BSR/ASHRAE Standard 17-2015R

Public Review Draft

Method of Testing Capacity of Electronic and Thermostatic Refrigerant Expansion Valves

First Public Review (January 2022)
(Complete Draft for Full Review)

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FOREWORD

This is a revision of ANSI/ASHRAE Standard 17-2015.

This standard was prepared under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). It may be used in whole or in part, by an association or government agency with due credit to ASHRAE. Adherence is strictly on a voluntary basis and merely in the interests of obtaining uniform standards throughout the industry.

This standard prescribes a method of testing capacity of thermostatic expansion valves for use in air-conditioning and refrigeration systems. This standard does not specify the test conditions to be used for obtaining the standard rating. That is done in a rating standard developed by the Air-Conditioning, Heating, and Refrigeration Institute (AHRI). The latest edition of AHRI Standard 750 is referenced for the test conditions to be used in obtaining standard ratings for thermostatic refrigerant expanding valves.

The changes made for the 2022 revision are as follows:
- Changed example calculations to R-410A; was R-22.
- references have been updated.

1. PURPOSE

This standard prescribes a method of testing the capacity of electronic and thermostatic refrigerant expansion valves for use in vapor-compression refrigeration systems.

2. SCOPE

2.1 This standard is applicable to

a. electronic and thermostatic expansion valves (also referred to in this standard as expansion valves) as defined in Section 3, “Definitions,”

b. expansion valves of the direct-acting type but not the pilot-operated type, and
c. many currently used refrigerants deemed available and suitable according to ANSI/ASHRAE Standard 15¹ and ANSI/ASHRAE Standard 34.²

2.2 This standard specifies procedures, apparatus, and instrumentation that will produce accurate capacity data.

2.3 This standard does not
a. specify tests for production, specification compliance, or field testing of expansion valves, nor
b. specify capacity rating conditions for testing expansion valves. These may be found in AHRI
Standard 750 Thermostatic Refrigerant Expansion Valves\(^3\), AHRI Standard 751 Thermostatic
Refrigerant Expansion Valves\(^4\), AHRI 1370 Performance Rating of Electronic Expansion
Valves\(^5\), and AHRI 1371 Performance Rating of Electronic Expansion Valves\(^6\).

3. DEFINITIONS

The following definitions apply only to parts and terms used in this standard.

capacity of an expansion valve: the refrigerating effect in kW (Btu/h or tons) of refrigeration,
produced by the mass flow of refrigerant that will pass through the valve under the conditions that
are cited in Section 5.

certified standard instrument: an instrument calibrated by the manufacturer or other reliable
agency and certified as traceable to the National Institute of Standards and Technology (NIST).

direct-acting valve: an expansion valve designed so that the valve plug opens the valve port in
inverse response to sensed equalizer pressure and in direct response to temperature-sensing
element temperature. The valve plug is positioned through direct mechanical linkage to the
actuating element (e.g., diaphragm or bellows).

electric expansion valve (EXV): an electrically driven device which regulates the flow of volatile
refrigerant in a refrigeration system.

evaporator: an evaporatively cooled heat exchanger.

external equalizer: in a thermostatic expansion valve, a connection from a selected point in the
low-pressure part of the circuit to the system pressure-sensing side of the actuating element such
that the selected point pressure is transmitted to the actuating element (e.g., diaphragm or bellows).

initial valve opening: a minimal valve opening position not to exceed 0.05 mm (0.002 in.).

internal equalizer: in a thermostatic expansion valve, an integral internal port or passage whereby
the system pressure-sensing side of the actuating element (e.g., diaphragm or bellows) is exposed
to valve outlet pressure.

liquid refrigerant flowmeter: a device for determining the refrigerant mass flow rate.

nominal capacity: the capacity reported by the manufacturer for an expansion valve, citing
appropriate standard, i.e., ANSI/AHRI Standard 750\(^6\), or equivalent, for the rating conditions.

operating superheat: the difference between the temperature at the temperature-sensing element
and the system refrigerant vapor saturation temperature corresponding to the valve equalizer
pressure.
permanent bleed rate: the capacity of the permanent bleed provision under the conditions cited in Section 5, expressed either as a percentage of the nominal capacity or in kW (Btu/h or tons) of refrigerating effect produced by the evaporation of that amount of refrigerant flow.

permanent bleed-type valve: a valve that has a fixed flow passage incapable of being closed by action of the valve. Such a fixed orifice permits a flow through or in parallel with the main valve port.

pilot-operated valve: expansion valve of a type used on large capacity systems (e.g., direct-expansion chillers) where the required capacity per valve is beyond the range of direct-acting valves; this type of valve is under the control of a direct-acting valve.

refrigerant: the working fluid in a refrigerating system that absorbs heat by evaporating at a low temperature and pressure and rejects heat on condensing at a higher temperature and pressure.

shall/shall not: indicate that the provision is mandatory if compliance with the standard is claimed.

should/is recommended: indicate that the provision is not mandatory but is desirable as good practice.

static superheat: the superheat required to position the valve at the initial valve opening.

superheat change: the difference between the static superheat and the operating superheat.

temperature-sensing element: the part of the expansion valve that senses the temperature at the superheat control point, normally located at the outlet of the evaporator. This element may be remote or integral to the expansion valve body.

test valve: the thermostatic expansion valve being tested for capacity in accordance with this standard.

thermostatic expansion valve (TXV): a device for controlling superheat by regulating the mass flow of refrigerant to a refrigeration load, actuated by changes in equalizer pressure and temperature-sensing element temperature.

valve plug: a movable part that provides a variable restriction in a port.

4. CONDITIONS FOR TESTING CAPACITY

4.1 Testing for capacity of thermostatic expansion valves (TXVs) shall be performed in accordance with Section 8 of this standard.

4.2 The liquid refrigerant entering the TXV shall be subcooled at least 5°C (10°F).

4.3 The refrigerant shall be free from contamination. Refer to AHRI Standard 700\(^\text{7}\) for refrigerant specifications.
4.4 The lubricant concentration in the refrigerant shall not exceed 2% by mass.

4.5 If testing capacity is for rating purposes, use standard test conditions found in the related industry standard, AHRI Standard 750\(^3\), 751\(^4\), 1370\(^5\), and 1371\(^6\).

5. **DATA REQUIRED FOR REPORTING CAPACITY**

5.1 The predetermined test conditions shall include the following values:
   a. Refrigerant designation according to ANSI/ASHRAE Standard 34.\(^2\)
   b. Temperature of test medium entering the expansion valve.
   c. Pressures at the expansion valve inlet and outlet.

5.1.1 For Thermostatic Expansion Valves only:
   a. External equalizer pressure (if applicable).
   b. Temperature at the temperature-sensing element.
   c. Static superheat.
   d. Superheat change.

5.1.2 For Electronic Expansion Valves:
   a. The input signal, duty cycle to the valve, or valve position as required.
   b. If the test medium is refrigerant, the electric expansion valve (EXV) outlet temperature shall be measured.

5.2 The refrigerant mass flow rate or air volumetric flow rate (for EXVs only) shall be the measured value.

6. **TEST INSTRUMENTS**

6.1 Measurement equipment shall be certified standard instruments of the types listed in this section.

6.2 Temperature-Measuring Instruments

6.2.1 Temperature shall be measured with any device meeting the requirements of ANSI/ASHRAE Standard 41.1.\(^8\)

6.2.2 Accuracy of temperature-measuring instruments shall be within ±0.15°C (0.25°F).

6.3 Pressure-Measuring Instruments

6.3.1 Pressure shall be measured with any device meeting the requirements of ASHRAE Standard 41.3.\(^9\)

6.3.2 Accuracy of pressure-measuring instruments shall be within ±0.5% of the pressure reading.
6.4 Refrigerant Flow-Measuring Instruments. Accuracy of flow-measuring instruments shall be within ±1.0% of the indicated value.

6.5 Other Instruments.

6.5.1 (TXV’s only) Dial or other indicators to measure valve plug position relative to the valve port shall have a scale graduated in 0.03 mm (0.001 in.) or finer increments.

6.5.2 (EXV’s only.) The input signal, duty cycle to the valve, or valve position as required.

7. TEST APPARATUS

7.1 TXV Air Fixture. The static superheat setting of the thermostatic expansion valve (TXV) shall be measured with the test valve installed in an air fixture as described in Figure 1 or 2. The fixture shall contain all the essential elements shown, and instrumentation shall conform to the requirements of Section 6.

7.2 TXV Refrigerant Fixture. The capacity of the TXV shall be measured with the test valve installed in a refrigerant fixture as described in Figure 3 or 4. The system shall contain all the essential elements shown, and instrumentation shall conform to the requirements of Section 6.

7.3 EXV Fixture. The electric expansion valve (EXV) capacity shall be measured with either air or refrigerant using the fixtures described in Figure 5 or 6. The system shall contain all the essential elements shown, and instrumentation shall conform to the requirements of Section 6.

7.4 Main Length. The inlet and outlet mains connected to the valve being tested shall be straight for a minimum of fourteen (14) internal diameters from the face of the valve inlet and outlet connections.

7.5 Pressure-Tap Holes. Pressure-tap holes shall be located at appropriate points on the circumference of the main. With horizontal mains, the pressure-tap hole position depends on the fluid flowing. For liquids, the pressure-tap holes shall be level with or below the centerline of the main but not on the bottom of the main due to possible blockage of the hole by foreign matter. The inner surface of the main adjacent to the holes shall be free of imperfections such as rivet heads, jogs, or other sources of eddies. All pressure-tap holes shall be located at the same elevation and on the same side of the main. The pressure-tap hole internal diameter shall be straight and of uniform size for not less than two diameters from the main internal surface. The inner rim of the hole shall be flush with the inner surface of the main and be free of any burrs, excessive chamfers, or jagged edges.

7.5.1 Pressure-tap hole diameters shall be approximately 10% of the main internal diameter except that hole diameters shall not be larger than 5 mm (3/16 in.) or smaller than 0.8 mm (1/32 in.).

7.5.2 Upstream pressure-tap holes shall be located in the main, two (2) internal main diameters upstream from the face of the inlet connection of the valve being tested.
7.5.3 Downstream pressure-tap holes shall be located in the main, six (6) internal main diameters downstream from the face of the outlet connection of the valve under test.

7.6 Fluid Temperature Measurement Locations. Measurement of the temperature of the fluid entering the valve shall be made at a point located not more than twelve (12) internal main diameters upstream from the face of the inlet connection of the valve. If an intrusive temperature-measuring device is used, care should be taken to avoid disturbing flow patterns at the pressure-tap holes.

8. TEST PROCEDURE, Thermostatic Expansion Valve only.

8.1 Static Superheat and Initial Valve Opening

8.1.1 Place the thermostatic expansion valve (TXV) in the appropriate air fixture (Figure 1 or 2) and adjust the test valve to the static superheat at which the capacity is to be measured. The test valve inlet pressure for the air fixture shall be the same as the test valve inlet pressure for the refrigerant fixture. The temperature of the regulated temperature bath shall be equal to the sum of the vapor saturation temperature at the test valve equalizer pressure and the static superheat.

![Figure 1 Air fixture for remote temperature-sensing element valves.](image-url)
8.1.2 The test orifice size for any test condition shall be selected so that the opening of the TXV during the static superheat test shall not exceed 0.05 mm (0.002 in.). Dial or other indicator in accordance with Section 6.5 shall determine the amount of opening.

8.2 Refrigerant System Test

8.2.1 The static superheat at which the test valve capacity is to be measured shall be pre-set according to the procedure described in Section 8.1.

8.2.2 Install the test valve in the appropriate refrigerant fixture (Figure 3 or 4) using appropriate procedures to exclude air and other contaminants. Test for refrigerant leaks and configure the fixture for refrigerant flow through the valve being tested.

8.2.3 Stabilize the temperature at the temperature-sensing element as the sum of the temperature defined in Section 8.1.1 and the superheat change.

8.2.4 Start flow through the test valve and adjust hand throttling valves to obtain stable operating conditions at the intended inlet temperature, inlet pressure, outlet pressure, and equalizer pressure if applicable.

8.2.5 Make the necessary observations and record the data as required by Section 5.

8.3 Permanent Bleed Rate Test. This test is only applicable to permanent bleed-type valves.

8.3.1 Install the test valve being tested according to Section 8.2.2. Provide a means to maintain the valve plug in the closed position.
8.3.2 Perform the test as described in Sections 8.2.4 and 8.2.5.
9.0 TEST PROCEDURE, Electronic Expansion Valve only.

9.1 EXV Capacity Open Position

9.1.1 The capacity of the electronic expansion valve (EXV) can be determined at any position within the operating position of the valve. The tester shall specify the position where the capacity is determined.

9.1.2 Typically, a curve of flow vs. open position is generated (see Figure 9); however, this is not necessary if only maximum capacity is desired.

9.2 Refrigerant System Test

9.2.1 Install the test valve in the refrigerant fixture (Figure 5) using appropriate procedures to exclude air and other contaminants. Test for refrigerant leaks and configure the fixture for refrigerant flow through the valve being tested. A bypass circuit shall be used as necessary to ensure stable conditions at the EXV inlet.

9.2.2 Open EXV to selected position and start flow through the test valve and adjust any bypass circuit controls to obtain stable operating conditions at the intended inlet temperature, inlet pressure, and outlet pressure.

9.2.3 Make the necessary observations and record the data as required by Section 5.

9.2.4 If a flow curve is desired, adjust EXV to new opening and repeat steps 9.2.2 - 9.2.3.

Figure 5 Refrigerant fixture for electronic expansion valves.
9.3 Air Test

9.3.1 Install the test valve in the air fixture (Figure 6) using appropriate procedures to exclude any contaminants.

9.3.2 Open EXV to selected position and start flow through the test valve. Adjust pressure regulator to required inlet pressure and wait until stable operating conditions are reached.

9.3.3 Make the necessary observations and record the data as required by Section 5.

9.3.4 If a flow curve is desired, adjust EXV to new opening and repeat steps 9.3.2 - 9.3.3.

Figure 6 Refrigerant fixture for integral temperature-sensing element valves.

9.3.5 The refrigerant flow may be predicted from the airflow as follows: (see Informative Appendix B for an example calculation).

Note: The following method to predict the refrigerant flow can be used for airflow measurements where \( \Delta P/P_1 \leq 0.47 \). Airflow cannot be used at measurement conditions of \( \Delta P/P_1 > 0.47 \).

9.3.5.1 Compute the \( \sqrt{\rho \Delta P_R} \) corresponding to the application condition, i.e., the new fluid and flow conditions.

9.3.5.2 Compute the \( \sqrt{\rho \Delta P_T} \) corresponding to the measured mass flow \( (w_T) \).

9.3.5.3 The predicted capacity \( (w_R) \) is given by the following equation:
\[ w_R = w_T \frac{\sqrt{\Delta P_R}}{\sqrt{\Delta P_T}} \quad (1) \]

where

\( w = \text{mass flow rate kg/h (lb/h)} \)
\( \rho = \text{fluid density entering valve, kg/m}^3 \text{ (lb/ft}^3) \)
\( \Delta P = \text{pressure drop across valve, i.e., } P_1 - P_2 \)
\( P = \text{absolute pressure} \)

Subscripts

\( R = \text{refers to the refrigerant and/or conditions} \)
\( T = \text{refers to test fluid and/or conditions} \)
\( 1 = \text{refers to conditions at the inlet of the valve} \)
\( 2 = \text{refers to conditions at the outlet of the valve} \)

10. CAPACITY CALCULATION

\[ \text{CAPACITY} = w (h_g - h_f) \quad (2) \]

where

\( w = \text{refrigerant mass flow rate, kg/h (lb/h)} \)
\( h_g = \text{enthalpy of saturated refrigerant vapor at the measured equalizer pressure, kJ/kg (Btu/lb)} \)
\( h_f = \text{enthalpy of saturated refrigerant liquid at the measured test valve inlet temperature, kJ/kg (Btu/lb)} \)

The enthalpy values \((h_g \text{ and } h_f)\) of some refrigerants at various temperatures may be found in \textit{ASHRAE Handbook—Fundamentals}\textsuperscript{10} in the chapter entitled “Thermophysical Properties of Refrigerants.” More extensive properties are available in the NIST Standard Reference Database 23, entitled \textit{NIST Thermodynamic and Transport Properties of Refrigerants and Refrigerant Mixtures—REFPROP10}\textsuperscript{11}.

\textit{SI Example test report:}

Refrigerant R-410A (a Zeotropic mixture)
Liquid temperature 40°C
Inlet pressure 2733 kPa absolute
Outlet pressure 1258 kPa absolute
External equalizer pressure 936 kPa absolute
Temperature-sensing element temperature 11°C  
Static superheat 3°C  
Superheat change 3°C  
Refrigerant flow rate 300 kg/h  

\( h_g = 427.55 \text{ kJ/kg} \)  
\( h_f = 266.3 \text{ kJ/kg} \)  

Capacity = 13.4 kW  

\textit{I-P Example test report:}  

Refrigerant R-410A (a Zeotropic mixture)  
Liquid temperature 100°F  
Inlet pressure 396 psia  
Outlet pressure 182 psia  
External equalizer pressure 136 psia  
Temperature-sensing element temperature 52°F  
Static superheat 6°F  
Superheat change 6°F  
Refrigerant flow rate 600 lb/h  

\( h_g = 183.8 \text{ Btu/lb} \)  
\( h_f = 114.5 \text{ Btu/lb} \)  

Capacity = 41,580 Btu/h  

11. REFERENCES  


(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX A

Additional testing outlined in this appendix is provided for informational purposes only. The tests are not required to obtain the capacity of a thermostatic expansion valve. They are often used as development or analysis tools by valve manufacturers and users.

A1. VERY SMALL FLOW EXCEPTION

The capacity or flow curve for a thermostatic expansion valve (TXV) has a portion, at very small values of flow, where the normal incremental relationship between the flow and temperature-sensing element temperature changes does not apply. This deviation is due to necessary mechanical tolerances and clearances that are present to some degree in all valves.

The theoretical flow curve of a perfectly configured valve is shown as curve A on Figure 7; the flow-temperature values progress at a uniform rate to zero, without deviation. Curve B represents the flow curve for a typical commercial TXV. It differs from A in that the curve becomes flatter during the final increments before the valve is tightly closed. Within normal limits, the flat portion of the curve has no important effect on the operation of refrigerating equipment since the flow rates involved are extremely low. However, for valves in which clearances and configuration errors are excessive, the flat portion becomes a significant factor in normal operation. This condition is illustrated by curve C.

A2. VALVE OPENING VS. TEMPERATURE SENSING ELEMENT TEMPERATURE (SOMETIMES REFERRED TO AS VALVE TEMPERATURE GRADIENT)

Note: In the air test fixture, flow through the orifice shall be stopped to facilitate this test.

With the TXV installed in the air fixture of Figure 1 or 2, increase the temperature-sensing element temperature in increments of no more than 1°C (2°F) until valve motion stops. Hold the test valve outlet and external equalizer pressure at a constant value equal to the initial opening pressure by operating the outlet needle valve. Plot a curve of test valve opening vs. temperature-sensing element temperature from the minimum to the maximum temperature-sensing element temperature. (See typical curve, Figure 8.)

A3. REFRIGERANT FLOW VS. VALVE OPENING

Install the TXV in the refrigerant fixture of Figure 3 or 4. Equip the test valve with a mechanical means for opening and closing the test valve, and provide means for measuring the test valve opening (see Section 6.5). Plot refrigerant mass flow vs. test valve opening for at least five equally
spaced points, including the initial valve opening. Maintain the specified inlet and outlet test pressure. (See typical curve, Figure 9.)

A4. DETERMINATION OF SUPERHEAT CHANGE AT OTHER CAPACITIES

From the curves of Sections A2 and A3, using test valve opening as the common measurement, plot refrigerant mass flow as the ordinate vs. temperature-sensing element temperature as the abscissa. (See typical curve, Figure 10.) At the refrigerant mass flow indicated by the initial valve opening (see Section 8), draw a line parallel to the abscissa, and at the point of intersection with the refrigerant mass flow curve, establish an initial opening reference point on the temperature-sensing element temperature scale (Figure 10). Determine the mass flow at the selected capacity by solving the equation in Section 10 for refrigerant mass flow. At the calculated refrigerant mass flow, draw a line parallel to the abscissa, and at the point of intersection with the refrigerant mass flow curve, establish another reference point on the temperature-sensing element temperature scale (Figure 10). The difference between the two reference point temperatures represents the amount of superheat change from initial opening to the test valve opening at the selected capacity.

A5. EXAMPLE

Determine the superheat change for a TXV with a static superheat setting of 3°C (6°F) and a flow curve as illustrated in Figure 9. The load is 8.0 kW (27,300 Btu/h) at a 5°C (40°F) evaporator temperature with a 40°C (100°F) liquid temperature entering the TXV on an R-410A (a Zeotropic mixture) system.

Calculate refrigerant mass flow:

SI Example:

\[
\begin{align*}
  w &= \frac{CAPACITY}{(h_g - h_f)} = \frac{8.0 \text{ kW}}{(428.9 \text{ kJ/kg} - 207.7 \text{ kJ/kg})} = 130 \text{ kg/h} \\
  \text{Determine superheat change:} \\
  \text{Superheat change} &= 10°C - 8°C = 2°C \\
  \end{align*}
\]

I-P Example:

\[
\begin{align*}
  w &= \frac{CAPACITY}{(h_g - h_f)} = \frac{27,300 \text{ Btu/h}}{(184.4 \text{ Btu/lb} - 89.3 \text{ Btu/lb})} = 287 \text{ lb/h} \\
  \text{Determine superheat change:} \\
  \text{Superheat change} &= 49°F - 46°F = 3°F
\end{align*}
\]
Figure 7 Valve opening characteristics.

Figure 8 Air test: test valve opening vs. temperature-sensing element temperature.
Figure 9 Refrigerant test: refrigerant flow vs. test valve opening.

Figure 10 Example.
Figure 11 Refrigerant flow vs. temperature-sensing element temperature.
INFORMATIVE APPENDIX B

Example calculation of refrigerant flow from measured airflow.

**Airflow measurement conditions:**
- \( P_1 = 0.201 \) MPa, EXV inlet pressure, absolute
- \( T_1 = 22^\circ\)C, EXV inlet temperature, absolute
- \( P_2 = 0.101325 \) MPa (atmospheric pressure), EXV outlet pressure
- \( \rho_T = 2.377 \) kg/m\(^3\) EXV inlet temperature
- \( \Delta P_T = P_1 - P_2 = 100,000 \) Pa, pressure drop across EXV

\( w_T = 18.37 \) kg/hr, measured airflow rate

**Refrigerant conditions for which capacity is wanted:**
- \( R410a \)
- \( P_1 = 2.31 \) MPa, EXV inlet pressure, absolute (0\(^\circ\)C subcool)
- \( P_2 = 0.933 \) MPa, EXV outlet pressure, absolute (0\(^\circ\)C superheat)
- \( \rho_T = 987.52 \) kg/m\(^3\)
- \( \Delta P_R = P_1 - P_2 = 1,380,000 \) Pa

\[
\begin{align*}
w_R &= w_T \frac{\sqrt{\rho \Delta P_R}}{\sqrt{\rho \Delta P_T}} = 18.37 \cdot \sqrt{\frac{987.52 \cdot 1,380,000}{18.37 \cdot 100,000}} = 500.3 \text{ kg/hr}
\end{align*}
\]