AIRAH DA20 Design Guide

Humid Tropical Air Conditioning

- The previous DA 20
  - First published 1997
  - 36 pages

- Current DA 20
  - Review process commenced 2013
  - Review Group involved 7 designers across Australia
  - 12 additional reviewers
  - 136 pages
AIRAH DA20 Design Guide

– Scope
– Climate, Comfort, External Air, Internal Moisture
– Building Design Elements
– A/C Selection & Application
– A.C System Design
– Installation, Commissioning and Maintenance
– Appendices
  • Climate Data
  • Ventilative Cooling for Comfort in Humid Tropics
Location of Hot Humid Regions

- North of 23°28’ S
  (Tropic of Capricorn 23.4 °S)
  (Tennant Creek – 900 km inland from Darwin??)

- Areas where the summer outdoor design Dew Point exceeds the indoor dry bulb temperature
  (Port Hedland at 39.5 °DB / 28.0 °CWB / 24.3 °CDP, 20.3 °S, so a couple of degrees south of there??)

- National Construction Code?
  (Provides building and building services energy guidelines but does not define Hot Humid Regions)
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National Construction Code
Climate Zones for Thermal Design

Comes close but Halls Creek?

We are chasing hot / humid ambient design parameters
• One of the major failings of the old DA 20 was identification of hot humid regions:

Based on mean temperature, mean rainfall and the type of fauna present.
Figure 2.1: Australian Climate Classes
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3pm Vapour pressure (hPa)
January 2013

24.1 °CDP
23.0 °CDP
Australia and New Zealand cold and hot-humid regions with mixed demand between

Residential HVAC system zones
- Red: Hot-humid (air conditioning)
- Yellow: Mixed (heating and cooling)
- Blue: Cold (heating required)

Figure 2.3: Three zone heating/cooling regions map.
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Northern Region

BMW – Northern Regions HVAC Design
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Balgo
North West Regions
Southern Regions
Blackstone

Climate zones based on temperature and humidity

WA Police Accommodations Standards
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• Section 3 – Building Design and System Selection
  • Passive Design
  • Low Energy Design
    – Natural Ventilation
    – Mechanical Ventilation
    – Evaporative Cooling
    – Hybrid Systems (Ceiling Fans / AC)
  • Refrigerated Cooling Systems

Type of HVAC system will be dependent on intended building use, building design and internal design conditions.
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- Building Elements
- Vapour Migration and Condensation
  - Vapour Seals
  - Insulation
  - Sislation position
  - Air tightness of the fabric
  - Thermal bridging / cold tracking
  - Moisture permeantation
  - Air / dust infiltration
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• Section J building efficiency/insulation versus dehumidification

  – Insulation
    On which side the insulation does the foil face (vapour barrier) go – to the outside or inside?
    Simple Rule –
    The vapour barrier goes on the most hot and humid side.

  – Building air tightness
    Can we rely on the builder to provide an airtight building, a full vapour barrier?
    Will the design of the building prevent infiltration?
    2 x NO!!
    Rule No 1 - Pressurize
CASE 2: Vapour barrier in wrong location
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CASE 1: Good Practice

Temperature °C

- Inside
  - Insulation structure
  - Room
  - Dry Bulb
- Outside
  - Dry Bulb
  - Vapour barrier
  - Dew Point
  - Satisfactory vapour barrier
  - Ideal vapour barrier
Mould formed in wall sheeting saturated by condensation
Once mould has established itself, it does not take long to grow. Hard to completely remove. Given the right conditions (moisture, food), mould will grow again, sometimes months / years later.

- Mould spore
- Food (dust)
- Moisture / water
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Failure of vapour barrier
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• Fungal Contamination of HVAC systems
  • Ducts
  • Coils
  • Drip trays
  • Condensate drains
  • Ceiling diffusers
  • Discharge louvres of wall splits, cassettes
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Underside of A/C unit drip tray.
Insufficient insulation between tray and casing.
Carnarvon – saturated return air filter from secondary FCU
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Section 4.9

Covers Controls, Control Logic & Control Routines

– Scheduled and non scheduled start / stop
– Occupied / unoccupied modes
– Space temperature reset
– Economy cycle
– Night purge
– Dehumidification control
– Ventilation interlocks
– Demand controlled ventilation
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Section 5

Covers Air Conditioning System Design

– Controlling Indoor Humidity
– Outdoor air based strategies for humidity control
– Heat recovery
– Air distribution system arrangements
– Constant volume, variable volume
– Variable refrigerant flow systems
– Chilled beam systems
– Plantrooms
– Piping (refrigerant and chilled water)
– Ductwork details
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Going down the path for air conditioning

• Ambient Design Conditions
  – CAMEL
  – ASHRAE (Appendix B of DA 20)
  – AIRAH Handbook
  – Building Management & Works Design Guidelines
  – WA Police Design Guidelines
  – Rio Tinto, FMG, etc, etc
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CAMEL

Comfort design conditions are temperatures that do not occur more than 10 days per year – at 3 PM, averaged over years.

CAMEL calculates space heat load and airflow rate.

Table 1: Design Conditions based on climatic data

<table>
<thead>
<tr>
<th>Map</th>
<th>Location</th>
<th>Western Australia</th>
<th>Perth Ro</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Design Conditions based on climatic data</td>
<td>before</td>
<td>1990</td>
</tr>
<tr>
<td></td>
<td>3pm *CDB</td>
<td>36.6</td>
<td>36.6</td>
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<tr>
<td></td>
<td>3pm *CWB</td>
<td>22.4</td>
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<td>Years on which Design Conditions based</td>
<td>1979-1988</td>
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Table 2: Design Conditions based on climatic data

<table>
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<td>3pm *CDB</td>
<td>36.7</td>
<td>36.7</td>
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<tr>
<td></td>
<td>3pm *CWB</td>
<td>22.1</td>
<td>22.1</td>
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Table 3: Design Conditions based on climatic data

<table>
<thead>
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<th>Map</th>
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<th>Broome Amd</th>
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<td>Design Conditions based on climatic data</td>
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<td>1990</td>
</tr>
<tr>
<td></td>
<td>3pm *CDB</td>
<td>36.8</td>
<td>37.4</td>
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<td></td>
<td>3pm *CWB</td>
<td>28.5</td>
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<td></td>
<td>Years on which Design Conditions based</td>
<td>1979-1988</td>
<td></td>
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</table>

Table 4: Design Conditions based on climatic data

<table>
<thead>
<tr>
<th>Map</th>
<th>Location</th>
<th>Western Australia</th>
<th>Broome Airport</th>
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<tbody>
<tr>
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<td>Design Conditions based on climatic data</td>
<td>before</td>
<td>1990</td>
</tr>
<tr>
<td></td>
<td>3pm *CDB</td>
<td>35.7</td>
<td>36.4</td>
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<td></td>
<td>3pm *CWB</td>
<td>27.9</td>
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<tr>
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<td>Years on which Design Conditions based</td>
<td>1990-2012</td>
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</table>

No DB / CWB
No WB / CDB
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ASHRAE (Appendix B)

BROOME AIRPORT, Australia

<table>
<thead>
<tr>
<th>Coldest Month</th>
<th>Heating DB</th>
<th>99,6%</th>
<th>99%</th>
<th>Humidification DP/MCDB and HR</th>
<th>99,6%</th>
<th>99%</th>
<th>Coldest month WS/MCDB</th>
<th>0,4%</th>
<th>1%</th>
<th>MCWS/PCWD to 99,6% DB</th>
<th>MCWS</th>
<th>PCWD</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>(b)</td>
<td>(c)</td>
<td>(d)</td>
<td>(e)</td>
<td>(f)</td>
<td>(g)</td>
<td>(h)</td>
<td>(i)</td>
<td>(j)</td>
<td>(k)</td>
<td>(l)</td>
<td>(m)</td>
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<tr>
<td>(1)</td>
<td>7</td>
<td>10,9</td>
<td>12,4</td>
<td>-6,1</td>
<td>2,3</td>
<td>26,9</td>
<td>-3,2</td>
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<table>
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<tr>
<th>Annual Cooling, Dehumidification, and Enthalpy Design Conditions</th>
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<tr>
<td>Hottest Month</td>
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<tr>
<td>---------------</td>
</tr>
<tr>
<td>(a)</td>
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<tr>
<td>(2)</td>
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</table>

<table>
<thead>
<tr>
<th>Dehumidification DP/MCDB and HR</th>
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<tr>
<td>(a)</td>
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<tr>
<td>(3)</td>
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</table>

<table>
<thead>
<tr>
<th>Extreme Annual Design Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme Max WB</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>(a)</td>
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<tr>
<td>(4)</td>
</tr>
</tbody>
</table>
For hot humid regions, there are three design conditions that need to be addressed:

- Heat Load Calculations for building heat gain, typically dry bulb / wet bulb (Room sensible heat gain to determine airflow)
- Wet bulb / coincidental dry bulb for cooling coil performance calculations (Cooling capacity based on design airflow)
- Ambient conditions for selection of condensing units, air cooled chillers, cooling towers
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Ambient Design Parameters

PSYCHROMETRIC CHART
NORMAL TEMPERATURES
SI METRIC UNITS
Barometric Pressure 101,325 kPa
SEA LEVEL

Cooling Coil Condition
33.5 CDB / 29.1
37.4 / 28.5

Air Cooled Chiller Condition
37.8 / 23.2 CWB
36.6 / 20.1 CWB

AIRAH Handbook - Perth
AIRAH Handbook - Broome
BMW Design Guidelines
If, for Perth, the actual ambient conditions (dry bulb) exceed design, what are the consequences?

Higher indoor temperatures, for relatively short periods of time. No building damage.

If, for Broome, the actual ambient conditions (coincidental dry bulb / wet bulb) exceed design, what are the consequences?

Potentially huge – collapsing ceilings, mould growth
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- Internal Comfort Conditions

Note that “Operative temperature” is not the same as the space temperature measured by a thermometer or temperature sensor.
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#### Indoor Design Conditions

**Dew Point / Dry Bulb / Relative Humidity**

If the intent is to increase (Max) dry bulb space temperature, then humidity needs to be reduced to remain at or under 13.0 °C DP to prevent mould growth.

<table>
<thead>
<tr>
<th>DP</th>
<th>22.5 °CDB</th>
<th>23.0 °CDB</th>
<th>23.5 °CDB</th>
<th>24.0 °CDB</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.0 °CDP</td>
<td>54.9 %RH</td>
<td>53.3 %RH</td>
<td>51.7 %RH</td>
<td>50.2 %RH</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DP</th>
<th>24.5 °CDB</th>
<th>25.0 °CDB</th>
<th>25.5 °CDB</th>
<th>26.0 °CDB</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.0 °CDP</td>
<td>48.7 %RH</td>
<td>47.3 %RH</td>
<td>45.9 %RH</td>
<td>44.6 %RH</td>
</tr>
</tbody>
</table>
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• Outside Air
  – Strategies for treating the outside air component whilst minimising energy and still meeting statutory requirements.

• Building Pressurisation
  – Dealing with air tightness
  – Building leakage
  – Infiltration
  – Affect on building performance and internal moisture content
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• System Selection and Design

There isn't just one solution to the design.

  • DX Evaporator Coils and moisture removal
  • DX Evaporator Coils and Entering Air Temperature
  • DX Units for Pre-conditioning Outside Air
  • DX Vs Chilled water systems
  • Heating water systems
  • Heat Rejection equipment
    – Condensers
    – Cooling Towers
    – Dry Coolers (or air cooled chillers)
Don’t assume that a single row coil in a humid environment will remove enough moisture.

Example
Let us take a small room that is say 100m² floor area and 300m³ volume. Let’s assume an average heat load of 150 w/m² gives us 15kW load. Assume for the purposes that we put fresh air into the space of 10 l/s/person at 1 person per 10 provides 100 l/s. Assume a 40 kJ/kg gives about 4.5 kW cooling to remove the moisture to get to 22 at 50% gives 100 ml per minute of water, 6 l/hr.

A typical split for comparison gives us 2 l/hr moisture removal from the coil would barely remove 1/3 of that moisture.
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DX Systems

Evaporator Coil Entering Air Limitations

Ambient Temperature 37.8 °C (Broome)
Return air temperature at 24.5 °C
% of Outside Air / Supply Air Varies
Mix Entering Air on Coil Condition

<table>
<thead>
<tr>
<th>% O/A</th>
<th>20%</th>
<th>25%</th>
<th>30%</th>
<th>35%</th>
</tr>
</thead>
<tbody>
<tr>
<td>DB EAT</td>
<td>27.2</td>
<td>27.9</td>
<td>28.5</td>
<td>29.1</td>
</tr>
</tbody>
</table>

Some A/C units can incorporate hot gas bypass and operate up to 31 °C – 33 °C EAT

What happens when Ambient > 37.8 °C?
DX Systems

Evaporator Coil Entering Air Limitations

A classroom of 20 primary school students (population rate at 1 person / 2 m²),
Classroom area = 40 m²
Outside air 12 l/s / person, reduced to 7.5 l/s for use of particulate filters = 150 l/s
Supply air flow rate = 10 l/s / m² = 400 l/s
Evaporator Mix EAT Condition = 29.5 °C
To achieve EAT < 28.0 °C, increase supply air to 580 l/s (increase 45%), 14.5 l/s / m²
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DX Systems

100% Outside Air Using DX (Pre-conditioners)

**Daikin FXMW** – FM Units Nominal Capacity 14.0 – 28 kWr, 300 – 580 l/s

- Uses hot gas bypass
- Typically Max Ambient Temperature - 33.0 °C DB / 28.0 °C WB
- Leaving Air Condition – 18.0 °C DB
- Equivalent Length of Refrigerant Piping – 7.5 m horizontal

What happens when Ambient > 33.0 °C DB?
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- So the above deals with Typical Commercial Building arrangements. What about less usual scenarios;
  - Ventilative Cooling
  - Relationship between air velocity and comfort
  - Hybrid and Mixed Mode Systems
  - Spot Cooling
  - Evaporative Cooling
  - Heating
  - Installation and commissioning
  - Operation and maintenance
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What is paramount?

- Building construction
- Building Pressurization
- Selection of the right combination of air conditioning plant and equipment to handle ambient conditions for both the “Wet and Dry Seasons” and maintain acceptable indoor temperature and humidity
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DA 20 has a wealth of information that needs to be fully digested for you to make the correct design choices

Thank You