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ADDENDA

ANSI/ASHRAE Addendum a to
ANSI/ASHRAE Standard 41.2-2022

Standard Methods for Air Velocity and Airflow Measurement

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

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FOREWORD

Addendum a updates the test plan to include pretest and post-test uncertainty, updates the steady-state criteria sections, and adds an airflow mixing section.

Informative Note: In this addendum, changes to the current standard 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 Standard 41.2-2022

Revise Section 3 as shown.

3. DEFINITIONS

computational fluid dynamics: the use of applied mathematics, physics, and computational software to visualize how a gas or liquid flows, as well as how the gas or liquid affects objects as it flows past.

[. . .]

Revise Section 5.1 as shown.

[. . .]

The test plan shall specify:

a. The maximum allowable value for either the accuracy or the measurement uncertainty of the air velocity or airflow measurement system.
b. The values to be determined and recorded that are selected from this list: air velocity, air velocity pretest uncertainty, air velocity post-test uncertainty, volumetric airflow rate, volumetric airflow pretest uncertainty, volumetric airflow post-test uncertainty, standard volumetric airflow rate, standard volumetric airflow rate pretest uncertainty, standard volumetric airflow rate post-test uncertainty, mass airflow rate, mass airflow pretest uncertainty, and mass airflow post-test uncertainty,
c. Any combination of test points and targeted set points to be performed together with operating tolerances.

Revise Section 5.3.1.4.3 as shown. Delete Figure 5-1 (not shown).

5.3.1.4.3 Steady-State Air Velocity Criteria for Test Points. Starting with the time set to zero, sample not less than 30 air velocity 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 air velocity 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 air velocity fluctuations during operation near the steady-state conditions.

Record each sampled air velocity measurement V_i and the corresponding time t_i. Apply the least-squares line method to determine the slope b of the air velocity data trend line ~~illustrated in Figure 5-1~~ using Equation 5-2.

$$b = \left\{\frac{[N(\sum_{i=1}^{N} t_i V_i) - (\sum_{i=1}^{N} t_i)(\sum_{i=1}^{N} V_i)]}{[N(\sum_{i=1}^{N} t_i^2) - (\sum_{i=1}^{N} t_i)^2]}\right\} \tag{5-2}$$

Informative Note: It should be noted that the units for the slope in Equation 5-2 are air velocity, m/s (fpm), divided by the units that the user has selected for time.

~~**Figure 5-1 Graphical illustration of the method for determining the steady-state air velocity criteria for test points.**~~

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~~Determine the mean offset μ of the sampled data using Equation 5-3, and then calculate the standard deviation σ using Equation 5-4.~~

$$\cancel{\mu = \frac{1}{N}\left[\sum_{i=1}^{N}(V_i - bt_i)\right] \quad \text{m/s (fpm)}} \qquad \cancel{(5\text{-}3)}$$

$$\cancel{\sigma = \left[\left(\frac{1}{N-2}\right)\sum_{i=1}^{N}(V_i - bt_i - \mu)^2\right]^{1/2} \quad \text{m/s (fpm)}} \qquad \cancel{(5\text{-}4)}$$

The mean of the sampled air velocity, $\overline{V}$, is defined by Equation ~~5-5~~5-3.

$$\overline{V} = \frac{1}{N}\left[\sum_{i=1}^{N}(V_i)\right] \quad \text{m/s (fpm)} \qquad (5\text{-}\cancel{5}3)$$

~~$\overline{V}$, as determined by Equation 5-5, represents the steady-state mean air velocity provided that one of the following criteria is satisfied:~~

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 5-4, where V_L is the operating tolerance limit.

$$V_{max} - V_{min} \le V_L \quad \text{m/s (fpm)} \qquad (5\text{-}4)$$

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

$$|b \times \Delta t| \le 0.5 \times V_L \quad \text{m/s (fpm)} \qquad (5\text{-}5)$$

$\overline{V}$, as determined by Equation 5-3, represents the steady-state mean air velocity, where Equations 5-4 and 5-5 are both satisfied.

~~a. Apply Equation 5-6 if 2σ ≥ V_L, where V_L is the specified operating tolerance limit for air velocity, and if Equation 6 is satisfied by not less than 95% of the sampled air velocities.~~

$$\cancel{|V_i - \mu| \le 2\sigma \quad \text{m/s (fpm)}} \qquad \cancel{(5\text{-}6)}$$

~~The horizontal dotted lines, that are located 2σ above and below μ, are the boundaries of the 95% sampled air velocities scatter envelope.~~

~~b. Apply Equation 5-7 if V_L ≥ 2σ, where V_L is the specified operating tolerance limit for air velocity, and if Equation 5-7 is satisfied by not less than 95% of the sampled air velocities.~~

$$\cancel{|V_i - \mu| \le V_L \quad \text{m/s (fpm)}} \qquad \cancel{(5\text{-}7)}$$

~~In Figure 5-1, the horizontal dashed lines that are located V_L above and below μ are the boundaries of the 95% sampled velocity scatter envelope.~~

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

Revise Section 5.3.1.4.4 as shown. Delete Figure 5-2 (not shown).

5.3.1.4.4 Steady-State Air Velocity Criteria for Targeted Set Points. Starting with the time set to zero, sample not less than 30 air velocity measurements N at equal time intervals δt over a test duration Δt where Δt is in time units. Equation ~~5-8~~5-6 states the relationship of the test duration to the number of samples and the equal time intervals.

$$\Delta t = (N-1)\delta t \qquad (5\text{-}\cancel{8}6)$$

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 volumetric airflow flow rate fluctuations during operation near the steady-state conditions.

Record each sampled air velocity measurement V_i and the corresponding time t_i. Apply the least-squares line method to determine the slope b of the air velocity data trend line ~~illustrated in Figure 5-2~~ using Equation ~~5-9~~5-7.

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$$b = \left\{ \frac{[N(\sum_{i=1}^{N} t_i V_i) - (\sum_{i=1}^{N} t_i)(\sum_{i=1}^{N} V_i)]}{[N(\sum_{i=1}^{N} t_i^2) - (\sum_{i=1}^{N} t_i)^2]} \right\}$$ (5-~~9~~7)

Informative Note: It should be noted that the units for the slope in Equation ~~5-9~~5-7 are air velocity, m/s (fpm), divided by the units that the user has selected for time.)

~~**Figure 5-2 Graphical illustration of the method for determining the steady-state air velocity criteria for targeted set points.**~~

~~Determine the mean offset μ of the sampled data using Equation 5-10, and then calculate the standard deviation σ using Equation 5-11.~~

$$\cancel{\mu = \frac{1}{N}[\sum_{i=1}^{N}(V_i - bt_i)] \quad \text{m/s (fpm)}}$$ ~~(5-10)~~

$$\cancel{\sigma = \left[\left(\frac{1}{N-2}\right)\sum_{i=1}^{N}(V_i - bt_i - \mu)^2\right]^{1/2} \quad \text{m/s (fpm)}}$$ ~~(5-11)~~

The mean of the sampled air velocities $\overline{V}$ is defined by Equation ~~5-12~~5-8.

$$\overline{V} = \frac{1}{N}[\sum_{i=1}^{N}(V_i)] \quad \text{m/s (fpm)}$$ (5-~~12~~8)

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 5-9, where V_L is the operating tolerance limit.

$$V_{max} - V_{min} \le V_L \quad \text{m/s (fpm)}$$ (5-9)

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

$$|b \times \Delta t| \le 0.5 \times V_L \quad \text{m/s (fpm)}$$ (5-10)

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 V_{SP} is the set-point airflow velocity and V_L is the operating tolerance limit.

$$\left|V_{SP} - \overline{V}\right| \le 0.5 \times V_L \quad \text{m/s (fpm)}$$ (5-11)

$\overline{V}$, as determined by Equation 5-8, represents the steady-state mean air velocity, where Equations 5-9, 5-10, and 5-11 are all satisfied.

~~A tolerance on the fluctuations about the trend line represents a limit on the fluctuation level relative to the trend line of the sampled data. If the tolerance of fluctuations about the trend line is not specified in the test plan, the bounds for a 95% confidence limit for the fluctuations about the trend line shall then be determined according to Equation 5-13.~~

$$\cancel{\left|\overline{V} - V_{SP}\right| + |b\Delta t| + 2\sigma \le V_L \quad \text{m/s (fpm)}}$$ ~~(5-13)~~

~~The steady-state condition of the set point air velocity V_{SP} exists~~

~~a. where Equation 5-14 is satisfied by not less than 95% of the sampled air velocities where V_L is the operating tolerance limit for velocity~~

$$\cancel{(V_{SP} - V_L) \le V_i \le (V_{SP} + V_L) \quad \text{m/s (fpm)}}$$ ~~(5-14)~~

~~b. where~~

$$\cancel{-0.50V_L \le (\overline{V} - V_{SP}) \le 0.50V_L \quad \text{m/s (fpm)}}$$ ~~(5-15)~~

~~c. and where~~

$$\cancel{|b\Delta t| \le 0.50V_L \quad \text{m/s (fpm)}}$$ ~~(5-16)~~

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

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Revise Section 5.3.2.5.3 as shown. Delete Figure 5-3 (not shown).

5.3.2.5.3 Steady-State Volumetric Airflow Rate Criteria for Test Points. Starting with the time set to zero, sample not less than 30 volumetric airflow rate measurements N at equal time intervals δt over a test duration Δt where Δt is in time units. Equation ~~5-17~~5-12 states the relationship of the test duration to the number of volumetric airflow flow rate samples and the equal time intervals.

$$\Delta t = (N-1)\delta t \qquad (5\text{-}\cancel{17}12)$$

Record each sampled volumetric airflow rate measurement Q_i and the corresponding time t_i. Apply the least-squares line method to determine the slope b of the volumetric airflow rate data trend line ~~illustrated in Figure 5-3~~ using Equation ~~5-18~~5-13.

$$b = \left\{\frac{[N(\sum_{i=1}^{N} t_i Q_i) - (\sum_{i=1}^{N} t_i)(\sum_{i=1}^{N} Q_i)]}{[N(\sum_{i=1}^{N} t_i^2) - (\sum_{i=1}^{N} t_i)^2]}\right\} \qquad (5\text{-}\cancel{18}13)$$

Informative Note: It should be noted that the units for the slope in Equation ~~5-18~~5-13 are volumetric airflow flow rate, m^3/s (ft^3/min), divided by the units that the user has selected for time.

~~**Figure 5-3 Graphical illustration of the method for determining the steady-state volumetric airflow flow rate criteria for targeted set points.**~~

~~Determine the mean offset μ of the sampled data using Equation 5-19, and then calculate the standard deviation σ using Equation 5-20.~~

$$\cancel{\mu = \frac{1}{N}[\sum_{i=1}^{N}(Q_i - bt_i)] \quad m^3/s\ (ft^3/min)} \qquad \cancel{(5\text{-}19)}$$

$$\cancel{\sigma = \left[\left(\frac{1}{N-2}\right)\sum_{i=1}^{N}(Q_i - bt_i - \mu)^2\right]^{1/2} \quad m^3/s\ (ft^3/min)} \qquad \cancel{(5\text{-}20)}$$

The mean of the sampled volumetric airflow rates $\overline{Q}$ is defined by Equation ~~5-21~~5-14.

$$\overline{Q} = \frac{1}{N}[\sum_{i=1}^{N}(Q_i)] \quad m^3/s\ (ft^3/min) \qquad (5\text{-}\cancel{21}14)$$

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.

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

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

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

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

~~$\overline{Q}$, as determined by Equation 5-21, represents the steady-state mean volumetric airflow rate provided that one of the following criteria is satisfied:~~

~~a. Apply Equation 5-22 if $2\sigma \ge Q_L$, where Q_L is the specified operating tolerance limit for volumetric airflow rate, and if Equation 5-22 is satisfied by not less than 95% of the sampled volumetric airflow rates.~~

$$\cancel{|Q_i - \mu| \le 2\sigma \quad m^3/s\ (ft^3/min)} \qquad \cancel{(5\text{-}22)}$$

~~In Figure 5-3, the horizontal dotted lines that are located 2σ above and below μ are the boundaries of the 95% sampled volumetric airflow rate scatter envelope.~~

~~b. Apply Equation 5-23 if $Q_L \ge 2\sigma$, where Q_L is the specified operating tolerance limit for volumetric airflow rate, and if Equation 5-23 is satisfied by not less than 95% of the sampled volumetric airflow rates.~~

$$\cancel{|Q_i - \mu| \le Q_L \quad m^3/s\ (ft^3/min)} \qquad \cancel{(5\text{-}23)}$$

~~In Figure 5-3, the horizontal dashed lines that are located Q_L above and below μ are the boundaries of the 95% sampled volumetric airflow rate scatter envelope.~~

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

Revise Section 5.3.2.5.4 as shown. Delete Figure 5-4 (not shown).

5.3.2.5.4 Steady-State Volumetric Airflow Rate Criteria for Targeted Set Points. Starting with the time set to zero, sample not less than 30 volumetric airflow rate measurements N at equal time intervals δt over a test duration Δt where Δt is in time units. Equation ~~5-24~~5-17 states the relationship of the test duration to the number of samples and the equal time intervals.

$$\Delta t = (N-1)\delta t \qquad (5\text{-}\cancel{24}17)$$

Record each sampled volumetric airflow rate measurement Q_i and the corresponding time t_i. Apply the least-squares line method to determine the slope b of the volumetric airflow rate data trend line ~~illustrated in Figure 5-4~~ using Equation ~~5-25~~5-18.

$$b = \left\{\frac{[N(\sum_{i=1}^{N} t_i Q_i) - (\sum_{i=1}^{N} t_i)(\sum_{i=1}^{N} Q_i)]}{[N(\sum_{i=1}^{N} t_i^2) - (\sum_{i=1}^{N} t_i)^2]}\right\} \qquad (5\text{-}\cancel{25}18)$$

Informative Note: It should be noted that the units for the slope in Equation ~~5-25~~5-18 are volumetric airflow flow rate, m^3/s (ft^3/min), divided by the units that the user has selected for time.)

~~**Figure 5-4 Graphical illustration of the method for determining the steady state volumetric airflow rate criteria for targeted set points.**~~

~~Determine the mean offset μ of the sampled data using Equation 5-26, and then calculate the standard deviation σ using Equation 5-27.~~

$$\cancel{\mu = \frac{1}{N}[\sum_{i=1}^{N}(Q_i - bt_i)] \quad \text{m}^3\text{/s (ft}^3\text{/min)}} \qquad \cancel{(5\text{-}26)}$$

$$\cancel{\sigma = \left[\left(\frac{1}{N-2}\right)\sum_{i=1}^{N}(Q_i - bt_i - \mu)^2\right]^{1/2} \quad \text{m}^3\text{/s (ft}^3\text{/min)}} \qquad \cancel{(5\text{-}27)}$$

The mean of the sampled volumetric airflow rates $\overline{Q}$ is defined by Equation ~~5-28~~5-19.

$$\overline{Q} = \frac{1}{N}[\sum_{i=1}^{N}(Q_i)] \quad \text{m}^3\text{/s (ft}^3\text{/min)} \qquad (5\text{-}\cancel{28}19)$$

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.

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

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

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

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 airflow rate and Q_L is the operating tolerance limit.

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

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

~~A tolerance on the fluctuations about the trend line represents a limit on the fluctuation level relative to the trend line of the sampled data. If the tolerance of fluctuations about the trend line is not specified in the test plan, the bounds for a 95% confidence limit for the fluctuations about the trend line shall then be determined according to Equation 5-29.~~

$$\cancel{\left|\overline{Q} - Q_{SP}\right| + |b\Delta t| + 2\sigma \le Q_L \quad \text{m}^3\text{/s (ft}^3\text{/min)}} \qquad \cancel{(5\text{-}29)}$$

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~~The steady-state condition of the set point volumetric airflow rate Q_{SP} exists~~

~~a. where Equation 5-30 is satisfied by not less than 95% of the sampled volumetric airflow rates where Q_L is the operating tolerance limit for volumetric airflow rate~~

$$(Q_{SP} - Q_L) \le Q_i \le (Q_{SP} + Q_L) \quad \mathrm{m^3/s\ (ft^3/min)} \qquad \text{~~(5-30)~~}$$

~~b. where~~

$$0.50Q_L \le (\overline{Q} - Q_{SP}) \le 0.50Q_L \quad \mathrm{m^3/s\ (ft^3/min)} \qquad \text{~~(5-31)~~}$$

~~c. and where~~

$$|b\Delta t| \le 0.50Q_L \quad \mathrm{m^3/s\ (ft^3/min)} \qquad \text{~~(5-32)~~}$$

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

Revise Section 5.3.2.7.3 as shown. Delete Figure 5-5 (not shown).

5.3.2.7.3 Steady-State Mass Airflow Rate Criteria for Test Points. Starting with the time set to zero, sample not less than 30 mass airflow rate measurements N at equal time intervals δt over a test duration Δt where Δt is in time units. Equation ~~5-33~~5-23 states the relationship of the test duration to the number of mass airflow rate samples and the equal time intervals.

$$\Delta t = (N-1)\delta t \qquad (5\text{-}~~33~~23)$$

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 mass airflow rate fluctuations during operation near the steady-state conditions.

Record each sampled mass airflow rate measurement $\dot{m}_i$ and the corresponding time t_i. Apply the least-squares line method to determine the slope b of the mass airflow rate data trend line ~~illustrated in Figure 5-5~~ using Equation ~~5-34~~5-24.

$$b = \left\{ \frac{[N(\sum_{i=1}^{N} t_i \dot{m}_i) - (\sum_{i=1}^{N} t_i)(\sum_{i=1}^{N} \dot{m}_i)]}{[N(\sum_{i=1}^{N} t_i^2) - (\sum_{i=1}^{N} t_i)^2]} \right\} \qquad (5\text{-}~~34~~24)$$

Informative Note: It should be noted that the units for the slope in Equation ~~5-34~~5-24 are mass airflow rate, kg/s ($\mathrm{lb_m}$/min), divided by the units that the user has selected for time.

~~**Figure 5-5 Graphical illustration of the method for determining the steady-state mass airflow rate criteria for test points.**~~

~~Determine the mean offset μ of the sampled data using Equation 5-35, and then calculate the standard deviation σ using Equation 5-36.~~

$$\mu = \frac{1}{N}[\sum_{i=1}^{N} (\dot{m}_i - bt_i)] \quad \mathrm{kg/s\ (lb_m/min)} \qquad \text{~~(5-35)~~}$$

$$\sigma = \left[\left(\frac{1}{N-2}\right)\sum_{i=1}^{N} (\dot{m}_i - bt_i - \mu)^2\right]^{1/2} \quad \mathrm{kg/s\ (lb_m/min)} \qquad \text{~~(5-36)~~}$$

The mean of the sampled mass airflow rates $\overline{\dot{m}}$ is defined by Equation ~~5-37~~5-25.

$$\overline{\dot{m}}_i = \frac{1}{N}[\sum_{i=1}^{N} (\dot{m}_i)] \quad \mathrm{kg/s\ (lb_m/min)} \qquad (5\text{-}~~37~~25)$$

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 5-26, where $\dot{m}_L$ is the operating tolerance limit.

$$\dot{m}_{max} - \dot{m}_{min} \le \dot{m}_L \quad \mathrm{kg/s\ (lb_m/min)} \qquad (5\text{-}26)$$

The restriction on the slope of the trend line b is defined in Equation 5-27, where Δt is the sample time interval.

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$$|b \times \Delta t| \le 0.5 \times \dot{m}_L \quad \text{kg/s (lb}_m\text{/min)} \qquad (5\text{-}27)$$

$\bar{\dot{m}}$, as determined by Equation ~~5-37~~5-25, represents the steady-state mean mass airflow rate~~ provided that one of the following criteria is satisfied~~, where Equations 5-26 and 5-27 are both satisfied.

~~a. Apply Equation 5-38 if $2\sigma \ge \dot{m}_L$, where $\dot{m}_L$ is the specified operating tolerance limit for mass airflow rate, and if Equation 5-38 is satisfied by not less than 95% of the sampled mass airflow rates.~~

~~$|\dot{m}_i - \mu| \le 2\sigma$ kg/s (lb$_m$/min) (5-38)~~

~~In Figure 5-5, the horizontal dotted lines that are located 2σ above and below μ are the boundaries of the 95% sampled mass airflow rate scatter envelope.~~

~~b. Apply Equation 5-39 if $\dot{m}_L \ge 2\sigma$, where $\dot{m}_L$ is the specified operating tolerance limit for mass airflow rate, and if Equation 5-39 is satisfied by not less than 95% of the sampled mass airflow rates.~~

~~$|\dot{m}_i - \mu| \le \dot{m}_L$ kg/s (lb$_m$/min) (5-39)~~

~~In Figure 5-5, the horizontal dashed lines that are located $\dot{m}_L$ above and below μ are the boundaries of the 95% sampled mass airflow rate scatter envelope.~~

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

Revise Section 5.3.2.7.4 as shown.

5.3.2.7.4 Steady-State Mass Airflow Rate Criteria for Targeted Set Points. Starting with the time set to zero, sample not less than 30 mass airflow rate measurements N at equal time intervals δt over a test duration Δt where Δt is in time units. Equation ~~5-40~~5-28 states the relationship of the test duration to the number of samples and the equal time intervals.

$$\Delta t = (N-1)\delta t \qquad (5\text{-}\cancel{40}28)$$

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 mass airflow rate fluctuations during operation near the steady-state conditions.

Record each sampled mass airflow rate measurement $\dot{m}_i$ and the corresponding time t_i. Apply the least-squares line method to determine the slope b of the mass airflow rate data trend line ~~illustrated in Figure 5-6~~ using Equation ~~5-41~~5-29.

$$b = \left\{\frac{[N(\sum_{i=1}^{N} t_i\dot{m}_i) - (\sum_{i=1}^{N} t_i)(\sum_{i=1}^{N} \dot{m}_i)]}{[N(\sum_{i=1}^{N} t_i^2) - (\sum_{i=1}^{N} t_i)^2]}\right\} \qquad (5\text{-}\cancel{41}29)$$

Informative Note: It should be noted that the units for the slope in Equation ~~5-41~~5-29 are mass airflow rate, kg/s (lb$_m$/min), divided by the units that the user has selected for time.

~~**Figure 5-6 Graphical illustration of the method for determining the steady-state mass airflow rate criteria for targeted set points.**~~

~~Determine the mean offset μ of the sampled data using Equation 5-42, and then calculate the standard deviation σ using Equation 5-43.~~

~~$\mu = \frac{1}{N}[\sum_{i=1}^{N}(\dot{m}_i - bt_i)]$ kg/s (lb$_m$/min) (5-42)~~

~~$\sigma = \left[\left(\frac{1}{N-2}\right)\sum_{i=1}^{N}(\dot{m}_i - bt_i - \mu)^2\right]^{1/2}$ kg/s (lb$_m$/min) (5-43)~~

The mean of the sampled mass airflow rates $\bar{\dot{m}}$ is defined by Equation ~~5-44~~5-30.

$$\bar{\dot{m}}_i = \frac{1}{N}[\sum_{i=1}^{N}(\dot{m}_i)] \quad \text{kg/s (lb}_m\text{/min)} \qquad (5\text{-}\cancel{44}30)$$

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 5-31, where $\dot{m}_L$ is the operating tolerance limit.

$$\dot{m}_{max} - \dot{m}_{min} \le \dot{m}_L \quad \text{kg/s (lb}_m\text{/min)} \qquad (5\text{-}31)$$

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The restriction on the slope of the trend line b is defined in Equation 5-32, where Δt is the sample time interval.

$$|b \times \Delta t| \le 0.5 \times \dot{m}_L \quad \text{kg/s (lb}_\text{m}\text{/min)} \tag{5-32}$$

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 5-33, where $\dot{m}_{SP}$ is the set point mass airflow rate and $\dot{m}_L$ is the operating tolerance limit.

$$\left|\dot{m}_{SP} - \overline{\dot{m}}\right| \le 0.5 \times \dot{m}_L \quad \text{kg/s (lb}_\text{m}\text{/min)} \tag{5-33}$$

$\overline{\dot{m}}$, as determined by Equation 5-18, represents the steady-state mean refrigerant mass flow rate, where Equations 5-31, 5-32, and 5-33 are all satisfied.

~~A tolerance on the fluctuations about the trend line represents a limit on the fluctuation level relative to the trend line of the sampled data. If the tolerance of fluctuations about the trend line is not specified in the test plan, the bounds for a 95% confidence limit for the fluctuations about the trend line shall then be determined according to Equation 5-45.~~

~~$$\left|\overline{\dot{m}_i} - \dot{m}_{SP}\right| + |b\Delta t| + 2\sigma \le \dot{m}_L \quad \text{kg/s (lb}_\text{m}\text{/min)} \tag{5-45}$$~~

~~The steady-state condition of the set point mass airflow rate $\dot{m}_{SP}$ exists~~

~~a. where Equation 5-46 is satisfied by not less than 95% of the sampled mass airflow rates where $\dot{m}_L$ is the operating tolerance limit for mass airflow rate~~

~~$$(\dot{m}_{SP} - \dot{m}_L) \le \dot{m}_i \le (\dot{m}_{SP} + \dot{m}_L) \quad \text{kg/s (lb}_\text{m}\text{/min)} \tag{5-46}$$~~

~~b. where~~

~~$$0.50\dot{m}_L \le (\overline{\dot{m}} - \dot{m}_{SP}) \le 0.50\dot{m}_L \quad \text{kg/s (lb}_\text{m}\text{/min)} \tag{5-47}$$~~

~~c. and where~~

~~$$|b\Delta t| \le 0.50\dot{m}_L \quad \text{kg/s (lb}_\text{m}\text{/min)} \tag{5-48}$$~~

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

Revise Section 8 as shown below. Delete old Figure 8-6 (not shown) and add new Figures 8-6, 8-7, and 8-8 as shown.

8. AIRFLOW MEASUREMENT DUCT FEATURES AND ~~COMPONENTS~~ AND UNIT-UNDER-TEST AIRSTREAM AIRFLOW MIXING COMPONENTS

8.1 Overview. Duct features ~~Features~~ used in the airflow measurement single-nozzle ducts and single- and multiple-nozzle chambers that are described in Section 9 include static pressure taps, piezometer rings, and flow straighteners.~~, transition pieces, and variable air supply or exhaust systems.~~ Airstream airflow mixing components, if any, are an integral part of the unit under test (UUT).

[. . .]

~~**8.5 Transformation Pieces.** Transformation pieces used to connect rectangular units under test (UUTs) to round single-nozzle ducts or single-or multiple-nozzle chambers, or round UUTs to rectangular single-nozzle ducts or single-or multiple-nozzle chambers shall be made in compliance with Figure 8-6.~~

8.6 UUT Airstream Airflow Mixing Components. Airflow mixing components shall be applied to single airflow streams or to the junction of two airflow streams to obtain more uniform air temperatures and air velocities. Figures 8-6, 8-7, and 8-8 are examples of airflow mixing components.

The air-mixer portion of ASHRAE Research Project 1733-TRP is an example of the application of computational fluid dynamics to visualize the effectiveness of candidate air-mixer geometries to create uniform air temperatures and velocities. A summary of the results of that effort is provided in a technical paper authored by Hyunjin Park and Christian K. Bach[10].

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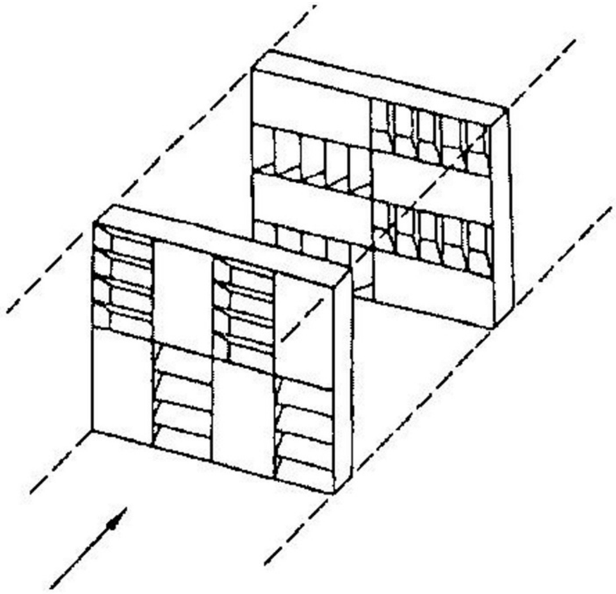

Figure 8-6 Opposing louvers in a rectangular duct.

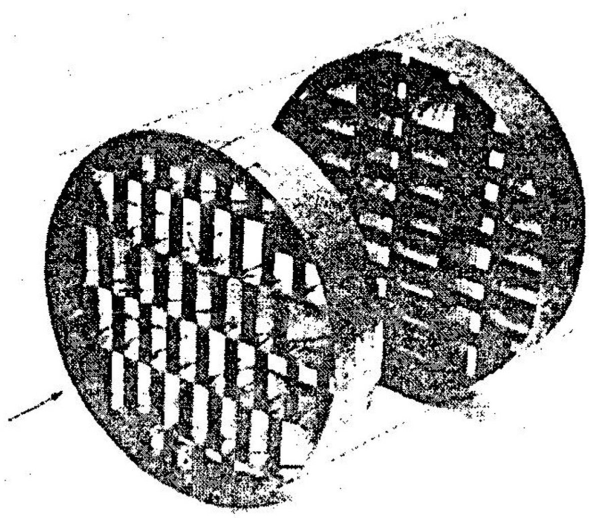

Figure 8-7 Opposing grids in a round duct.

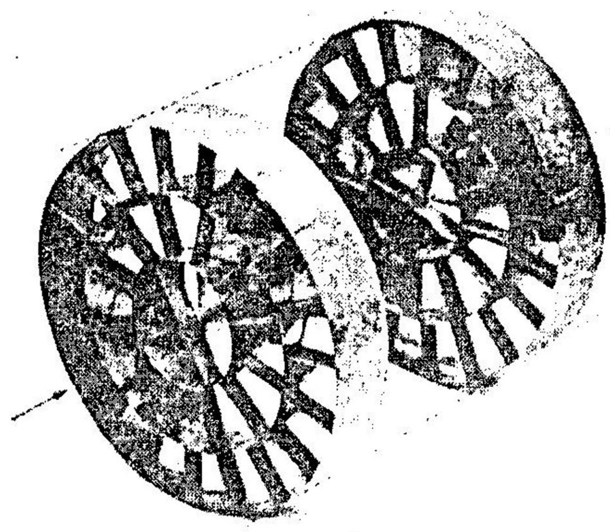

Figure 8-8 Opposing grids in a round duct.

Revise Section 12 as shown.

12. REFERENCES

[. . .]

10. Park, H., and C.K. Bach. 2021.*Performance Characterization of Air Mixing Devices for Square Ducts*, *Applied Thermal Engineering* 199.

[. . .]

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1/24