ADDENDA

ANSI/ASHRAE Addendum a to
ANSI/ASHRAE Standard 41.3-2022

Standard Methods for Pressure Measurement

Approved by ASHRAE and the American National Standards Institute on January 31, 2023.

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.*

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 41.3-2022

Revise Section 5.6.3 as shown. Replace old Figure 2 (not shown) with the new version as indicated.

5.6.3 Steady-State Pressure Criteria for Test Points

[. . .]

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

a. Apply Equation 6 if $2\sigma \geq P_L$, where P_L is the specified operating tolerance limit for pressure, and if Equation 6 is satisfied by not less than 95% of the sampled pressures.

$$|P_i - \mu| \leq 2\sigma \qquad \text{Pa (psia)} \tag{6}$$

~~To help to illustrate this criterion, the two dashed lines in Figure 1 are parallel to the trend line and offset by a dimension equal to 2σ. In other words, the dashed lines show the 95% scatter envelope about the trend line.~~ The horizontal dotted lines that are located 2σ above and below μ are the boundaries of the 95% sampled pressure scatter envelope.

b. Apply Equation 7 if $P_L \geq 2\sigma$, where P_L is the specified operating tolerance limit for pressure, and if Equation 7 is satisfied by not less than 95% of the sampled pressures.

$$|P_i - \mu| \leq P_L \qquad \text{Pa (psia)} \tag{7}$$

~~To help to illustrate this criterion, the two dashed lines in Figure 1 are parallel to the trend line and offset by a dimension equal to 2σ. In other words, the dashed lines show the 95% scatter envelope about the trend line.~~ The horizontal dashed lines that are located P_L above and below μ are the boundaries of the 95% sampled pressure scatter envelope.

[. . .]

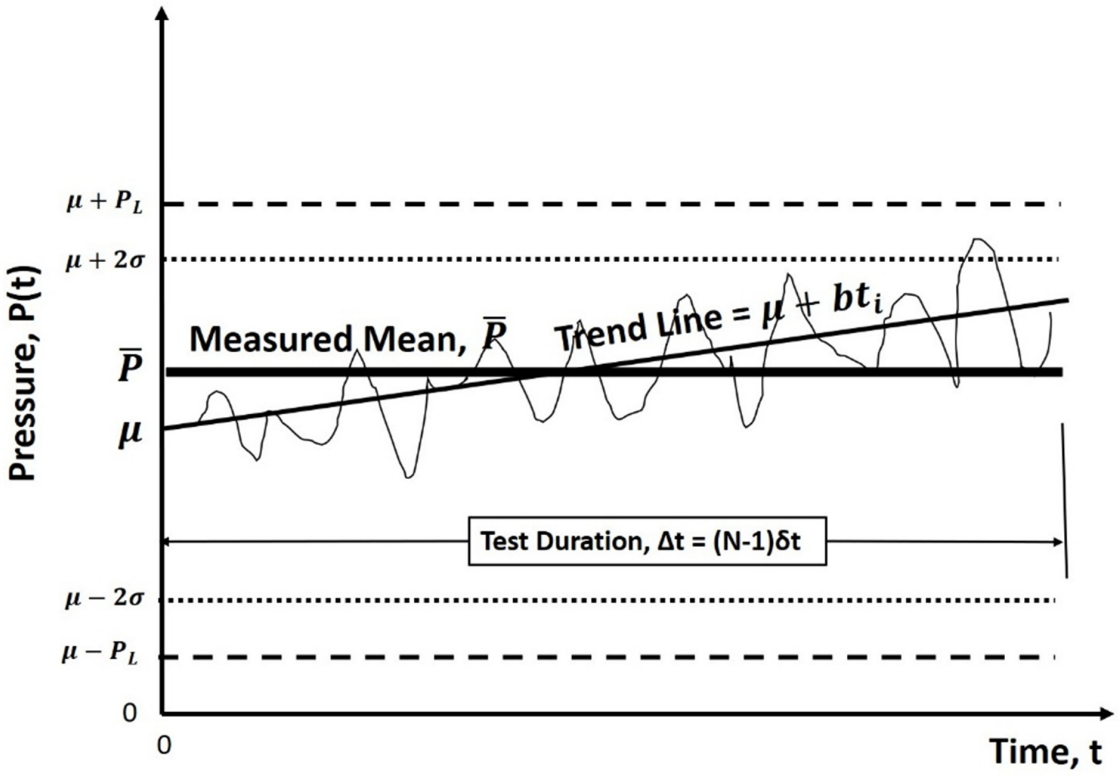

Figure 2 Graphical illustration of the method for determining pressure criteria for test points.

Revise Section 5.6.4 as shown. Replace old Figure 3 (not shown) with the new version as indicated.

5.6.4 Steady-State Pressure Difference Criteria for Test Points

[. . .]

Record each sampled pressure difference measurement ~~P_i~~ $\underline{\Delta P_i}$ and the corresponding time t_i. Apply the least-squares line method to determine the slope b of the pressure difference data trend line illustrated in Figure 3 using Equation 9.

$$b = \left\{ \frac{[N(\sum_{i=1}^{N} t_i P_i) - (\sum_{i=1}^{N} t_i)(\sum_{i=1}^{N} P_i)]}{[N(\sum_{i=1}^{N} t_i^2) - (\sum_{i=1}^{N} t_i)^2]} \right\} \tag{9}$$

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

[. . .]

Determine the mean offset μ of the sampled offset data ~~$(P_i - bt_i)$~~ $\underline{(\Delta P_i - bt_i)}$ using Equation 10, and then calculate the standard deviation σ using Equation 11.

$$\mu = \frac{1}{N}[\sum_{i=1}^{N} (P_i - bt_i)] \qquad \text{Pa (psia)} \tag{10}$$

$$\mu = \frac{1}{N}[\sum_{i=1}^{N} (\Delta P_i - bt_i)] \qquad \text{Pa (psid)}$$

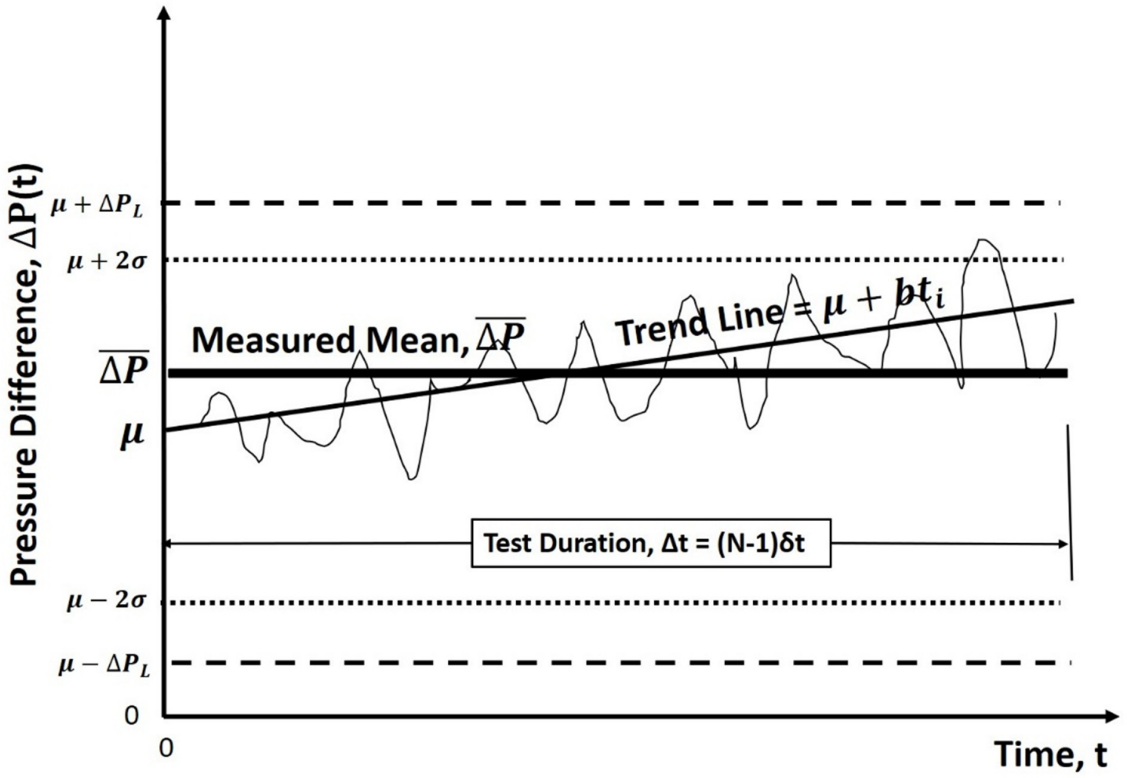

Figure 3 Graphical illustration of the method for determining pressure difference criteria for test points.

~~$$\sigma = \left[\left(\frac{1}{N-2}\right)\sum_{i=1}^{N}(P_i - bt_i - \mu)^2\right]^{1/2} \quad \text{Pa (psia)}$$~~ (11)

$$\sigma = \left[\left(\frac{1}{N-2}\right)\sum_{i=1}^{N}(\Delta P_i - bt_i - \mu)^2\right]^{1/2} \quad \text{Pa (psid)}$$

The mean of the sampled pressure differences ~~$\overline{P}_l$~~ $\overline{\Delta P}$ is defined by Equation 12.

~~$$\overline{P}_l = \frac{1}{N}\left[\sum_{i=1}^{N}(P_i)\right] \quad \text{Pa (psia)}$$~~ (12)

$$\overline{\Delta P} = \frac{1}{N}\left[\sum_{i=1}^{N}(\Delta P_i)\right] \quad \text{Pa (psid)}$$

~~$\overline{P}$~~ $\overline{\Delta P}$, as determined by Equation 12, represents the steady-state mean pressure difference provided that one of the following criteria is satisfied:

a. Apply Equation 13 if ~~$2\sigma \geq P_L$, where P_L~~ $2\sigma \geq \Delta P_L$, where ΔP_L is the specified operating tolerance limit for pressure difference, and if Equation 6 is satisfied by not less than 95% of the sampled pressure differences.

~~$$|P_i - \mu| \leq 2\sigma \quad \text{Pa (psia)}$$~~ (13)

$$|\Delta P_i - \mu| \leq 2\sigma \quad \text{Pa (psid)}$$

~~To help to illustrate this criterion, the two dashed lines in Figure 2 are parallel to the trend line and offset by a dimension equal to 2σ. In other words, the dashed lines show the 95% scatter envelope about the trend line.~~ The horizontal dotted lines that are located 2σ above and below μ are the boundaries of the 95% sampled pressure difference scatter envelope.

b. Apply Equation 14 if ~~$P_L \geq 2\sigma$, where P_L~~ $\Delta P_L \geq 2\sigma$, where ΔP_L is the specified operating tolerance limit for pressure difference, and if Equation ~~7~~14 is satisfied by not less than 95% of the sampled pressure differences.

~~$$|P_i - \mu| \leq P_L \quad \text{Pa (psia)}$$~~ (14)

$$|\Delta P_i - \mu| \leq \Delta P_L \quad \text{Pa (psid)}$$

~~To help to illustrate this criterion, the two dashed lines in Figure 2 are parallel to the trend line and offset by a dimension equal to 2σ. In other words, the dashed lines show the 95% scatter envelope about the trend line.~~ The horizontal dashed lines that are located ΔP_L above and below μ are the boundaries of the 95% sampled pressure difference scatter envelope.

[. . .]

Revise Section 5.6.5 as shown. Replace old Figure 4 (not shown) with the new version as indicated.

5.6.5 Steady-State Pressure Criteria for Targeted Set Points

[. . .]

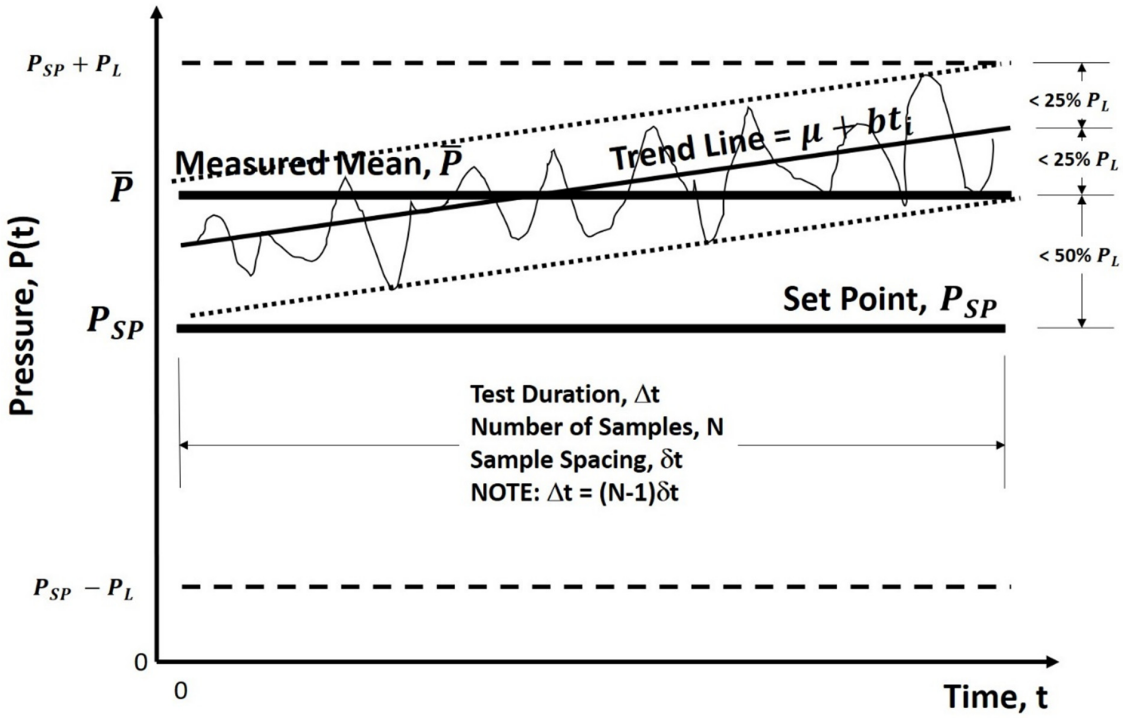

Figure 4 Graphical illustration of the method for determining pressure criteria for targeted set points.

[. . .]

Revise Section 5.6.6 as shown. Replace old Figure 5 (not shown) with the new version as indicated.

5.6.6 Steady-State Pressure Difference Criteria for Targeted Set Points

[. . .]

Record each sampled pressure difference measurement ~~P_i~~ ΔP_i and the corresponding time t_i. Apply the least-squares line method to determine the slope b of the pressure difference data trend line illustrated in Figure 5 using Equation 25.

$$b = \left\{ \frac{[N(\sum_{i=1}^{N} t_i P_i) - (\sum_{i=1}^{N} t_i)(\sum_{i=1}^{N} P_i)]}{[N(\sum_{i=1}^{N} t_i^2) - (\sum_{i=1}^{N} t_i)^2]} \right\} \tag{25}$$

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

[. . .]

Determine the mean offset μ of the sampled offset data ~~$(P_i - bt_i)$~~ $(\Delta P_i - bt_i)$ using Equation 26, and calculate the standard deviation σ using Equation 27.

~~$$\mu = \frac{1}{N}[\sum_{i=1}^{N}(P_i - bt_i)] \quad \text{Pa (psia)}$$~~ (26)

$$\mu = \frac{1}{N}[\sum_{i=1}^{N}(\Delta P_i - bt_i)] \quad \text{Pa (psia)}$$

~~$$\sigma = \left[\left(\frac{1}{N-2}\right)\sum_{i=1}^{N}(P_i - bt_i - \mu)^2\right]^{1/2} \quad \text{Pa (psia)}$$~~ (27)

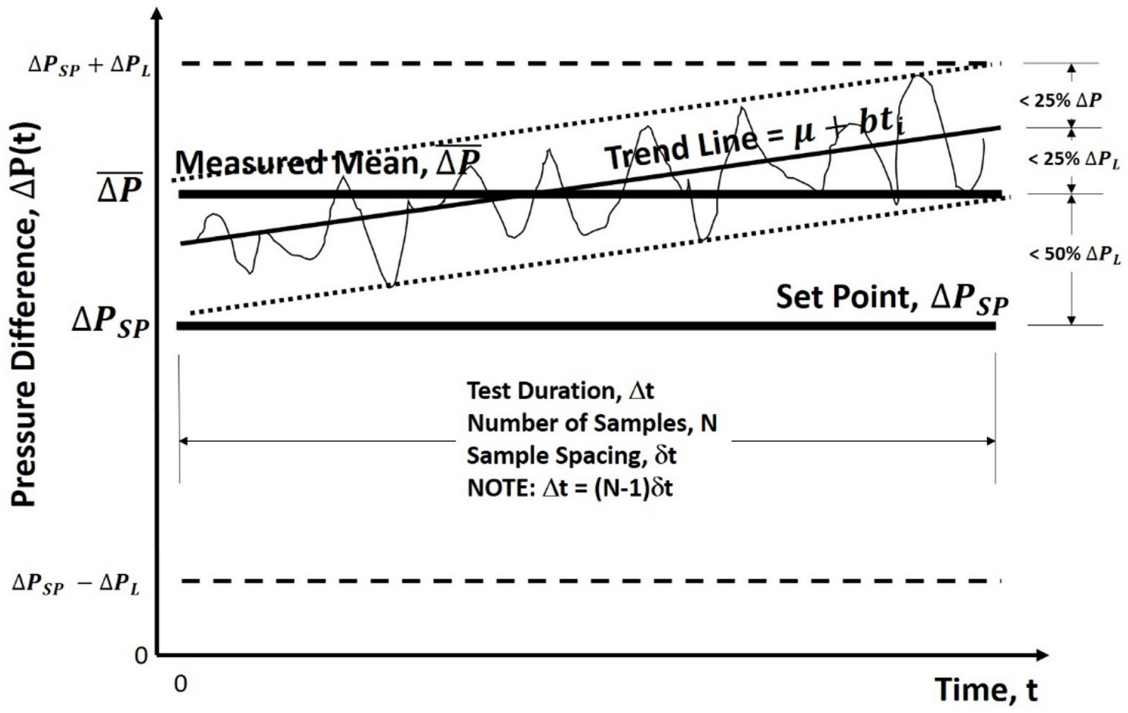

Figure 5 Graphical illustration of the method for determining pressure difference criteria for targeted set points.

$$\sigma = \left[\left(\frac{1}{N-2}\right)\sum_{i=1}^{N}(\Delta P_i - bt_i - \mu)^2\right]^{1/2} \qquad \text{Pa (psia)}$$

The mean of the sampled pressure differences ~~$\overline{P}$~~ $\overline{\Delta P}$ is defined by Equation 28.

~~$$\overline{P} = \frac{1}{N}\left[\sum_{i=1}^{N}(P_i)\right] \qquad \text{Pa (psia)}$$~~ (28)

$$\overline{\Delta P} = \frac{1}{N}\left[\sum_{i=1}^{N}(\Delta P_i)\right] \qquad \text{Pa (psia)}$$

A tolerance on the fluctuations about the trend line ~~$P_i = a + bt_i$~~ $\Delta P_i = a + bt_i$ represents a bound 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, it shall be determined from Equations 5-26 and 5-27. A 95% confidence limit bound on the fluctuations about the trend line shall then be determined as ±2σ according to Equation 29.

~~$$\left|P_i - (a + bt_i)\right| \le 2\sigma \qquad \text{Pa (psia)}$$~~ (29)

$$\left|\Delta P_i - (a + bt_i)\right| \le 2\sigma \qquad \text{Pa (psia)}$$

The steady-state condition of the set-point pressure difference ~~P_{SP}~~ ΔP_{SP} exists

a. where Equation 30 is satisfied by not less than 95% of the sampled pressure differences where ~~P_L~~ ΔP_L is the operating tolerance limit for pressure difference

~~$$(P_{SP} - P_L) \le P_i \le (P_{SP} + P_L) \qquad \text{Pa (psia)}$$~~ (30)

$$(\Delta P_{SP} - \Delta P_L) \le \Delta P_i \le (\Delta P_{SP} + \Delta P_L) \qquad \text{Pa (psia)}$$

b. where

~~$$0.50P_L \le (\overline{P} - P_{SP}) \le 0.50P_L \qquad \text{Pa (psia)}$$~~ (31)

$$-0.50\Delta P_L \le (\overline{\Delta P} - \Delta P_{SP}) \le 0.50\Delta P_L \qquad \text{Pa (psia)}$$

c. and where

~~$$|b\Delta t| \le 0.50P_L \qquad \text{Pa (psia)}$$~~ (32)

$$|b\Delta t| \le 0.50\Delta P_L \qquad \text{Pa (psia)}$$

[. . .]

Revise Informative Appendix B, Section B1 as shown.

B1. EXAMPLE

In this example, an absolute pressure transducer with an operating range of 0 to 3447 kPa (0 to 500 psia) is used to measure the pressure of a gas, so the full scale (FS) of the instrument is 3447 kPa (500 psia). The corresponding pressure transducer voltage output range is from 0 to 5 VDC. The calibration temperature is 21.1°C (70°F). This uncertainty example uses ASME PTC 19.1 [1] to establish a framework for estimating the systematic standard uncertainty b_r of pressure measurement where the result R is a function of independent parameters. For this example, $b_r = \Delta P$, and $R = P$. Note that, in general, using a commercial equation solver software, such as MATLAB or EES, significantly reduces the time and effort required to complete an uncertainty analysis.

[. . .]

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