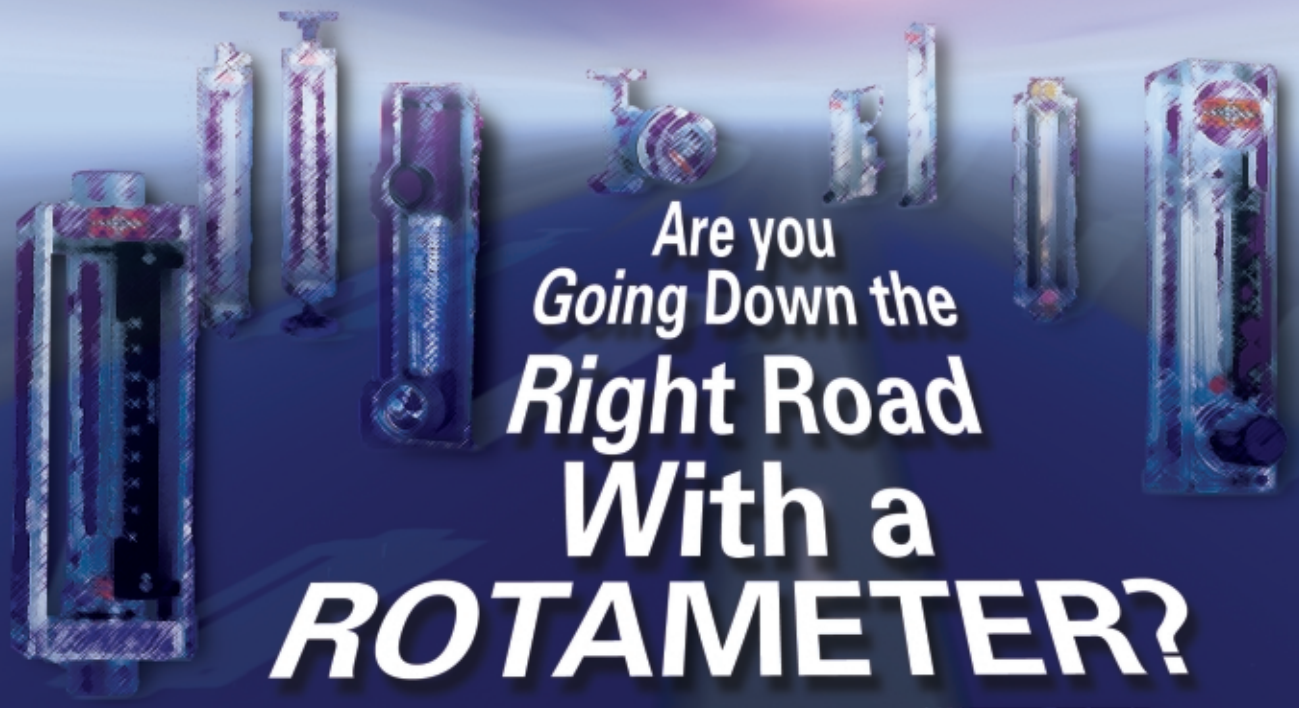
WHEN COST IS A FACTOR



Are you *Going* Down the *Right* Road With a *ROTAMETER?*

WITTER PUBLISHING

WHEN COST IS A FACTOR

Are you going down the right road with a rotameter?

They're simple and inexpensive, performing as well or better than many high-tech flowmeters on the market. This article covers the application conditions that point to rotameters as a possible first choice.

Broadly speaking the key advantages of rotameters for process flow measurements include:

• *Readability* — With a glass tube meter, the main metering elements (float and tube) as well as the fluid being metered are clearly visible. The user can immediately see any accumulation of dirt or other foreign matter deposited on the float or tube walls. For this reason, a glass tube rotameter, kept clean, can be used as a back up to check the performance of another type of remote reading flowmeter.

Often overlooked, rotameters continue to provide practical solutions for many flow metering applications.

By John E. Scheer

• *Sustained high repeatability* — The float moves freely in the metering tube, experiencing no friction or hysteresis. The rotameter thus attains the ideal design goal of having high repeatability and maintaining it over years of service.

• *Wide rangeability* — Rotameters typically offer a rangeability of 10 to 1 from maximum to minimum flow rate without impairment of repeatability.

• *Linear scale* — Because area variation is the measure of flow rate (rather than head or differential pressure), the calibration curve is practically a straight line. This means that the meter can have an indicating linear scale with evenly spaced divisions. So users can read low flow rates with the same degree of accuracy as the higher flow rates in a particular rotameter's range.

• *Low pressure loss* — Because the area between the float and tapered tube increases with flow rate, pressure loss (pressure drop) across the float is low and relatively constant. This reduces pumping costs. Also, a meter can be selected to provide a lower drop by use of an oversize tube with a light float.

• *Viscosity compensation* — The float can be designed to compensate for normal variations in viscosity so that certain viscous oils and chemicals, such as sulfuric acid, can be measured accurately, in spite of wide temperature changes.

• *Readily corrosion-proofed* — Because of its design simplicity, a rotameter can be economically constructed of highly corrosion-resistant materials. It can measure fluid flows that no other type of meter can handle.

• *Easy to install and maintain* — Its inherent simplicity of design makes the rotameter easy to install and maintain. It mounts vertically in the pipe without need for pipe taps, connecting lines, seal pots, valves or requirements for a straight run of pipe upstream or downstream as required with a differential pressure transmitter. Nor is there the need to keep such parts free of foreign matter

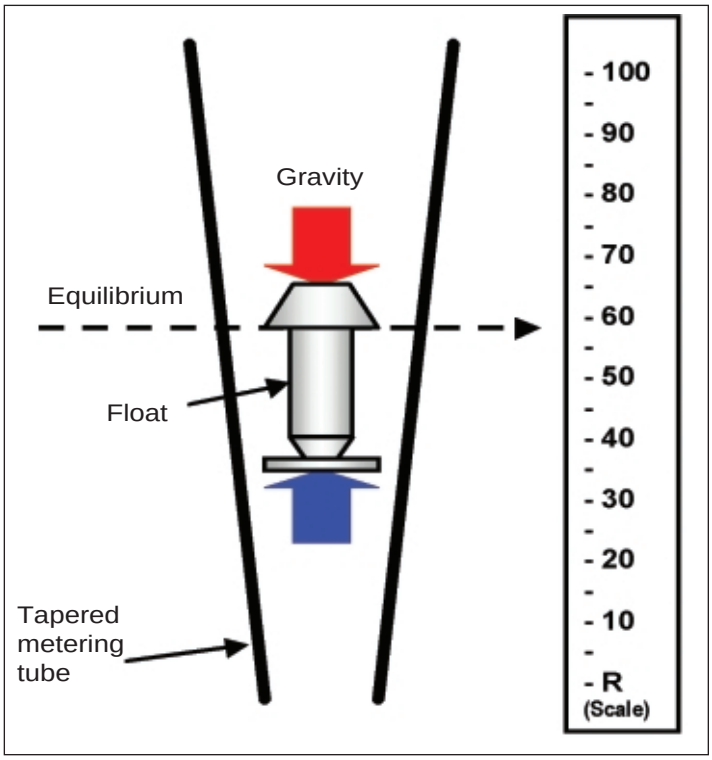


Figure 1

The float's position varies linearly with volumetric flow rate. It represents a balance between float weight and the upward force of flow. Higher float positions offer larger annular areas around the float for the increased fluid flow rates.

Components and Materials

Rotameters come in a broad selection of construction material and accessories, including alarm contacts, remote transmission, and controls.

Glass Tubes

Tapered metering tubes precision formed of borosilicate glass constituted the original rotameters introduced in the mid 1940's. They still represent most general purpose rotameters available today. Because the float is visible in the glass tube, the meter shows flow rate readings on linear scale having direct or percent graduations on the glass surface or on an adjacent vertical detachable scale.

General purpose glass tube meters adapt to measuring numerous liquids and gases. Exceptions include those applications where glass is prohibited for safety reasons — high temperatures or pressures, or where the fluid is incompatible with glass, such as hydrofluoric acid. Glass tube meters often come equipped with high-strength, plastic safety shields to protect workers in case the glass tube breaks from shock, such as from an unusual water hammer or an accidental blow.

Often, repeatability of a measurement serves the user's needs, and in this respect these meters can repeat a given flow rate reading with a degree of precision of about +/- 0.5 percent of full scale. For alarm signals or on-off control, alarm contacts can be easily added to signal abnormally high or low flow rates.

The glass tube meter assembly has a metal body, rigidly constructed to maintain tube alignment. End fittings of various designs provide process pipe connections — either threaded female or flanged. At both ends of the glass tube, O-rings or packing glands seal the tube to the end fittings. Some designs provide for easy removal of the glass tube to facilitate cleaning or range change without removing the meter from the pipeline.

Metal Tubes

These rotameters, sometimes called armored meters, suit applications where the temperature or pressure exceeds the limits of glass tube rotameters. The material of construction is generally corrosion-resistant Type 316 stainless steel, but other corrosion-resistant materials are available.

Since the float is not visible, flow indication is by a pointer. This is achieved via a magnet inside the float and an external follower magnet linked to the pointer. Metal-tube rotameters may be specified in applications that require remote transmission of the measured flow rate since this feature is not generally available with glass tube meters.

Metal tube meters are well suited to measuring steam flow. They are also useful where the nature of the measured fluid would obscure reading a float position, such as dark or opaque liquids.

The float can also be coupled to actuate high and/or low flow alarms or an electronic converter that generates a 4 to 20 mA measurement signal. This signal transmits the measured flow rate over a two-wire cable to a remote indicator, recorder or controller. The 4 to 20 mA signal can also provide a local digital display, HART protocol output, and scaled pulse output for flow totalization. The HART output allows remote communication over the same two-wire cable that carries the flow rate signal. This provides remote digital access to the meter and a link to plant wide control systems.

Plastic Tubes

Rotameters with transparent plastic tubes offer a very cost-effective alternative to glass or metal meters for numerous inert fluids measurements. A popular model has one-piece, clear acrylic tube construction that is practically unbreakable in most industrial process applications. Plastic tube meters are often used as low-flow purgemeters since they offer a low-cost, reliable solution for many OEM applications.

Float Designs

For the small purgemeters, the float often consists of a ball made of black glass, stainless steel, sapphire, carboloy, or tantalum. For larger sizes, in both glass and metal designs, the float is machined from corrosion-resistant materials with variations to suit the application.

Floats are available in a variety of shapes and materials of construction, with varying densities that can be used to change the meter's range. While Type 316 stainless steel is one common material, for specific applications other materials include tantalum, Hastelloy C, Monel, Teflon, and PVC.

• *Sight-glass functionality* — A glass tube rotameter installed in a process line can also serve as a sight-glass, eliminating the need and cost of a separate device to show that the process fluid is flowing in the line.

• *Non-electric* — Simple indication of flow rate locally with a rotameter

Early methods of simplifying the sizing process included the development of nomographs and slide rules

requires no connection to an electric power source, hence, no need for explosion proofing where flammable fluids may be present.

• *Low flow rates* — Liquid flow rates down to a milliliter per minute and equally low gas flow rates are possible.

• *Easily converted to different fluids* — A model installed for service on one fluid can be re-calibrated for measurement of another fluid. Today a software program makes this a quick and easy task.

• *Familiar* — Many prospective users understand or readily pick up the simple operation of a rotameter.

How Rotameters Work

Every rotameter basically consists of two components: a tapered metering tube made of glass, metal, or plastic and a float that rides within the tube. Floats come in a wide variety of shapes, sizes, weights and materials of construction. These two simple components can be fabricated in innumerable variations to meet a wide range of application needs in terms of capacity, temperature, pressure, and in the case of liquids, viscosity.

The rotameter must be installed with the tube vertical. Fluid enters the narrow end of the tapered tube from below, flows up and around the float, and exits from the top. The position of the float within the tapered tube represents a balance between the float's downward weight and the upward force of the flow (See Figure 1). To balance the float against the full force of gravity, the measuring tube must be exactly vertical.

As flow increases, the float rises in the tube, and vice versa. For an increasing flowrate, the tube's taper provides a larger annular area for the flow at the float's new position, creating a new balance point. The variable annular area for the flow path puts the rotameter in a class of flowmeters called variable area meters.

The fluid volumetric flowrate varies linearly with the annular area between the tube and the float. So the vertical position of the float within the tube becomes a linear function of volumetric flow rate. Rotameters can measure the volumetric flow rates of many liquids and gases, including steam.

Application Ranges

The range of application conditions for rotameters have the following typical limits:

• *Flow range* — liquid (water) flow rates from 0.65 cc/min. to 530 GPM, gas (air) flowrates from 47 scc/m to 860 scfm.

• *Typical design pressures* — metal tube: up to 1500 psig; glass tube: up to 300 psig, plastic tube: up to 100 psig.

• *Typical design temperatures* — metal tube: Up to 900 °F; glass tube: up to 250 °F; plastic tube: up to 150 °F.

• *Signal* — visual and/or electronic.

• *Typical accuracy* — 2 to 10 percent full scale, depending on type, size and calibration

• *Repeatability* — 0.5 to 1 percent of full scale.

• *Viscosity* — liquids up to 200 centipoises (cps).

• *Rangeability* — 5:1 to 12:1.

Figure 2
Purgemeters are rotameters that monitor very low flow rates of fluid that flushes out process piping used for measurement sensors

• *Sizes* — pipe from ⅛ to 4-inches in diameter.

• *End connections* — flanged or threaded.

Rotameters are suitable for clear and dirty liquids, but not slurries. They are also unsuitable for applications characterized by reverse or pulsating flow. By properly choosing the materials of construction, a particular rotameter can be applied to corrosive liquids and high pressure gases, as well as steam.

Flow rate readings for a given rotameter float design can be affected by liquids having an operating viscosity above a certain value, known as the Viscosity Immunity Ceiling (V.I.C.). For liquid operating viscosities below this value, the rotameter can be sized and scaled based on

standard data. Liquids having an operating viscosity above the rotameter's V.I.C. value require special sizing and calibration. The manufacturer's catalog should list the V.I.C. value in centipoises for each rotameter. Heavier floats with sharp edges tend to have high V.I.C. values, being the least affected by liquid viscosity. Ball floats, on the other hand, are the most affected by fluid viscosity.

Measuring Very Low Flow Rates

In terms of total worldwide sales, rotameter models classified as purgemeters dominate the field today. Purgemeters, (See Figure 2) are rotameters that monitor a fluid that flushes out process piping used for measurement sensors. The ISA concisely defines the purgemeter as "…a device designed to measure small flow rates of liquids and gases used for purging measurement piping." While other kinds of flowmeters can serve as purgemeters, the low-capacity rotameters are by far the usual choice. And they can be used for other low flow applications, such as monitoring the continuous flow of lubricant to a bearing.

Typically, for water, the flowrate measured by purgemeters is well under a gallon per minute (GPM) and for air, less than 2 standard cubic feet per minute (SCFM). Inclusion of a needle valve with the purgemeter makes it convenient to set the desired purge flow rate.

In one typical process application, the purgemeter monitors and controls the supply of air to a bubble tube used to measure liquid level, as in Figure 3. With this technique, a small, but uninterrupted flow of air (or inert gas such as nitrogen) is easily set and monitored by the use of the low-capacity rotameter with a built-in needle valve.

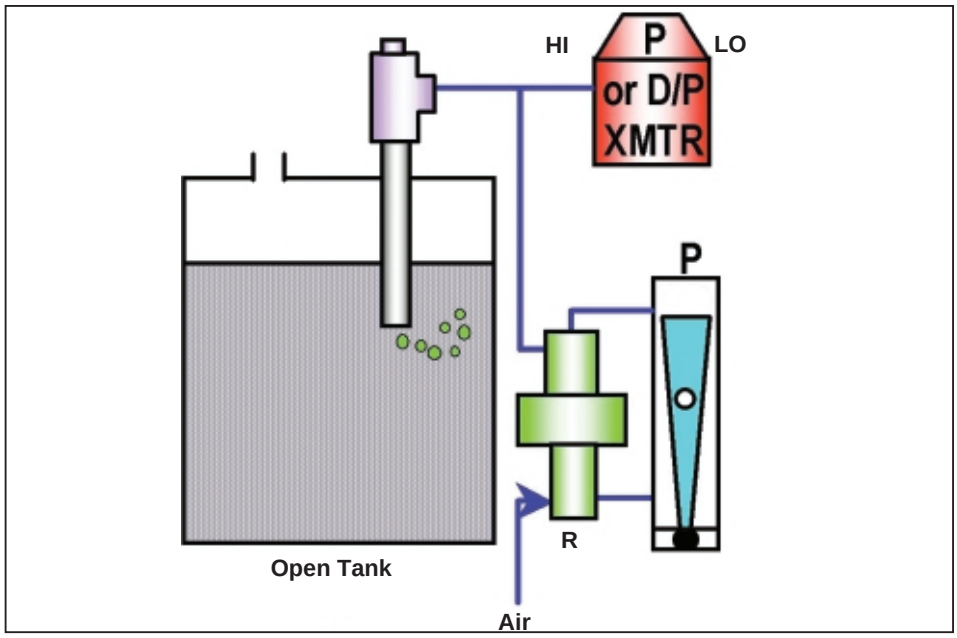


Figure 3

In this typical process application, the purgemeter monitors and regulates the supply of air to a bubble tube used to measure liquid level of an open tank via a differential pressure cell (one side vented to ambient).

Often the exact flow rate is not critical, but it must be low to insure no increase in head backpressure resulting from the pressure drop through the purge piping and dip tube. Conversely, the flow cannot be interrupted or the backpressure may decrease below that of the head, giving an incorrect level reading and possibly allowing the process liquid to reflux back to the rotameter or d/p transmitter. The purge supply gas pressure should exceed the maximum line pressure by about 10 psi.

Measuring Very High Flow Rates

To cost-effectively handle very high flow rates of liquids or gases, the rotameter can be installed in a by-pass line around an orifice plate in the main line (see Figure 4). The differential pressure developed by the orifice plate causes a corresponding flow through the rotameter. A ranging orifice, integral with the meter, proportions the by-pass flow to the main line flow, permitting use of a ½-inch size rotameter regardless of the size of the main pipeline. Since the float position in a variable-area flowmeter is linear with flow rate, the rotameter can be used to indicate main line flow rate in direct flow units on a linear scale.

Key benefits offered by this by-pass system for very high flows include:

- Rangeability of 12½ to 1, as compared to 4:1 for differential pressure meters commonly used with orifice plates.
- Optionally, rotameter scale readings can be graduated in direct flow units for flow in the main pipeline.
- Easy range change or cleaning of metering tube without disassembly or removal of meter from the

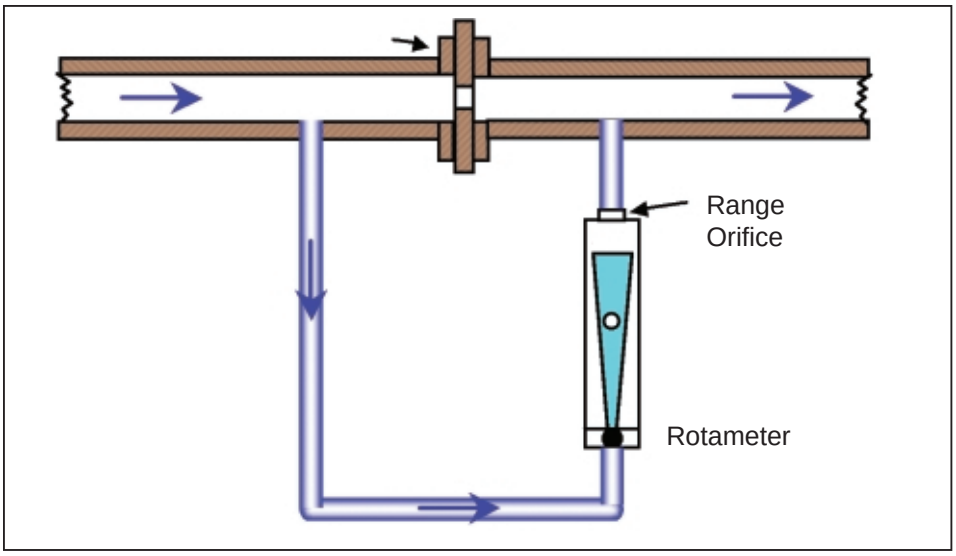


Figure 4
To cost-effectively handle very high flow rates of liquids or gases, the rotameter can be installed in a by-pass line around an orifice plate in the main line. The flow through the rotameter varies linearly with the flowrate through the main pipeline.

bypass line. Simply valve off the small bypass line to remove clean the rotameter's tapered tube.

- Useful where the flow measurement must be made in a hazardous area where electric power is unavailable or would be potentially dangerous.

Choosing a Rotameter

Early methods of simplifying the sizing process included the development of nomographs and slide rules. Today, most manufacturers have taken all the factors and data involved in sizing a rotameter and developed a sophisticated software program. A free software download for making the calculation is available online at the following web address: www.abbinfozone.com.

In short, the practical metering technology underlying rotameters often represents the most cost-effective solution to a flow measurement application. Engineers should weigh their suitability against the higher price tag for more sophisticated solutions. FC

About the Author

John Scheer has over 20 years experience in industrial measurement and controls marketing with ABB, Fischer & Porter and Honeywell. His early experiences included assignments in R&D and product engineering. He is a member of ISA and ASM International. He holds a B.S. in Engineering from Drexel University. Scheer is currently the senior product manager for the variable area flowmeter business at ABB Inc, Automation Technology Products Division, Instrumentation Business Unit, 125 E. County Line Road, Warminster, PA 19075.

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