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

Standard Methods for Pressure Measurement


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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.
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

[...]

\( P \), 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.

\[
|P_i - \mu| \leq 2\sigma \quad \text{Pa (psia)} \tag{6}
\]

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 \( 2\sigma \). In other words, the dashed lines show the 95\% scatter envelope about the trend line. The horizontal dotted lines that are located \( \pm 2\sigma \) above and below \( \mu \) 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.

\[
|P_i - \mu| \leq P_L \quad \text{Pa (psia)} \tag{7}
\]

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 \( 2\sigma \). 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 \( \mu \) 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 \( P_i \Delta P_i \) 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.

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

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

Determine the mean offset \( \mu \) of the sampled offset data \( (P_i - bt_i) \) using Equation 10, and then calculate the standard deviation \( \sigma \) using Equation 11.

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

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

![Figure 3 Graphical illustration of the method for determining pressure difference criteria for test points.](image-url)
The mean of the sampled pressure differences $\overline{P}$ is defined by Equation 12.

$$\overline{P} = \frac{1}{N} \sum_{i=1}^{N} (P_i) \quad \text{Pa (psia)}$$

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

$\overline{P} \Delta P$, 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 $P_L \geq \Delta P_L$, where $\Delta P_L$ 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.

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

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

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 $2\sigma$. In other words, the dashed lines show the 95% scatter envelope about the trend line. The horizontal dotted lines that are located $2\sigma$ above and below $\mu$ are the boundaries of the 95% sampled pressure difference scatter envelope.

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

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

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

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 $2\sigma$. In other words, the dashed lines show the 95% scatter envelope about the trend line. The horizontal dashed lines that are located $\Delta P_L$ above and below $\mu$ 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.

[...]

Test Duration, $\Delta t$
Number of Samples, $N$
Sample Spacing, $\delta t$

NOTE: $\Delta t = (N-1)\delta t$
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 \( P_i \Delta P_i \) 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 5 using Equation 25.

\[
\begin{align*}
\sigma &= \frac{1}{(N-2)} \sum_{i=1}^{N} (P_i - bt_i - \mu)^2 \quad \text{Pa (psia)}
\end{align*}
\]

Determine the mean offset \( \mu \) of the sampled offset data \( (P_i - bt_i) \) using Equation 26, and calculate the standard deviation \( \sigma \) using Equation 27.

\[
\begin{align*}
\mu &= \frac{1}{N} \sum_{i=1}^{N} (P_i - bt_i) \quad \text{Pa (psia)}
\end{align*}
\]

\[
\begin{align*}
\mu &= \frac{1}{N} \sum_{i=1}^{N} (P_i - bt_i) \quad \text{Pa (psia)}
\end{align*}
\]

\[
\begin{align*}
\sigma &= \left[ \frac{1}{(N-2)} \sum_{i=1}^{N} (P_i - bt_i - \mu)^2 \right]^{1/2} \quad \text{Pa (psia)}
\end{align*}
\]
The mean of the sampled pressure differences \( \bar{P} \Delta P \) is defined by Equation 28.

\[
\bar{P} = \frac{1}{N} \sum_{i=1}^{N} (P_i) \quad \text{Pa (psia)}
\]

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

A tolerance on the fluctuations about the trend line \( P_i = a + b t_i \Delta P_i = a + b t_i \) 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 \( \pm 2\sigma \) according to Equation 29.

\[
|P_i - (a + b t_i)| \leq 2\sigma \quad \text{Pa (psia)}
\]

\[
|\Delta P_i - (a + b t_i)| \leq 2\sigma \quad \text{Pa (psia)}
\]

The steady-state condition of the set-point pressure difference \( P_{SP}, \Delta P_{SP} \) exists

a. where Equation 30 is satisfied by not less than 95% of the sampled pressure differences where \( P_L, \Delta P_L \) is the operating tolerance limit for pressure difference

\[
(P_{SP} - P_L) \leq P_i \leq (P_{SP} + P_L) \quad \text{Pa (psia)}
\]

\[
(\Delta P_{SP} - \Delta P_L) \leq \Delta P_i \leq (\Delta P_{SP} + \Delta P_L) \quad \text{Pa (psia)}
\]

b. where

\[
-0.50P_L \leq (P - P_{SP}) \leq 0.50P_L \quad \text{Pa (psia)}
\]

\[
-0.50\Delta P_L \leq (\Delta P - \Delta P_{SP}) \leq 0.50\Delta P_L \quad \text{Pa (psia)}
\]

c. and where

\[
|b\Delta t| \leq 0.50P_L \quad \text{Pa (psia)}
\]

\[
|b\Delta t| \leq 0.50\Delta P_L \quad \text{Pa (psia)}
\]

[ . . . ]

**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 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 \(^4\) 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.

[ . . . ]
ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE’s members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted Standards and the practical state of the art.

ASHRAE’s short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the Standards and Guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive Technical Committee structure, continue to generate up-to-date Standards and Guidelines where appropriate and adopt, recommend, and promote those new and revised Standards developed by other responsible organizations.

Through its Handbook, appropriate chapters will contain up-to-date Standards and design considerations as the material is systematically revised.

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The effects of the design and selection of equipment and systems will be considered within the scope of the system’s intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE’s primary concern for environmental impact will be at the site where equipment within ASHRAE’s scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.
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