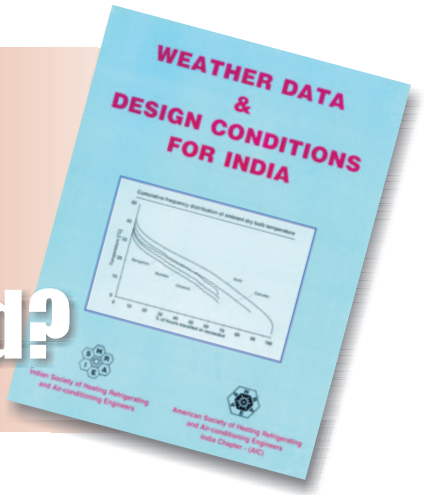
# What Outside Design Conditions should I use in calculating a heat load?

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For years, Indian HVAC engineers have been using legacy weather data of unknown origin for Indian cities, leading to overdesigning of equipment and wastage of energy. In 1999 the Tata Energy Research Institute (TERI), http://www.teriin.org/ developed a set of hourly Indian weather data sets for 52 stations from measured sequences of climatic data from 1981 to 1992 based on the concept of "coincident" temperatures in line with and in the format as published in the ASHRAE *Handbook of Fundamentals, 1997*.

The set of weather data was created in TMY2 format, a commonly used format in the industry, and was developed for use in building energy and thermal simulation programmes.

In 2004 the weather data set was converted to the EPW format by ISHRAE for use with EnergyPlus® *, an energy and thermal simulation programme developed primarily by the LBNL Simulation Research Group (http:/simulationresearch.lbl.gov/), the UIUC Building Systems Lab. (http://www.bso.uiuc.edu/) and other contributors.

The weather data for Indian cities has been uploaded on the world wide web for use by Energy Plusâ and other users. Please see *References* at the end of this article for the exact url.

Recently the outside design conditions based on mean coincident values was adopted by BIS, the Bureau of Indian Standards.

## What is meant by "coincident" temperature?

The weather data in use earlier was not the "coincident" data. As an example, for any outside design dry bulb temperature, the corresponding wet bulb temperature was not the wet bulb temperature occurring simultaneously at that dry bulb temperature. In all probability, it was the maximum wet bulb temperature for the particular season in question.

The "mean coincident wet bulb temperature", on the other hand, means the average wet bulb temperature occurring at the same time as the design dry bulb temperature, and in that particular 2.8°C (5° F) interval.

For the first time, the research carried out by TERI provided users with the "coincident" temperatures.

## Categories of design weather data based on annual frequency of occurrence

In addition, the design weather data was classified into three categories, viz., 2%, 1% and 0.4% annual frequency of occurrence.

The design values represent the value that is exceeded on average by the indicated percentage of the total number of hours in a year (8,760). In other words, the 0.4%, 1.0%, and 2.0% values are exceeded 35, 88, and 175 hours per year respectively.

The weather data for a particular city, at 2% annual frequency of occurrence means that for 2% of the hours in a year, (i.e., (2/100) x 24 x 365 = 175 hours), the temperature will be above the temperature in question.

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### About the Author

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For example, for the city of Mumbai, the legacy summer outside design conditions being considered so far have been 35°C (95°F) and 28.3°C (83°F). Compare this with the 2% dry bulb temperature, and mean coincident wet bulb temperature from the new weather data, which is 33.5°C (92.3°F) and 24°C (75.2°F), figures which are values lower than the legacy data.

It is also understood that the air conditioning system would now be designed such that for around 2% of the hours in a year, the outside condition would be higher than the design condition. This is acceptable practice for comfort air conditioning where construction costs take priority over the exact maintenance of inside design conditions, and could result in considerable savings in initial equipment costs and running loads.

If slightly more stringent conditions are desired, then the 1% values can be considered, and for very stringent industrial applications, where the maintenance of inside design conditions take priority irrespective of the outside design conditions, the 0.4% values should be considered.

## "Summer", "Monsoon" and winter design conditions

While earlier, outside design conditions were provided under the sub-heads of "Summer", "Monsoon" and "Winter", these sub-heads do not exist in the new classification based on annual occurrences.

Instead, for calculating instantaneous space loads for summer conditions, one would usually use the Cooling DB temperature / Mean coincident WB temperature while for instantaneous space loads for monsoon conditions, one would use the Cooling WB temperature / Mean Coincident DB temperature.

For winter space loads, one would use the Heating DB temperature / Mean coincident Wet bulb temperature.

(For dehumidification processes, one would use the Cooling WB temperature / Mean Coincident DB temperature).

## Possible erroneous applications of coincident temperature weather data

Merely following the above over-simplified rule for instantaneous space loads blindly however, could lead to serious errors in design.

Consider the situation for a 100% outside air application, (or for a treated fresh air application, or even for an application where the outside air ventilation loads are high):

Assuming that the design is being carried out for the city of Mumbai, we list out the enthalpies of air for both the outside design conditions under investigation.

## Comparison of design conditions

City: Mumbai

Annual frequency of occurrence: 2%

Where,

DB is the dry bulb temperature, °C

WB is the wet bulb temperature, °C

| Design DB with Mean Coincident WB | | | Design WB with Mean Coincident DB | | |
|---|---|---|---|---|---|
| DB | WB | h | DB | WB | h |
| 33.5°C (92.3°F) | 24.0°C (75.2°F) | 71.92 kJ/kg (38.54 Btu/Lb) | 31.10°C (87.98°F) | 27.2°C (80.96°F) | 85.88 kJ/kg (44.56 Btu/lb) |

h is the enthalpy (the total heat content), in kJ/kg

In the first case for Design DB and mean coincident WB, the enthalpy of the outside air is 71.92 kJ/kg (38.54 Btu/lb), and would be exceeded for a period of 175 hours as explained earlier.

In the second case for Design WB and mean coincident DB, the enthalpy of the outside air, 85.88 kJ/kg (44.56 Btu/lb) would exceed for a far greater number of hours than in the first case.

Had the outside design conditions been selected as the DB temperature and mean coincident WB temperature, there would have been serious under-sizing of the equipment and the system would have been pushed to its limits for a far greater number of hours.

This article brings out the importance of analyzing the nature of the load, adopting and selecting the appropriate outside design conditions as per BIS standards for the calculation of space loads, to prevent gross under-sizing in particular, of equipment.

## References

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*(2) Proceedings of the 23rd National Renewable Energy Convention*, pp. 284-289, edited by R. L. Sawhney, D. Buddhi, and R. P. Gautam. Indore: Devi Ahilya Vishwavidyalaya.

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(3) Review of Inside Design Conditions in Air Conditioned Spaces, by N. S. Hukmani, *Air Conditioning and Refrigeration Journal, January 2004*. (http://www.hvacindia.com journals_20042005/2004jan/article05.html)

*(4) Weather Data & Design Conditions for India* published by ISHRAE and ASHRAE India Chapter.

(5) url : http://www.eere.energy.gov/buildings/energyplus/cfm/weather_data3.cfm/region=2_asiawmo_region_2/country=IND/cname=India.

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## Outside Design Conditions for Indian Cities.

| Station Name | Cooling DB/MCWB | | | | | | Cooling WB/MCDB | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.40% | | 1.00% | | 2.00% | | 0.40% | | 1.00% | | 2.00% | |
| | DB | MCWB | DB | MCWB | DB | MCWB | WB | MCDB | WB | MCDB | WB | MCDB |
| | °C | °C | °C | °C | °C | °C | °C | °C | °C | °C | °C | °C |
| Ahmedabad | 42.3 | 24.1 | 41.2 | 23.5 | 40.0 | 24.3 | 28.7 | 34.3 | 28.2 | 33.6 | 27.8 | 33.1 |
| Akola | 43.4 | 24.0 | 42.2 | 23.3 | 41.0 | 23.6 | 27.6 | 37.8 | 26.7 | 34.4 | 26.1 | 33.5 |
| Allahabad | 43.7 | 23.4 | 42.2 | 23.5 | 40.8 | 22.7 | 28.8 | 33.0 | 28.4 | 32.8 | 28.0 | 32.6 |
| Aurangabad | 40.3 | 22.1 | 39.3 | 22.9 | 38.3 | 21.3 | 26.3 | 36.2 | 25.3 | 33.1 | 24.7 | 31.4 |
| Bangalore | 34.7 | 19.6 | 34.0 | 19.6 | 33.1 | 19.2 | 23.5 | 28.9 | 22.9 | 28.2 | 22.5 | 27.7 |
| Barmar | 43.1 | 24.2 | 42.0 | 23.6 | 41.0 | 23.3 | 28.5 | 37.9 | 27.8 | 35.3 | 27.2 | 33.3 |
| Bhagalpur | 42.4 | 26.8 | 40.7 | 27.4 | 38.9 | 25.6 | 30.0 | 37.1 | 29.6 | 36.4 | 29.2 | 35.2 |
| Bhopal | 41.7 | 22.0 | 40.5 | 21.7 | 39.3 | 21.3 | 26.0 | 31.0 | 25.6 | 30.3 | 25.2 | 29.9 |
| Bhubaneshwar | 38.9 | 25.5 | 37.6 | 26.6 | 36.3 | 26.3 | 29.4 | 35.2 | 28.9 | 33.3 | 28.5 | 32.7 |
| Bikaner | 44.8 | 22.4 | 43.4 | 22.4 | 42.0 | 23.1 | 28.5 | 34.6 | 27.9 | 33.1 | 27.3 | 34.7 |
| Kolkata | 37.2 | 25.4 | 36.2 | 26.1 | 35.2 | 26.5 | 29.5 | 34.3 | 29.0 | 33.4 | 28.6 | 32.7 |
| Chennai | 38.4 | 26.2 | 37.3 | 26.7 | 36.3 | 26.4 | 29.1 | 33.8 | 28.6 | 33.2 | 28.1 | 31.9 |
| Dehradun | 37.8 | 23.5 | 36.3 | 23.9 | 34.8 | 22.8 | 27.0 | 31.3 | 26.5 | 30.1 | 26.0 | 29.8 |
| Dibrugarh | 34.0 | 27.0 | 33.2 | 26.8 | 32.3 | 26.7 | 28.3 | 32.6 | 27.8 | 31.8 | 27.4 | 31.3 |
| Gorakpur | 41.4 | 26.2 | 40.3 | 26.0 | 39.1 | 26.4 | 29.9 | 35.2 | 29.7 | 35.5 | 29.4 | 34.7 |
| Guwahati | 34.4 | 26.9 | 33.4 | 27.3 | 32.7 | 26.8 | 28.8 | 32.4 | 28.3 | 31.8 | 27.9 | 31.5 |
| Gwalior | 43.9 | 23.0 | 42.5 | 22.9 | 41.3 | 23.5 | 27.9 | 32.9 | 27.6 | 32.4 | 27.3 | 32.7 |
| Hissar | 44.7 | 26.5 | 43.3 | 25.8 | 41.7 | 27.9 | 30.1 | 40.2 | 29.9 | 39.0 | 29.4 | 36.8 |
| Hyderabad | 40.4 | 22.5 | 39.2 | 22.5 | 38.2 | 22.4 | 25.6 | 33.7 | 25.2 | 32.4 | 24.8 | 32.0 |
| Imphal | 31.1 | 23.3 | 30.2 | 23.5 | 29.6 | 22.9 | 25.0 | 29.5 | 24.6 | 28.6 | 24.3 | 28.3 |
| Indore | 41.1 | 20.7 | 40.4 | 20.6 | 38.9 | 21.0 | 25.7 | 31.0 | 25.2 | 30.0 | 24.8 | 29.8 |
| Jabalpur | 42.6 | 22.7 | 41.2 | 23.2 | 39.8 | 22.5 | 26.8 | 31.8 | 26.4 | 32.0 | 26.0 | 31.2 |
| Jagdelpur | 39.4 | 22.3 | 38.6 | 22.5 | 37.4 | 22.4 | 26.4 | 32.4 | 25.9 | 31.8 | 25.4 | 30.7 |
| Jaipur | 42.8 | 22.5 | 41.4 | 22.6 | 39.4 | 22.6 | 27.4 | 33.1 | 27.0 | 32.1 | 26.6 | 31.7 |
| Jaisalmer | 43.7 | 23.7 | 42.5 | 23.1 | 41.4 | 23.5 | 27.7 | 34.8 | 27.3 | 34.5 | 26.9 | 34.4 |
| Jamnagar | 37.1 | 24.4 | 36.1 | 25.6 | 35.3 | 25.1 | 29.2 | 33.0 | 28.4 | 32.5 | 27.9 | 32.0 |
| Jodhpur | 42.0 | 23.2 | 40.8 | 23.0 | 39.6 | 22.7 | 28.0 | 35.4 | 27.4 | 33.7 | 26.9 | 33.8 |
| Jorhat | 34.4 | 28.2 | 33.6 | 27.7 | 32.9 | 27.3 | 28.7 | 32.7 | 28.3 | 32.1 | 28.0 | 31.8 |
| Kota | 43.5 | 23.0 | 42.4 | 22.6 | 41.2 | 22.6 | 27.3 | 35.2 | 26.8 | 33.0 | 26.5 | 31.2 |
| Lucknow | 42.0 | 24.2 | 40.8 | 24.8 | 39.3 | 24.5 | 28.8 | 33.3 | 28.4 | 32.4 | 28.0 | 32.2 |
| Mumbai | 35.3 | 22.8 | 34.3 | 23.3 | 33.5 | 24.0 | 27.9 | 31.8 | 27.5 | 31.3 | 27.2 | 31.1 |
| Nagpur | 43.8 | 23.6 | 42.6 | 23.9 | 41.4 | 23.6 | 21.2 | 31.2 | 26.6 | 33.2 | 26.2 | 31.9 |
| Nellore | 40.4 | 27.8 | 39.0 | 28.1 | 37.8 | 27.2 | 30.0 | 37.1 | 29.4 | 35.4 | 28.8 | 34.0 |
| New Delhi | 41.8 | 23.6 | 40.6 | 23.8 | 39.3 | 23.5 | 28.4 | 33.3 | 28.0 | 33.3 | 27.6 | 32.7 |
| Panjim | 34.0 | 24.8 | 33.5 | 25.2 | 33.0 | 25.2 | 27.7 | 32.3 | 27.4 | 31.5 | 27.0 | 30.9 |
| Patna | 40.7 | 23.4 | 39.5 | 23.7 | 38.0 | 24.7 | 29.0 | 33.9 | 28.6 | 33.1 | 28.3 | 32.6 |
| Pune | 38.4 | 20.5 | 37.4 | 20.4 | 36.3 | 20.6 | 24.8 | 30.9 | 24.4 | 30.6 | 24.0 | 29.6 |
| Raipur | 43.6 | 23.3 | 42.2 | 23.3 | 40.8 | 23.0 | 27.1 | 31.8 | 26.8 | 32.0 | 26.5 | 31.2 |
| Rajkot | 40.8 | 23.1 | 39.9 | 23.8 | 38.9 | 23.4 | 28.1 | 33.9 | 27.6 | 33.3 | 27.1 | 32.3 |
| Ramagundam | 43.4 | 25.6 | 42.2 | 25.1 | 40.7 | 25.8 | 28.3 | 37.3 | 27.9 | 35.6 | 27.4 | 34.4 |
| Ranchi | 38.9 | 22.1 | 37.7 | 21.8 | 36.4 | 21.5 | 26.2 | 31.7 | 25.6 | 30.4 | 25.2 | 29.2 |
| Ratnagiri | 34.1 | 22.4 | 33.4 | 23.2 | 32.8 | 23.6 | 27.6 | 31.1 | 27.3 | 30.8 | 27.0 | 30.2 |
| Raxaul | 38.6 | 23.1 | 36.9 | 24.5 | 35.5 | 24.6 | 28.9 | 33.0 | 28.4 | 32.0 | 28.1 | 31.8 |
| Saharanpur | 41.3 | 23.8 | 39.6 | 24.6 | 38.1 | 24.0 | 28.5 | 33.6 | 28.1 | 32.9 | 27.8 | 32.5 |
| Shillong | 24.2 | 19.7 | 23.5 | 19.4 | 22.8 | 18.9 | 20.7 | 23.3 | 20.3 | 22.7 | 19.9 | 22.2 |
| Sholapur | 41.1 | 21.6 | 40.1 | 21.6 | 39.1 | 21.2 | 26.6 | 32.6 | 25.8 | 32.1 | 25.1 | 31.5 |
| Surat | 38.4 | 22.7 | 36.9 | 23.9 | 35.7 | 23.4 | 28.3 | 32.4 | 27.9 | 31.7 | 27.6 | 31.4 |
| Texpur | 34.2 | 27.4 | 33.3 | 26.5 | 32.5 | 27.1 | 28.9 | 32.8 | 28.4 | 31.8 | 28.0 | 31.4 |
| Tiruchirapalli | 39.6 | 24.6 | 38.7 | 25.1 | 37.8 | 24.9 | 27.7 | 34.5 | 27.2 | 33.7 | 26.9 | 33.3 |
| Thiruvananthapuram | 33.9 | 26.0 | 33.4 | 26.1 | 32.9 | 25.9 | 27.7 | 32.4 | 27.4 | 31.9 | 27.0 | 31.0 |
| Veraval | 35.2 | 23.9 | 33.8 | 23.5 | 32.8 | 26.6 | 29.1 | 32.3 | 28.7 | 31.6 | 28.4 | 31.1 |
| Visakhapatnam | 36.4 | 26.5 | 35.6 | 27.3 | 35.0 | 27.1 | 29.2 | 33.8 | 28.8 | 33.0 | 28.4 | 32.5 |

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