**Draft PDS-02 MINHERS Addendum 82, Direct Expansion HP & AC Modeling**

***Modify MINHERS Chapter 3 section 303.1 as follows:***

**Exception 4: RESNET Home Energy Ratings shall be calculated using the modifications of Standards ANSI/RESNET/ICC 301~~-2019~~ established by MINHERS addenda:**

• [**Addendum 66,**](https://www.resnet.us/wp-content/uploads/FS_Adndm66f_v3.pdf) **~~and~~ CO2e Index**

# • [Addendum 79~~.~~](https://www.resnet.us/wp-content/uploads/FS_Adndm79f_InformNoteCrctn.pdf), Table 5.1.2(1) Informative Note Correction

# • Addendum 77, Integrated Heat Pump Water Heater (iHPWH)

• **Addendum 82, Direct Expansion Heat Pump and Air Conditioner Modeling**

***Modify the ANSI/RESNET/ICC 301-2022 Appendix C by adding the following:***

# C.*x* Direct Expansion Modeling

**C.*x.1* Nomenclature**

# Symbols

|  |  |  |
| --- | --- | --- |
| **Symbol** | **Description** | **Units** |
| Q | Heat (used for heating/cooling capacities and fan heat) | kBtu/h |
| P | Power | W |
| p | Specific Fan Power | W/cfm |
| SHR | Sensible Heat Ratio for cooling | - |
| V | Volumetric airflow | cfm |
| v | Volumetric airflow per rated net total capacity | cfm/ton |
| m | Mass airflow |  |
| T | Temperature | °F |

# Subscripts

|  |  |
| --- | --- |
| **Subscript** | **Description** |
| gross | Does not include fan heat/power |
| net | Includes fan heat/power |
| clg | Cooling |
| tot | Total (cooling capacity) |
| sen | Sensible (cooling capacity) |
| htg | Heating |
| ss | Steady-state (heating), does not include defrost effects |
| int | Integrated (heating), includes defrost effects |
| A | AHRI “A” cooling rating conditions (95°F outdoor drybulb, 80°F indoor drybulb, 67°F indoor wetbulb) |
| full | Rated full load compressor speed. Note: For some variable speed systems, the rated full load compressor speed can be lower than the maximum load compressor speed. |
| max | Maximum load compressor speed |
| min | Minimum load compressor speed |
| i | Compressor speed/staging index |
| rated | Corresponding to the AHRI rating procedure. May be different from operational values observed in the field. |
| op | Corresponding to installed operation. Used to distinguish from values corresponding to rating procedures. |
| fan | Indoor fan |
| odb | Outdoor unit entering drybulb |
| iwb | Indoor unit entering wetbulb |
| idb | Indoor unit entering drybulb |

## C.*x*.2 Scope

Current scope includes the scope of AHRI 210/240. Not currently included are:

* Multi-splits
* Window AC/Portable AC
* PTAC/PTHP
* Ground source heat pumps

## C.*x*.3 Objective

Define the best representation of as-installed performance for unitary air-conditioning and airsource heat pump equipment at all combinations of conditions encountered in a predictive building performance model. This often requires interpretations, extrapolations, and assumptions for many aspects of operation beyond equipment ratings, design conditions, and product documentation.

## C.*x*.4 Net-to-Gross Performance Conversions

System performance shall be modeled using gross performance of the direct expansion system where the indoor fan performance is treated separately. Where net performance is provided, gross performance shall be determined by removing the impact of rated fan power/heat as follows:

Qgross,tot,clg,i = Qnet,tot,clg,I + Qfan,clg,i

Pgross,clg,i = Pnet,clg,i - Pfan,clg,i

Qgross,ss,htg,i = Qnet,ss,htg,i - Qfan,ss,htg,i

Pgross,ss,htg,i = Pnet,ss,htg,i - Pfan,ss,htg,i

The rated fan flow rate is:

Vrated,clg, i = vclg,rated,i\*Qnet,tot,clg,A,i\*(0.083 ton/(kBtu/hr))

Vrated,htg,ss, i = vrated,htg,ss,i\*Qnet,ss,htg,H1,i\*(0.083 ton/(kBtu/hr))

Where the values of vrated,mode,i (for all speeds) are:

|  |  |  |
| --- | --- | --- |
| **System Type** | **Mode** | **vrated (cfm/ton)** |
| Ducted | Cooling | 400 |
| Ducted | Heating | 400 |
| Ductless | Cooling | 400 |
| Ductless | Heating | 400 |

The rated fan power is determined using the specific fan power listed below.

|  |  |  |
| --- | --- | --- |
| **System Type** | **Fan Motor Type** | **prated (W/cfm)** |
| Ducted | PSC | 0.414 |
| Ducted | BPM | 0.281 |
| Ductless | PSC | 0.414 |
| Ductless | BPM | 0.171 |

Rated fan power is:

Pfan,rated = prated\*Vrated,clg,full

Fan power assumed in net performance at any speed or mode is then calculated as:

**BPM Motors (Ducted Systems):** Pfan,rated,mode,i = Pfan,rated\*(Vrated,mode,i/Vrated,clg,full)2.75

**BPM Motors (Ductless Systems):** Pfan,rated,mode,i = Pfan,rated\*(Vrated,mode,i/Vrated,clg,full)3

**PSC Motors:** Pfan,rated,mode,i = Pfan,rated\*(Vrated,mode,i/Vrated,clg,full)\*(0.3\*(Vrated,mode,i/Vrated,clg,full) + 0.7))

## C.*x*.4 Variability with Indoor Conditions

Gross performance shall be modified to account for variations in indoor conditions relative to the indoor conditions under which the data is provided.

Qgross,tot,clg,i = Qgross,tot,clg,Todb,i\*fQ,clg,i(Tiwb,Todb,v)/fQ,clg,i(67°F,Todb,vclg,i)

Pgross,clg,i = Pgross,clg,Todb,i\*fEIR,clg,i(Tiwb,Todb,v)/fEIR,clg,i(67°F,Todb,vclg,i)\*fQ,clg,i(Tiwb,Todb,v)/fQ,clg,i(67°F,Todb,vclg,i) Qgross,ss,htg,i = Qgross,ss,htg,Todb,i\*fQ,htg,i(Tidb,Todb,v)/fQ,htg,i(70°F,Todb,vhtg,ss,i)

Pgross,ss,htg,i = Pgross,ss,htg,Todb,i\*fEIR,htg,i(Tidb,Todb,v)/fEIR,htg,i(70°F,Todb,vhtg,ss,i)\*fQ,htg,i(Tidb,Todb,v)/fQ,htg,i(70°F,Todb,vhtg,ss,i)

where the functions above are defined as:

f(T1,T2,v) = (c1 + c2\*T1 + c3\*T12 + c4\*T2 + c5T22 + c6T1\*T2)\*(c7 + c8\*v/[400 cfm/ton] + c9\*(v/[400 cfm/ton])2)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Function:** | **fQ,clg(Tiwb,Todb,v)** | **fEIR,clg(Tiwb,Todb,v)** | **fQ,htg(Tidb,Todb,v)** | **fEIR,htg(Tidb,Todb,v)** |
| **c1** | 3.717717741 | -3.400341169 | 0.568706266 | 0.722917608 |
| **c2** | -0.09918866 | 0.135184783 | -0.000747282 | 0.003520184 |
| **c3** | 0.000964488 | -0.001037932 | -1.03432E-05 | 0.000143097 |
| **c4** | 0.005887776 | -0.007852322 | 0.00945408 | -0.005760341 |
| **c5** | -1.2808E-05 | 0.000183438 | 5.0812E-05 | 0.000141736 |
| **c6** | -0.000132822 | -0.000142548 | -6.77828E-06 | -0.000216676 |
| **c7** | 0.718664047 | 1.143487507 | 0.694045465 | 2.185418751 |
| **c8** | 0.41797409 | -0.13943972 | 0.474207981 | -1.942827919 |
| **c9** | -0.136638137 | -0.004047787 | -0.168253446 | 0.757409168 |

Cooling variations shall be held constant for Tiwb less than 57°F and greater than 72°F, and for Todb less than 75°F. These functions are also referenced in the methodology for two-stage and single-stage systems.

## C.*x*.5 Calculation of Net Performance

Net capacity and power must be determined at all combinations of outdoor drybulb temperatures and compressor speeds. The following nomenclature is adopted to combine metrics, normalizations (if applicable), outdoor temperatures, and compressor speeds into distinct terms used in the modeling approach:

Metrics:

* Q = Net Capacity
* P = Net Power
* EIR = Net Energy Input Ratio (defined as Power/Capacity)
* COP = Net Coefficient of Performance (defined as Capacity/Power)

Normalizations:

* r = ratio (quantity relative to value at maximum compressor speed)
* m = maintenance (quantity relative to next least extreme outdoor temperature)
* mslope = maintenance slope (used to define how maintenance changing below 5°F)

Heating Outdoor Temperatures:

* 47 = 47°F
* 17 = 17°F
* 5 = 5°F
* LCT = Lowest Catalogued Temperature (product-specific value from NEEP data)
* Tmin = Minimum Compressor Operating Temperature (used in the model)

Cooling Outdoor Temperatures:

* 82 = 82°F
* 95 = 95°F

Compressor Speeds:

* min = Minimum capacity compressor speed
* full = Rated full load capacity compressor speed
* max = Maximum capacity compressor speed

For example, “EIRm5max” is the Energy Input Ratio maintenance at 5°F and maximum capacity compressor speed. It is the ratio of the EIR at 5°F relative to the EIR at 17°F (the next least extreme temperature) at maximum capacity compressor speed.

The following data from an AHRI Certificate shall be used as input to the model:

* *Q47full*: Heating Capacity (H1Full) High Stage (47°F)
* *Q17full*: Heating Capacity (H3Full) High Stage (17°F)
* *HSPF2* (Region IV)
* *Q95full*: Cooling Capacity (AFull) High Stage (95°F)
* *EER2* (AFull) High Stage (95°F)
* *SEER2*

**C.*x*.6 Variable Capacity Systems (Systems with Three or More Stages)**

Net heating performance data is defined at each combination of three compressor speeds (Minimum, Full, and Maximum) and four outdoor temperatures (Tmin, 5°F, 17°F, and 47°F).

Net cooling performance is defined at each combination of three compressor speeds (Minimum, Full, and Maximum) and two outdoor temperatures (82°F and 95°F).

The following mean values of normalized data from the NEEP database shall be used to determine the full set of performance data:

|  |  |  |
| --- | --- | --- |
| **Quantity** | **Definition** | **Mean Value** |
| Qr47full | Q47full/Q47max | 0.908 |
| Qr47min | Q47min/Q47max | 0.272 |
| Qr17full | Q17full/Q17max | 0.817 |
| Qr17min | Q17min/Q17max | 0.341 |
| Qm5max | Q5max/Q17max | 0.866 |
| Qr5full | Q5full/Q5max | 0.988 |
| Qr5min | Q5min/Q5max | 0.321 |
| QmslopeLCTmax | (1 - Q5max/QLCTmax)/(5°F - LCT) | -0.025 |
| QmslopeLCTmin | (1 - Q5min/QLCTmin)/(5°F - LCT) | -0.024 |
| Qr95full | Q95full/Q95max | 0.934 |
| Qm95max | Q95max/Q82max | 0.940 |
| Qm95min | Q95min/Q82min | 0.948 |
| EIRr47full | (P47full/Q47full)/(P47max/Q47max) | 0.939 |
| EIRr47min | (P47min/Q47min)/(P47max/Q47max) | 0.730 |
| EIRm17full | (P17full/Q17full)/(P47full/Q47full) | 1.351 |
| EIRr17full | (P17full/Q17full)/(P17max/Q17max) | 0.902 |
| EIRr17min | (P17min/Q17min)/(P17max/Q17max) | 0.798 |
| EIRm5max | (P5max/Q5max)/(P17max/Q17max) | 1.164 |
| EIRr5full | (P5full/Q5full)/(P5max/Q5max) | 1.000 |
| EIRr5min | (P5min/Q5min)/(P5max/Q5max) | 0.866 |
| EIRmslopeLCTmax | (1 - (PLCTmax/QLCTmax)/(P5max/Q5max))/(5°F - LCT) | 0.012 |
| EIRmslopeLCTmin | (1 - (PLCTmin/QLCTmin)/(P5min/Q5min))/(5°F - LCT) | 0.012 |
| EIRr95full | (P95full/Q95full)/(P95max/Q95max) | 0.928 |
| EIRm95max | (P95max/Q95max)/(P82max/Q82max) | 1.326 |
| EIRm95min | (P95min/Q95min)/(P82min/Q82min) | 1.315 |

The following values are determined using bi-linear interpolation of the tables provided. The values in these tables are developed such that the model of the equipment results in consistent seasonal ratings when simulating the AHRI 210/240 2023 test procedures.

*COP47full*:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | HSPF2 |  | |
| Qm17full | 7 | 9.25 | 11.5 | 13.75 | 16 |
| 0.500 | 2.762 | 4.149 | 5.934 | 8.392 | 11.948 |
| 0.540 | 2.696 | 3.941 | 5.490 | 7.463 | 10.060 |
| 0.620 | 2.579 | 3.627 | 4.821 | 6.190 | 7.779 |
| 0.780 | 2.467 | 3.305 | 4.167 | 5.054 | 5.967 |
| 1.100 | 2.345 | 3.091 | 3.834 | 4.573 | 5.307 |

*COP82min*:

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **SEER2** |  |
| **SEER2/EER2** | 14 | 24.5 | 35 |
| 1.000 | 4.047 | 7.061 | 10.058 |
| 1.747 | 6.175 | 10.289 | 14.053 |
| 2.120 | 14.240 | 23.262 | 30.962 |
| 2.307 | 19.508 | 31.842 | 42.388 |
| 2.400 | 23.029 | 37.513 | 49.863 |

Full performance is calculated using the following equations based on the mean values of normalized data from the NEEP database (in **bold**) and the AHRI certified rating data (in *italics*):

|  |  |
| --- | --- |
| **Value** | **Equation** |
| Q47max | *Q47full* / **Qr47full** |
| Q47min | Q47max \* **Qr47min** |
| Q17max | *Q17full* / **Qr17full** |
| Q17min | Q17max \* **Qr17min** |
| Q5max | Q17max \* **Qm5max** |
| Q5full | Q5max \* **Qr5full** |
| Q5min | Q5max \* **Qr5min** |
| QTminmax | Q5max / ( 1 - **QmslopeLCTmax**\*(5°F - Tmin)) |
| QTminmin | Q5min / ( 1 - **QmslopeLCTmin**\*(5°F - Tmin)) |
| QTminfull | QTminmin + (Q5full - Q5min)/(Q5max - Q5min)\*(QTminmax - QTminmin) |
| P47full | *Q47full* / (*COP47full* \* 3.412 Btu/Wh) |
| P47max | P47full / (**Qr47full** \* **EIRr47full**) |
| P47min | P47max \* (**Qr47min** \* **EIRr47min**) |
| P17full | P47full \* ((*Q17full*/*Q47full*) \* **EIRm17full**) |
| P17max | P17full / (**Qr17full** \* **EIRr17full**) |
| P17min | P17max \* (**Qr17min** \* **EIRr17min**) |
| P5max | P17max \* (**Qm5max** \* **EIRm5max**) |
| P5full | P5full / (**Qr5full** \* **EIRr5full**) |
| P5min | P5max \* (**Qr5min** \* **EIRr5min**) |
| PTminmax | P5max / ((QTminmax/Q5max) \* ( 1 - **EIRmslopeLCTmax**\*(5°F - Tmin))) |
| PTminmin | P5min / ((QTminmin/Q5min) \* ( 1 - **EIRmslopeLCTmin**\*(5°F - Tmin))) |
| PTminfull | PTminmin + (P5full - P5min)/(P5max - P5min)\*(PTminmax - PTminmin) |
| Q95max | *Q95full* / **Qr95full** |
| Q82max | Q95max / **Qm95max** |
| P95full | *Q95full* / *EER2* |
| P95max | P95full / (**Qr95full** \* **EIRr95full**) |
| P82max | P95max / (**Qm95max** \* **EIRm95max**) |
| Q95min | Q95max \*(0.029 + 0.369\*(Q82max/P82max)/*COP82min*) |
| Q82min | Q95min / **Qm95min** |
| Q82full | Q82min + (*Q95full* - Q95min)/(Q95max - Q95min)\*(Q82max - Q82min) |
| P82min | Q82min / (COP82min \* 3.412 Btu/Wh) |
| P95min | P82min \* (Qm95min \* **EIRm95min**) |
| P82full | P82min + (P95full - P95min)/(P95max - P95min)\*(P82max - P82min) |

## C.*x*.7 Two Stage Systems

Net heating performance data is defined at each combination of two compressor speeds (Minimum and Full) and four outdoor temperatures (Tmin, 5°F, 17°F, and 47°F).

Net cooling performance is defined at each combination of two compressor speeds (Minimum and Full) and two outdoor temperatures (82°F and 95°F).

The following values of normalized data shall be used to determine the full set of performance data:

|  |  |  |
| --- | --- | --- |
| **Quantity** | **Definition/Calculation** | **Value** |
| Qm95full | Q95full/Q82full = 1.0 / fQ,clg,i(67°F,82°F,400W/cfm) | 0.936 |
| EIRm17full | (P17full/Q17full)/(P47full/Q47full) = fEIR,htg,i(70°F,17°F,  400W/cfm) | 1.356 |
| EIRm95full | (P95full/Q95full)/(P82full/Q82full) =  1.0 / fEIR,clg,i(67°F,82°F,400W/cfm) | 1.244 |
| QrHmin | Qmin/Qfull for all heating temperatures | 0.712 |
| EIRrHmin | (Pmin/Qmin)/(Pfull/Qfull) for all heating temperatures | 0.850 |
| QrCmin | Qmin/Qfull for all cooling temperatures | 0.728 |

The following values are determined using bi-linear interpolation of the tables provided. The values in these tables are developed such that the model of the equipment results in consistent seasonal ratings when simulating the AHRI 210/240 2023 test procedures.

*COP47full*:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **HSPF2** |  |  |
| **Qm17full** | 5 | 6.5 | 8 | 9.5 | 11 |
| 0.500 | 1.794 | 2.592 | 3.583 | 4.852 | 6.536 |
| 0.533 | 1.779 | 2.540 | 3.464 | 4.611 | 6.073 |
| 0.600 | 1.757 | 2.456 | 3.270 | 4.227 | 5.371 |
| 0.733 | 1.720 | 2.325 | 2.980 | 3.691 | 4.467 |
| 1.000 | 1.659 | 2.176 | 2.703 | 3.239 | 3.785 |

*COP82min*:

|  |  |  |
| --- | --- | --- |
|  | **SEER2** | |
| **SEER2/EER2** | 6 | 22 |
| 1.000 | 1.777 | 6.517 |
| 2.400 | 2.105 | 7.717 |

Full performance is calculated using the following equations based on the normalized data (in **bold**) and the AHRI certified rating data (in *italics*):

|  |  |
| --- | --- |
| **Value** | **Equation** |
| Q47min | *Q47full* \* **QrHmin** |
| Q17min | *Q17full* \* **QrHmin** |
| P47full | *Q47full* / (*COP47full* \* 3.412 Btu/Wh) |
| P17full | P47full \* ((*Q17full*/*Q47full*) \* **EIRm17full**) |
| P47min | P47full \* (**QrHmin** \* **EIRrHmin**) |
| P17min | P17full \* (**QrHmin** \* **EIRrHmin**) |
| Q82full | Q95full / **Qm95full** |
| Q95min | Q95full \* **QrCmin** |
| Q82min | Q82full \* **QrCmin** |
| P95full | *Q95full* / *EER2* |
| P82full | P95full / (**Qm95full** \* **EIRm95full**) |
| P82min | Q82min / (*COP82min* \* 3.412 Btu/Wh) |
| P95min | P82min \* (**Qm95full** \* **EIRm95full**) |

## C.*x*.7 Single Stage Systems

Net heating performance data is defined at the “Full” compressor speed for four outdoor temperatures (Tmin, 5°F, 17°F, and 47°F).

Net cooling performance is defined at the “Full” compressor speed for two outdoor temperatures (82°F and 95°F).

The following values of normalized data shall be used to determine the full set of performance data:

|  |  |  |
| --- | --- | --- |
| **Quantity** | **Definition/Calculation** | **Value** |
| Qm95full | Q95full/Q82full = 1.0 / fQ,clg,i(67°F,82°F,400W/cfm) | 0.936 |
| EIRm17full | (P17full/Q17full)/(P47full/Q47full) = fEIR,htg,i(70°F,17°F,400W/cfm) | 1.356 |

The following values are determined using bi-linear interpolation of the tables provided. The values in these tables are developed such that the model of the equipment results in consistent seasonal ratings when simulating the AHRI 210/240 2023 test procedures.

*COP47full*:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | **HSPF2** |  |  |
| **Qm17full** | 5 | 6.5 | 8 | 9.5 | 11 |
| 0.500 | 1.971 | 2.844 | 3.933 | 5.327 | 7.178 |
| 0.533 | 1.963 | 2.801 | 3.819 | 5.085 | 6.699 |
| 0.600 | 1.946 | 2.720 | 3.622 | 4.683 | 5.951 |
| 0.733 | 1.915 | 2.589 | 3.318 | 4.111 | 4.975 |
| 1.000 | 1.904 | 2.498 | 3.102 | 3.718 | 4.345 |

Full performance is calculated using the following equations based on the normalized data (in **bold**) and the AHRI certified rating data (in *italics*):

|  |  |
| --- | --- |
| **Value** | **Equation** |
| P47full | *Q47full* / (*COP47full* \* 3.412 Btu/Wh) |
| P17full | P47full \* ((*Q17full*/*Q47full*) \* **EIRm17full**) |
| P95full | *Q95full* / *EER2* |
| Q82full | Q95full / **Qm95full** |
| P82full | Q82full / ((*SEER2*/(1.0 – 0.5\*CD))) where CD=0.08 |

## C.*x*.8 Extrapolation of Performance at other Outdoor Temperatures

Net capacity (total and steady state) and net input power are extrapolated for all speeds according to the table below:

|  |  |  |
| --- | --- | --- |
| **Mode** | **Temperature** | **Extrapolation** |
| Cooling | < 82°F | Linear from 82°F and 95°F cooling performance. Exception: Cooling power extrapolates linearly to the temperature where the lowest speed cooling power is 50% of the lowest speed cooling power at 82°F, and held constant at lower temperatures. |
| Cooling | > 95°F | Linear from 82°F and 95°F cooling performance |
| Heating | Minimum compressor operating temperature (if different from lowest temperature where heating performance is provided) | Linear from lowest two temperatures where heating performance is provided |
| Heating | >47°F | Linear from 17°F and 47°F heating performance |

~~The equipment is assumed to not operate beyond the temperatures listed above.~~

## C.*x*.9 Sensible Cooling Capacity

Calculate gross SHR at AHRI “A” conditions for each speed from:

SHRgross,A,i = 0.708[[1]](#footnote-1)

Calculate “A0” coil constant from Bypass Factor at “A” conditions for each speed, using the Apparatus Dew Point methodology.

Bypass Factor for any speed at given operating conditions is:

BFi = eA0,i/mclg,i

Gross sensible cooling capacity is calculated from the gross total cooling capacity and the Bypass Factor using the corresponding Apparatus Dew Point conditions.

# Defrost

The integrated heating capacity and power of the heat pump shall be reduced for any outdoor drybulb temperature lower than the maximum defrost temperature (40°F) using the equations below[[2]](#footnote-2).

fdef(Todb) = max(min(0.134-0.003\*Todb, 0.08), 0)

Qgross,int,htg,i = Qgross,ss,htg,i\*[1 - 1.8\*fdef(Todb)]

Pgross,int,htg,i = Pgross,ss,htg,i\*[1 - 0.3\*fdef(Todb)]

While defrosting in systems with supplemental heat, the supplemental heat is active and the indoor fan is running during the defrost period. The supplemental heater is cycled or modulated to add exactly enough heat to offset the reduced capacity.

Pan heaters are assumed to operate at 150W whenever the outdoor temperature is below 32°F.

## C.*x*.10 Operating Performance

Operating performance is determined based on the gross performance of the system (interpolated based on outdoor temperature), and the sensible load on the system:

* If the sensible load is less than the minimum capacity of the system at the current operating conditions, the system will cycle between performance at minimum capacity and off. While cycling, a degradation coefficient of 0.08 shall be applied to single stage and two stage systems, and a degradation coefficient of 0.40 shall be applied to variable speed systems.
* If the sensible load is greater than the maximum capacity of the system at the current operating conditions, the system will operate at maximum capacity.
* If the sensible load is between the capacity of two speeds, the gross performance is interpolated using the ratio of the load to the gross sensible capacities at the speeds above and below the load.

When cycling, the cycling ratio is the ratio of the sensible load to the minimum sensible capacity at the current operating conditions:

fcyc = Loadsen/Qsen,min

The additional energy related to cycling degradation is accounted for by adjusting the power:

Pgross,cyc = Pgross,min/[1+CD\*(fcyc - 1)]

## C.*x*.11 Indoor Fan Energy

The measured operational flow rate, Vop,measured, and fan power, Pfan,op,measured, shall be measured at a known mode (htg/clg) and compressor speed, i, according to RESNET/ACCA 310.

vop = Vop,measured/(Qnet,mode,A/H1,i\*(0.083 ton/(kBtu/hr)))

The operational airflow rate shall be calculated at all other combinations of mode and compressor speed:

Vop,clg,i = vop\*Qnet,tot,clg,A,i\*(0.083 ton/(kBtu/hr))

Vop,htg,ss,i = vop\*Qnet,ss,htg,H1,i\*(0.083 ton/(kBtu/hr))

Operational fan power for each mode and compressor speed shall be calculated

**BPM Motors (Ducted Systems):** Pfan,op,mode,i = Pfan,op,measured\*(Vop,mode,i/Vop,measured)2.75

**BPM Motors (Ductless Systems):** Pfan,op,mode,i = Pfan,op,measured\*(Vop,mode,i/Vop,measured)3

**PSC Motors:** Pfan,op,mode,i = Pfan,op,measured\*(Vop,mode,i/Vop,measured)\*(0.3\*(Vop,mode,i/Vop,measured) + 0.7))

## C.*x*.12 Supplemental Heating

Supplemental heating shall ~~only~~ operate when there is not adequate capacity (in the compressor and/or gas backup) to meet the full load, including when the outdoor temperature falls below the minimum compressor operating temperature. Supplemental heating shall only provide the additional amount of heat to meet the load. The supplemental heating capacity in both the Rated Home and the Reference Home shall be sized to meet the building heating load.

If the system does not have supplemental heating, the system in the Rated Home shall include electric resistance supplemental heat that operates only when the integrated heating capacity is not adequate to meet the load (and not during defrost operation).

## C.*x*.13 Standby Power

Crankcase power = 10 W per ton of rated full load net cooling capacity when the system is not on and the temperature is below 50°F.

**C.*x*.14 Minimum Rated Features**

|  |  |  |  |
| --- | --- | --- | --- |
| **Feature** | **Description** | **Source** | **Default** |
| Qnet,tot,clg,A,full | Rated full load net total cooling capacity at AHRI  “A” (95°F) conditions | AHRI Certificate/Directory | Required |
| SEER2 | Seasonal Energy Efficiency Ratio as defined by AHRI 210/240-2023 | AHRI Certificate | Required |
| EER2 | Energy Efficiency Ratio at AHRI “A” (95°F) conditions as defined by AHRI  210/240-2023 | AHRI Certificate | Required |
| Qnet,ss,htg,H1,full | Rated full load net steady-state heating capacity at AHRI “H1” (47°F) conditions | AHRI Certificate | Required |
| Qnet,ss,htg,H3,full | Rated full load net steady-state heating capacity at AHRI “H3” (17°F) conditions | AHRI Certificate | Required |
| HSPF2 | Heating Seasonal Performance Factor as defined by AHRI 210/240-2023 | AHRI Certificate | Required |
| Number of  Speeds/stages | Number of speeds/stages used in compressor control: | Product Literature | Required |
|  | Single Stage  Two Stage  Variable Capacity |  |  |
| Fan Motor Type | Type of motor used by the indoor fan | Product Literature | Permanent Split Capacitor (PSC) for single speed equipment, otherwise Brushless Permanent Magnet  (BPM) |
| Type of  Supplemental  Heating | Electric Resistance  Fossil Fuel Furnace  None | Product literature, visual inspection | Electric Resistance |
| Minimum  Compressor  Operating  Temperature | Minimum outdoor temperature for compressor heating operation | For Electric  Resistance Supplemental Heating:  Product Literature,  NEEP Database  Lowest Catalogued  Temperature (LCT)  For Fossil Fuel Supplemental Heating:  30°F | For Electric Resistance Supplemental Heating:  Number of Speeds <= 2: 0°F  Number of Speeds > 2: -20°F      For Fossil Fuel Supplemental Heating:  No Default |
| ~~Maximum~~  ~~Compressor~~  ~~Operating~~  ~~Temperature~~ | ~~Maximum~~  ~~temperature for~~ ~~compressor cooling~~ ~~operation~~ | ~~Product Literature~~ | ~~125°F~~ |

1. (Informative) Based on regressions developed by Proctor Engineering, min(1, -0.3890114 + 0.002743\*vrated,clg,i) [↑](#footnote-ref-1)
2. (Informative) Based on Central Valley Research Homes project data [↑](#footnote-ref-2)