

# **2021 Equipment Thermal Guidelines for Data Processing Environments**

## **ASHRAE TC 9.9 Reference Card**

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Fifth Edition, Revised and Expanded

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**Table 2.1 2021 Thermal Guidelines for Air Cooling—  
SI Version (I-P Version in Appendix B)**

Equipment Environment Specifications for Air Cooling							
Product Operation <sup>b,c</sup>							Product Power Off <sup>c,d</sup>
Class <sup>a</sup>	Dry-Bulb Temp. <sup>e,g</sup> , °C	Humidity Range, Noncond. <sup>h, i, k, l, n</sup>	Max. Dew Point <sup>k</sup> , °C	Max. Elev. <sup>e,i,m</sup> , m	Max. Rate of Change <sup>f</sup> , °C/h	Dry-Bulb Temp., °C	RH <sup>k</sup> , %
<b>Recommended (suitable for Classes A1 to A4; explore data center metrics in this book for conditions outside this range.)</b>							
<b>A1 to A4</b>	18 to 27	−9°C DP to 15°C DP and 70% rh <sup>n</sup> or 50% rh <sup>n</sup>					
<b>Allowable</b>							
<b>A1</b>	15 to 32	−12°C DP and 8% rh to 17°C DP and 80% rh <sup>k</sup>	17	3050	5/20	5 to 45	8 to 80 <sup>k</sup>
<b>A2</b>	10 to 35	−12°C DP and 8% rh to 21°C DP and 80% rh <sup>k</sup>	21	3050	5/20	5 to 45	8 to 80 <sup>k</sup>
<b>A3</b>	5 to 40	−12°C DP and 8% rh to 24°C DP and 85% rh <sup>k</sup>	24	3050	5/20	5 to 45	8 to 80 <sup>k</sup>
<b>A4</b>	5 to 45	−12°C DP and 8% rh to 24°C DP and 90% rh <sup>k</sup>	24	3050	5/20	5 to 45	8 to 80 <sup>k</sup>
<b>B</b>	5 to 35	8% to 28°C DP and 80% rh	28	3050	N/A	5 to 45	8 to 80
<b>C</b>	5 to 40	8% to 28°C DP and 80% rh	28	3050	N/A	5 to 45	8 to 80

\* For potentially greater energy savings, refer to Appendix C for the process needed to account for multiple server metrics that impact overall TCO.

## Notes for Table 2.1, 2021 Thermal Guidelines for Air Cooling— SI Version (I-P Version in Appendix B)

- a. Classes A3, A4, B, and C are identical to those included in the 2011 version of the thermal guidelines (ASHRAE 2012). The 2015 version of the A1 and A2 classes (ASHRAE 2015b) has expanded RH levels compared to the 2011 version.
- b. Product equipment is powered on.
- c. Tape products require a stable and more restrictive environment (similar to Class A1 as specified in 2008). Typical requirements: minimum temperature is 15°C, maximum temperature is 32°C, minimum RH is 20%, maximum RH is 80%, maximum DP is 22°C, rate of change of temperature is less than 5°C/h, rate of change of humidity is less than 5% rh per hour, and no condensation.
- d. Product equipment is removed from original shipping container and installed but not in use, e.g., during repair, maintenance, or upgrade.
- e. Classes A1, A2, B, and C—Derate maximum allowable dry-bulb temperature 1°C/300 m above 900 m. Above 2400 m altitude, the derated dry-bulb temperature takes precedence over the recommended temperature. Class A3—Derate maximum allowable dry-bulb temperature 1°C/175 m above 900 m. Class A4—Derate maximum allowable dry-bulb temperature 1°C/125 m above 900 m.
- f. For tape storage: 5°C in an hour. For all other ITE: 20°C in an hour and no more than 5°C in any 15-minute period of time. The temperature change of the ITE must meet the limits shown in the table and is calculated to be the maximum air inlet temperature minus the minimum air inlet temperature within the time window specified. The 5°C and 20°C temperature change is considered to be a temperature change within a specified period of time and not a rate of change. See Appendix K for additional information and examples.
- g. With a diskette in the drive, the minimum temperature is 10°C (not applicable to Classes A1 or A2).
- h. The minimum humidity level for Classes A1, A2, A3, and A4 is the higher (more moisture) of the -12°C dew point and the 8% rh. These intersect at approximately 25°C. Below this intersection (~25°C) the dew point (-12°C) represents the minimum moisture level, while above it, RH (8%) is the minimum.
- i. Based on research funded by ASHRAE and performed at low RH (Pommerenke et al. 2014), the following are the minimum requirements:
  - 1) Data centers that have non-ESD floors and where personnel are allowed to wear non-ESD shoes may need increased humidity given that the risk of generating 8 kV increases slightly from 0.27% at 25% rh to 0.43% at 8% rh (see Appendix D for more details).
  - 2) All mobile furnishing/equipment is to be made of conductive or static-dissipative materials and bonded to ground.
  - 3) During maintenance on any hardware, a properly functioning and grounded wrist strap must be used by any personnel who contacts ITE.
- j. To accommodate rounding when converting between SI and I-P units, the maximum elevation is considered to have a variation of ±0.1%. The impact on ITE thermal performance within this variation range is negligible and enables the use of the rounded value of 3050 m.
- k. See Appendix L for graphs that illustrate how the maximum and minimum DP limits restrict the stated RH range for each of the classes for both product operations and product power off.
- l. For the upper moisture limit, the limit is the minimum absolute humidity of the DP and RH stated. For the lower moisture limit, the limit is the maximum absolute humidity of the DP and RH stated.
- m. Operation above 3050 m requires consultation with the IT supplier for each specific piece of equipment.
- n. If testing with silver or copper coupons results in values less than 200 and 300 Å/month, respectively, then operating up to 70% rh is acceptable. If testing shows corrosion levels exceed these limits, then catalyst-type pollutants are probably present and RH should be driven to 50% or lower. See note 3 of Section 2.2 for more details.

**Table 2.2 2021 Thermal Guidelines for High-Density Servers—  
SI Version (I-P Version in Appendix B)**

Equipment Environment Specifications for High-Density Air Cooling							
Class <sup>a</sup>	Product Operation <sup>b,c</sup>					Product Power Off <sup>c,d</sup>	
	Dry-Bulb Temp. <sup>e,g</sup> , °C	Humidity Range, Noncond. <sup>h,i,k,l,n</sup>	Max. Dew Point, °C	Max. Elev. <sup>e,j,m</sup> , m	Max. Rate of Change <sup>f</sup> , °C/h	Dry-Bulb Temp., °C	RH, %
<b>Recommended</b>							
<b>HI</b>	18 to 22	-9°C DP to 15°C DP and 70% rh <sup>n</sup> or 50% rh <sup>n</sup>					
<b>Allowable</b>							
<b>HI</b>	15 to 25	-12°C DP and 8% rh to 17°C DP and 80% rh <sup>k</sup>	17	3050	5/20	5 to 45	8 to 80 <sup>k</sup>

## Notes for Table 2.2, 2021 Thermal Guidelines for High-Density Servers— SI Version (I-P Version in Appendix B)

- a. This is a new class specific to high-density servers. It is at the discretion of the ITE manufacturer to determine the need for a product to use this high-density server class. Classes A1 through A4 are separate and are shown in Table 2.1.
- b. Product equipment is powered on.
- c. Tape products require a stable and more restrictive environment (similar to 2011 Class A1). Typical requirements: minimum temperature is 15°C, maximum temperature is 32°C, minimum RH is 20%, maximum RH is 80%, maximum DP is 22°C, rate of change of temperature is less than 5°C/h, rate of change of humidity is less than 5% rh per hour, and no condensation.
- d. Product equipment is removed from original shipping container and installed but not in use, e.g., during repair, maintenance, or upgrade.
- e. For H1 class only—Derate maximum allowable dry-bulb temperature 1°C/500 m above 900 m. Above 2400 m altitude, the derated dry-bulb temperature takes precedence over the recommended temperature.
- f. For tape storage: 5°C in an hour. For all other ITE: 20°C in an hour and no more than 5°C in any 15-minute period of time. The temperature change of the ITE must meet the limits shown in the table and is calculated to be the maximum air inlet temperature minus the minimum air inlet temperature within the time window specified. The 5°C and 20°C temperature change is considered to be a temperature change within a specified period of time and not a rate of change. See Appendix K for additional information and examples.
- g. With a diskette in the drive, the minimum temperature is 10°C. With the lowest allowed temperature of 15°C, there is no problem with diskettes residing in this H1 environment.
- h. The minimum humidity level for Class H1 is the higher (more moisture) of the –12°C DP and the 8% rh. These intersect at approximately 25°C. Below this intersection (~25°C) the DP (–12°C) represents the minimum moisture level, while above it, RH (8%) is the minimum.
- i. Based on research funded by ASHRAE and performed at low RH (Pommerenke et al. 2014), the following are the minimum requirements:
  - 1) Data centers that have non-ESD floors and where personnel are allowed to wear non-ESD shoes may need increased humidity given that the risk of generating 8 kV increases slightly from 0.27% at 25% rh to 0.43% at 8% rh (see Appendix D for more details).
  - 2) All mobile furnishing/equipment is to be made of conductive or static-dissipative materials and bonded to ground.
  - 3) During maintenance on any hardware, a properly functioning and grounded wrist strap must be used by any personnel who contacts ITE.
- j. To accommodate rounding when converting between SI and I-P units, the maximum elevation is considered to have a variation of  $\pm 0.1\%$ . The impact on ITE thermal performance within this variation range is negligible and enables the use of the rounded value of 3050 m.
- k. See Appendix L for graphs that illustrate how the maximum and minimum DP limits restrict the stated RH range for both product operations and product power OFF.
- l. For the upper moisture limit, the limit is the minimum absolute humidity of the DP and RH stated. For the lower moisture limit, the limit is the maximum absolute humidity of the DP and RH stated.
- m. Operation above 3050 m requires consultation with the IT supplier for each specific piece of equipment.
- n. If testing with silver or copper coupons results in values less than 200 and 300 Å/month, respectively, then operating up to 70% rh is acceptable. If testing shows corrosion levels exceed these limits, then catalyst-type pollutants are probably present and RH should be driven to 50% or lower. See note 3 of Section 2.2 for more details.

# Air Cooling Environmental Conditions and Class Definitions

## Environmental Conditions

**Recommended:** Facilities should be designed and operated to target the recommended range.

**Allowable:** IT manufacturers test their equipment to verify it will function within these conditions. This is not a statement of reliability but of the functionality of the ITE. To enable the greatest latitude in use of all the classes, power and thermal management features may be triggered within the allowable range to ensure there are no thermal excursions outside the capability of the ITE under extreme load conditions. In addition to the allowable dry-bulb temperature and dew-point ranges, the maximum relative humidity (RH) and maximum elevation values are part of the allowable operating environment definitions.

## Environmental Class Definitions

**General:** Operating within a particular environmental class requires full operation of the equipment over the entire allowable environmental range, based on non-failure conditions.

**Product Operation:** Product equipment is powered on.

**Product Power OFF:** Product equipment is removed from the original shipping container and installed but not in use, e.g., during repair, maintenance, or upgrade.

**Class A1:** Typically a data center with tightly controlled environmental parameters (dew point, temperature, and RH) and mission-critical operations; types of products typically designed for this environment are enterprise servers and storage products.

**Class A2/A3/A4:** Typically an information technology (IT) space with some control of environmental parameters (dew point, temperature, and RH); types of products typically designed for this environment are volume servers, storage products, personal computers,

and workstations. Among these three classes, A2 has the narrowest temperature and moisture requirements and A4 has the widest environmental requirements.

**Class B:** Typically telecommunications spaces (entrance rooms, IT and equipment rooms), offices, and homes with minimal control of environmental parameters; types of products typically designed for this environment are LAN switches, office computers, personal computers, workstations, laptops, and printers.

**Class C:** Typically telecommunications, point-of-sale, light industrial, or factory spaces with weather protection, sufficient winter heating and ventilation; types of products typically designed for this environment are telecommunication equipment, point-of-sales equipment, ruggedized controllers, and mobile devices.

**Class H1:** Typically a zone within a data center that is cooled to lower temperatures to accommodate high-density air-cooled products.

**Table 3.1 2021 Thermal Guidelines for Liquid Cooling**

<b>Equipment Environment Specifications for Liquid Cooling</b>			
<b>Liquid Cooling Class</b>	<b>Typical Infrastructure Design</b>		<b>Facility Water Supply Temperature, °C (°F)<sup>a</sup></b>
	<b>Primary Facilities</b>	<b>Secondary/ Supplemental Facilities</b>	
<b>W17</b>	} Chiller/cooling tower	Water-side economizer (cooling tower)	17 (62.6)
<b>W27</b>			27 (80.6)
<b>W32</b>	} Cooling tower	Chiller or district heating system	32 (89.6)
<b>W40</b>			40 (104)
<b>W45</b>	} Cooling tower	District heating system	45 (113)
<b>W+</b>			>45 (>113)

a. Minimum water temperature for all classes is 2°C (35.6°F).

## Liquid Cooling Environmental Class Definitions

- General:** Operating within an environmental class requires full performance of the equipment over the entire environmental range of the specified class, based on non-failure conditions.
- Class W17/W27:** Typically data centers that are traditionally cooled using chillers and a cooling tower, but with an optional water-side economizer to improve energy efficiency, depending on the location of the data center.
- Class W32/W40:** Typically operated without chillers in most locations; however, some locations may still require chillers.
- Class W45/W+:** Typically operated without chillers to take advantage of energy efficiency and reduce capital expense. Some locations may not be suitable for drycoolers.