ADDENDA

ANSI/ASHRAE Addendum a to
ANSI/ASHRAE Standard 41.8-2023

Standard Methods for Liquid Flow Measurement

Approved by ASHRAE and the American National Standards Institute on December 31, 2024.

This addendum was approved by a Standing Standard Project Committee (SSPC) 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 standard. Instructions for how to submit a change can be found on the ASHRAE® website (www.ashrae.org/continuous-maintenance).

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FOREWORD

Addendum a updates the steady-state criteria sections.

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

Addendum a to Standard 41.8-2023

Revise Section 3 as shown.

***accuracy*:** the degree of conformity of an indicated value to the ~~corresponding~~ true value.

Revise Section 5.1 as shown.

5.1 Test Plan. The test plan shall be one of the following options:

a. A document provided by the person or the organization that authorized the tests.
b. A method of test standard.
c. A rating standard.
d. A regulation or code.
e. Any combination of items a. through d.

The test plan shall specify:

~~a. The maximum allowable value for either the accuracy or the measurement uncertainty of the liquid flow measurement system.~~
<u>a. The minimum accuracy value or the maximum amount of measurement uncertainty of the liquid flow measurement system over the full range of operating conditions.</u>
b. The values to be determined and recorded are ~~any combinations~~ <u>to be</u> selected from this list: liquid mass flow measurement, liquid mass flow measurement pretest uncertainty, liquid mass flow measurement post-test uncertainty, liquid volumetric flow measurement, liquid volumetric flow pretest uncertainty, liquid volumetric flow post-test uncertainty, and mass measurement.
c. Any combination of test points and targeted set points to be performed together with operating tolerances.

Delete Section 5.3.2 as shown.

~~**5.3.2 Accuracy or Measurement Uncertainty.** A selected liquid flowmeter shall meet or exceed the required liquid flow measurement system accuracy or measurement uncertainty specified in the test plan in Section 5.1 over the full range of operating conditions.~~

Revise Section 5.3.5 as shown.

[. . .]

5.3.5.3 Steady-State Liquid Mass Flow Rate Criteria for Test Points. Starting with the time set to zero, sample not less than 30 liquid mass flow rate measurements N at equal time intervals δt over a test duration Δt, where Δt is in time units. Equation 5-1 states the relationship of the test duration to the number of liquid mass flow rate samples and the equal time intervals.

$$\Delta t = (N - 1)\delta t \tag{5-1}$$

Informative Note: Circumstances for measurement vary, so the user should select a duration of test and the equal time intervals based upon the longest period of the observed liquid mass flow rate fluctuations during operation near the steady-state conditions.

Record each sampled liquid mass flow rate measurement $\dot{m}_i$ and the corresponding time t_i. Apply the least-squares line method to determine the slope b of the liquid mass flow rate data trend line using Equation 5-2.

$$b = \left\{ \frac{[N(\sum_{i=1}^{N} t_i \dot{m}_i) - (\sum_{i=1}^{N} t_i)(\sum_{i=1}^{N} \dot{m}_i)]}{[N(\sum_{i=1}^{N} t_i^2) - (\sum_{i=1}^{N} t_i)^2]} \right\} \quad (5\text{-}2)$$

Informative Note: The units for the slope in Equation 5-2 are liquid mass flow rate, kg/s (lb_m/s), divided by the units that the user has selected for time.

The mean of the sampled liquid mass flow rates $\bar{\dot{m}}$ is defined by Equation 5-3.

$$\bar{\dot{m}} = \frac{1}{N}[\sum_{i=1}^{N} (\dot{m}_i)] \quad \text{kg/s (lb}_m\text{/s)} \quad (5\text{-}3)$$

~~$\bar{\dot{m}}$, as determined by Equation 5-3, represents the steady-state mean liquid mass flow rate provided that one of the following criteria is satisfied:~~

~~a. Apply Equation 5-4:~~

~~$$\dot{m}_{max} - \dot{m}_{min} \le \dot{m}_L \quad \text{kg/s (lb}_m\text{/s)} \quad (5\text{-}4)$$~~

~~b. Apply Equation 5-5:~~

~~$$|b \times \Delta t| \le 0.5 \times \dot{m}_L \quad \text{kg/s (lb}_m\text{/s)} \quad (5\text{-}5)$$~~

Informative Note: For further reading about this method of determining steady-state conditions, refer to Informative Appendix A, References A1 and A2.

The difference between the maximum and minimum sampled values must be less than or equal to the specified test operating tolerance as defined in Equation 5-4, where $\dot{m}_L$ is the operating tolerance limit.

$$\dot{m}_{max} - \dot{m}_{min} \le \dot{m}_L \quad \text{kg/s (lb}_m\text{/s)} \quad (5\text{-}4)$$

The restriction on the slope of the trend line b is defined in Equation 5-5, where Δt is the sample time interval.

$$|b \times \Delta t| \le 0.5 \times \dot{m}_L \quad \text{kg/s (lb}_m\text{/s)} \quad (5\text{-}5)$$

$\bar{\dot{m}}$, as determined by Equation 5-3, represents the steady-state mean refrigerant mass flow rate where Equations 5-4 and 5-5 are both satisfied.

Informative Note: For further reading about ~~this method~~ methods of determining steady-state conditions, refer to Informative Appendix A, References A1 and A2.

5.3.5.4 Steady-State Liquid Mass Flow Rate Criteria for Targeted Set Points. Starting with the time set to zero, sample not less than 30 liquid mass flow rate measurements N at equal time intervals δt over a test duration Δt, where Δt is in time units. Equation 5-6 states the relationship of the test duration to the number of samples and the equal time intervals.

$$\Delta t = (N - 1)\delta t \quad (5\text{-}6)$$

Informative Note: Circumstances for measurement vary, so the user should select a duration of test and the equal time intervals based upon the longest period of the observed liquid mass flow rate fluctuations during operation near the steady-state conditions.

Record each sampled liquid mass flow rate measurement $\dot{m}_i$ and the corresponding time t_i. Apply the least-squares line method to determine the slope b of the liquid mass flow rate data trend line using Equation 5-7.

$$b = \left\{ \frac{[N(\sum_{i=1}^{N} t_i \dot{m}_i) - (\sum_{i=1}^{N} t_i)(\sum_{i=1}^{N} \dot{m}_i)]}{[N(\sum_{i=1}^{N} t_i^2) - (\sum_{i=1}^{N} t_i)^2]} \right\} \quad (5\text{-}7)$$

Informative Note: The units for the slope in Equation 5-7 are liquid mass flow rate, kg/s (lb_m/s), divided by the units that the user has selected for time.

The mean of the sampled liquid mass flow rates, $\bar{\dot{m}}$, is defined by Equation 5-8.

$$\bar{\dot{m}} = \frac{1}{N}[\sum_{i=1}^{N} (\dot{m}_i)] \quad \text{kg/s (lb}_m\text{/s)} \quad (5\text{-}8)$$

~~The steady-state condition of the set point exists where Equation 5-9 is satisfied.~~

~~$$|\dot{m}_{SP} - \bar{\dot{m}}| \leq 0.5 \times \dot{m}_L \quad \text{kg/s (lb}_m\text{/s)} \qquad (5\text{-}9)$$~~

The difference between the maximum and minimum sampled values must be less than or equal to the specified test operating tolerance as defined in Equation 5-9, where $\dot{m}_L$ is the operating tolerance limit.

$$\dot{m}_{max} - \dot{m}_{min} \leq \dot{m}_L \quad \text{kg/s (lb}_m\text{/s)} \qquad (5\text{-}9)$$

The restriction on the slope of the trend line b is defined in Equation 5-10, where Δt is the sample time interval.

$$|b \times \Delta t| \leq 0.5 \times \dot{m}_L \quad \text{kg/s (lb}_m\text{/s)} \qquad (5\text{-}10)$$

The difference between the test condition and mean of the sampled values shall be less than or equal to half of the specified operating tolerance limit as defined in Equation 5-11 where $\dot{m}_{SP}$ is the set-point mass flow rate and $\dot{m}_L$ is the operating tolerance limit.

$$|\dot{m}_{SP} \times \bar{\dot{m}}| \leq 0.5 \times \dot{m}_L \quad \text{kg/s (lb}_m\text{/s)} \qquad (5\text{-}11)$$

$\bar{\dot{m}}$, as determined by Equation 5-11, represents the steady-state mean refrigerant mass flow rate where Equations 5-8, 5-9, and 5-10 are all satisfied.

Informative Note: For further reading about ~~this method~~ methods of determining steady-state conditions, refer to Informative Appendix A, References A1 and A2.

Revise Section 5.3.7 as shown.

[. . .]

5.3.7.3 Steady-State Liquid Volumetric Flow Rate Criteria for Test Points. Starting with the time set to zero, sample not less than 30 liquid volumetric flow rate measurements N at equal time intervals δt over a test duration Δt where Δt is in time units. Equation ~~5-10~~ 5-12 states the relationship of the test duration to the number of liquid volumetric flow rate samples and the equal time intervals.

$$\Delta t = (N - 1)\delta t \qquad (\sout{5\text{-}10}\,5\text{-}12)$$

Informative Note: Circumstances for measurement vary, so the user should select a duration of test and the equal time intervals based upon the longest period of the observed liquid volumetric flow rate fluctuations during operation near the steady-state conditions.

Record each sampled liquid volumetric flow rate measurement Q_i and the corresponding time t_i. Apply the least-squares line method to determine the slope b of the liquid volumetric flow rate data trend line using Equation ~~5-11~~5-13.

$$b = \left\{ \frac{[N(\sum_{i=1}^{N} t_i Q_i) - (\sum_{i=1}^{N} t_i)(\sum_{i=1}^{N} Q_i)]}{[N(\sum_{i=1}^{N} t_i^2) - (\sum_{i=1}^{N} t_i)^2]} \right\} \qquad (\sout{5\text{-}11}\,5\text{-}13)$$

Informative Note: The units for the slope in Equation ~~5-11~~5-13 are liquid volumetric flow rate, m^3/s (cfs), divided by the units that the user has selected for time.

The mean of the sampled liquid volumetric flow rates $\bar{Q}$ is defined by Equation ~~5-12~~5-14.

$$\bar{Q} = \frac{1}{N}[\sum_{i=1}^{N} (Q_i)] \quad \text{m}^3\text{/s (cfs)} \qquad (\sout{5\text{-}12}\,5\text{-}14)$$

~~$\bar{Q}$, as determined by Equation 5-12, represents the steady-state mean liquid volumetric flow rate provided that one of the following criteria is satisfied:~~

~~a. Apply Equation 5-13:~~

~~$$Q_{max} - Q_{min} \leq Q_L \quad \text{m}^3\text{/s (cfs)} \qquad (5\text{-}13)$$~~

~~b. Apply Equation 5-14:~~

~~$$|b \times \Delta t| \leq 0.5 \times Q_L \quad \text{m}^3\text{/s (cfs)} \qquad (5\text{-}14)$$~~

The difference between the maximum and minimum sampled values shall be less than or equal to the specified operating tolerance limit as defined in Equation 5-15, where Q_L is the operating tolerance limit.

$$Q_{max} - Q_{min} \le Q_L \quad \text{m}^3\text{/s (cfs)} \tag{5-15}$$

The restriction on the slope of the trend line b is defined in Equation 5-16 where Δ_t is the sample time interval.

$$|b \times \Delta t| \le 0.5 \times Q_L \quad \text{m}^3\text{/s (cfs)} \tag{5-16}$$

$\overline{Q}$, as determined by Equation 5-14, represents the steady-state mean liquid volumetric flow rate where Equations 5-15 and 5-16 are both satisfied.

Informative Note: For further reading about ~~this method~~ methods of determining steady-state conditions, refer to Informative Appendix A, References A1 and A2.

5.3.7.4 Steady-State Liquid Volumetric Flow Rate Criteria for Targeted Set Points. Starting with the time set to zero, sample not less than 30 liquid volumetric flow rate measurements N at equal time intervals δt over a test duration Δt, where Δt is in time units. Equation ~~5-15~~ 5-17 states the relationship of the test duration to the number of samples and the equal time intervals.

$$\Delta t = (N - 1)\delta t \qquad (\text{~~5-15~~}5\text{-}17)$$

Informative Note: Circumstances for measurement vary, so the user should select a duration of test and the equal time intervals based upon the longest period of the observed liquid volumetric flow rate fluctuations during operation near the steady-state conditions.

Record each sampled liquid volumetric flow rate measurement Q_i and the corresponding time t_i. Apply the least-squares line method to determine the slope b of the liquid volumetric flow rate data trend line using Equation ~~5-16~~5-18.

$$b = \left\{ \frac{[N(\sum_{i=1}^{N} t_i Q_i) - (\sum_{i=1}^{N} t_i)(\sum_{i=1}^{N} Q_i)]}{[N(\sum_{i=1}^{N} t_i^2) - (\sum_{i=1}^{N} t_i)^2]} \right\} \qquad (\text{~~5-16~~}5\text{-}18)$$

Informative Note: The units for the slope in Equation ~~5-16~~5-18 are liquid volumetric flow rate, m^3/s (cfs) divided by the units that the user has selected for time.

The mean of the sampled liquid volumetric flow rates $\overline{Q}$ is defined by Equation ~~5-17~~5-19.

$$\overline{Q} = \frac{1}{N}[\sum_{i=1}^{N}(Q_i)] \quad \text{m}^3\text{/s (cfs)} \qquad (\text{~~5-17~~}5\text{-}19)$$

~~The steady-state condition of the set point exists where Equation 5-18 is satisfied.~~

~~$\left|Q_{SP} - \overline{Q}\right| \le 0.5 \times Q_L$ m³/s (cfs) (5-18)~~

The difference between the maximum and minimum sampled values shall be less than or equal to the specified operating tolerance limit as defined in Equation 5-20, where Q_L is the operating tolerance limit.

$$Q_{max} - Q_{min} \le Q_L \quad \text{m}^3\text{/s (cfs)} \tag{5-20}$$

The restriction on the slope of the trend line b is defined in Equation 5-21, where Δt is the sample time interval.

$$|b \times \Delta t| \le 0.5 \times Q_L \quad \text{m}^3\text{/s (cfs)} \tag{5-21}$$

The difference between the test condition and mean of the sampled values shall be less than or equal to half of the specified operating tolerance limit as defined in Equation 5-22, where Q_{SP} is the set-point volumetric flow rate and Q_L is the operating tolerance limit.

$$\left|Q_{SP} \times \overline{Q}\right| \le 0.5 \times Q_L \quad \text{m}^3\text{/s (cfs)} \tag{5-22}$$

$\overline{Q}$, as determined by Equation 5-19, represents the steady-state mean liquid volumetric flow rate, where Equations 5-20, 5-21, and Equation 5-22 are all satisfied.

Informative Note: For further reading about ~~this method~~ methods of determining steady-state conditions, refer to Informative Appendix A, References A1 and A2.

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