BSR/ASHRAE/IES Addendum Y
to ANSI/ASHRAE/IES Standard 90.1-2019

Public Review Draft

Proposed Addendum Y to Standard 90.1-2019, Energy Standard for Buildings Except Low-Rise Residential Buildings

Second Public Review (May 2021)
(Draft Shows Proposed Independent Substantive Changes to Previous Public Review Draft)

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FOREWORD

Addendum Y has completed a first public review. There were some comments that necessitate an ISC to the first public review.

Refer the first public review of addendum Y for the changes that were introduced in the first public review. Only the changes being proposed as part of the second public review ISC are shown relative to the first public review are open for comments. The following is a summary of the proposed ISC changes.

ISC Change Summary

1. The first public review of the addendum included updated references to the new AHRI 550/590 (I-P)-2020 and AHRI551/591(SI)-2020 standards but the current language in first public review of addendum Y was not aligned with the formatting and naming approach in the AHRI standards so we will make some further updates in this second public review ISC.
2. Recently ASHRAE 90.1-2019 addendum X was released for public review and one of the comments recommended changing “fluid” to “liquid” in table 6.8.1-3, and there is a 2nd Public Review ISC for addendum X that has been generated to make this change. This ISC will also change the word “fluid” used to describe the heat transfer substance that is used in condensers and evaporators to “liquid”. The word “fluid” has been used in ASHRAE 90.1 since the 2004 version. But “fluid” is too general because it also could include air or any gas. Thus, it overlaps with and would technically also include "air-cooled" chillers, which was not the intent of the standard as air-cooled is separately covered in the requirements. Note that ASHRAE Standard 184-2016 refers to liquid-cooled, evaporatively-cooled, and air-cooled as the types of heat rejection in a refrigerant condenser (see Table 5-1). Also, the title of ASHRAE Standard 30 is "Method of Testing Liquid Chillers". AHRI 550/590(I-P) and AHRI 55 1/591(SI) also are being updated to switch to the use of word “liquid”.
3. In the column headers for the heating efficiency metrics, a comment was submitted to move footnote b from sub-title headers to the top-level header. This change makes sense as the a three sub-headers have the footnote b as shown below;

   Cooling Operation Efficiency [a,d,e,j]
   Heating Operation Efficiency, [b,e,j]
   Heat Pump Heating Full Load Heating Efficiency (COP_H) [~~b,~~f,h] ,W/W
   Simultaneous Cooling and Heating Full-Load Efficiency (COP_{SHC}) [~~b,~~i] ,W/W
   Heat Recovery Heating Full-Load Efficiency (COP_{HR}) [~~b,~~c,j] ,W/W

4. The title of the table has been changed from "Chillers" to "Water-Chilling Packages" to align with what is used in Table 6.8.1-3 and in AHRI 550/590(I-P) and AHRI 551/591(SI). The table efficiencies are for water-based applications but does define procedures to cover chillers with freeze protection liquids with a setpoint above 32 °F [0 °C]. In the foot notes the product name is also changed from "chillers" to "chilling packages" but we did not use "water-chilling" as many of the footnotes are covering how to address freeze protection liquids.
5. Added footnote n to clarified that the capacity category is refrigerating capacity in cooling mode. We used "refrigerating capacity" vs "cooling capacity" because AHRI 550/590(I-P) and AHRI 550/590 (SI) uses refrigerating to define the cooling mode capacity. This is similar to the other tables like 6.8.1-2 where the capacity is the cooling mode capacity and not the heating model capacity.
6. Added definitions for *heat recovery coefficient of performance (COP_{HR})* and s*imultaneous cooling and heating coefficient of performance (COP_{SHC})* as also added the abbreviations to section 3.3. The definitions align with AHRI 550/591 (I-P 2020) and AHRI 551/591 (SI 2020).
7. Note m is expanded to clarify the cooling evaporator liquid flow ratings requirements for heating operation and for heating only chiller operation that are not fully addressed in AHRI 550/590 and AHRI 551/591. The flow rates for combined heating and cooling flow rates are defined in AHRI 550/590 and AHRI 551/591 but we have also included the AHRI requirements for clarity.
8. Clarified the minimum requirements for a chiller package to be considered a heat recovery chiller package vs a desuperheater which is not covered by the requirements of 6.8.1-16.
9. Added note p to define what NA means following the method used in table 6.8.1-3
10. Added note q to clarify that water-to-water heat pumps with a capacity less than 135,000 Btu/h are covered by table 6.8.1-15
11. Increased the significant figures for rating conditions to align with AHRI 550/590 (I-P) and AHRI 551/591 (SI)
12. Made some corrections to the SI tables that introduced errors in the first public review that will appear as changes in the 2nd public review ISC, but these changes correct the errors and align with the published 2019 standard.
13. Made some editorial and italics corrections.

Cost Effectiveness

This addendum is just making editorial and requirement clarification corrections to the table 6.8.1-16 so cost effectiveness is not impacted.

[Note to Reviewers: This addendum makes proposed changes to the current standard. These changes are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) except where the reviewer instructions specifically describe some other means of showing the changes. Only these changes to the current standard are open for review and comment at this time. Additional material is provided for context only and is not open for comment except as it relates to the proposed changes.

Addendum Y to 90.1-2019

AHRI updated the reference standard AHRI 550/590 from 2018 to 2020 in section 12 (I-P). Make the following changes in section 12 (I-P)

Reference	Title
AHRI 550/590 (I-P)-2020	Performance Rating of Water-~~C~~chilling and Heat- Pump Water-~~H~~heating Packages Using the Vapor Compression Cycle

AHRI updated the reference standard AHRI 550/590 from 2018 to 2020 in section 12 (I-P). Make the following changes in section 12 (SI).

Reference	Title
AHRI 551/591 (SI)-2020	Performance Rating of Water-~~C~~chilling and Heat- Pump Water-~~H~~heating Packages Using the Vapor Compression Cycle

Add the following new definitions to section 3.2 which are aligned with the definitions in AHRI 550/590 (I-P) and AHRI 551/591 (SI)

…

heat recovery coefficient of performance (COP_{HR}) A ratio of the net heat recovery capacity plus the net refrigerating capacity to the total input Power at any given set of Rating Conditions. COP_{HR} applies to units that are operating in a manner that uses either all or only a portion of heat generated during chiller operation to heat a load, while the remaining heat, if any, is rejected to the outdoor ambient. COP_{HR} takes into account the beneficial cooling capacity, as well as the heat recovery capacity.

…

simultaneous cooling and heating coefficient of performance (COP_{SHC}) A ratio of the net heating capacity plus the net refrigerating capacity to the total input power at any given set of rating conditions. COP_{SHC} applies to units that are operating in a manner that uses both the net heating and refrigerating capacities generated during operation. COP_{SHC} takes into account the beneficial capacity, as well as the heating capacity.

…

Add the following to Section 3.3 (I-P and SI)

…

COP_{HR} *heat recovery coefficient of performance*
COP_{SHC} *simultaneous cooling and heating coefficient of performance*

…

Revise section 6.4.1.1 (I-P) and (SI) to change the title of the table 6.8.1-16 for item 6.4.1.1(p)

6.4.1.1 Minimum Equipment Efficiencies—Listed Equipment—Standard Rating and Operating Conditions

Equipment shown in Tables 6.8.1-1 through 6.8.1-20 shall have a minimum performance at the specified rating conditions when tested in accordance with the specified test procedure. Where multiple rating conditions or performance requirements are provided, the *equipment* shall satisfy all stated requirements unless otherwise exempted by footnotes in the table. *Equipment* covered under the Federal Energy Policy Act of 1992 (EPACT) shall have no minimum *efficiency* requirements for operation at minimum capacity or other than standard rating conditions. *Equipment* used to provide *service water-heating* functions as part of a combination system shall satisfy all stated requirements for the appropriate *space* heating or cooling category.

…..

p. Table 6.8.1-16, "Heat Pump and Heat Recovery ~~Chiller~~ Water-Chilling Packages—Minimum *Efficiency* Requirements"

Make the following changes to the IP table 6.8.1-16 *(note: footnotes are shown once, beginning on page 6)*

Table 6.8.1-16 Heat Pump and Heat Recovery ~~Chiller~~ Water-Chilling Packages – Minimum *Efficiency* Requirements

~~Equipment~~ *Equipment* Type	Size Category refrigerating capacity[n] ton_R	Cooling Operation *Efficiency*[a,d,e,j] Air Source (~~EER~~*EER* FL/*IPLV*), Btu/W-h ~~Fluid~~-Liquid-Source Power Input per Capacity (FL/~~IPLV~~*IPLV*) kW/ton_R		Heating Operation *Efficiency* [b,e,j]													Test Procedure
				Heating Source Conditions (leaving ~~fluid~~ liquid) or OAT (db/wb)[g] °F	Heat Pump Heating Full Load Heating *Efficiency* (COP_H)[b,f,h], W/W				Simultaneous Cooling and Heating Full-Load *Efficiency* (COP_{SHC})[b,i], W/W				Heat Recovery Heating Full-Load *Efficiency* (COP_{HR})[b,c,j], W/W				
					Entering/Leaving Heating ~~Fluid~~-Liquid Temperature				Entering/Leaving Heating ~~Fluid~~-Liquid Temperature				Entering/Leaving Heating ~~Fluid~~-Liquid Temperature				
		Path A	Path B		Low	Medium	High	Boost	Low	Medium	High	Boost	Low	Medium	Hot Water 1	Hot Water 2	
					95.00°F/ 105.00°F	105.00°F/ 120.00°F	120.00°F/ 140.00°F	120.00°F/ 140.00°F	95.00°F/ 105.00°F	105.00°F/ 120.00°F	120.00°F/ 140.00°F	120.00°F/ 140.00°F	95.00°F/ 105.00°F	105.00°F/ 120.00°F	90.00°F/ 140.00°F	120.00°F/ 140.00°F	
Air-Source	<150.0	≥9.595 FL ≥13.02 *IPLV*.IP	≥9.215 FL ≥15.01 *IPLV*.IP	47.00 db 43.00 wb[l]	≥3.290	≥2.770	≥2.310	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	AHRI 550/590
				17.00 db 15.00 wb[l]	≥2.029	≥1.775	≥1.483	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	
	≥150.0	≥9.595 FL ≥13.30 *IPLV*.IP	≥9.215 FL ≥15.30 *IPLV*.IP	47.00 db 43.00 wb[l]	≥3.290	≥2.770	≥2.310	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	
				17.00 db 15.00 wb[l]	≥2.029	≥1.775	≥1.483	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	
~~Fluid~~-Liquid-Source electrically operated positive displacement	≥11.25[q] and < 75.00	≤ 0.7895 FL ≤0.6316 *IPLV*.IP	≤0.8211FL ≤ 0.5263 *IPLV*.IP	44.00[m]	≥4.640	≥3.680	≥2.680	NA[p]	≥8.330	≥6.410	≥4.420	NA[p]	≥8.330	≥6.410	≥4.862	≥4.420	AHRI 550/590
				65.00[m]	NA[p]	NA[p]	NA[p]	≥3.550	NA[p]	NA[p]	NA[p]	≥6.150	NA[p]	NA[p]	NA[p]	NA[p]	
	≥75.00 and <150.0	≤0.7579 FL ≤0.5895 *IPLV*.IP	≤0.7895 FL ≤ 0.5158 *IPLV*.IP	44.00[m]	≥4.640	≥3.680	≥2.680	NA	≥8.330	≥6.410	≥4.420	NA	≥8.330	≥6.410	≥4.862	≥4.420	
				65.00[m]	NA[p]	NA[p]	NA[p]	≥3.550	NA[p]	NA[p]	NA[p]	≥6.150	NA[p]	NA[p]	NA[p]	NA[p]	
	≥150.0 and <300.0	≤0.6947 FL ≤0.5684 *IPLV*.IP	≤0.7158 FL ≤0.4632 *IPLV*.IP	44.00[m]	≥4.640	≥3.680	≥2.680	NA[p]	≥8.330	≥6.410	≥4.420	NA[p]	≥8.330	≥6.410	≥4.862	≥4.420	
				65.00[m]	NA[p]	NA[p]	NA[p]	≥3.550	NA[p]	NA[p]	NA[p]	≥6.150	NA[p]	NA[p]	NA[p]	NA[p]	
	≥300.0 and <600.0	≤0.6421 FL ≤0.5474 *IPLV*.IP	≤0.6579 FL ≤0.4316 *IPLV*.IP	44.00[m]	≥4.930	≥3.960	≥2.970	NA	≥8.900	≥6.980	≥5.000	NA[p]	≥8.900	≥6.980	≥5.500	≥5.000	
				65.00[m]	NA[p]	NA[p]	NA[p]	≥3.900	NA[p]	NA[p]	NA[p]	≥6.850	NA[p]	NA[p]	NA[p]	NA[p]	
	≥600.0	≤0.5895 FL ≤0.5263 *IPLV*.IP	≤0.6158 FL ≤0.4000 *IPLV*.IP	44.00[m]	≥4.930	≥3.960	≥2.970	NA	≥8.900	≥6.980	≥5.000	NA[p]	≥8.900	≥6.980	≥5.500	≥5.000	
				65.00[m]	NA[p]	NA[p]	NA[p]	≥3.900	NA[p]	NA[p]	NA[p]	≥6.850	NA[p]	NA[p]	NA[p]	NA[p]	

…

Table 6.8.1-16 Heat Pump and Heat Recovery ~~Chiller~~ Water-Chilling Packages – Minimum *Efficiency* Requirements *(continued)*

~~Equipment~~ *Equipment* Type	Size Category refrigerating capacity[n] ton$_R$	Cooling Operation *Efficiency*[a,d,e,j] Air Source (EER FL/*IPLV*), Btu/W-h ~~Fluid~~ Liquid-Source Power Input per Capacity (FL/~~IPLV~~*IPLV*) kW/ton$_R$		Heating Operation *Efficiency*[b,e,j]												Test Procedure
				Heating Source Conditions (leaving ~~fluid~~ liquid) or OAT (db/wb)[g] °F	Heat Pump Heating Full Load Heating *Efficiency* (COP_H)[b,~~f~~,h], W/W				Simultaneous Cooling and Heating Full-Load *Efficiency* (COP_{SHC})[b,~~i~~,j], W/W				Heat Recovery Heating Full-Load *Efficiency* (COP_{HR})[b,~~c~~,j], W/W			
					Entering/Leaving Heating ~~Fluid~~ Liquid Temperature				Entering/Leaving Heating ~~Fluid~~ Liquid Temperature				Entering/Leaving Heating ~~Fluid~~ Liquid Temperature			
		Path A	Path B		Low	Medium	High	Boost	Low	Medium	High	Boost	Low	Medium	Hot Water 1	Hot Water 2	
					95.00°F/ 105.00°F	105.00°F/ 120.00°F	120.00°F/ 140.00°F	120.00°F/140.00°F	95.00°F/ 105.00°F	105.00°F/ 120.00°F	120.00° F/ 140.00° F	120.00°F/ 140.00°F	95.00°F/ 105.00°F	105.00°F/ 120.00°F	90.00°F/ 140.00°F	120.00°F/ 140.00°F	
~~Fluid~~ Liquid-source electrically operated centrifugal	≥11.25[q] and < 75.00	≤0.6421 FL ≤0.5789 *IPLV*.IP	≤0.7316 FL ≤0.4632 *IPLV*.IP	44.00[m]	≥4.640	≥3.680	≥2.680	NA[p]	≥8.330	≥6.410	≥4.420	NA[p]	≥8.330	≥6.410	≥4.862	≥4.420	AHRI 550/590
				65 00[m]	NA[p]	NA[p]	NA[p]	≥3.550	NA[p]	NA[p]	NA[p]	≥6.150	NA[p]	NA[p]	NA[p]	NA[p]	
	≥75.00 and <150.0	≤0.5895 FL ≤0.5474 *IPLV*.IP	≤0.6684 FL ≤0.4211 *IPLV*.IP	44 00[m]	≥4.640	≥3.680	≥2.680	NA	≥8.330	≥6.410	≥4.420	NA	≥8.330	≥6.410	≥4.862	≥4.420	
				65 00[m]	NA[p]	NA[p]	NA[p]	≥3.550	NA[p]	NA[p]	NA[p]	≥6.150	NA[p]	NA[p]	NA[p]	NA[p]	
	≥150.0 and <300.0	≤0.5895 FL ≤0.5263 *IPLV*.IP	≤0.6263 FL ≤0.4105 *IPLV*.IP	44 00[m]	≥4.640	≥3.680	≥2.680	NA[p]	≥8.330	≥6.410	≥4.420	NA[p]	≥8.330	≥6.410	≥4.862	≥4.420	
				65 00[m]	NA[p]	NA[p]	NA[p]	≥3.550	NA[p]	NA[p]	NA[p]	≥6.150	NA[p]	NA[p]	NA[p]	NA[p]	
	≥300.0 and <600.0	≤0.5895 FL ≤0.5263 *IPLV*.IP	≤0.6158 FL ≤0.4000 *IPLV*.IP	44 00[m]	≥4.930	≥3.960	≥2.970	NA	≥8.900	≥6.980	≥5.000	≥NA	≥8.900	≥6.980	≥5.500	≥5.000	
				65 00[m]	NA[p]	NA[p]	NA[p]	≥3.900	NA[p]	NA[p]	NA[p]	≥6.850	NA[p]	NA[p]	NA[p]	NA[p]	
	≥600.0	≤0.5895 FL ≤0.5263 *IPLV*.IP	≤0.6158 FL ≤0.4000 *IPLV*.IP	44 00[m]	≥4.930	≥3.960	≥2.970	NA[p]	≥8.900	≥6.980	≥5.000	NA[p]	≥8.900	≥6.980	≥5.500	≥5.000	
				65 00[m]	NA[p]	NA[p]	NA[p]	≥3.900	NA[p]	NA[p]	NA[p]	≥6.850	NA[p]	NA[p]	NA[p]	NA[p]	

a. Cooling rating conditions are standard rating conditions defined in AHRI 550/590 (I-P) Table 4, except for ~~fluid~~ liquid-cooled centrifugal ~~chillers~~ chilling packages which can adjust cooling *efficiency* for nonstandard rating conditions using $K_{~~adj~~adj}$ procedure in accordance with Section 6.4.1.2.1

b. Heating Full Load Rating conditions are at standard rating conditions defined in AHRI 550/590 (I-P) Table 4 and includes the impact of defrost for air source heating ratings

c. For ~~fluid~~ liquid-source heat recovery ~~chillers~~ chilling packages that have capabilities for heat rejection to a heat recovery condenser and a tower condenser the COP_{HR} applies to operation at full load with 100% heat recovery (no tower rejection). Units that only have capabilities for partial heat recovery shall meet the requirements of Table 6.8.1-3

d For cooling operation compliance with both the FL and *IPLV* is required, but only compliance with Path A or Path B cooling *efficiency* is required.

e For units that operate in both cooling and heating compliance with both the cooling and heating *efficiency* is required.

f. For applications where the ~~equipment~~ chilling package is installed to operate only in heating compliance only with the heating performance COP_H is required ~~at standard rating conditions~~ at only one of the heating AHRI 550/590 (I-P) standard ratings conditions of Low, Medium, High, or Boost. Compliance with cooling performance is not required.

g. For air-source heat pumps compliance with both the 47.00 ºF and 17.00 ºF heating source OAT rating *efficiency* is required for heating.

h. For Heat Pump ~~chillers~~ chilling packages applications where the cooling capacity is not being used for conditioning, compliance with the heating performance COP_H is only required at ~~only~~ one of the four heating AHRI 550/590 (I-P) standard ratings conditions of Low, Medium, High, or Boost. Compliance with the cooling performance is required as defined in footnote a and d.

i. For simultaneous cooling and heating ~~chillers~~ chilling packages applications where there is simultaneous cooling and heating, compliance with the simultaneous cooling performance heat recovery COP_{SHC} at only one of the simultaneous cooling and heating AHRI 550/590 (I-P) standard ratings conditions of Low, Medium, High, or Boost. Compliance with the cooling only performance is required as defined in footnote a and d except as noted in footnote f.

j. For heat recovery ~~heating~~ ~~chillers~~ chilling packages applications where there is simultaneous cooling and heating, compliance with the heating performance heat recovery COP_{HR} is required at only one of the heating AHRI 550/590 (I-P) standard ratings conditions of Low, Medium, Hot Water 1, or Hot Water 2. Compliance with the cooling only performance is required as defined in footnote a and d.

k. ~~Chillers~~ Chilling packages employing a freeze-protection ~~fluid~~ liquid in accordance with Section 6.4.1.2.2 shall be tested or rated with water for the purpose of compliance with the requirements of this table.

l. Outdoor air entering dry bulb (db) temperature and wet bulb (wb) temperature.

m. Source-leaving ~~fluid~~ liquid temperature.
- The cooling evaporator liquid flow rate used for the heating rating for a reverse cycle air to water heat pumps shall be the flow rate determined during the full load cooling rating.
- The cooling evaporator liquid flow rate for the simultaneous cooling and heating and heat recovery liquid cooled chilling packages rating shall be the liquid flow rates from the cooling operation full load rating.
- For heating only fluid to fluid chiller packages the evaporator flow rate obtained with an entering liquid temperature of 54.00 °F and a leaving liquid temperature of 44.00 °F shall be used.

n. The Size category is the full load net refrigerating cooling mode capacity which is the capacity of the evaporator available for cooling of the thermal load external to the chilling package.

o A heat recovery condenser at its maximum load point must remove enough heat from the refrigerant to cool the refrigerant to remove all superheat energy and enter into condensation of the refrigerant. A heat recovery system where only the superheat is reduced is not covered by table 6.8.1-16 and is considered a desuperheater and the chiller package must comply with table 6.8.1-3.

p. NA means the requirements are not applicable.
q. Water-to-water heat pumps with a capacity less than 135,000 Btu/h are covered by table 6.8.1.15

Make the following changes to the SI Table 6.8.1-16 (note: footnotes are shown once, on page 8)

Table 6.8.1-16 Heat Pump and Heat Recovery ~~Chiller~~ Water-Chilling Packages – Minimum *Efficiency* Requirements

~~Equipment~~ *Equipment* Type	Size Category refrigerating capacity[n] *kW*	Cooling Operation Efficiency [a,d,e,j] (Air Source ~~COP~~*COP*$_C$, FL/*IPLV* W/W) ~~Fluid~~ Liquid-Source ~~Power Input per Capacity~~ *COP*$_C$ (FL/*IPLV*) W/W		Heating Operation *Efficiency* [b,e,j]													Test Procedure
				Heating Source Conditions (leaving ~~fluid~~ liquid) or OAT (db/wb)[g] °C	Heat Pump Heating Full Load Heating *Efficiency* (*COP*$_H$)[b,f,h], W/W				Simultaneous Cooling and Heating Full-Load *Efficiency* (*COP*$_{SHC}$)[b,i], W/W				Heat Recovery Heating Full-Load *Efficiency* (*COP*$_{HR}$)[b,c,i], W/W				
					Entering/Leaving Heating ~~Fluid~~ Liquid Temperature				Entering/Leaving Heating ~~Fluid~~ Liquid Temperature				Entering/Leaving Heating ~~Fluid~~ Liquid Temperature				
		Path A	Path B		Low	Medium	High	Boost	Low	Medium	High	Boost	Low	Medium	Hot Water 1	Hot Water 2	
					35.00°C/ 40.00°C	42.00°C/ 50.00°C	50.00°C/ 60.00°C	50.00°C/ 60.00°C	35.00°C/ 40.00°C	42.00°C/ 50.00°C	50.00°C/ 60.00°C	50.00°C/ 60.00°C	35.00°C/ 40.00°C	42.00°C/ 50.00°C	32.00°C/ 60.00°C	50.00°C/ 60.00°C	
Air-Source	≥39.57[q] and <~~150~~527.0	~~<528 kW~~ ≥2.836 FL ≥3.846 *IPLV*.SI	~~≥2.836 FL~~ ~~≥3.846 *IPLV*.SI~~ ≥2.723 FL ≥4.436 *IPLV*.SI	8.00 db[d] 6.00 wb[l]	≥3.250	≥2.720	≥3.330	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	AHRI 551/591
				-8.00 db[d] -9.00 wb[l]	≥2.048	≥1.747	≥1.492	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	
	≥~~150~~527.0	~~≥528 kW~~ ≥2.836 FL ≥3.930 *IPLV*.SI	~~≥2.836 FL~~ ~~≥3.930 *IPLV*.SI~~ ≥2.723 FL ≥4.520 *IPLV*.SI	8.00 db 6.00 wb[l]	≥3.250	≥2.720	≥3.330	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	
				-8.00 db -9.00 wb[l]	≥2.048	≥1.747	≥1.492	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	NA[p]	
~~Fluid~~ Liquid-Source electrically operated positive displacement	~~< 75~~-< 264.0	~~< 264~~ ≥4.459 FL ≥5.574 *IPLV*.SI	~~≥4.459 FL~~ ~~≥5.574 *IPLV*.SI~~ ≥4.287 FL ≥6.689 *IPLV*.SI	7.00 [m]	≥4.760	≥3.610	≥2.660	NA[p]	≥8.550	≥6.290	≥4.390	NA[p]	≥8.550	≥6.290	≥4.829	≥4.390	AHRI 551/591
				19.00 [m]	NA[p]	NA[p]	NA[p]	≥3.530	NA[p]	NA[p]	NA[p]	≥6.100	NA[p]	NA[p]	NA[p]	NA[p]	
	~~≥75 and <150~~ ≥264.0 and <528.0	~~≥264 and <528~~ ≥4.645 FL ≥5.972 *IPLV*.SI	~~≥4.645 FL~~ ~~≥5.972 *IPLV*.SI~~ ≥4.459 FL ≥6.825 *IPLV*.SI	7.00 [m]	≥4.760	≥3.610	≥2.660	NA	≥8.550	≥6.290	≥4.390	NA	≥8.550	≥6.290	≥4.829	≥4.390	
				19.00 [m]	NA[p]	NA[p]	NA[p]	≥3.530	NA[p]	NA[p]	NA[p]	≥6.100	NA[p]	NA[p]	NA[p]	NA[p]	
	~~≥150 and <300~~ ≥528.0 and <1055	~~≥528 and <1055~~ ≥5.067 FL ≥6.193 *IPLV*.SI	~~≥5.067 FL~~ ~~≥6.193 *IPLV*.SI~~ ≥4.918 FL ≥7.601 *IPLV*.SI	7.00 [m]	≥4.760	≥3.610	≥2.660	NA[p]	≥8.550	≥6.290	≥4.390	NA[p]	≥8.550	≥6.290	≥4.829	≥4.390	
				19.00 [m]	NA[p]	NA[p]	NA[p]	≥3.530	NA[p]	NA[p]	NA[p]	≥6.100	NA[p]	NA[p]	NA[p]	NA[p]	
	~~≥300 and <600~~ ≥1055 and <2110	~~≥1055 and <2110~~ ≥5.482 FL ≥6.432 *IPLV*.SI	~~≥5.482 FL~~ ~~≥6.432 *IPLV*.SI~~ ≥5.351 FL ≥8.157 *IPLV*.SI	7.00 [m]	≥5.060	≥3.880	≥2.950	NA[p]	≥9.140	≥6.850	≥4.960	NA[p]	≥9.140	≥6.850	≥5.456	≥4.960	
				19.00 [m]	NA[p]	NA[p]	NA[p]	≥3.870	NA[p]	NA[p]	NA[p]	≥6.800	NA[p]	NA[p]	NA[p]	NA[p]	
	~~≥600~~ ≥2110	~~≥2110~~ ≥5.972 FL ≥6.689 *IPLV*.SI	~~≥5.972 FL~~ ~~≥6.689 *IPLV*.SI~~ ≥5.717 FL ≥8.801 *IPLV*.SI	7.00 [m]	≥5.060	≥3.880	≥2.950	NA[p]	≥9.140	≥6.850	≥4.960	NA[p]	≥9.140	≥6.850	≥5.456	≥4.960	
				19.00 [m]	NA[p]	NA[p]	NA[p]	≥3.870	NA[p]	NA[p]	NA[p]	≥6.800	NA[p]	NA[p]	NA[p]	NA[p]	

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Table 6.8.1-16 Heat Pump and Heat Recovery ~~Chiller~~ Water-Chilling Packages – Minimum *Efficiency* Requirements *(continued)*

~~Equipment~~ *Equipment* Type	Size Category refrigerating capacity[n] *kW*	Cooling Operation Efficiency [a,d,e,j] (Air Source ~~COP~~*COP*$_C$, FL/*IPLV* W/W) ~~Fluid~~ Liquid ~~Power Input per Capacity~~ *COP*$_C$ (FL/*IPLV*) W/W		Heating Source Conditions (leaving ~~fluid~~ liquid) or OAT (db/wb)[g] °C	Heating Operation *Efficiency* [b,e,j]											
					Heat Pump Heating Full Load Heating *Efficiency* (*COP*$_H$)[b,f,h] , W/W				Simultaneous Cooling and Heating Full-Load *Efficiency* (*COP*$_{SHC}$)[b,i] ,W/W				Heat Recovery Heating Full-Load *Efficiency* (*COP*$_{HR}$)[b,c,j] ,W/W			
					Entering/Leaving Heating ~~Fluid~~ Liquid Temperature				Entering/Leaving Heating ~~Fluid~~ Liquid Temperature				Entering/Leaving Heating ~~Fluid~~ Liquid Temperature			
		Path A	Path B		Low	Medium	High	Boost	Low	Medium	High	Boost	Low	Medium	Hot Water 1	Hot Water 2
					35.00°C/ 40.00°C	42.00°C/ 50.00°C	50.00°C/ 60.00°C	50.00°C/ 60.00°C	35.00°C/ 40.00°C	42.00°C/ 50.00°C	50.00°C/ 60.00°C	50.00°C/ 60.00°C	35.00°C/ 40.00°C	42.00°C/ 50.00°C	32.00°C/ 60.00°C	50.00°C/ 60.00°C
~~Fluid~~ Liquid-source electrically operated centrifugal	< 264.0	≥5.482 FL ≥6.081 *IPLV*.SI	≥4.812 FL ≥7.601 *IPLV*.SI	7.00 [m]	≥4.760	≥3.610	≥2.660	NA	≥8.550	≥6.290	≥4.390	NA	≥8.550	≥6.290	≥4.829	≥4.390
				19.00 [m]	NA[p]	NA[p]	NA[p]	≥3.530	NA[p]	NA[p]	NA[p]	≥6.100	NA[p]	NA[p]	NA[p]	NA[p]
	≥264.0 and <528.0	≥5.482 FL ≥6.081 *IPLV*.SI	≥5.267 FL ≥ 8.361 *IPLV*.SI	7.00 [m]	≥4.760	≥3.610	≥2.660	NA	≥8.550	≥6.290	≥4.390	NA	≥8.550	≥6.290	≥4.829	≥4.390
				19.00 [m]	NA[p]	NA[p]	NA[p]	≥3.530	NA[p]	NA[p]	NA[p]	≥6.100	NA[p]	NA[p]	NA[p]	NA[p]
	≥528.0 and <1055	≥5.972 FL ≥6.432 *IPLV*.SI	≥5.621 FL ≥8.576 *IPLV*.SI	7.00 [m]	≥4.760	≥3.610	≥2.660	NA	≥8.550	≥6.290	≥4.390	NA	≥8.550	≥6.290	≥4.829	≥4.390
				19.00 [m]	NA[p]	NA[p]	NA[p]	≥3.530	NA[p]	NA[p]	NA[p]	≥6.100	NA[p]	NA[p]	NA[p]	NA[p]
	≥1055 and <2110	≥5.972 FL ≥6.689 *IPLV*.SI	≥5.717 FL ≥8.801 *IPLV*.SI	7.00 [m]	≥5.060	≥3.880	≥2.950	NA	≥9.140	≥6.850	≥4.960	NA	≥9.140	≥6.850	≥5.456	≥4.960
				19.00 [m]	NA[p]	NA[p]	NA[p]	≥3.870	NA[p]	NA[p]	NA[p]	≥6.800	NA[p]	NA[p]	NA[p]	NA[p]
	≥2110	≥5.972 FL ≥6.689 *IPLV*.SI	≥5.717 FL ≥8.801 *IPLV*.SI	7.00 [m]	≥5.060	≥3.880	≥2.950	NA[p]	≥9.140	≥6.850	≥4.960	NA[p]	≥9.140	≥6.850	≥5.456	≥4.960
				19.00 [m]	NA[p]	NA[p]	NA[p]	≥3.870	NA[p]	NA[p]	NA[p]	≥6.800	NA[p]	NA[p]	NA[p]	NA[p]

Test Procedure
AHRI 551/591

a. Cooling rating conditions are standard rating conditions defined in AHRI ~~550/590~~551/591 (SI) Table 4, except for ~~fluid~~ liquid-cooled centrifugal ~~chillers~~ chilling packages which can adjust cooling *efficiency* for nonstandard rating conditions using K~~adj~~adj procedure in accordance with Section 6.4.1.2.1
b. Heating Full Load Rating conditions are at standard rating conditions defined in AHRI ~~550/590~~551/591 (SI) Table 4 and includes the impact of defrost for air source heating ratings
c. For ~~fluid~~ liquid -source heat recovery ~~chillers~~ chilling packages that have capabilities for heat rejection to a heat recovery condenser and a tower condenser the *COP*$_{HR}$ applies to operation at full load with 100% heat recovery (no tower rejection). Units that only have capabilities for partial heat recovery shall meet the requirements of Table 6.8.1-3
d. For cooling operation compliance with both the FL and *IPLV* is required, but only compliance with path A or Path B cooling *efficiency* is required.
e. For units that operate in both cooling and heating compliance with both the cooling and heating *efficiency* is required.
f. For applications where the ~~equipment~~ chilling package is installed to operate only in heating compliance only with the heating performance *COP*$_H$ is required at standard rating conditions. Compliance with cooling performance is not required.
g. For air-source heat pumps compliance with both the 8.00 ºC and -8.00 ºC heating source OAT rating *efficiency* is required for heating.
h. For Heat Pump ~~chillers~~ chilling packages applications where the cooling capacity is not being used for conditioning, compliance with the heating performance *COP*$_H$ is only required at ~~only~~ one of the four heating AHRI ~~550/590~~551/591 (SI) standard ratings conditions of Low, Medium, High, or Boost. Compliance with the cooling performance is required as defined in footnote a and d.
i. For simultaneous cooling and heating ~~chillers~~ chilling packages applications where there is simultaneous cooling and heating, compliance with the simultaneous cooling performance heat recovery *COP*$_{SHC}$ is only required at ~~only~~ one of the four simultaneous cooling and heating AHRI ~~550/590~~551/591 (SI) standard ratings conditions of Low, Medium, High, or Boost. Compliance with the cooling only performance is required as defined in footnote a and d.
j. For heat recovery heating ~~chillers~~ chilling packages applications where there is simultaneous cooling and heating, compliance with the heating performance heat recovery *COP*$_{HR}$ is only required at ~~only~~ one of the four heating AHRI ~~550/590~~551/591 (SI) standard ratings conditions of Low, Medium, Hot Water 1, or Hot Water 2. Compliance with the cooling only performance is required as defined in footnote a and d.
k. ~~Chillers~~ Chilling packages employing a freeze-protection ~~fluid~~ liquid in accordance with Section 6.4.1.2.2 shall be tested or rated with water for the purpose of compliance with the requirements of this table
l. Outdoor air entering dry bulb (db) temperature and wet bulb (wb) temperature
m. Source-leaving ~~fluid~~ liquid temperature.
- The cooling evaporator liquid flow rate used for the heating rating for a reverse cycle air to water heat pumps shall be the flow rate determined during the full load cooling rating.
- The cooling evaporator liquid flow rate for the simultaneous cooling and heating and heat recovery liquid cooled chilling packages rating shall be the liquid flow rates from the cooling operation full load rating.
- For heating only fluid to fluid chiller packages the evaporator flow rate obtained with an entering liquid temperature of 12.00 °C and a leaving liquid temperature of 7.00 °C shall be used.

n. The Size category is the full load net refrigerating cooling mode capacity which is the capacity of the evaporator available for cooling of the thermal load external to the chilling package.
o A heat recovery condenser at its maximum load point must remove enough heat from the refrigerant to cool the refrigerant to remove all superheat energy and enter into condensation of the refrigerant. A heat recovery system where only the superheat is reduced is not covered by table 6.8.1-16 and is considered a desuperheater and the chiller package must comply with table 6.8.1-3
p. NA means the requirements are not applicable
q. Water-to-water heat pumps with a capacity less than 39.57 kW are covered by table 6.8.1.15