BSR/ASHRAE Addendum b to ANSI/ASHRAE Standard 41.2-2022

Public Review Draft

Proposed Addendum b to Standard 41.2-2022, Standard Methods for Air Velocity and Airflow Measurement

First Public Review (October 2023)
(Draft shows Proposed Changes to Current Standard)

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FOREWORD
The purpose of 41.2-2022 Addendum b. is to correct and clarify the method for determining the inlet air density for single- and multiple-nozzle chambers.

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 b to Standard 41.2-2022

Revise Section 9.3.6.1 as shown below.

9.3.6.1 Measurements. Measurements required for nozzle airflow calculations are:

a. Inlet duct geometrically equivalent diameter D_E, m (ft)
b. Nozzle throat diameter d, m (ft)
c. Nozzle inlet absolute pressure p_1, Pa (in. of water)
d. Nozzle differential pressure $\Delta p = (p_1 - p_2)$, Pa (in. of water)
e. Nozzle inlet dry-bulb temperature t_1, °C (F)
f. Nozzle inlet humidity measurement in the form of relative humidity, dew point temperature, or wet-bulb temperature in compliance with ANSI/ASHRAE Standard 41.6[4] is required unless dry air is used for the test.

(***Informative Note:*** As prescribed in Section 5.3.2.9, obtain ~~Obtain~~ nozzle inlet density for dry and moist air from ASHRAE RP-1485 using nozzle inlet absolute pressure, temperature, and humidity.)

Revise Section 9.3.6.3.4 as shown below.

9.3.6.3.4 Volumetric Airflow Rates for a Single-Nozzle Duct. Single-nozzle duct volumetric airflow rates shall be obtained from Equation 9-21 in SI units or Equation 9-22 in I-P units.

In SI units:

$$Q = CA\varepsilon\sqrt{\frac{2(\Delta p)}{\rho_1(1-E\beta^4)}} \tag{9-21}$$

where

Q = nozzle volumetric airflow rate, m^3/s
C = nozzle discharge coefficient, dimensionless

A = nozzle throat area, m^2
ε = nozzle expansibility factor, dimensionless
Δp = nozzle differential pressure, Pa
ρ_1 = nozzle inlet air density <u>for dry or moist air</u>, kg/m^3
E = flow kinetic energy coefficient = 1.043[7]
β = d/D_h, dimensionless

(***Informative Note:*** The superscript "7" in "1.043[7]" above is reference number, not an exponent.)

In I-P units:

$$Q = 1097.8CA\varepsilon\sqrt{\frac{(\Delta p)}{\rho_1(1-E\beta^4)}} \tag{9-22}$$

where

Q = nozzle volumetric airflow rate, cfm
C = nozzle discharge coefficient, dimensionless
A = nozzle throat area, ft^2
ε = nozzle expansibility factor, dimensionless
Δp = nozzle differential pressure, in. of water
ρ_1 = nozzle inlet air density <u>for dry or moist air</u>, lb_m/ft^3
E = flow kinetic energy coefficient = 1.043[7], dimensionless
β = d/D_h, dimensionless
1097.8 = units conversion coefficient, dimensionless

(***Informative Note:*** The superscript "7" in "1.043[7]" above is reference number, not an exponent.)

Revise Section 9.3.6.3.9 as shown below.

9.3.6.3.9 Mass Airflow Rate for a Single-Nozzle Duct. The mass airflow rate for single nozzles shall be obtained from Equation 9-27, <u>where ρ_1 is the nozzle inlet air density for dry or moist air</u>, kg/m^3 (lb_m/ft^3) and Q is the volumetric airflow rate, m^3/s (cfm), using Equation 9-21 in SI units or Equation 9-22 in I-P units.

$$\dot{m} = \rho_1 Q, \text{ kg/s } (\text{lb}_\text{m}/\text{min}) \tag{9-27}$$

Revise Section 9.3.6.4.7 as shown below.

9.3.6.4.7 Volumetric Airflow Rate for Single- and Multiple-Nozzle Chambers. The volumetric airflow rate for single- and multiple-nozzle chambers shall be obtained from Equation 9-33 in SI units or from Equation 9-34 in I-P units where the area is measured at the plane of the throat taps or nozzle exit for nozzles without throat taps.[7] The denominator in these equations includes the term $(1-E\beta^4)$. However, $\beta = 0$ for single- and multiple-nozzle chambers, so $(1-E\beta^4) = 1$, and Equations 9-32 and 33 become Equations 9-34 and 9-35.

In SI units:

$$Q = \left[\sum_{i=1}^{N}(C_i A_i \varepsilon_i)\right]\sqrt{\frac{2\Delta p}{\rho_1(1-E\beta^4)}} \qquad \text{(9-32)}$$

where

Q = volumetric flow rate, m^3/s
N = number of nozzles in use, dimensionless
C = discharge coefficient, dimensionless
A = nozzle throat area, m^2
ε = nozzle expansibility factor, dimensionless
Δp = nozzle differential pressure, Pa
ρ_1 = nozzle inlet air density for dry or moist air, kg/m^3
E = flow kinetic energy coefficient =1.043[7], dimensionless
β = 0

(***Informative Note:*** The superscript "7" in "1.0437" above is reference number, not an exponent.)

In I-P units:

$$Q = 1097.8\left[\sum_{i=1}^{N}(C_i A_i \varepsilon_i)\right]\sqrt{\frac{\Delta p}{\rho_1(1-E\beta^4)}} \qquad \text{(9-33)}$$

where

Q = nozzle volumetric flow rate, cfm
N = number of nozzles in use, dimensionless
C = discharge coefficient, dimensionless
A = nozzle throat area, ft^2
ε = expansibility factor, dimensionless
Δp = nozzle differential pressure, (in. of water)
ρ_1 = nozzle inlet air density for dry or moist air, lb_m/ft^3
E = flow kinetic energy coefficient =1.043[7], dimensionless
β = 0
1097.8 = units conversion coefficient, dimensionless

(***Informative Note:*** The superscript "7" in "1.043[7]" above is reference number, not an exponent.)

In SI units:

$$Q = \left[\sum_{i=1}^{N}(C_i A_i \varepsilon_i)\right]\sqrt{\frac{2\Delta p}{\rho_1}} \qquad \text{(9-34)}$$

where

Q = volumetric flow rate, m^3/s
N = number of nozzles in use, dimensionless
C = discharge coefficient, dimensionless
A = nozzle throat area, m^2
ε = nozzle expansibility factor, dimensionless
Δp = nozzle differential pressure, Pa

ρ_1 = nozzle inlet air density for dry or moist air, kg/m^3

In I-P units:

$$Q = 1097.8\left[\sum_{i=1}^{N}(C_i A_i \varepsilon_i)\right]\sqrt{\frac{\Delta p}{\rho_1}} \quad (9\text{-}35)$$

where

Q = nozzle volumetric flow rate, cfm
N = number of nozzles in use, dimensionless
C = discharge coefficient, dimensionless
A = nozzle throat area, ft^2
ε = expansibility factor, dimensionless
Δp = nozzle differential pressure, (in. of water)
ρ_1 = nozzle inlet air density for dry or moist air, lb$_m$/ft^3
1097.8 = units conversion coefficient, dimensionless

Revise Section 9.3.6.4.8 as shown below.

9.3.6.4.8 Standard Airflow Rate for Single- and Multiple-Nozzle Chambers. The standard airflow rate for single- and multiple-nozzle chambers shall be calculated in compliance with Section 4.5 using Equation 9-34 in SI units or Equation 9-35 in I-P units where ρ_1 = air density for dry or moist air, kg/m^3 (lb$_m$/ft^3)

$$\text{Standard cubic meters/second} = \frac{\rho_1 Q}{1.202} \quad (9\text{-}36)$$

$$\text{Standard cubic feet/minute (scfm)} = \frac{\rho_1 Q}{0.075} \quad (9\text{-}37)$$

Revise Section 9.3.6.4.9 as shown below.

9.3.6.4.9 Mass Airflow Rate for Single- and Multiple-Nozzle Chambers. The mass airflow rate for single- and multiple-nozzle chambers shall be obtained from Equation 9-38, where ρ_1 is the nozzle inlet air density for dry or moist air, kg/m^3 (lb$_m$/ft^3) and Q is the volumetric airflow rate using Equation 9-34 in SI units or Equation 9-35 in I-P units.

$$\dot{m} = \rho_1 Q, \text{ kg/s (lb}_m\text{/min)} \quad (9\text{-}38)$$

In Normative Appendix F, Legacy Single- and Multiple Nozzle Chamber Requirements, revise Section F3.1 as shown below.

F3.1 Measurements. Measurements required for nozzle airflow calculations are:

a. Inlet duct geometrically equivalent diameter D_E, m (ft)
b. Throat diameter d, m (ft)

c. Inlet absolute pressure p_1, Pa (in. of water)
d. Differential pressure $\Delta p = (p_1 - p_2)$, (in. of water)
e. Inlet dry-bulb temperature, t_1 °C (°F)
f. Inlet humidity measurement in the form of relative humidity, dew point temperature, or wet bulb temperature in compliance with ASHRAE Standard 41.6[5] is required unless dry air is used for the test.

In Normative Appendix F, Legacy Single- and Multiple Nozzle Chamber Requirements, revise Section F4.7 as shown below.

F4.7 Volumetric Airflow Rate for Single- and Multiple-Nozzle Chambers. The volumetric airflow rate for single- or multiple-nozzle chambers shall be obtained from Equation F-8 in SI units or from Equation F-9 in I-P units where the area is measured at the plane of the throat taps or nozzle exit for nozzles without throat taps.[7] The denominator in these equations includes the term $(1\text{-}E\beta^4)$. However, $\beta = 0$ for single- and multiple-nozzle chambers, so $(1\text{-}E\beta^4) = 1$, and Equations F-8 and F-9 become Equations F-10 and F-11.

$$Q = \left[\sum_{i=1}^{N}(C_i A_i \varepsilon_i)\right]\sqrt{\frac{2\Delta p}{\rho_1(1-E\beta^4)}} \text{ m}^3\text{/s} \quad \text{(F-8)}$$

where

Q = volumetric flow rate, m^3/s
N = number of nozzles in use, dimensionless
C = discharge coefficient, dimensionless
A = nozzle throat area, m^2
ε = nozzle expansibility factor, dimensionless
Δp = nozzle differential pressure, Pa
ρ_1 = nozzle inlet air density for dry or moist air, kg/m^3
E = flow kinetic energy coefficient=1.043[7] , dimensionless
β = 0

(Informative Note: The superscript "7" in "1.043[7]" above is reference number, not an exponent.)

$$Q = 1097.8\left[\sum_{i=1}^{N}(C_i A_i \varepsilon_i)\right]\sqrt{\frac{\Delta p}{\rho_1(1-E\beta^4)}} \quad \text{cfm} \quad \text{(F-9)}$$

where

Q = nozzle volumetric flow rate, cfm
N = number of nozzles in use, dimensionless
C = discharge coefficient, dimensionless
A = nozzle throat area, ft^2
ε = expansibility factor, dimensionless
Δp = nozzle differential pressure, (in. of water)
ρ_1 = nozzle inlet air density for dry or moist air, $\text{lb}_\text{m}/\text{ft}^3$
E = flow kinetic energy coefficient=1.043[7], dimensionless
β = 0

1097.8 = units conversion coefficient, dimensionless

(Informative Note: The superscript "7" in "1.043[7]" above is reference number, not an exponent.)

$$Q = \left[\left[\sum_{i=1}^{N} (C_i A_i \varepsilon_i)\right]\right] \sqrt{\frac{2\Delta p}{\rho_1}} \quad \text{m}^3/\text{s} \qquad \text{(F-10)}$$

where

Q = volumetric flow rate, m^3/s
N = number of nozzles in use, dimensionless
C = discharge coefficient, dimensionless
A = nozzle throat area, m^2
ε = nozzle expansibility factor, dimensionless
Δp = nozzle differential pressure, Pa
ρ_1 = nozzle inlet air density for dry or moist air, kg/m^3

$$Q = 1097.8\left[\sum_{i=1}^{N} (C_i A_i \varepsilon_i)\right] \sqrt{\frac{\Delta p}{\rho_1}} \quad \text{cfm} \qquad \text{(F-11)}$$

where

Q = nozzle volumetric flow rate, cfm
N = number of nozzles in use, dimensionless
C = discharge coefficient, dimensionless
A = nozzle throat area, ft^2
ε = expansibility factor, dimensionless
Δp = nozzle differential pressure, (in. of water)
ρ_1 = nozzle inlet air density for dry or moist air, lb_m/ft^3
1097.8 = units conversion coefficient, dimensionless

In Normative Appendix F, Legacy Single- and Multiple Nozzle Chamber Requirements, revise Section F3.1 as shown below.

F4.9 Mass Airflow Rate for Single- and Multiple-Nozzle Chambers. The mass airflow rate for multiple-nozzle chambers shall be obtained from Equation F-14 where ρ_1 is the nozzle inlet air density for dry or moist air in SI units or IP units, and Q is the volumetric airflow rate in SI units in Equation F-10 in SI units or F-11 in IP units.

$$\dot{m} = \rho_1 Q \text{ , kg/s (lb}_\text{m}\text{/min)} \qquad \text{(F-14)}$$