



Fundamentals of HVAC

Design Conditions



What you will Learn in this Lesson

- Indoor design conditions
- Outdoor design conditions: Weather Data
- Other factors affecting design
- Temperatures in adjacent unoccupied spaces
- Problems

Introduction

This class covers the selection, specification, and determination of the indoor and outdoor environmental conditions that are to be expected at “design time” or the conditions that will govern the sizing of the heating, cooling, and ventilating equipment.

Indoor Design Conditions

- Physiological Principles
 - The purpose of any HVAC system is to provide an environment for human occupants to live and work.
 - Thermal comfort is difficult to please everyone.
- Standard 55 expresses thermal comfort as “that condition of mind that expresses satisfaction with the thermal environment.”

Direct Design Parameters

- Dry Bulb
- Wet Bulb
- Dew Point
- Relative Humidity
- Air velocity

Space Conditions

- Design temperature and humidity conditions are selected to provide occupant comfort or to meet the needs of the equipment (i.e. computers) located within the space
- Thermal comfort conditions can be found in ASHRAE Standard 55
- Design conditions affect the design load in two ways
 - First, the dry bulb temperature affects the heat transfer rate through the building envelope and the sensible portion of the ventilation and infiltration loads.
 - Second, the design relative humidity affects the latent load from infiltration and ventilation. The latter can be significant.

AHRI Test Conditions: Indoor Air

AHRI 340/360 Unitary and Heat Pump Equip

- Cooling: Standard
 - 80.0 F dry bulb
 - 67.0 F wet bulb
- Cooling: Low Temp
 - 67.0 F dry bulb
 - 57.0 F wet bulb
- Heating
 - 70.0 F dry bulb
 - 60.0 F wet bulb

Application Specific Temperature

- Natatoriums
- Health Care
 - Patient rooms
 - Resident rooms
 - Operating rooms
- Exercise Rooms
- Ice Rinks
- Museums and Libraries

Natatoriums

- The most important design parameter is humidity ratio
- Latent heat gains are huge in pool areas
- Pool evaporation is a little known science

$$wp = A/Y(pw-pa)(95+0.425V)$$

Where:

wp = evaporation of water, lb/hr

A = area of pool surface

Y = latent heat required to change water to vapor at surface water temperature, Btu/lb

pw = saturation pressure at water temp, in. Hg

pa = saturation pressure at room air dew point, in. Hg

V = air velocity over water surface, fpm

Natatoriums

- A modified evaporation equation was developed by ASHRAE

$$wp = 0.1 * A * (pw - pa) * Fa$$

- *Where:*

Type of Pool	<i>Fa</i>
Baseline(unoccupied pool)	0.5
Residential	0.5
Condominium	0.65
Therapy	0.65
Hotel	0.8
Public school	1.0
Whirlpool, spa	1.0
Wavepool, water slide	1.5

Typical Natatorium Design Conditions

Pool Type	Air Temp	Water Temp	RH %
Recreational	75-85	75-85	50-60
Therapeutic	80-85	85-95	50-60
Competition	78-85	76-82	50-60
Diving	80-85	80-90	50-60
Elderly Swimmers	84-90	85-90	50-60
Hotel	82-85	82-86	50-60
Whirlpool, spa	80-85	97-104	50-60

Health Care

- Design conditions for healthcare are governed by public health departments in local jurisdictions
- Many jurisdictions use the FGI Guidelines and ASHRAE Standard 170

Health Care Design Conditions

ASHRAE Standard 170 specifies the acceptable range of temperatures and humidity levels in various spaces along with air change rates

Space	Pressure in. wg	OA ACH	Total ACH	RH %	Dry Bulb (F)
Patient Room	N/R	2	6	Max 60	70-75
PE Room	Positive 0.01	2	12	Max 60	70-75
AII Room	Negative 0.01	2	12	Max 60	70-75
OR	Positive 0.01	4	20	Max 60	68-75
Lab	Negative	2	6	N/R	70-75

Exercise Rooms

- Most exercise spaces have relatively low loads
- Exhaust is necessary but not especially high
- Room temps are generally cooler: 68-72 F
- Humidity should be controlled to stay below 60%
- Wall mounted propeller fans are the best method of cooling people

Ice Rinks

- Ice sheets cause radiant effects on spectators
- High air temperatures cause increased ice loads
- Small spectator areas
 - Spectator areas are typically around 70 °F
 - All areas must be less than 50% RH to prevent fog

Museums and Libraries

- There are special considerations for design parameters in museums and libraries
- Books, artifacts, and rare old documents are destroyed by the effects of temperature and humidity
- Relative humidity is held below 53% and must be held very steady ($\pm 2\%$ RH)
- Room temperatures are held between 68 and 72 F and change must be very slow and gradual

Archives

- Paper stores for archival purposes require very low temperatures and very low humidity
- Temperatures must be below 65 °F and humidity at around a stable 35% to 40%
- The desiccation point for microfilm and magnetic tape is 35% RH so humidification is needed to stay above this point

Outdoor Design Conditions

- There is a difference between weather and design weather
- Design weather is for determining peak loads and sizing equipment, annual weather is for calculating annual energy use
 - Exception: annual weather data is used in calculating loads based on the heat balance method
- There are several weather parameters available which are used for different purposes

Outdoor Design Conditions

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Design conditions for ATLANTA, GA, USA

Station Information

Station name	WMO#	Lat	Long	Elev	StdP	Hours +/- UTC	Time zone code	Period
<i>1a</i>	<i>1b</i>	<i>1c</i>	<i>1d</i>	<i>1e</i>	<i>1f</i>	<i>1g</i>	<i>1h</i>	<i>1i</i>
ATLANTA	722190	33.65N	84.42W	1033	14.155	-5.00	NAE	7201

Annual Heating and Humidification Design Conditions

Coldest month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB	
			99.6%			99%			0.4%		1%			
	99.6%	99%	DP	HR	MCDB	DP	HR	MCDB	WS	MCDB	WS	MCDB	MCWS	PCWD
2	3a	3b	4a	4b	4c	4d	4e	4f	5a	5b	5c	5d	6a	6b
1	18.8	23.9	1.9	6.3	24.9	6.7	8.1	29.0	26.1	36.4	24.2	37.3	11.8	320

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest month	Hottest month DB range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%			
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD
7	8	9a	9b	9c	9d	9e	9f	10a	10b	10c	10d	10e	10f	11a	11b
7	17.5	93.9	74.8	91.6	74.3	89.3	73.5	77.4	88.5	76.3	86.8	75.3	85.1	9.0	300

Dehumidification DP/MCDB and HR									Enthalpy/MCDB					
0.4%			1%			2%			0.4%		1%		2%	
DP	HR	MCDB	DP	HR	MCDB	DP	HR	MCDB	Enth	MCDB	Enth	MCDB	Enth	MCDB
12a	12b	12c	12d	12e	12f	12g	12h	12i	13a	13b	13c	13d	13e	13f
74.3	133.2	82.0	73.3	128.5	80.5	72.4	124.7	79.7	33.7	88.6	32.6	87.0	31.7	85.6

Outdoor Design Conditions: Location

- Name of the station
- Latitude and longitude
- Elevation
- Standard pressure at the elevation
- Time zone
- Data period (7201 means period from 1972 to 2001)

Outdoor Design Conditions: Heating

- Coldest month (i.e. lowest average DB temp)
- Dry bulb 99.6% and 99.0%
- Dew-Point 99.6% and 99.0%
- Humidity ratio grains per pound
- Mean coincident dry-bulb temperature (at this dew point)
- Wind speed 0.4% and 1.0% for coldest month
- Mean coincident dry-bulb temperature at that wind speed
- Mean wind speed coincident at 99.6% dry-bulb temperature and most frequent wind direction

Outdoor Design Conditions: Cooling

- Hottest Month
- Daily temperature range for hottest month
- Dry-bulb temperature 0.4%, 1.0%, and 2.0%
- Mean coincident wet-bulb temperature
- Wet-bulb temperature 0.4%, 1.0%, and 2.0%
- Mean coincident dry-bulb temperature
- Mean wind speed coincident with 0.4% dry-bulb temperature
- Most frequent wind direction at that speed
- Dew-Point temperature 0.4%, 1.0% and 2.0%
- Humidity Ratio at that dew-point and pressure in gr/lb
- Mean coincident dry-bulb temperature at dew-point
- Enthalpy 0.4%, 1.0% and 2.0%
- Mean coincident dry-bulb temperature at enthalpy

Outdoor Design Conditions: Which Ones?

- The designer, engineer, or other user must decide which set(s) of conditions and probability of occurrence apply to the design situation under consideration.
- The logical use for these parameters are:
 - Dry-bulb with MCWB is used to size heating and cooling equipment
 - Wet-bulb with MCDB is used to size cooling towers, evaporative condensers and DOAS
 - Wind speed and direction with the 0.4% DB is used to find quantities of infiltration
 - Dew-point is used to size desiccant wheels, swamp coolers, and DOAS
 - Enthalpy is used for calculating loads due to infiltration and ventilation

Other Factors that Affect Design Conditions

- The single largest influence on design in the twenty first century is annual energy consumption
- An emphasis should be placed on the part load efficiency of building systems
- This usually means part load equipment efficiency and controllability of systems
- Other factors include: flexibility, appearance, durability, serviceability, and environmental impact

End of Lesson

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