6.3 Hydrometers


Types: Laboratory or industrial, can be indicating or transmitting

Design Pressure: Generally atmospheric, but the glass variable area flowmeter designs can be used up to 100 PSIG (6.9 bars)

Design Temperature: Generally to 200°F (93°C)

Materials of Construction: Laboratory units are made of glass and unbreakable plastics; industrial units are available in similar materials as are variable area flow-meters (Section 2.27).

Ranges: Minimum span is 0.05 SG; maximum span is 0.5 SG. Spans can be selected within the specific gravity range of 0.6 and 2.1. Minimum scale divisions are 0.0005 SG.

Inaccuracy: 1% of span

Cost: Laboratory units cost between $15 and $50. Industrial indicators start at around $500, and transmitters at $2000 in standard materials. (Costs are higher for corrosion-resistant materials.)

Partial List of Suppliers: ABB Inc. (www.abb.com);
Brooklyn Thermometer Co. (www.brooklyntermometer.com)
Cole-Parmer Instrument Co. (www.coleparmer.com)
Elite Scientific Corp. (www.ambalayellowpages.com)
ERTCO (Ever Ready Thermometer Co.) (www.ertco.com/hydrometers)
H-B Instrument Co. (www.hbinstruments.com)
Princo Instruments Inc. (www.princo instruments.com)

INTRODUCTION

According to Archimedes' principle, when a body is immersed in a fluid, its weight drops by the same amount as the weight of the liquid that it has displaced. Therefore, all hydrometers will sink until they displace the same mass of liquid as their own mass. The volume of liquid displaced is indicated by the level on the scale and density is the ratio of the hydrometer’s mass divided by the displaced volume. As the density of liquids change with temperature, most hydrometers include a thermometer for temperature compensation purposes.

DESIGN VARIATIONS

The hydrometer element consists of a weighted float with a small-diameter indicator stem attachment at the top of the float as shown on Figure 6.3a. The stem is graduated in any of the density units discussed in Section 6.1. The hydrometer has a constant-weight body, which, if immersed in fluids with differing densities, will displace differing volumes of fluid. Therefore, the degree of stem scale submersion is an indication of the fluid's density. Readings are made at the point where the stem emerges from the liquid. The accuracy of

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Density Measurement

measurement is a function of the combined effects of surface tension, turbulence, and sample contamination.

In-Line Designs

One of the simplest in-line density indicators is illustrated in Figure 6.3b. It consists of a transparent glass tee with a hydrometer and a thermometer inside. Constant level is maintained in this tee, because the process fluid sample enters from the bottom and overflows. The sample flow rate is maintained at less than 1 gal/m (3.78 l/m) to minimize the effects of velocity and turbulence. If the process temperature varies, a thermometer is added to allow for manual temperature compensation.

Industrial Designs

The hydrometer element can be mounted inside a variable-area flowmeter (Section 2.27) housing. In such designs, as shown in Figure 6.3c, overflow pipes are provided to maintain the constant level inside the glass tube. Standard accessories include needle valves for sample flow rate control at about 15 gal/h (57 l/h) and integral thermometers.

Wetted parts are available in the same range of materials as for variable area flowmeters. These units can withstand up to 200°F (93°C) and 100 PSIG (690 kPa). Specific gravity (SG) spans of 0.1 to 0.5 are available and can be selected within the limits of 0.6 and 2.1 SG. Reading inaccuracy is 1% of span or the smallest division on the scale, which can range from 0.001 to 0.005 SG.

Transmitters

The variable immersion hydrometer element mounted in a rotameter housing can also be obtained as a transmitter for remote readout, as illustrated in Figure 6.3d three-dimensional. This electronic transmitter can be the servo-operated impedance bridge type and can be provided with automatic temperature compensation. Such compensation will convert the actual density, which is detected to the density that it would correspond to at a predetermined base temperature. Ranges, accuracies, and design limitations are the same as given for the local indicator version, discussed earlier.

The stem position of the hydrometer can also be detected optically. In this design, as the stem rises and falls it changes the amount of light that passes to a photocell. The photocell output is calibrated in specific gravity units.

Another transmitting hydrometer design is the capacitance type. Here, a stainless steel hydrometer positions a dielectric cup inside two insulated, concentric cylinders. The resulting change in capacitance is proportional to density. Automatic temperature compensation is provided with this unit so that the transmitted output signal can be referenced to 60°F (16°C). The transmission can either be analog or digital.

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CONCLUSIONS

The hydrometers discussed above are basic to density measurement. They are accurate, frictionless, and direct-indicating without the need for mechanical linkages or external energy sources. They are compatible with most corrosive fluids.

Their limitations are also multiple, because the float position should not be affected by anything except the fluid density. Effects of the velocity, friction, turbulence, and viscosity of the process must all be minimized. In addition, material buildup on the float cannot be tolerated, because the basis of hydrometer operation is the assumption that the weight of the float is constant. For these reasons, hydrometers should only be considered for use on clean, nonviscous process fluids when the sample flow rate is controlled at around 1 gal/h.

Bibliography