BSR/ASHRAE Standard 23P

Public Review Draft

Methods for Performance Testing Positive Displacement Refrigerant Compressors and Compressor Units

Second Public Review (December 2020)
(Draft Shows Proposed Independent Substantive Changes to Previous Public Review Draft)

This draft has been recommended for public review by the responsible project committee. To submit a comment on this proposed standard, go to the ASHRAE website at www.ashrae.org/standards-research--technology/public-review-drafts and access the online comment database. The draft is subject to modification until it is approved for publication by the Board of Directors and ANSI. Until this time, the current edition of the standard (as modified by any published addenda on the ASHRAE website) remains in effect. The current edition of any standard may be purchased from the ASHRAE Online Store at www.ashrae.org/bookstore or by calling 404-636-8400 or 1-800-727-4723 (for orders in the U.S. or Canada).

ASHRAE, 1791 Tullie Circle, NE, Atlanta GA 30329-2305

FOREWORD

The first 23P full public review (PPR1) that ended on May 25, 2020, had no public review comments. Since then, ASHRAE editors and publication staff have processed the publication version of Standard 23 up to the point where the Chair and the voting members of SPC-23P reviewed the galley proof.

During the review of the galley proof, one of the SPC-23P voting members found that a substantive portion had been omitted from the first 23P full public review draft. Correcting that error of omission, plus making a few other substantive improvements are the subject of this 23P Independent Substantive Change (ISC) Publication Public Review (PPR) draft.

This is a review of Independent Substantive Changes that were made since the last (first) Public Review. Text that was removed from the previous Public Review is provided for reference but is shown in ~~strikeout~~, and text that has been added is shown with underlines.

Only these changes are open to comment at this time. All other material is provided for context only and is not open for Public Review comment except as it relates to the proposed changes.

Section 5.1 has been improved by the addition of Item e.

5.1 Test Plan. A test plan shall specify the operating conditions and operating tolerances for each test point to be performed. A test plan shall also specify the calculations to be performed at each test point. The test plan shall be one of the following:

a. A document provided by the person or the organization that authorized the tests and calculations to be performed.
b. A method of test standard.
c. A rating standard.
d. A regulation or code.
e. Any combination of items a. through d.

Portions of Section 5.2 have been rewritten to improve clarity and to revise Section 5.2 Item b. to conform with current practice of locating a refrigerant mass flowmeter in the liquid line of a calorimeter.

5.2 Primary and Confirming Refrigerant Mass Flow Rate Measurements. ~~Each test data point shall consist of a primary test and a simultaneous, independent confirming test at a specified set of operating conditions if a calorimeter test method is selected to be the primary test method.~~ A simultaneous, independent confirming test at the specified set of operating conditions is not required if a flowmeter test method is selected to be the primary test method. However, if a calorimeter test method is selected to be the primary test method, each test data point shall consist of a primary test and a simultaneous, independent confirming test at the specified set of operating conditions. To be independent:

a. the confirming test measurement systems shall be separate from the corresponding measurement systems in the primary test, and
b. the fluid flows and heat transfers in the confirming test shall ~~neither share nor~~ not influence the fluid flows or heat transfers in the primary method.

~~A simultaneous, independent confirming test at a specified set of operating conditions is not required if a flowmeter test method is selected to be the primary method.~~

Compressor or compressor unit ratings shall be determined from refrigerant mass flow rates obtained by the primary method of test. ~~The refrigerant mass flow rates obtained from the primary test if a test~~

~~calorimeter method are valid only if the corresponding measured refrigerant mass flow rate from the confirming test is within ±3% of the primary test measurement.~~ If a calorimeter method is selected to be the primary test method, the refrigerant mass flow rates obtained from the primary test method are valid only if the corresponding measured refrigerant mass flow rate from the confirming test is within ±3% of the refrigerant mass flow rate obtained from the primary test.

Table 1 lists the test method alternatives for measuring refrigerant mass flow rates. The user shall select one of these six test methods to be the primary test method and one of these six test methods to be the confirming test method.

TABLE 1 Alternative test methods for measuring refrigerant mass flow rates

List of Test Methods (Column A)	**Measurement Standard**	**Primary Test Method (Column B)**	**Confirming Test Method (Column C)**
Secondary Refrigerant Calorimeter	ASHRAE 41.9[1]	Select any test method listed in Column A.	Select any test method from Column A provided that the primary and confirming test methods are independent and performed simultaneously.
Secondary Fluid Calorimeter			
Primary Refrigerant Calorimeter			
Condenser Calorimeter			
Gaseous Refrigerant Flowmeter	ASHRAE 41.10[2]	Select either test method listed in Column A.	Confirming test is not required
Liquid Refrigerant Flowmeter			

Sections 5.8.1.1, 5.8.1.2, 5.8.1.3, and 5.8.1.4 have been corrected by replacing Equations 2, 4, 6, and 13 as shown (note: underlining new equations is not practical), and by adding the IP unit for power (hp) at the conclusion of all 4 sections.

5.8.1.1 Isentropic Efficiency for a Single-Stage Compressor. Figure 3a and 3b shows the cycle schematic and pressure-enthalpy diagram for a single-stage compressor. The cycle on Figure 3a includes liquid injection if required for cooling. The cycle on Figure 3b includes supercritical fluid injection if required for cooling.

The isentropic efficiency for a single-stage compressor as described in Figure 3a and 3b shall be calculated using Equation 1 for SI units or using Equation 2 for I-P units.

$$\eta = \frac{[\dot{m}_1(h_{3s} - h_{2s})]}{P} \times 100 \quad (1)$$

~~$$\eta = \frac{[(h_{3s} - h_2)]}{P} \times 0.02931$$~~

$$\eta = \frac{\dot{m}_l(h_{3s} - h_{2s})}{P} \times 0.0393 \quad (2)$$

where

η = isentropic efficiency for a single-stage stage compressor, %
$\dot{m}_1$ = refrigerant mass flow rate entering the compressor, kg/s (lb_m/h)
h_{2s} = specific enthalpy of refrigerant vapor at suction pressure and temperature entering the compressor, kJ/kg (Btu/lb_m)
h_{3s} = specific enthalpy of refrigerant vapor at discharge pressure following an isentropic compression of the refrigerant from compressor suction pressure and temperature, kJ/kg (Btu/lb_m)
P = total power input to the UUT, kW (hp)

5.8.1.2 Isentropic Efficiency for a Multi-Stage Compressor. The isentropic efficiency for a multi-stage compressor shall be calculated using Equation 3 for SI units or using Equation 4 for I-P units.

$$\eta = \frac{\left[\sum_{i=1}^{NS} \dot{m}_i (h_{3is} - h_{2is})\right]}{P} \times 100 \quad (3)$$

$$\eta = \frac{\left[\sum_{i=1}^{NS} \dot{m}_i (h_{3is} - h_{2is})\right]}{P} \times 0.02931$$

$$\eta = \frac{\left[\sum_{i=1}^{NS} \dot{m}_i (h_{3is} - h_{2is})\right]}{P} \times 0.0393 \quad (4)$$

where

η = isentropic efficiency for a multi-stage compressor, %
NS = number of compressor stages
$\dot{m}_i$ = refrigerant mass flow rate entering the compressor stage *i*, kg/s (lb_m/h)
h_{2is} = specific enthalpy of refrigerant vapor at suction pressure and temperature entering the compressor stage *i*, kJ/kg (Btu/lb_m)
h_{3is} = specific enthalpy of refrigerant vapor at the discharge pressure for stage *i* following an isentropic compression of the refrigerant from compressor stage suction pressure and temperature, kJ/kg (Btu/lb_m)
P = total power input to the UUT, kW(hp)

5.8.1.3 Isentropic Efficiency for a Two-Stage Compressor with Vapor Injection. Figure 4a and 4b shows the cycle schematic and pressure-enthalpy diagram for a two-stage compressor with vapor injection using a flash tank economizer. Figure 5a and 5b shows the cycle schematic and pressure-enthalpy diagram for a two-stage compressor with vapor injection using a heat exchanger economizer and liquid refrigerant that is extracted upstream of the economizer. Figure 6a and 6b shows the cycle schematic and pressure-enthalpy diagram for a two-stage compressor with vapor injection using a heat exchanger economizer and liquid refrigerant that is extracted downstream of the economizer.

The isentropic efficiency for a two-stage compressor with vapor injection using an economizer shall be calculated using Equation 5 for SI units or using Equation 6 for I-P units.

$$\eta = \frac{\left[\dot{m}_1 (h_{3_{1S}} - h_{2_{1S}}) + \dot{m}_2 (h_{3_{2S}} - h_{2_{2S}})\right]}{P} \times 100 \quad (5)$$

$$\eta = \frac{\left[\dot{m}_1 (h_{3_{1S}} - h_{2_{1S}}) + \dot{m}_2 (h_{3_{2S}} - h_{2_{2S}})\right]}{P} \times 0.02931$$

$$\eta = \frac{[\dot{m}_1(h_{3_{1s}} - h_{2_{1s}}) + \dot{m}_2(h_{3_{2s}} - h_{2_{2s}})]}{P} \times 0.0393 \quad (6)$$

where

η = isentropic efficiency for a two-stage stage compressor with vapor injection, %

$\dot{m}_1$ = refrigerant mass flow rate entering the compressor, kg/s (lb_m/h)

$\dot{m}_2$ = refrigerant mass flow rate after mixing the injection flow and inlet flow, kg/s (lb_m/h)

$h_{2_{1s}}$ = specific enthalpy of refrigerant vapor at suction pressure and temperature entering the compressor, kJ/kg (Btu/lb_m)

$h_{2_{2s}}$ = specific enthalpy of refrigerant vapor after mixing the intermediate pressure flow at state point 5 with the flow at state point 3_{1s} shall be calculated using Equation 7 kJ/kg (Btu/lb_m)

$$h_{2_{2s}} = \frac{(\dot{m}_1 h_{3_{1s}} + \dot{m}_{inj} h_5)}{\dot{m}_2} \quad (7)$$

$h_{3_{1s}}$ = specific enthalpy of refrigerant vapor at intermediate pressure following an isentropic compression of the refrigerant from compressor suction pressure and temperature, kJ/kg (Btu/lb_m)

$h_{3_{2s}}$ = specific enthalpy of refrigerant vapor at compressor discharge pressure following an isentropic compression of the refrigerant from state point 2_{2S}, kJ/kg (Btu/lb_m)

h_5 = specific enthalpy of refrigerant injected into compressor at intermediate pressure, shall be calculated based on pressure p_5 and temperature T_5 measured within 50 mm (2 in.) of the inlet to the compressor except where otherwise specified by the test plan in Section 5.1, kJ/kg (Btu/lb_m)

$\dot{m}_{inj}$ = refrigerant mass flow rate injected into compressor at intermediate pressure, kg/s (lb_m/h)

a. For a flash tank economizer as shown in Figure 4a and 4b, $\dot{m}_{inj}$ shall be calculated using Equation 8 or Equation 9.
b. For a heat exchanger economizer as shown in Figure 5a and 5b, where liquid refrigerant is extracted upstream of the economizer, $\dot{m}_{inj}$ shall be measured in the liquid line at the inlet of Expansion Device 2 or calculated using Equation 10.
c. For a heat exchanger economizer as shown in Figure 6a and 6b, where liquid refrigerant is extracted downstream of the economizer, $\dot{m}_{inj}$ shall be measured in the liquid line at the inlet of Expansion Device 2 or calculated using Equation 11.

$$\dot{m}_{inj} = \frac{\dot{m}_1 \times x_{vapor}}{(1 - x_{vapor})} \quad (8)$$

$$m_{inj} = \dot{m}_2 - \dot{m}_1 \quad (9)$$

$$\dot{m}_{inj} = \frac{\dot{m}_1(h_{4_2} - h_{4_1})}{(h_5 - h_{4_2})} \quad (10)$$

$$\dot{m}_{inj} = \frac{\dot{m}_2(h_{4_2} - h_{4_1})}{(h_5 - h_{4_1})} \quad (11)$$

where

h_{4_2} = specific enthalpy of subcritical liquid refrigerant or specific enthalpy of supercritical refrigerant fluid entering economizer, kJ/kg (Btu/lbm)
h_{4_1} = specific enthalpy of liquid refrigerant leaving economizer, kJ/kg (Btu/lbm)
x_{vapor} = quality of refrigerant in economizer based on h_{4_2} and pressure p_5, %
P = total power input to the UUT, kW (hp)

5.8.1.4 Isentropic Efficiency for Compressors Connected in Series with Vapor Injection. Figure 7a and 7b shows the cycle schematic and pressure-enthalpy diagram for compressors connected in series with vapor injection using a flash tank economizer. Figure 8a and 8b shows the cycle schematic and pressure-enthalpy diagram for compressors connected in series with vapor injection using a heat exchanger economizer and liquid refrigerant that is extracted upstream of the economizer. Figure 9a and 9b shows the cycle schematic and pressure-enthalpy diagram for compressors connected in series with vapor injection using a heat exchanger economizer and liquid refrigerant that is extracted downstream of the economizer.

The isentropic efficiency for compressors connected in series with vapor injection using an economizer shall be calculated using Equation 12 for SI units or using Equation 13 for I-P units.

$$\eta = \frac{[\dot{m}_1(h_{3_{1s}} - h_{2_{1s}}) + \dot{m}_2(h_{3_{2s}} - h_{2_{2s}})]}{P} \times 100 \quad (12)$$

~~$$\eta = \frac{[\dot{m}_1(h_{3_{1s}} - h_{2_{1s}}) + \dot{m}_2(h_{3_{2s}} - h_{2_{2s}})]}{P} \times 0.02931$$~~

$$\eta = \frac{[\dot{m}_1(h_{3_{1s}} - h_{2_{1s}}) + \dot{m}_2(h_{3_{2s}} - h_{2_{2s}})]}{P} \times 0.0393 \quad (13)$$

where

η = isentropic efficiency for compressors connected in series with vapor injection, %
$\dot{m}_1$ = refrigerant mass flow rate entering the first compressor, kg/s (lbm/h)
$\dot{m}_2$ = refrigerant mass flow rate after mixing the injection flow rate and inlet flow to the first compressor, kg/s (lbm/h)
$h_{2_{1s}}$ = specific enthalpy of refrigerant vapor entering the first compressor, kJ/kg (Btu/lbm)
$h_{2_{2s}}$ = specific enthalpy of refrigerant vapor after mixing the intermediate pressure flow at state point 5 with the flow at state point 3_{1s} shall be calculated using Equation 14, kJ/kg (Btu/lbm)

$$h_{2_{2s}} = \frac{(\dot{m}_1 h_{3_{1s}} + \dot{m}_{inj} h_5)}{\dot{m}_2} \quad (14)$$

$h_{3_{1s}}$ = specific enthalpy of refrigerant vapor at intermediate pressure following an isentropic compression of the refrigerant from compressor suction pressure and temperature, kJ/kg (Btu/lbm)
$h_{3_{2s}}$ = specific enthalpy of refrigerant vapor at compressor discharge pressure following an isentropic compression of the refrigerant from state point 2_{2S}, kJ/kg (Btu/lbm)
h_5 = specific enthalpy of refrigerant injected into compressor at intermediate pressure, shall be calculated based on pressure p_5 and temperature T_5 measured within 50 mm (2 in.) of the inlet to the compressor except where otherwise specified by the test plan in Section 5.1, kJ/kg (Btu/lbm)
$\dot{m}_{inj}$ = refrigerant mass flow rate injected into compressor at intermediate pressure, kg/s (lbm/h).

a. For a flash tank economizer as shown in Figure 7a and 7b, $\dot{m}_{inj}$ shall be calculated using Equation 15 or Equation16.
b. For a heat exchanger economizer as shown in Figure 8a and 8b, where liquid refrigerant is extracted upstream of the economizer, $\dot{m}_{inj}$ shall be measured in the liquid line at the inlet of Expansion Device 2 or calculated using Equation 17.
c. For a heat exchanger economizer as shown in Figure 9a and 9b, where liquid refrigerant is extracted downstream of the economizer, $\dot{m}_{inj}$ shall be measured in the liquid line at the inlet of Expansion Device 2 or calculated using Equation 18.

$$\dot{m}_{inj} = \frac{\dot{m}_1(x_{vapor})}{(1-x_{vapor})} \tag{15}$$

$$\dot{m}_{inj} = \dot{m}_2 - \dot{m}_1 \tag{16}$$

$$\dot{m}_{inj} = \frac{\dot{m}_1(h_{4_2}-h_{4_1})}{(h_5-h_{4_2})} \tag{17}$$

$$\dot{m}_{inj} = \frac{\dot{m}_2(h_{4_2}-h_{4_1})}{(h_5-h_{4_1})} \tag{18}$$

where

h_{4_2} = specific enthalpy of liquid refrigerant or supercritical refrigerant fluid entering economizer, kJ/kg (Btu/lb_m)
h_{4_1} = specific enthalpy of liquid refrigerant leaving economizer, kJ/kg (Btu/lb_m)
x_{vapor} = quality of refrigerant in economizer based on h_{4_2} and pressure p_5, %
P = total power input to the UUT, kW (hp)

Section 5.8.2 has been modified to correct the referenced section numbers.

5.8.2 Capacity. The capacity of a UUT, if required by the test plan in Section 5.1, shall be calculated as described in Section ~~5.7.2.1~~ 5.8.2.1 or ~~5.7.2.2~~ 5.8.2.2.

Section 7.6.1 has been modified to include information that was inadvertently omitted from the 23P PPR draft.

7.6.1 Measured Compressor Test Results for Operation at Subcritical Pressures of the Refrigerant

a. Ambient air temperature, °C (°F).
b. Specifics regarding ambient circulation over the UUT if required by the test plan.
c. Barometric pressure if a pressure sensing device is referenced to atmospheric pressure.
d. Electrical data if required by the test plan:
    a. Voltage, V.
    b. Frequency, Hz.
    c. Current, A:
        i. Single phase current, A
        ii. Three phase current, A, for all 3 legs.
    d. Power factor.
    e. Power Input, W(hp).
e. Compressor speed if required by the test plan:
    a. Shaft rotational speed, rev/s (rpm).
    b. Shaft input frequency, Hz, for linear compressors or membrane compressors.

f. Suction pressure, kPa (psia).
g. Suction temperature, °C (°F).
h. Discharge pressure, kPa (psia).
i. Discharge temperature, °C (°F).
j. Refrigerant temperature, °C (°F), entering the injection points if vapor injection is included.
k. Refrigerant pressure, kPa (psia), entering the injection points if vapor injection is included.
l. Refrigerant temperature, °C (°F), entering the calorimeter or flowmeter for the primary test method.
m. Refrigerant pressure, kPa (psia), entering the calorimeter or flowmeter for the primary test method.
n. Refrigerant temperature, °C (°F), leaving the calorimeter or flowmeter for the primary test method.
o. Refrigerant pressure, kPa (psia), leaving the calorimeter or flowmeter for the primary test method.
p. Refrigerant temperature, °C (°F), entering the calorimeter or flowmeter for the confirming test method.
q. Refrigerant pressure, kPa (psia), entering the calorimeter or flowmeter for the confirming test method.
r. Refrigerant temperature, °C (°F), leaving the calorimeter or flowmeter for the confirming test method.
s. Refrigerant pressure, kPa (psia), leaving the calorimeter or flowmeter for the confirming test method.
t. Lubricant circulation rate, % by mass, for the primary test.
u. Refrigerant mass flow rates:
    a. If supercritical fluid or vapor injection is not included, or if injection is included and the injected refrigerant mass flow rate is calculated using Equation 8, 9, 10, or 11, then either of the following shall be selected for the primary and confirming tests:
        i. Total refrigerant mass flow rate entering the compressor, kg/s (lb_m/h),
        ii. Total refrigerant mass flow rate leaving the compressor, kg/s (lb_m/h).
    b. If supercritical fluid or vapor injection is included and the injected refrigerant mass flow rate is not calculated using Equation 8, 9, 10, or 11, then select one of the methods below:
        i. Total refrigerant mass flow rate kg/s (lb_m/h), measured at each of the following locations, entering the compressor, leaving the compressor, and entering the injection points.
        ii. Total refrigerant mass flow rate kg/s (lb_m/h), measured at any two locations, with confirming measurements at both locations.
v. Compressor torque, N-m (ft-lb_f), if required by the test plan.
w. Power input to compressor including ancillaries, W (hp).

In Section 7.6.2.u., the equation numbers have been corrected.

7.6.2 Measured Compressor Test Results for Operation at Supercritical Pressures of the Refrigerant

a. Ambient air temperature, °C (°F).
b. Specifics regarding ambient circulation over the UUT if required by the test plan.
c. Barometric pressure if a pressure sensing device is referenced to atmospheric pressure.
d. Electrical data if required by the test plan:
    1. Voltage, V.
    2. Frequency, Hz.
    3. Current, A:
        i. Single phase current, A.

ii. Three phase current, A, for all 3 legs.
4. Power factor.
5. Power input, W(hp).

e. Compressor speed if required by the test plan:
   1. Shaft rotational speed, rev/s (rpm).
   2. Shaft input frequency, Hz, for linear compressors or membrane compressors.
f. Suction pressure, kPa (psia).
g. Suction temperature, °C (°F).
h. Discharge pressure, kPa (psia).
i. Discharge temperature, °C (°F).
j. Refrigerant temperature, °C (°F), entering the injection points if vapor injection is included.
k. Refrigerant pressure, kPa (psia), entering the injection points if vapor injection is included.
l. Refrigerant pressure, kPa (psia), entering the calorimeter or flowmeter for the primary test method.
m. Refrigerant temperature, °C (°F), entering the calorimeter or flowmeter for the primary test method.
n. Refrigerant pressure, kPa (psia), leaving the calorimeter or flowmeter for the primary test method.
o. Refrigerant temperature, °C (°F), leaving the calorimeter or flowmeter for the primary test method.
p. Refrigerant pressure, kPa (psia), entering the calorimeter or flowmeter for the confirming test method.
q. Refrigerant temperature, °C (°F), entering the calorimeter or flowmeter for the confirming test method.
r. Refrigerant pressure, kPa (psia), leaving the calorimeter or flowmeter for the confirming test method.
s. Refrigerant temperature, °C (°F), leaving the calorimeter or flowmeter for the confirming test method.
t. Lubricant circulation rate, % by mass, for the primary test.
u. Refrigerant mass flow rates:
   1. If supercritical fluid or vapor injection is not included, or if injection is included and the injected refrigerant mass flow rate is calculated using Equation ~~5-9~~ 8, ~~5-10~~ 9, ~~5-13~~ 10, or ~~5-14~~ 11, then either of the following shall be selected for the primary and confirming tests:
      i. Total refrigerant mass flow rate entering the compressor, kg/s (lb_m/h),
      ii. Total refrigerant mass flow rate leaving the compressor, kg/s (lb_m/h).
   2. If supercritical fluid or vapor injection is included and the injected refrigerant mass flow rate is not calculated using Equation ~~5-9~~ 8, ~~5-10~~ 9, ~~5-13~~ 10, or ~~5-14~~ 11, then select one of the methods below:
      i. Total refrigerant mass flow rate kg/s (lbm/h), measured at each of the following locations, entering the compressor, leaving the compressor, and entering the injection points.
      ii. Total refrigerant mass flow rate kg/s (lbm/h), measured at any two locations, with confirming measurements at both locations.
v. Compressor torque, N-m (ft-lb_f), if required by the test plan.

Power input to compressor including ancillaries, W (hp).

The title of Section 9.6.1 has been modified to include the word, Unit, that was inadvertently omitted from the 23P PPR draft. Additionally, the Equation numbers in Section 9.6.1.y have been corrected.

9.6.1 Measured Compressor Unit Test Results for Operation at Subcritical Pressures of the Refrigerant

a. Average condenser inlet dry-bulb air temperature, °C (°F), if the condensing unit is air-cooled or evaporatively-cooled.

- b. Average condenser inlet wet-bulb air temperature, °C (°F)if the condensing unit is evaporatively-cooled.
- c. Liquid-cooled condenser inlet temperature if the condensing unit is liquid-cooled.
- d. Liquid-cooled condenser outlet temperature if the condensing unit is liquid-cooled.
- e. Specifics regarding ambient airflow circulation over the UUT if required by the test plan.
- f. Ambient temperature, °C (°F).
- g. Barometric pressure if a pressure sensing device is referenced to atmospheric pressure.
- h. Electrical data if required by the test plan:
    - a. Voltage, V.
    - b. Frequency, Hz.
    - c. Current, A:
        - i. Single phase current, A
        - ii. Three phase current, A, for all 3 legs.
    - d. Power factor.
    - e. Power Input, W(hp).
- i. Compressor speed if required by the test plan:
    - a. Shaft rotational speed, rev/s (rpm).
    - b. Shaft input frequency, Hz, for linear compressors or membrane compressors.
- j. Suction pressure, kPa (psia).
- k. Suction return gas temperature, °C (°F).
- l. Discharge pressure, kPa (psia).
- m. Discharge temperature, °C (°F).
- n. Refrigerant temperature, °C (°F), entering the calorimeter or flowmeter for the primary test method.
- o. Refrigerant pressure, kPa (psia), entering the calorimeter or flowmeter for the primary test method.
- p. Refrigerant temperature, °C (°F), leaving the calorimeter or flowmeter for the primary test method.
- q. Refrigerant pressure, kPa (psia), leaving the calorimeter or flowmeter for the primary test method.
- r. Refrigerant temperature, °C (°F), entering the calorimeter or flowmeter for the confirming test method.
- s. Refrigerant pressure, kPa (psia), entering the calorimeter or flowmeter for the confirming test method.
- t. Refrigerant temperature, °C (°F), leaving the calorimeter or flowmeter for the confirming test method.
- u. Refrigerant pressure, kPa (psia), leaving the calorimeter or flowmeter for the confirming test method.
- v. Refrigerant temperature, °C (°F), entering the injection points if vapor injection is included.
- w. Refrigerant pressure, kPa (psia), entering the injection points if vapor injection is included.
- x. Lubricant circulation rate, % by mass, for the primary test.
- y. Refrigerant mass flow rates:
    - a. If vapor injection is not included, or if injection is included and the injected refrigerant mass flow rate is calculated using Equation ~~5-9~~ 15, ~~5-10~~ 16, ~~5-13~~ 17, or ~~5-14~~ 18, then select one of the following:
        - i. Total refrigerant mass flow rate entering the compressor unit, kg/s (lb_m/h), obtained by a primary and confirming test.
        - ii. Total refrigerant mass flow rate leaving the compressor unit, kg/s (lb_m/h), obtained by a primary and confirming test.

  b. If vapor injection is included and the injected refrigerant mass flow rate is not calculated using Equation ~~5-9~~ 15, ~~5-10~~ 16, ~~5-13~~ 17, or ~~5-14~~ 18, then select one of the methods below:
     i. Total refrigerant mass flow rate kg/s (lb_m/h), measured at each of the following locations, entering the compressor, leaving the compressor, and entering the injection points.
     ii. Total refrigerant mass flow rate kg/s (lb_m/h), measured at any two locations, with confirming measurements at both locations

z. Compressor torque, N-m (ft-lb_f), if required by the test plan.

aa. Power input to compressor including ancillaries, W (hp).

In Section 9.6.2.y., the equation numbers have been corrected.

9.6.2 Measured Compressor Unit Test Results for Operation at Supercritical Pressures of the Refrigerant

a. Average gas cooler inlet dry-bulb air temperature, °C (°F), if the gas cooler is air-cooled or evaporatively-cooled.
b. Average gas cooler inlet wet-bulb air temperature, °C (°F), if the gas cooler is evaporatively-cooled.
c. Liquid-cooled gas cooler inlet temperature, °C (°F), if the gas cooler is liquid-cooled.
d. Liquid-cooled gas cooler outlet temperature, °C (°F), if the gas cooler is liquid-cooled.
e. Ambient air temperature, °C (°F).
f. Specifics regarding ambient airflow circulation over the UUT if required by the test plan.
g. Barometric pressure if a pressure sensing device is referenced to atmospheric pressure.
h. Electrical data if required by the test plan:
   1. Voltage, V.
   2. Frequency, Hz.
   3. Current, A:
      i. Single phase current, A.
      ii. Three phase current, A, for all 3 legs.
   4. Power factor.
   5. Power input, W(hp).
i. Compressor speed if required by the test plan:
   1. Shaft rotational speed, rev/s (rpm).
   2. Shaft input frequency, Hz, for linear compressors or membrane compressors.
j. Suction pressure, kPa (psia).
k. Suction return gas temperature, °C (°F).
l. Discharge pressure, kPa (psia).
m. Discharge temperature, °C (°F).
n. Refrigerant pressure, kPa (psia), entering the calorimeter or flowmeter for the primary test method.
o. Refrigerant temperature, °C (°F), entering the calorimeter or flowmeter for the primary test method.
p. Refrigerant pressure, kPa (psia), leaving the calorimeter or flowmeter for the primary test method.
q. Refrigerant temperature, °C (°F), leaving the calorimeter or flowmeter for the primary test method.
r. Refrigerant pressure, kPa (psia), entering the calorimeter or flowmeter for the confirming test method.
s. Refrigerant temperature, °C (°F), entering the calorimeter or flowmeter for the confirming test method.
t. Refrigerant pressure, kPa (psia), leaving the calorimeter or flowmeter for the confirming test method.

u. Refrigerant temperature, °C (°F), leaving the calorimeter or flowmeter for the confirming test method.
v. Refrigerant temperature, °C (°F), entering the injection points if vapor injection is included.
w. Refrigerant pressure, kPa (psia), entering the injection points if vapor injection is included.

x. Lubricant circulation rate, % by mass, for the primary test.
y. Refrigerant mass flow rates:
    1. If supercritical fluid or vapor injection is not included, or if injection is included and the injected refrigerant mass flow rate is calculated using Equation ~~5-9~~ 15, ~~5-10~~ 16, ~~5-13~~ 17, or ~~5-14~~ 18, then select one of the following:
        i. Total refrigerant mass flow rate entering the compressor unit, kg/s (lb_m/h), obtained by a primary and confirming test.
        ii. Total refrigerant mass flow rate leaving the compressor unit, kg/s (lb_m/h), obtained by a primary and confirming test.
    2. If supercritical fluid or vapor injection is included and the injected refrigerant mass flow rate is not calculated using Equation ~~5-9~~ 15, ~~5-10~~ 16, ~~5-13~~ 17, or ~~5-14~~ 18, then select one of the methods below:
        i. Total refrigerant mass flow rate kg/s (lbm/h), measured at each of the following locations, entering the compressor, leaving the compressor, and entering the injection points.
        ii. Total refrigerant mass flow rate kg/s (lbm/h), measured at any two locations, with confirming measurements at both locations.

z. Compressor torque, N-m ($ft \cdot lb_f$), if required by the test plan.
aa. Power input to compressor including ancillaries, W (hp).