HUMIDITY AND BEST PRACTICE IN NORTHWEST PROJECTS

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May 2016
TOPICS TO BE COVERED

- Bad Practice
  - Building Construction
  - Design & Installation

- Design Considerations
  - Location & Climate
  - Mould & Mildew
  - Building Construction
  - Building Leakage and Infiltration
  - Service and Maintenance

- Design Parameters
  - Wet Season & Dry Season
  - Comfort Conditions
  - Dehumidification

- Air Conditioning Design Considerations

- Air Conditioning Plant Types & Limitations
  - Direct Expansion (DX)
  - VRV / VRF
  - Packaged Units
  - Heat Reclaim Units
  - Pre-conditioners

- Devil in the Detail
BAD PRACTICE
Building Construction (Vapour Barrier)
BAD PRACTICE

Design & Installation - The prime issue is condensation
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DESIGN CONSIDERATIONS – LOCATION & CLIMATE

CLIMATE ZONES BASED ON TEMPERATURE AND HUMIDITY

Projection: Lambert conformal with standard parallels (40°S, 40°N)

Based on a standard 30-year climatology (1961-1990)
© Commonwealth of Australia 2005
MOULD & MILDEW

The growth of mould requires five ingredients:

- Oxygen
- Moisture
- Food
- Temperature
- Spores

From the Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH) Design Manual DA 20 – “In a comfortable human environment the temperature is ideal for most fungi and it is virtually impossible to eliminate spores and food. Killing mould and mildew is generally effective only for limited periods. If food and water are available, fungus will grow back. Removing water necessary for fungal growth is often the most practical means of controlling mould and mildew, particularly when the problem spreads to walls, carpets and other parts of a building structure. Note that fungus can derive water from the air, not necessarily in pools (liquid). In practice, mould is controlled by limiting surface condensation and the moisture in materials by controlling the indoor relative humidity.”
VAPOUR BARRIER - WALLS

CASE 1. GOOD PRACTICE

CASE 2. VAPOUR BARRIER IN WRONG LOCATION
VAPOUR BARRIER - ROOF

Australian Building Codes Board
Information Handbook – Condensation in Buildings
THERMAL BRIDGING (COLD TRACKING)

(a) Thermal Bridging

- Heat leakage through frame reduces thermal performance
- Cold frame leads to increased potential for condensation
- Cooler internal face adjacent frame may lead to uneven staining on internal lining (referred to as ghosting)

(b) Thermal Break

- Thermal break stops heat leakage through frame
- Thermal break creates warm frame significantly reducing the potential for condensation and increasing the life expectancy of the frame
- Thermal break can create a small ventilated and drained cavity to deal with any moisture at the back of the cladding. Particularly important for impermeable cladding
- Ensures an even temperature on the internal lining significantly reducing the likelihood of ghosting
BUILDING LEAKAGE & INFILTRATION

- Vapour Barrier
- Door Seals
- Air Locks
- Positive Building Pressure**

ASHRAE Handbook identifies leakage rates as:
- Leaky at 4 l/s/m²
- Average at 2 l/s/m²
- Tight at 0.7 l/s/m²

There are many other country standards, however Australia does not have a standard, although it does try to address infiltration under the National Construction Code.

Building positive pressurization is a basic design principle that must be maintained at all times, particularly in hot humid regions.
SERVICE & MAINTENANCE

- Location of air conditioning plant
  - Plantrooms
  - Ceiling space
  - Exposed to weather
- Type of air conditioning plant – can it be maintained by local service technicians
- Ease of serviceability
  - Service access
  - Maintenance
  - Spare parts
- Redundancy
- Replacement
- Economic Operating Life
DESIGN PARAMETERS

BMW Northern Regions Design Guidelines

States:
Areas with a winter ambient condition above 15 °C do not require provisions for heating unless either:
- The site is occupied 24 hours / day, or
- It is specifically requested by BMW or Department

Design indoor conditions stated as:
- 22.5 °C ± 1.5 °C, for cooling design of 24.0 °C,
- 50 % RH directly controlled by coil selection, 65% for high occupancy areas

Note - The cooling design conditions stated are only the dry season temperatures.

The new DA 20 – Air Conditioning, Cooling & Comfort in Hot Humid Tropical Climates, about to be released, makes limited reference to both DA 09 Australian weather data and ASHRAE formatted data.

<table>
<thead>
<tr>
<th>Location</th>
<th>Ambient Design Conditions °C</th>
<th>db</th>
<th>°C wb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broome (Cape Leveque)</td>
<td>33.7 / 28.8</td>
<td>34.2 / 29.4</td>
<td>19.8</td>
</tr>
<tr>
<td>Broome (La Grange Mission)</td>
<td>37.8 / 29.1</td>
<td>40.4 / 29.8</td>
<td>15</td>
</tr>
<tr>
<td>Cananvon</td>
<td>35.0 / 25.6</td>
<td>38.4 / 27.1</td>
<td>9.4</td>
</tr>
<tr>
<td>Derby</td>
<td>38.8 / 28.1</td>
<td>42.8 / 28.2</td>
<td>10.5</td>
</tr>
<tr>
<td>Derby (Cockatoo Island)</td>
<td>33.7 / 27.7</td>
<td>35.1 / 28.7</td>
<td>21.3</td>
</tr>
<tr>
<td>Derby (Koolan Island)</td>
<td>34.2 / 27.7</td>
<td>35.9 / 29.5</td>
<td>20.2</td>
</tr>
<tr>
<td>Fitzroy Crossing</td>
<td>42.0 / 26.9</td>
<td>41.9 / 28.3</td>
<td>15.1</td>
</tr>
<tr>
<td>Goldsworthy</td>
<td>43.5 / 26.9</td>
<td>45.4 / 28.0</td>
<td>15.6</td>
</tr>
<tr>
<td>Halls Creek</td>
<td>41.0 / 24.5</td>
<td>41.7 / 25.2</td>
<td>13.9</td>
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<tr>
<td>Halls Creek (Turkey Creek)</td>
<td>41.6 / 25.8</td>
<td>39.6 / 28.7</td>
<td>14.9</td>
</tr>
<tr>
<td>Kalumburu</td>
<td>37.9 / 28.2</td>
<td>39.8 / 28.7</td>
<td>15.5</td>
</tr>
<tr>
<td>Kalumburu (Mitchell Plateau)</td>
<td>38.9 / 26.7</td>
<td>38.2 / 28.5</td>
<td>15.8</td>
</tr>
<tr>
<td>Kurrajong</td>
<td>38.9 / 27.6</td>
<td>42.6 / 29.0</td>
<td>15</td>
</tr>
<tr>
<td>Kununurra</td>
<td>40.3 / 27.3</td>
<td>41.3 / 27.7</td>
<td>18.1</td>
</tr>
<tr>
<td>Kurri Bay</td>
<td>35.1 / 27.6</td>
<td>36.3 / 28.4</td>
<td>20.2</td>
</tr>
<tr>
<td>Learmonth</td>
<td>41.9 / 25.9</td>
<td>43.6 / 27.2</td>
<td>11.3</td>
</tr>
<tr>
<td>Mandora</td>
<td>39.6 / 29.1</td>
<td>42.0 / 30.0</td>
<td>15</td>
</tr>
<tr>
<td>Marble Bar</td>
<td>44.6 / 25.8</td>
<td>46.2 / 26.5</td>
<td>13.4</td>
</tr>
<tr>
<td>Mardie</td>
<td>41.0 / 27.6</td>
<td>43.9 / 28.6</td>
<td>12.6</td>
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<tr>
<td>Newman</td>
<td>41.2 / 23.1</td>
<td>43.0 / 27.6</td>
<td>8.1</td>
</tr>
<tr>
<td>Onslow</td>
<td>40.4 / 27.6</td>
<td>45.3 / 28.0</td>
<td>12.5</td>
</tr>
<tr>
<td>Port Hedland</td>
<td>39.5 / 28.0</td>
<td>41.2 / 29.0</td>
<td>14.4</td>
</tr>
<tr>
<td>Roebourne</td>
<td>42.6 / 27.8</td>
<td>44.5 / 27.8</td>
<td>15.2</td>
</tr>
<tr>
<td>Wyndham</td>
<td>41.8 / 27.5</td>
<td>43.7 / 27.9</td>
<td>18.8</td>
</tr>
</tbody>
</table>
Which design condition would you use for an air cooled chiller / condenser??
Note that "Operative Temperature" is not the same as the space temperature as measured by a thermometer or temperature sensor. Operative temperature takes into account temperature, humidity, air speed, metabolic rate, and clothing insulation.
AIR CONDITIONING SYSTEMS

Main Design Requirements:

- Designed to suit application
- Positive building pressurization at all times
- Maintain acceptable indoor air quality (temperature, humidity, air movement)
- Cooling capacity and operation to suit wet and dry seasons
- Relatively high airflow rates and air circulation
- Continuous dehumidification, even at part load
- Lower cooling coil air velocities (≤1.8 m/s)
- Reasonable level of air filtration (primary / secondary filters)
- Prevent cold tracking / condensation
- Provide a level of redundancy
- High level of energy efficiency
- Reasonably smart control system
- Extended economical operating life
- Lower maintenance costs
AIR CONDITIONING PLANT

DX Split Systems ("Off the Shelf") - with staged compressors

Types typically include wall splits, cassettes, underslung and ducted

- Can only provide limited dehumidification due to coil depth
- Cannot provide continuous dehumidification (Pre-conditioner required)
- Limit on entering air temperature onto evaporator coil for high minimum outside applications
- No control over leaving air temperature
- Coil water carry-over at high fan speed
- Insufficient thermal insulation to prevent condensation
- Poor air distribution for wall, cassette and underslung units
- Proprietary control system
VRV / VRF SYSTEMS

DX Split Inverter Systems ("Off the Shelf")
Types typically include wall splits, cassettes, underslung and ducted
- Can only provide limited dehumidification
- Cannot provide continuous dehumidification (Pre-conditioner required)
- Limit on entering air temperature onto evaporator coil for high minimum outside applications
- No control over leaving air temperature
- Coil water carry-over at high fan speed at full cooling capacity
- Insufficient thermal insulation to prevent condensation
- Poor air distribution for wall, cassette and underslung units
- Proprietary control system
- Compliance issues with AS 1677 – short term exposure to refrigerants
PACKAGED AIR CONDITIONING UNITS

“Off the Shelf” (Hitachi, Actron, Dunn Air)
PACKAGED AIR CONDITIONING UNITS

Commercial Grade (Specialized Engineering, Temperzone, Cosair)
100% OUTSIDE AIR (DX) SYSTEMS

Rotary Heat Exchangers (Munters and others)
HEAT RECLAIM - VENTILATION
100% OUTSIDE AIR (DX) SYSTEMS

Pre-conditioner Ducted DX units with electronic expansion valve (Daikin & Others)

- Typically can only provide limited dehumidified airflow (300, 460 & 585 l/s)
- Nominal design ambient condition 33 °C DB / 28 °C WB / 68% RH
- Can operate up to 43 °C but cooling capacity drops substantially
- Supply air set point nominally set for 18 °C DB
100% OUTSIDE AIR (DX) SYSTEMS
Pre-conditioner Air to Air Heat Exchangers (Air Change and others)
## 100% OUTSIDE AIR (DX) SYSTEMS

### Pre-conditioner Air to Air Heat Exchangers (Air Change and others)

<table>
<thead>
<tr>
<th>SUPPLY AIR REQUIREMENT</th>
<th>Dry Bulb</th>
<th>Wet Bulb</th>
<th>Humidity Ratio (gm/kg)</th>
<th>Relative Humidity (%)</th>
<th>Specific Volume (m³/kg)</th>
<th>Enthalpy (kJ/kg)</th>
<th>Dew Point (°C)</th>
<th>Air Flow Rate (l/s)</th>
<th>Mass Flow Rate (kg/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Air</td>
<td>24.0</td>
<td>17.00</td>
<td>9.2356</td>
<td>48.7</td>
<td>0.8543</td>
<td>47.6424</td>
<td>12.87</td>
<td>1000</td>
<td>1.1705</td>
</tr>
</tbody>
</table>

| MAX SA Temp at specified OA | 34.57 |

| Outdoor Air | 40.0 | 28.00 | 19.0185 | 40.7 | 0.9143 | 89.1783 | 24.12 | 1070 | 1.1705 |
| Air Off HX (precool) | 29.1 | 25.40 | 19.0090 | 74.5 | 0.8895 | 77.8477 | 24.11 | 1033 | 1.1705 |
| Air off Evaporator | 12.9 | 12.97 | 9.2356 | 105.0 | 0.8234 | 58.1118 | 12.87 | 963 | 0.6704 |
| Air Bypass | 12.9 | 12.87 | 9.2356 | 100.0 | 0.8234 | 39.3118 | 12.87 | 469 | 0.6704 |
| Air Off HX (Reheat) | 34.5 | 20.41 | 9.2356 | 27.0 | 0.8543 | 59.4118 | 12.87 | 531 | 0.6704 |
| Supply Air | 24.0 | 16.99 | 9.2356 | 49.6 | 0.8543 | 47.6245 | 12.86 | 1000 | 1.1705 |
| HX pre-cool Intermediate Point | 45.0 | 27.99 | 18.0080 | 40.7 | 0.9143 | 89.1542 | 24.11 | 1033 | 1.1286 |
| Evap Intermediate Point | 29.1 | 19.70 | 9.2356 | 26.7 | 0.8690 | 52.6568 | 12.87 | 963 | 1.1077 |
| HX reheat Intermediate Point | 12.9 | 12.87 | 9.2356 | 100.0 | 0.8234 | 35.2643 | 12.87 | 531 | 0.6455 |
| Atmospheric Pressure | 101.325 |
| Sensible HX Eff (Precool) | 0.41 |

### Assumptions

<table>
<thead>
<tr>
<th>Mass Flow Rate (kg/h)</th>
<th>Total (kW)</th>
<th>Sum of Sensible &amp; Latent (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HX Precool Sensible (kW)</td>
<td>1.1705</td>
<td>13.2343</td>
</tr>
<tr>
<td>HX Precool Latent (kW)</td>
<td>1.1705</td>
<td>0.0285</td>
</tr>
<tr>
<td>Evap Load Sensible (kW)</td>
<td>1.1705</td>
<td>19.3780</td>
</tr>
<tr>
<td>Evap Load Latent (kW)</td>
<td>1.1705</td>
<td>29.2406</td>
</tr>
</tbody>
</table>

| Overall Cooling kW Requirement | 61.88 |

| HX Reheat Sensible (kW) | 0.6001 | 13.2528 | 13.26 |

| Total Reheat kW | 13.25 |

### Summary

<table>
<thead>
<tr>
<th>Total Cooling Capacity</th>
<th>Evap Capacity</th>
<th>Total cooling+reheat</th>
<th>Energy Saved-total</th>
</tr>
</thead>
<tbody>
<tr>
<td>61.9</td>
<td>48.6</td>
<td>75.1</td>
<td>35.3%</td>
</tr>
</tbody>
</table>
100% OUTSIDE AIR – HEAT RECLAIM

Run-around Coils with Chilled Water (Control of leaving air temperature)
FAN COIL UNITS

- Sandwich panel construction
- Minimum 50 mm thick insulation
- Incorporate anti-cold tracking (fan discharge, access doors, construction joints)
- Anti-vibration mounts / fans spring mounted
- Coiling and heating coils as required (for dehumidification or part run around coils)
- Cooling Coil Air Velocity <= 1.8 m/s
CHILLED WATER

- Chiller – Air Cooled or Water Cooled

Water Quality
Redundancy (Multiple chillers, dual circuits, multiple compressors)
Maintenance
DEVIL IN THE DETAIL

- Location and selection of diffusers
- Diffuser and cushion head details
- Ductwork insulation
- Insulation of duct mounted dampers / fire dampers
- Flexible connections at AC unit
- Cold tracking of AC units
- Filter bank access (primary & secondary?)
- Drip trays & condensate drains
- Back draft dampers
- Insulation of exhaust ductwork
- Control system & logic
- Maintenance access
- Commissioning & tuning
DEVIL IN THE DETAIL
THANK YOU

QUESTIONS ???