

## Proposed Clarification to ASHRAE Thermal Guidelines SI Units Table

### 2011 Thermal Guidelines – SI Version

Classes (e)	Equipment Environmental Specifications for Air Cooling							
	Product Operations <sup>b,c</sup>					Product Power Off <sup>c,d</sup>		
	Dry-Bulb Temperature (°C) <sup>e,g</sup>	Humidity Range, non-Condensing <sup>h,i</sup>	Maximum Dew Point (°C)	Maximum Elevation <sup>e,j</sup> (m)	Maximum Temperature Change in an Hour (°C) <sup>f</sup>	Dry-Bulb Temperature (°C)	Relative Humidity (%)	Maximum Dew Point (°C)
<b>Recommended</b> (Suitable for all 4 classes; explore data center metrics in this paper for conditions outside this range)								
A1 to A4	18 to 27	5.5°C DP to 60% RH and 15°C DP						
<b>Allowable</b>								
A1	15 to 32	20% to 80% RH	17	3050	5/20	5 to 45	8 to 80	27
A2	10 to 35	20% to 80% RH	21	3050	5/20	5 to 45	8 to 80	27
A3	5 to 40	-12°C DP & 8% RH to 85% RH	24	3050	5/20	5 to 45	8 to 85	27
A4	5 to 45	-12°C DP & 8% RH to 90% RH	24	3050	5/20	5 to 45	8 to 90	27
B	5 to 35	8% RH to 80% RH	28	3050	NA	5 to 45	8 to 80	29
C	5 to 40	8% RH to 80% RH	28	3050	NA	5 to 45	8 to 80	29

\*The 2008 recommended ranges as shown here and in Table 2.1 can still be used for data centers. For potentially greater energy savings, refer to the section "Detailed Flowchart for the Use and Application of the ASHRAE Data Center Classes" in Appendix C for the process needed to account for multiple server metrics that impact overall TCO.

#### Notes for Table 2.3, 2011 Thermal Guidelines – SI Version

- a. Classes A1, A2, B, and C are identical to 2008 classes 1, 2, 3 and 4. These classes have simply been renamed to avoid confusion with classes A1 thru A4. The recommended envelope is identical to that published in the 2008 version of Thermal Guidelines.
- b. Product equipment is powered ON.
- c. Tape products require a stable and more restrictive environment (similar to Class A1). Typical requirements: minimum temperature is 15°C, maximum temperature is 32°C, minimum relative humidity is 20%, maximum relative humidity is 80%, maximum dew point is 22°C, temperature change requirement is less than 5°C in an hour, the change in humidity is less than 5% RH in an hour with 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. A3 - Derate maximum allowable dry-bulb temperature 1°C/175 m above 900 m. A4 - Derate maximum allowable dry-bulb temperature 1°C/125 m above 900 m.
- f. For tape storage equipment: 5°C in an hour. For all other IT equipment: 20°C in an hour and no more than 5°C in any 15 minute period of time. The temperature change of the IT Equipment must meet the limits shown in the table above, and is calculated to be the maximum air inlet temperature minus the minimum air inlet temperature within any time window as 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 the Addendum for additional information and examples.
- g. With diskette in the drive, the minimum temperature is 10°C

- h. The minimum humidity level for class A3 and A4 is the higher (more moisture) of the  $-12^{\circ}\text{C}$  dew point and the 8% RH. These intersect at approximately  $25^{\circ}\text{C}$ . Below this intersection ( $\sim 25^{\circ}\text{C}$ ) the dew point ( $-12^{\circ}\text{C}$ ) represents the minimum moisture level, while above it, RH (8%) is the minimum.
- i. Moisture levels lower than  $0.5^{\circ}\text{C}$  DP, but not lower than  $-12^{\circ}\text{C}$  DP or 8% RH, can be accepted if appropriate control measures are implemented to limit the generation of static electricity on personnel and equipment in the data center. All personnel and mobile furnishings/equipment must be connected to ground via an appropriate static control system. The following items are considered the minimum requirements (see Appendix A for additional details):
  - 1) Conductive Materials
    - a) Conductive flooring
    - b) Conductive footwear on all personnel that go into the datacenter, including visitors just passing through;
    - c) All mobile furnishing/equipment will be made of conductive or static dissipative materials.
  - 2) During maintenance on any hardware, a properly functioning 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 rounded values of 3050 m (10,000 ft).  
New note: operation above 3050 m requires consultation with IT supplier for each specific piece of equipment.

# Proposed Clarification to ASHRAE Thermal Guidelines

## I-P Units Table

### 2011 Thermal Guidelines – I-P Version

Classes (a)	Equipment Environmental Specifications for Air Cooling							
	Product Operations <sup>b,c</sup>					Product Power Off <sup>e,d</sup>		
	Dry-Bulb Temperature (°F) <sup>e,g</sup>	Humidity Range, non-Condensing <sup>h,i</sup>	Maximum Dew Point (°F)	Maximum Elevation (ft) <sup>e,j</sup>	Maximum Temperature Change in an Hour (°F) <sup>f</sup>	Dry-Bulb Temperature (°F)	Relative Humidity (%)	Maximum Dew Point (°F)
<b>Recommended</b> (Suitable for all 4 classes; explore data center metrics in this paper for conditions outside this range)								
A1 to A4	64.4 to 80.6	41.9°F DP to 60% RH and 59°F DP						
<b>Allowable</b>								
A1	59 to 89.6	20 to 80% RH	62.6	10,000	9/36	41 to 113	8 to 80	80.6
A2	50 to 95	20 to 80% RH	69.8	10,000	9/36	41 to 113	8 to 80	80.6
A3	41 to 104	10.4°F DP & 8% RH to 85% RH	75.2	10,000	9/36	41 to 113	8 to 85	80.6
A4	41 to 113	10.4°F DP & 8% RH to 90% RH	75.2	10,000	9/36	41 to 113	8 to 90	80.6
B	41 to 95	8% RH to 80% RH	82.4	10,000	NA	41 to 113	8 to 80	84.2
C	41 to 104	8% RH to 80% RH	82.4	10,000	NA	41 to 113	8 to 80	84.2

\*The 2008 recommended ranges as shown here and in Table 2.1 can still be used for data centers. For potentially greater energy savings, refer to the section “Detailed Flowchart for the Use and Application of the ASHRAE Data Center Classes” in Appendix C for the process needed to account for multiple server metrics that impact overall TCO.

#### Notes for Table 2.3, 2011 Thermal Guidelines – I-P Version

- Classes A1, A2, B, and C are identical to 2008 classes 1, 2, 3 and 4. These classes have simply been renamed to avoid confusion with classes A1 thru A4. The recommended envelope is identical to that published in the 2008 version of Thermal Guidelines.
- Product equipment is powered ON.
- Tape products require a stable and more restrictive environment (similar to Class A1). Typical requirements: minimum temperature is 59°F, maximum temperature is 89.6°F, minimum relative humidity is 20%, maximum relative humidity is 80%, maximum dew point is 71.6°F, change of temperature is less than 9°F in an hour, the change in humidity is less than 5% RH in an hour with no condensation.
- Product equipment is removed from original shipping container and installed but not in use, e.g., during repair maintenance, or upgrade.
- Classes A1, A2, B and C - Derate maximum allowable dry-bulb temperature 1.8°F/984 ft above 2953 ft. Above 7874 ft altitude, the derated dry-bulb temperature takes precedence over the recommended temperature. A3 - Derate maximum allowable dry-bulb temperature 1.8°F/574 ft above 2953 ft. A4 - Derate maximum allowable dry-bulb temperature 1.8°F/410 ft above 2953 ft.
- For tape storage: 9°F in an hour. For all other IT equipment: 36°F in an hour and no more than 9°F in any 15 minute period of time. The temperature change of the IT Equipment must meet the limits shown in the table above, and is calculated to be the maximum air inlet temperature minus the minimum air inlet temperature within any time window as specified. The 9°F and 36°F temperature change is considered to be a temperature

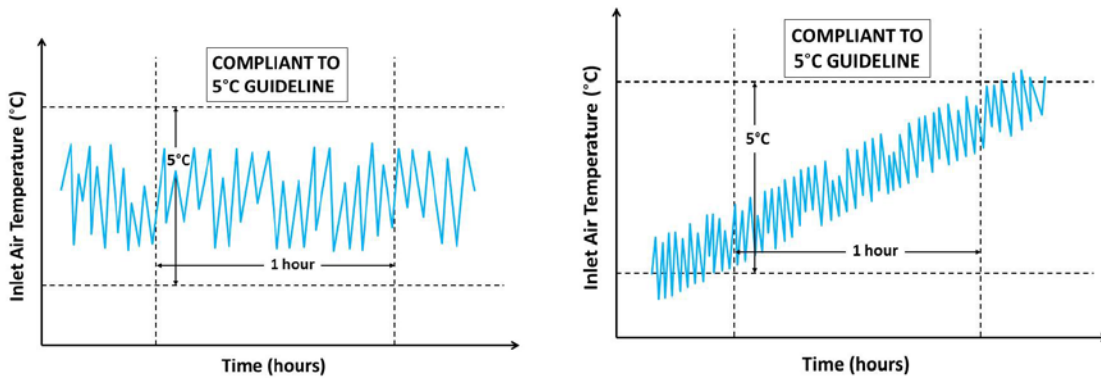
change within a specified period of time and not a rate of change. See the Addendum for additional information and examples.

- g. With diskette in the drive, the minimum temperature is 50°F.
- h. The minimum humidity level for class A3 and A4 is the higher (more moisture) of the 10.4°F dew point and the 8% RH. These intersect at approximately 77°F. Below this intersection (~77°F) the dew point (10.4°F) represents the minimum moisture level, while above it, RH (8%) is the minimum.
- i. Moisture levels lower than 32.9°F DP, but not lower than 10.4°F DP or 8% RH, can be accepted if appropriate control measures are implemented to limit the generation of static electricity on personnel and equipment in the data center. All personnel and mobile furnishings/equipment must be connected to ground via an appropriate static control system. The following items are considered the minimum requirements (see Appendix A for additional details):
  - 1) Conductive Materials
    - a) Conductive flooring
    - b) Conductive footwear on all personnel that go into the datacenter, including visitors just passing through;
    - c) All mobile furnishing/equipment will be made of conductive or static dissipative materials.
  - 2) During maintenance on any hardware, a properly functioning 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 rounded values of 3050 m (10,000 ft).  
New note: operation above 3050 m requires consultation with IT supplier for each specific piece of equipment.

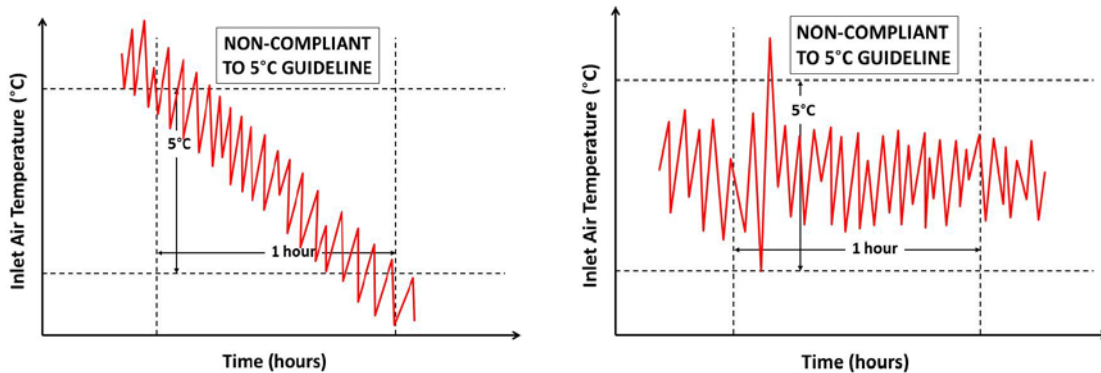
## ADDENDUM

The 5°C in an hour (tape equipment) and 20°C in an hour (other types of IT equipment not including tape) inlet air temperature change requirements are not temperature rates of change. Figures 1, 2, 3, and 4 below provide examples of air inlet temperatures that are either compliant or non-compliant to the ASHRAE temperature change requirements for data center rooms with and without tape-based IT equipment.

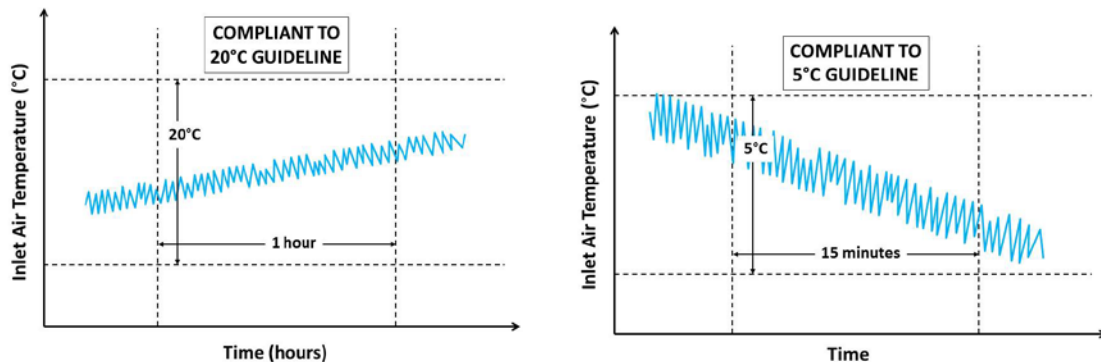
**Figures 1A and 1B** Examples of tape equipment inlet air temperature vs. time that are compliant to the 5°C in an hour temperature change requirement for data center rooms with tape equipment.



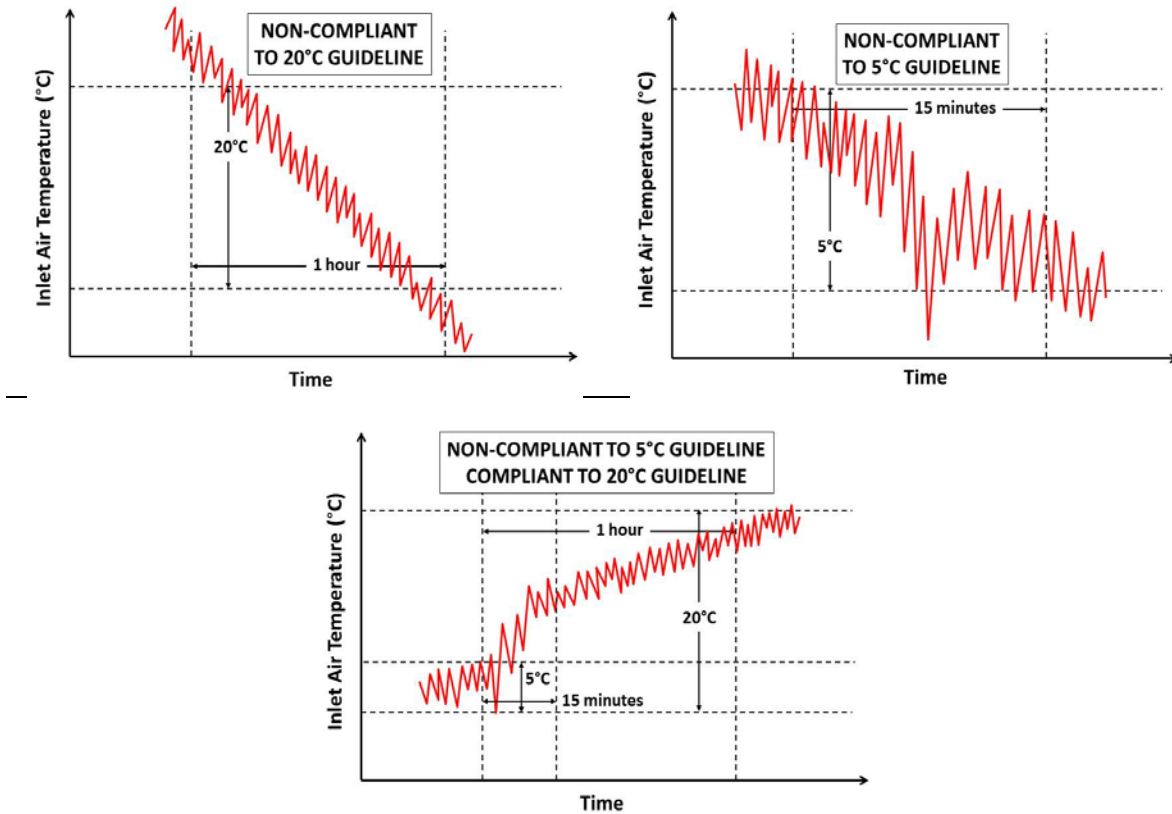
**Figures 2A and 2B** Examples of tape equipment inlet air temperature vs. time that are non-compliant to the 5°C in an hour temperature change requirement for data center rooms with tape equipment.



**Figures 3A and 3B** Examples of equipment inlet air temperature vs. time that are compliant to the 20°C in an hour and the 5°C in 15 minutes temperature change requirement for data center rooms that contain other types of IT equipment not including tape.

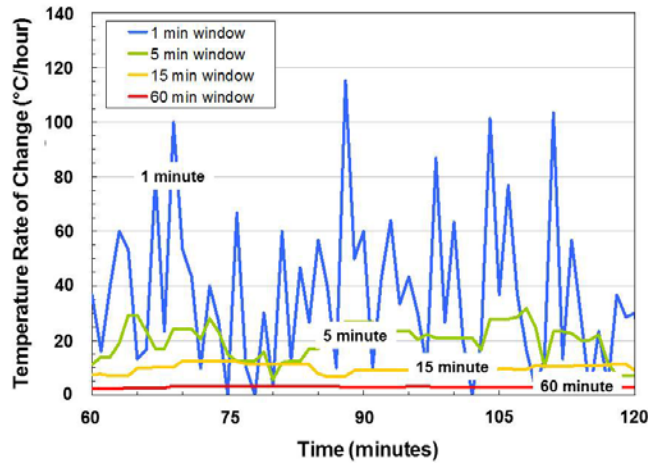


**Figures 4A, 4B, and 4C** Examples of equipment inlet air temperature vs. time that: A) are non-compliant to the 20°C in an hour, B) are non-compliant to the 5°C in 15 minutes temperature change, and C) are non-compliant to the 5°C in an hour requirement but comply with the 20°C in an hour requirement for data center rooms that contain other types of IT equipment, not including tape.

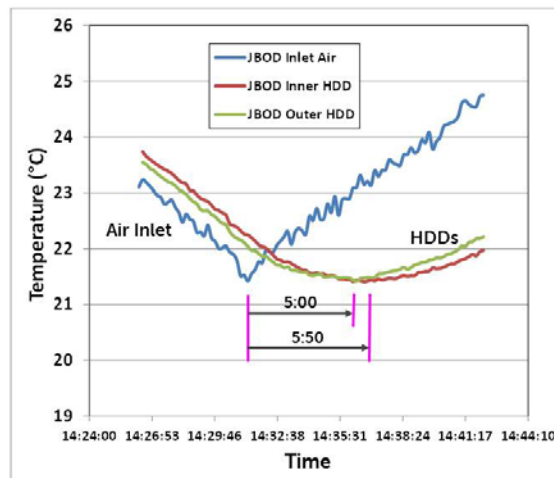


The control algorithms of many data center HVAC systems generate small but rapid fluctuations in the cold air supply temperature that can have a very high rate of temperature change (see Figure 5). These small changes are not a problem for IT equipment functionality and reliability because the time scale of the air inlet temperature changes is typically too short for a large thermal mass, such as a storage array, to respond to the changes (see Figure 6).

**Figure 5** Example of IT equipment air inlet temperature rate of change ( $^{\circ}\text{C}/\text{hour}$ ) calculated over 1 minute, 5 minute, 15 minute, and 60 minute time intervals.



**Figure 6** Example of a time delay between an inlet air temperature change to a storage array and the corresponding temperature change in the hard disk drives of the storage array.



A time lag of 5 minutes is not unusual for hard disk drives in a piece of IT equipment to respond to a change in air inlet temperature. Small but rapid air temperature changes from the data center HVAC system generally occur on a time scale much less than the time lag of the hard disk drives so the hard drives don't have a chance to respond to the rapid rates of temperature change in the air stream. The extent of temperature change in the hard disk drives may also be reduced by the cooling fan control algorithm of the equipment enclosure. Thus, hard disk drives in IT equipment are significantly buffered from temperature changes and the rate of temperature change of the air in the equipment inlet air stream. Other sub-assemblies within the IT equipment (e.g. solid state drives, option cards, power supplies, etc.) are also somewhat buffered from data center air temperature changes but to a degree dependent on their thermal mass, cooling air flow, and location within the IT equipment.

The intent of defining inlet air temperature change requirement as  $5^{\circ}\text{C}$  and  $20^{\circ}\text{C}$  for tape and other types of IT equipment, respectively, is two-fold: 1) to provide data center facility level requirements that will keep the critical internal components and sub-assemblies of the IT equipment within the manufacturer's requirements, and 2) avoid costly and unnecessary data center HVAC system and facility upgrades that might be needed to comply with the former rate of change based requirement.