EnergyPlus  
Engineering Reference

The Reference to EnergyPlus Calculations  
(in case you want or need to know)

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#### Standard Rating of Single-Speed DX Cooling Coils

For small single-speed direct expansion (DX) cooling coils, the industry standard ratings of Standard Rating Cooling Capacity and Seasonal Energy Efficiency Ratio (SEER) are calculated according to ANSI/AHRI Standard 210/240 (AHRI 2008). These ratings apply to unitary air conditioners and air-source unitary heat pumps with air-cooled condensers with standard rating cooling capacities under 19 kW (<65,000 Btu/hr). For larger DX cooling coils, the industry standard ratings of Standard Rating Cooling Capacity, Energy Efficiency Ratio (EER), and Integrated Energy Efficiency Ratio (IEER) are calculated according to ANSI/AHRI Standard 340/360 (AHRI 2007). These ratings apply to unitary air conditioners and air-source unitary heat pumps with standard rating cooling capacities from 19 kW to below 73.2 kW (65,000 Btu/hr to <250,000 Btu/hr).

For the Coil:Cooling:DX:SingleSpeed object in EnergyPlus, these standard ratings are not direct inputs to the model. However, these standard ratings can be calculated using user-entered information for the Coil:Cooling:DX:SingleSpeed object. Since users sometimes lump the performance of several smaller DX cooling units into a single larger cooling coil object for simulation purposes, EnergyPlus outputs the Standard Rating Cooling Capacity, SEER, EER, and IEER regardless of the magnitude of the standard rating cooling capacity of the coil. It is up to the user to determine which standard ratings are applicable to the cooling coil(s) they are modeling. These standard rating values are provided in the eplusout.eio output file (Ref. OutputDetailsAndExamples.pdf) and also in the predefined tabular output reports (Output:Table:SummaryReports object, Equipment Summary). Currently, the standard ratings are only calculated and output for single-speed DX cooling coils with air-cooled condensers. If the single-speed DX coling coil is specified with an evaporatively-cooled condenser, then no standard ratings are output from EnergyPlus at this time.

Note: The standard ratings described in this section require that the DX cooling coil model be evaluated at specific operating conditions (i.e., specific wet-bulb temperatures for air entering the cooling coil and dry-bulb temperatures for air entering the air-cooled [outdoor] condenser). If the cooling coil performance curves can not be evaluated at the required test conditions, then a standard rating value calculated at the curves limit will be output and a warning message will written to eplusout.err. For example, if the curve object (Curve:Biquadratic) for Total Cooling Capacity Function of Temperature Curve has a minimum value of 21C for dry-bulb temperature entering the air-cooled condenser coil, the IEER calculation requires that EERD be calculated at 18.3C – so, this would result in IEER calculatd at user specified curve limit as an output and a warning message in the eplusout.err file.

The standard rating cooling capacity (AHRI 2007, AHRI 2008) is calculated as follows:



where,

 = Standard Rating (Net) Cooling Capacity (W)

 = Rated Total (Gross) Cooling Capacity, user input (W)

= Total Cooling Capacity Function of Temperature Curve evaluated with 19.44°C wet-bulb temperature air entering the cooling coil and 35.0°C dry-bulb temperature air entering the air-cooled (outdoor) condenser (dimensionless)

= Total Cooling Capacity Function of Flow Fraction Curve evaluated at a flow fraction of 1.0 (dimensionless)

= Rated Evaporator Fan Power Per Volume Flow Rate, user input ( W/(m3/s) )

= Rated Air Volume Flow Rate, user input (m3/s)

The Rated Evaporator Fan Power Per Volume Flow rate is a user-entered value, with a default of 773.3 W/(m3/s)) if the user leaves this input field blank. The default value is taken from ANSI/AHRI Standards 210/240 and 340/360 where it is defined for systems which do not have a cooling coil fan furnished as part of the system (e.g., a DX cooling coil mounted in the ductwork downstream of a gas furnace where the furnace contains the fan used for air distribution across the gas heating coil and the downstream DX cooling coil). The test conditions in ANSI/AHRI Standards 210/240 and 340/360 vary the external static pressure (i.e., pressure drop associated with ductwork and other devices external to the indoor fan/coil section) seen by the supply air fan based on the standard rating cooling capacity. Note, however, that external static pressure in actual installations is typically much higher. Further details regarding indoor fan power per volume flow rate can be found in Walker and Lutz (2005) and Walker (2007), including differences between Permanent Split Capacitor (PSC) and Brushless Permanent Magnet (BPM) fan motors. Especially at the low external static pressures defined in the ANSI/AHRI Standards, BPM motors (e.g., Electronically Commutated Motors (ECMs)) can draw significantly less power (e.g., 50-75% less) than PSC motors.

The seasonal energy efficiency ratio (SEER) is calculated as follows:









where,

*PLF0.5*  = Part Load Fraction Correlation Curve evaluated at a part load ratio (PLR) of 0.5 (dimensionless)

*EERTestB* = Energy efficiency ratio with 19.44°C wet-bulb temperature air entering the cooling coil, 27.78°C dry-bulb temperature air entering the air-cooled (outdoor) condenser, and rated air volume flow through the cooling coil (W/W)

= Net total cooling capacity with 19.44°C wet-bulb temperature air entering the cooling coil, 27.78°C dry-bulb temperature air entering the air-cooled (outdoor) condenser, and rated air volume flow through the cooling coil (W)

 = Total Cooling Capacity Function of Temperature Curve evaluated with 19.44°C wet-bulb temperature air entering the cooling coil and 27.78°C dry-bulb temperature air entering the air-cooled (outdoor) condenser (dimensionless)

 = Total electric power (compressors, condenser fans and evaporator fan) with 19.44°C wet-bulb temperature air entering the cooling coil, 27.78°C dry-bulb temperature air entering the air-cooled (outdoor) condenser, and rated air volume flow through the cooling coil (W)

 = Coefficient of Performance at Rated Conditions, user input (W/W)

 = Energy Input Ratio Function of Temperature Curve evaluated with 19.44°C wet-bulb temperature air entering the cooling coil and 27.78°C dry-bulb temperature air entering the air-cooled (outdoor) condenser (dimensionless)

= Energy Input Ratio Function of Flow Fraction Curve evaluated at a flow fraction of 1.0 (dimensionless).

Energy Efficiency Ratio (EER) is another standard rating (AHRI 2007), and it is defined as the ratio of the total cooling capacity to the total power input at any given set of rating conditions, expressed in W/W (or Btu/W-h). For this class of air-cooled DX cooling coils, EER is calculated at rated test conditions as follows:







where,

*EER* = Energy Efficiency Ratio (W/W)

= Total electric power (compressors, condenser fans and evaporator fan) with 19.44°C wet-bulb temperature air entering the cooling coil, 35.0°C dry-bulb temperature air entering the air-cooled (outdoor) condenser, and air flow rate across the evaporator at the Rated Air Volume Flow Rate (W).

 = Total Cooling Capacity Function of Temperature Curve evaluated with 19.44°C wet-bulb temperature air entering the cooling coil and 35.0°C dry-bulb temperature air entering the air-cooled (outdoor) condenser (dimensionless)

 = Energy Input Ratio Function of Temperature Curve evaluated with 19.44°C wet-bulb temperature air entering the cooling coil and 35.0°C dry-bulb temperature air entering the air-cooled (outdoor) condenser (dimensionless)

The Integrated Energy Efficiency Ratio (IEER) is intended to be a measure of merit for the cooling coil’s part-load efficiency. IEER replaced Integrated Part-Load Value (IPLV) as the part-load performance metric in Std. 340/360 as of January 1, 2010. Full details regarding the IEER calculation are available in ANSI/AHRI Std. 340/360 (AHRI 2007). A summary of the IEER calculations made by EnergyPlus for single-speed air-cooled DX cooling coils is provided below:



where,

 = *EER* at 100% net capacity at AHRI standard rating conditions (same as EER calculation shown above)

 = *EER* at 75% net capacity and reduced outdoor air temperature

 = *EER* at 50% net capacity and reduced outdoor air temperature

= *EER* at 25% net capacity and reduced outdoor air temperature









where,

 = Net total cooling capacity with 19.44°C wet-bulb temperature air entering the cooling coil rated air volume flow through the cooling coil (W). The dry-bulb temperature of air entering the air-cooled condenser varies (B = 27.5°C, C = 20.0°C, D = 18.3°C).

 = Total electric power (compressors, condenser fans and evaporator fan) with 19.44°C wet-bulb temperature air entering the cooling coil and air flow rate across the evaporator at the Rated Air Volume Flow Rate (W). The dry-bulb temperature of air entering the air-cooled condenser varies (B = 27.5°C, C = 20.0°C, D = 18.3°C). = Electric power of the compressor and condenser fan at the various part-load ratios, with 19.44°C wet-bulb temperature air entering the cooling coil and rated supply air volume flow rate (W). The dry-bulb temperature of air entering the air-cooled condenser varies per the part-load ratio (B = 27.5°C, C = 20.0°C, D = 18.3°C).

 = Energy Input Ratio Function of Temperature Curve evaluated with 19.44°C wet-bulb temperature air entering the cooling coil and dry-bulb temperature of air entering the air-cooled condenser corresponding to the reduced part-load ratio (B = 27.5°C, C = 20.0°C, D = 18.3°C) (dimensionless).

= degradation coefficient to account for cycling of the compressor = 1.13 – 0.13*LF*.

 = fractional “on” time at the desired load point

The load factor (*LF*) is the fractional “on” time for the desired reduced load points (75%, 50%, or 25%) calculated from the following equation:



where,

** = Part-load operating points, i.e., 75% (B), 50% (C), 25% (D)

The calculations for *QTotal,Net,PartLoad* and *PowerTotal,PartLoad* are calculated in nearly the same way as *QTotal,Net,TestB* and *PowerTotal,TestB* are calculated for SEER (defined above). The only difference is that these cooling capacity and power values, used for calculating EERB/EERC/EERD for IEER, are calculated for a series of dry-bulb temperatures of air entering the air-cooled condenser (B = 27.5°C, C = 20.0°C, D = 18.3°C) and part-load performance degradiation correction is also applied to the condensing unit electric power calculation.

#### Basin Heater For Two-Stage DX Coil

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