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

Public Review Draft

Proposed Addendum a to Standard 41.8-2023, Standard Methods for Liquid Flow Measurement

First Public Review (September 2024)
(Draft shows Proposed Changes to Current Standard)

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Standard 41.8-2023 Addendum a.
Standard Methods for Liquid Flow Measurement

(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

The primary purpose of 41.8-2023 Addendum a is to update the steady-state criteria sections.

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 below.

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

Revise Section 5.1 as shown below.

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.~~
b. <u>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>
c. 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.
d. Any combination of test points and targeted set points to be performed together with operating

tolerances.

Delete Section 5.3.2 as shown below.

~~**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 below.

5.3.5 Steady-State Test Criteria for Liquid Mass Flow Rate Measurements. Liquid mass flow rate test data shall be recorded at steady-state conditions if specified in the test plan in Section 5.1.

5.3.5.1 Steady-State Test Criteria for Liquid Mass Flow Rate Measurements Under Laboratory Test Conditions. If the test plan requires liquid mass flow rate test data points to be recorded at steady-state test conditions and provides the operating condition tolerance but does not specify the steady-state criteria, then determine that steady-state test conditions have been achieved using one of the following methods:

a. Apply the steady-state criteria in Section 5.3.5.3 if the test plan provides test points for liquid mass flow rate measurement.
b. Apply the steady-state criteria in Section 5.3.5.4 if the test plan provides targeted set points for liquid mass flow rate measurement.

5.3.5.2 Steady-State Test Criteria for Liquid Mass Flow Rate Measurements Under Field Test Conditions. If the test plan requires liquid mass flow rate test data points to be recorded at steady-state test conditions and provides the operating condition tolerance but does not specify the steady-state criteria, the methods in Section 5.3.5.1 are optional.

Informative Note: The steady-state methods in Section 5.3.5.1 are likely to be impractical under field test conditions. Section 5.3.6 provides instructions for making measurements that are not at steady state conditions.

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.

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

Informative Note: It should be noted that 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.

$$\bar{\dot{m}} = \frac{1}{N}\left[\sum_{i=1}^{N} (\dot{m}_i)\right] \text{ kg/s } (lb_m/s) \qquad (5\text{-}3)$$

~~$\bar{\dot{m}}$, 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:~~

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

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

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

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.

$$\dot{m}_{max} - \dot{m}_{imin} \le \dot{m}_L \text{ kg/s } (lb_m/s) \qquad (5\text{-}4)$$

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

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

$\bar{\dot{m}}$, 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.

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

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.

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

Informative Note: It should be noted that 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.

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

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

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

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.

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

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

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

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.

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

$\bar{\dot{m}}$, 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 below.

5.3.7 Steady-State Test Criteria for Liquid Volumetric Flow Rate Measurements. Liquid volumetric flow rate test data shall be recorded at steady-state conditions if specified in the test plan in Section 5.1.

5.3.7.1 Steady-State Test Criteria for Liquid Volumetric Flow Rate Measurements Under Laboratory Test Conditions. If the test plan requires liquid volumetric flow rate test data points to be recorded at steady-state test conditions and provides the operating condition tolerance but does not specify the steady-state criteria, then determine that steady-state test conditions have been achieved using one of the following methods:

a. Apply the steady-state criteria in Section 5.3.7.3 if the test plan provides test points for liquid volumetric flow rate measurement.
b. Apply the steady-state criteria in Section 5.3.7.4 if the test plan provides targeted set points for liquid volumetric flow rate measurement.

5.3.7.2 Steady-State Test Criteria for Liquid Volumetric Flow Rate Measurements Under Field Test Conditions. If the test plan requires liquid volumetric flow rate test data points to be recorded at steady-state test conditions and provides the operating condition tolerance but does not specify the steady-state criteria, the methods in Section 5.3.7.1 are optional.

Informative Note: The steady-state methods in Section 5.3.7.1 are likely to be impractical under field test conditions. Section 5.3.8 provides instructions for making measurements that are not at steady state conditions.

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.

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

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.

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

Informative Note: It should be noted that the units for the slope in Equation ~~5-11~~ 5-13 are liquid volumetric flow rate, m³/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.

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

~~$\bar{Q}$, 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:~~

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

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

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

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.

$$Q_{max} - Q_{imin} \leq Q_L \text{ m}^3\text{/s (cfs)} \qquad (5\text{-}15)$$

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

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

$\bar{Q}$, 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.

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

Informative Note: It should be noted that 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 $\bar{Q}$ is defined by Equation ~~5-17~~ 5-19.

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

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

~~$$|Q_{SP} - \bar{Q}| \leq 0.5 \times Q_L \text{ m}^3\text{/s (cfs)} \qquad (5\text{-}18)$$~~

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.

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

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

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

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.

$$|Q_{SP} - \bar{Q}| \leq 0.5 \times \mathrm{Q}_L \text{ m}^3\text{/s (cfs)} \quad (5\text{-}22)$$

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