ASHRAE Addendum a to
ASHRAE Guideline 13-2007

ASHRAE ADDENDA

Specifying Direct Digital Control Systems

Approved by the ASHRAE Standards Committee on October 12, 2010 and by the ASHRAE Board of Directors on October 18, 2010.

This addendum was approved by a Standing Guideline Project Committee (SGPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the guideline. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE Web site (www.ashrae.org) or in paper form from the Manager of Standards.

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American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
1791 Tullie Circle NE, Atlanta, GA 30329
www.ashrae.org

SPECIAL NOTE

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a. interpretation of the contents of this Guideline,
b. participation in the next review of the Guideline,
c. offering constructive criticism for improving the Guideline, or
d. permission to reprint portions of the Guideline.

(This foreword is not part of this guideline but is included for information only.)

FOREWORD

This addendum incorporates hydronic flowmeters into the guideline. This material was adapted from the CSU Metering Guide available at www.calstate.edu/cpdc/ae/mech_systems_review.shtml.

Note: In this addendum, changes to the current guideline are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum a to ASHRAE Guideline 13-2007

[Insert a new Section 8.11.9.4 and related Paragraph P and renumber current Section 8.11.9.4 and Paragraph P as Section 8.11.9.5 and Paragraph Q.]

8.11.9.4 Hydronic Flowmeters. Flowmeters commonly used for commercial HVAC applications include the following types:

- Turbine
- Full-bore magnetic
- Single point magnetic
- Vortex shedding
- Transit time ultrasonic

The features, advantages, and disadvantages of these meters are summarized in the table below, with application issues summarized as follows:

- The turbine meter is perhaps the most common for HVAC applications because of its low cost, but it is prone to clogging on open systems such as condenser water systems. Because of the moving parts, routine maintenance is required.
- Full-bore magnetic flowmeters are the best type of hydronic flowmeter from an accuracy standpoint (very accurate even at very low flow rates) and operational standpoint (lowest maintenance costs, longest lasting), but they are expensive. Until recently they were extremely expensive because most manufacturers designed the meters for the more demanding industrial market, but commercial-quality meters are now available at much lower cost. Because the full-bore meter senses the entire water flow (not just a single point), they are much less sensitive to installation problems; as long as turbulence does not cause reversing eddy currents within the flow tube, the meter will be accurate.
- Single-point magnetic meters are often used for large piping when the cost of full-bore meters becomes prohibitive, but because they measure flow at only a single point in the pipe, they are much less accurate than full bore meters.
- Vortex shedding meters were more common before magnetic meters came down in price. They are now more commonly used on gas and steam flow. A significant limitation is that they are not very accurate at low flow.
- Ultrasonic meters are non-invasive; i.e., they do not require any openings into the pipe, and were initially used for ad hoc flow measurements such as for test and balance. Installation details are critical. Manufacturers provide jigs and assemblies to ensure that the sensors are accurately installed, but they are still prone to inaccuracies from installation error. Because they are non-invasive, ultrasonic meters are particularly applicable to retrofit applications.

For metering chilled and hot water flows at buildings, particularly for revenue purposes, the full-bore magnetic flowmeter may be the best option. The pipe sizes are generally small enough at building connections that these meters are affordable. Full bore magnetic flowmeters may also be the best choice for metering total central-plant output of variable-flow chilled water and for heating hot water systems. If budget constraints are such that full bore magnetic flowmeters are cost prohibitive, dual turbine meters may be an acceptable second choice. They are relatively inexpensive and reasonably accurate if well maintained.

TABLE 1 HW and CHW Flowmeter Comparison

Type	Configuration	Typical Accuracy/ Minimum Flow	Advantages	Disadvantages
Turbine (single for small pipes, dual for pipes 2.5" and larger)	Insertion	±2% 0.5 ft/s	• Usually least expensive • Insertion style allows easy retrofit (via hot tap) and removal for cleaning, replacement	• Can be fouled by contaminants in water; not recommended for open circuit systems • Moving parts result in lower operating life, possibly degrading accuracy • Requires correct installation depth to be accurate • Sensitive to installation details – long straight inlet and outlet runs required
Full-bore magnetic	Flow tube	±0.5% 0.05 ft/s	• Most accurate meter • Lowest minimum flow rate • Least sensitive to installation problems and requires least amount of straight piping runs at inlet and discharge • Very little maintenance required; no moving parts • Long life with little calibration required	• Most expensive meter, and especially expensive for large pipes (>12 in.) • Cannot be removed without shutting off system or providing an expensive bypass
Single point magnetic	Insertion	±1% 0.2 ft/s	• Insertion style allows easy retrofit (via hot tap) and removal for cleaning, replacement • Very little maintenance required; no moving parts • Long life with little calibration required	• Relatively expensive for small pipe sizes • Requires correct installation depth to be accurate • Sensitive to installation details – long straight inlet and outlet runs required
Vortex shedding	Insertion	±2% 1 ft/s	• Insertion style allows easy retrofit (via hot tap) and removal for cleaning, replacement	• Not accurate at low flows • Can be fouled by contaminants in water; • Requires correct installation depth to be accurate • Sensitive to installation details – long straight inlet and outlet runs required
Transit time ultrasonic	External	±0.5% 1 ft/s	• External mount allows easy retrofit and replacement • No moving parts and no parts exposed to fluid so maintenance costs are low	• Relatively expensive for small pipe sizes • Not accurate at low flows or quick rate of change • Requires correct configuration to be accurate – sensitive to configuration details such as pipe dimensions and wall thickness • Sensitive to installation details – long straight inlet and outlet runs and precise mounting required

P. Hydronic Flowmeters

1. Insertion-Type Turbine Meter
   a. Dual counter-rotating axial turbine elements, each with its own rotational sensing system, and an averaging circuit to reduce measurement errors due to swirl and flow profile distortion. Single turbine for piping 2 inches and smaller. Flow sensing turbine rotors shall be non-metallic and not impaired by magnetic drag.
   b. Insertion type complete with 'hot-tap' isolation valves to enable sensor removal without water supply system shutdown.
   c. Sensing method shall be impedance sensing (non magnetic and non-photoelectric)
   d. Volumetric accuracy
      1. ± 0.5% of reading at calibrated velocity
      2. ± 1% of reading from 3 to 30 ft/s (10:1 range)
      3. ± 2% of reading from 0.4 to 20 ft/s (50:1 range)
   e. Each sensor shall be individually calibrated and tagged accordingly against the manufacturer's primary standards which must be accurate to within 0.1% of flow rate and traceable to the National Institute of Standards and Technology (NIST).
   f. Maximum operating pressure of 400 psi and maximum operating temperature of 200°F continuous (220°F peak).
   g. All wetted metal parts shall be constructed of 316 stainless steel.
   h. Analog outputs shall consist of non-interactive zero and span adjustments, a DC linearly of 0.1% of span, voltage output of 0-10 Vdc, and current output of 4-20 mA.
2. Magnetic Flow-Tube Type Flowmeter
   a. Sensor shall be a magnetic flowmeter, which utilizes Faraday's Law to measure volumetric fluid flow through a pipe. The flowmeter shall consist of two elements, the sensor and the electronics. The sensor shall generate a measuring signal proportional to the flow velocity in the pipe. The electronics shall convert this EMF into a standard current output.
   b. Electronic replacement shall not affect meter accuracy (electronic units are not matched with specific sensors).
   c. Four-wire, externally powered, magnetic type flow transmitter with adjustable span and zero, integrally mounted to flow tube. Output signal shall be a digital pulse proportional to the flow rate (to provide maximum accuracy and to handle abrupt changes in flow). Standard 4-20 mA or 0-10 Vdc outputs may be used provided accuracy is as specified.
   d. Flow Tube:
      1. ANSI class 150 psig steel
      2. ANSI flanges
      3. Protected with PTFE, PFA, or ETFE liner rated for 245°F minimum fluid temperature
   e. Electrode and grounding material
      1. 316L Stainless steel or Hastelloy C
      2. Electrodes shall be fused to ceramic liner and not require o-rings.
   f. Electrical Enclosure: NEMA 4, 7
   g. Approvals:
      1. UL or CSA.
      2. NSF Drinking Water approval for domestic water applications
   h. Performance
      1. Accuracy shall be ±0.5% of actual reading from 3 to 30 ft/s flow velocities, and 0.015 ft/s from 0.04 to 3 ft/s.
      2. Stability: 0.1% of rate over six months.
      3. Meter repeatability shall be ±0.1% of rate at velocities > 3 ft/s.
3. Magnetic Insertion-Type Flowmeter
   a. Magnetic Faraday point velocity measuring device.
   b. Insertion type complete with hot-tap isolation valves to enable sensor removal without water supply system shutdown.
   c. 4-20 mA transmitter proportional to flow or velocity.
   d. Accuracy: larger of 1% of reading and 0.2 ft/s.
   e. Flow range: 0.2 to 20 ft/s, bidirectional.
   f. Each sensor shall be individually calibrated and tagged accordingly against the manufacturer's primary standards which must be accurate to within 0.1% of flow rate and traceable to the National Institute of Standards and Technology (NIST).

4. Vortex Shedding Flowmeter
   a. Output: 4-20 mA, 0-10 Vdc, 0-5 Vdc.
   b. Maximum Fluid Temperature: 800ºF (427 °C).
   c. Wetted Parts: Stainless Steel.
   d. Housing: NEMA 4X.
   e. Turndown: 25:1 minimum.
   f. Accuracy: 0.5% of calibrated span for liquids, 1% of calibrated span for steam and gases.
   g. Body: Wafer style or ANSI flanged to match piping specification.
5. Transit-Time Ultrasonic Flowmeter
   a. Clamp-On transit-time ultrasonic flowmeter
   b. Wide-Beam transducer technology
   c. 4-20 mA transmitter proportional to flow or velocity.
   d. Accuracy: 0.5% of reading in range 1 to 30 ft/s, 0.001 ft/s sensitivity.

[Revise renumbered Section 8.11.9.5—formerly Section 8.11.9.4—as shown below.]

~~8.11.9.4~~8.11.9.5 **Thermal Energy (Btu) Meter.** Thermal energy meters (often called Btu meters when the output is measured in British thermal units) measure flow, supply temperature, and return temperature to determine the thermal energy consumption (Btu or kWh) and demand (Btu/ h or kW) of thermal energy loads (e.g., hot water, chilled water, and steam). Btu meters may be either a stand-alone device or a "virtual" device created by a custom application controller that takes flow and temperature signals and then calculates the total consumption and peak demand.

The advantage of the stand-alone Btu wattmeter is lower installation cost because a Btu meter is factory programmed, tested, and calibrated, making start-up and commissioning of the Btu meter less time consuming.

The accuracy of the Btu meter is directly related to the accuracy of the temperature sensors. A ±1.0°F error and a 5°F temperature differential can cause an error of 20% in the energy calculation in addition to any error introduced by the flowmeter.

The following characteristics should be considered when specifying ~~power~~ energy monitoring devices:

- Required accuracy
- Accuracy of temperature sensors (RTDs, solid-state sensors, or thermistors): ±0.25%, matched or calibrated with respect to one another~~, RTD sensors or thermistors~~
- Accuracy of flowmeter: ~~±1.0%~~ See "Hydronic Flowmeters" section.
- UL listing, CSA approval
- Factory calibration: traceable to NIST with certification
- Memory: nonvolatile EEPROM memory retains values in the event of power loss
- Programming: factory programmed or user-programmed
- Communication protocols Display units: English or SI or the capability to select either units
- Compensation: built-in tables for density and pressure
- Calculation modes: heat, cool, heat and cool, charge/discharge
- Panel display: none or LED display
- Security for LED display models: password protection
- Inputs:
  - Flow
  - Entering temperature
  - Leaving temperature
  - Pressure (for steam applications)
- Outputs:
  - Pulse signal for energy (optional)
  - 4–20 mA signal for power (optional)
  - Sub-LAN output points
    - Total energy
    - Power
    - Flow
    - Density
    - Delta temperature
    - Energy consumption: hour, day, month, year (optional)

[Revise re-lettered Paragraph Q on page 61—formerly Paragraph P—as shown below.]

Q. Thermal Energy Meters
   1. Matched RTD, solid-state, or thermistor temperature sensors with a differential temperature accuracy of ±0.15°F.
   2. Flowmeter~~: that is accurate within ±1% at calibrated typical flow rate and does not exceed ±2% of actual reading over an extended 50:1 turndown range~~See "Hydronic Flowmeters" section.
   3. Unit accuracy of ±1% factory calibrated, traceable to NIST with certification.
   4. NEMA 1 enclosure.
   5. Panel mounted display.
   6. UL listed.
   7. Isolated 4–20 ma signals for energy rate and supply and return temperatures and flow.