Design Guide DA20 Humid Tropical Air Conditioning

March 2017

AIRAH

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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

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HUMIDITY ISSUES IN AUSTRALIAN CLIMATES WORKSHOP
Sydney 2016

– 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

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HUMIDITY ISSUES IN AUSTRALIAN CLIMATES WORKSHOP
Sydney 2016

Location of Hot Humid Regions

– North of $23^{0}28'$ S

(Tropic of Capricorn 23.4 ^{0}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 ^{0}DB / 28.0 ^{0}CWB / 24.3 ^{0}CDP, 20.3 ^{0}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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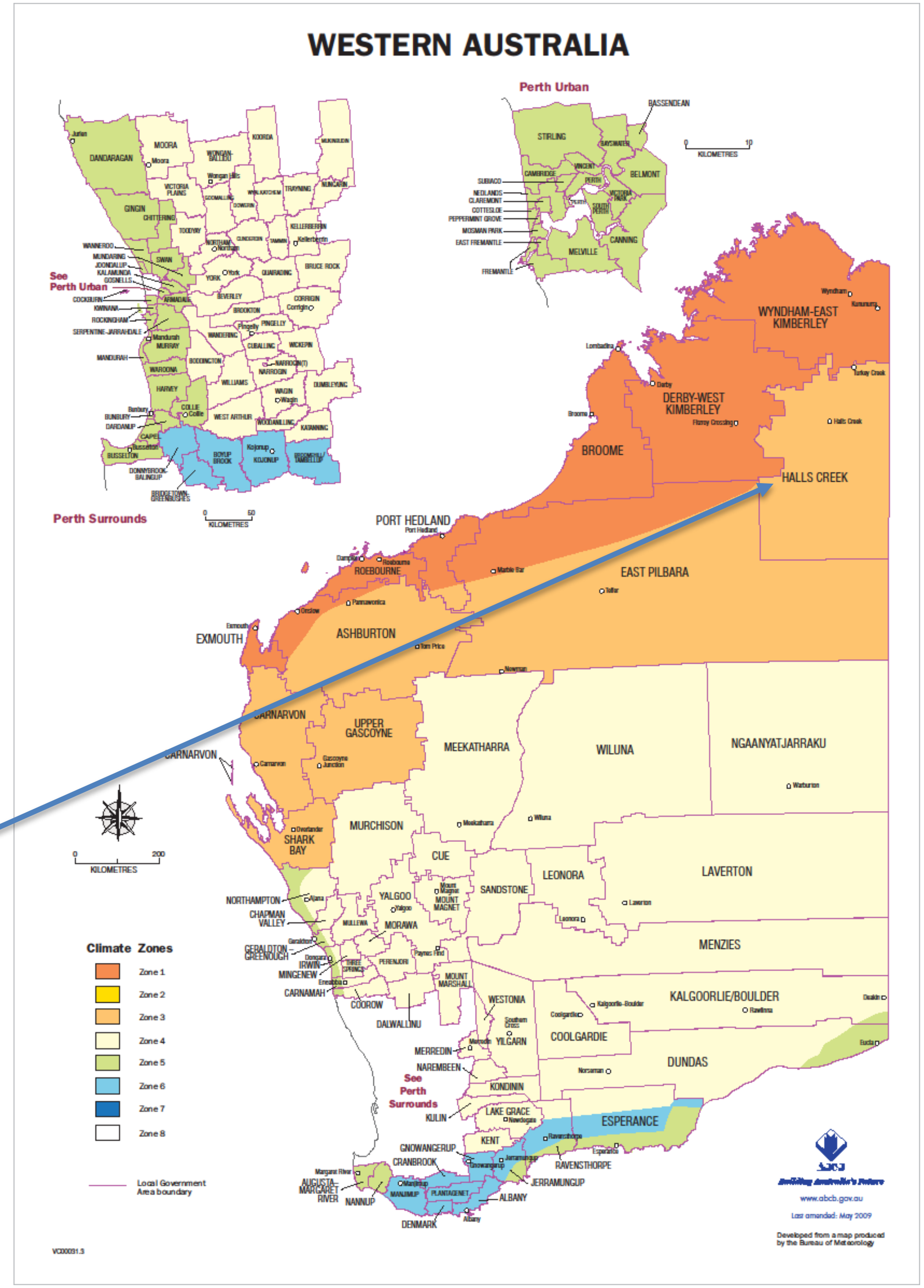
National Construction Code Climate Zones for Thermal Design

Comes close but Halls Creek?

We are chasing hot / humid ambient design parameters



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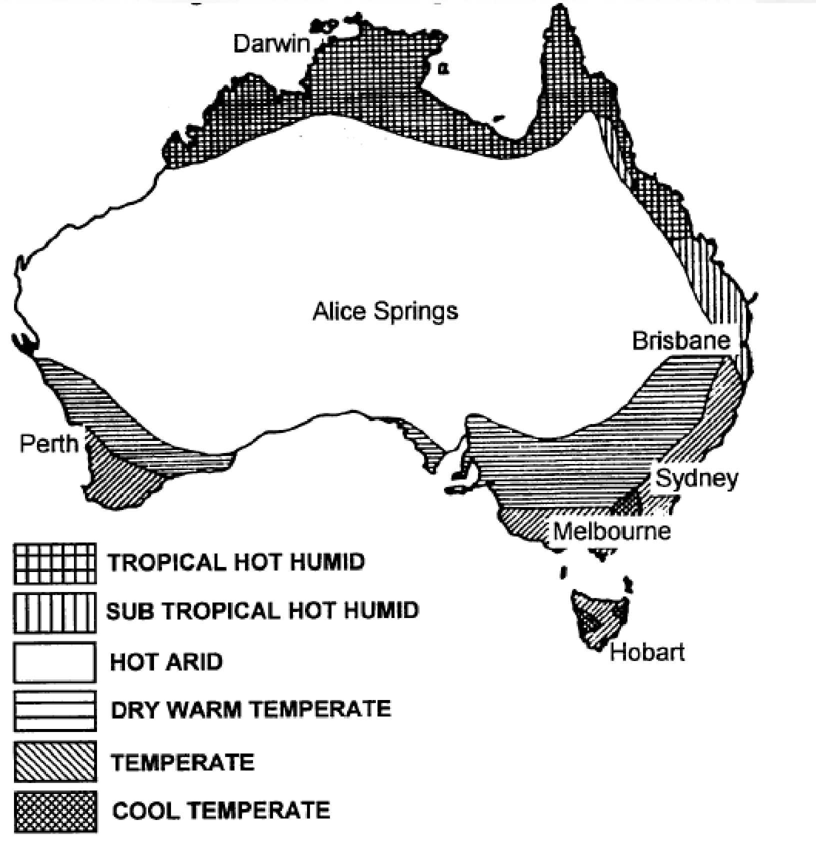
- One of the major failings of the old DA 20 was identification of hot humid regions:



Based on mean temperature, mean rainfall and the type of fauna present

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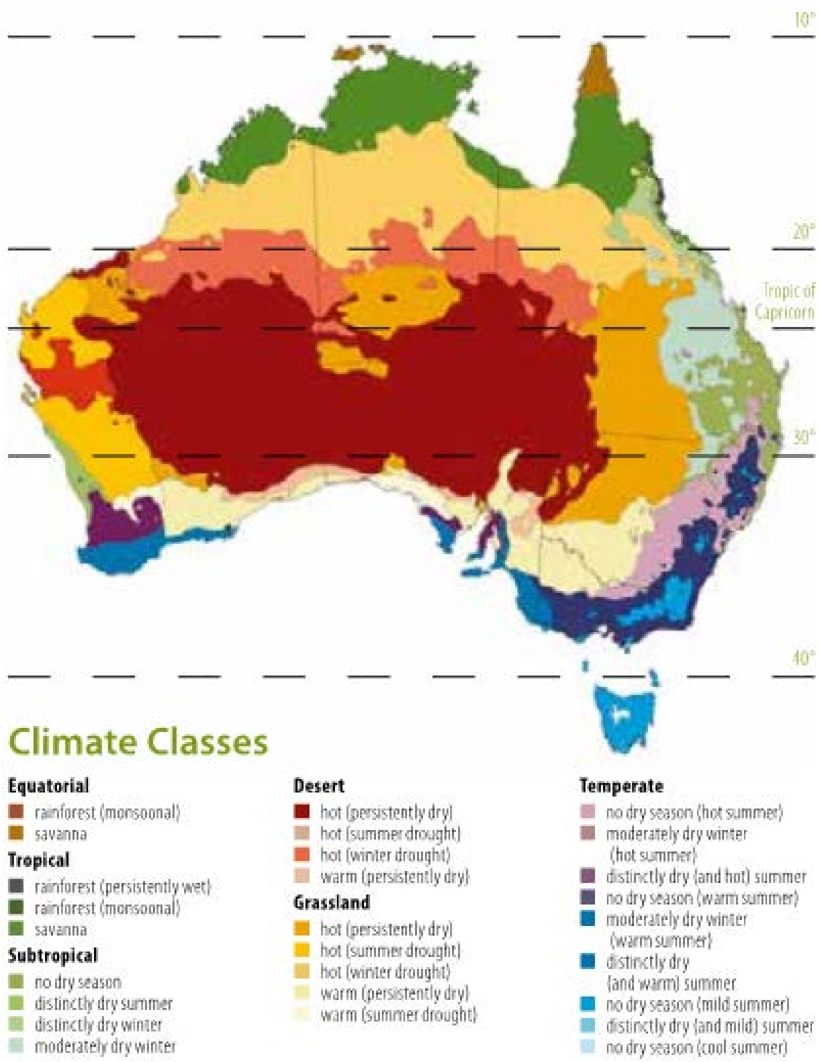

Figure 2.1: Australian Climate Classes

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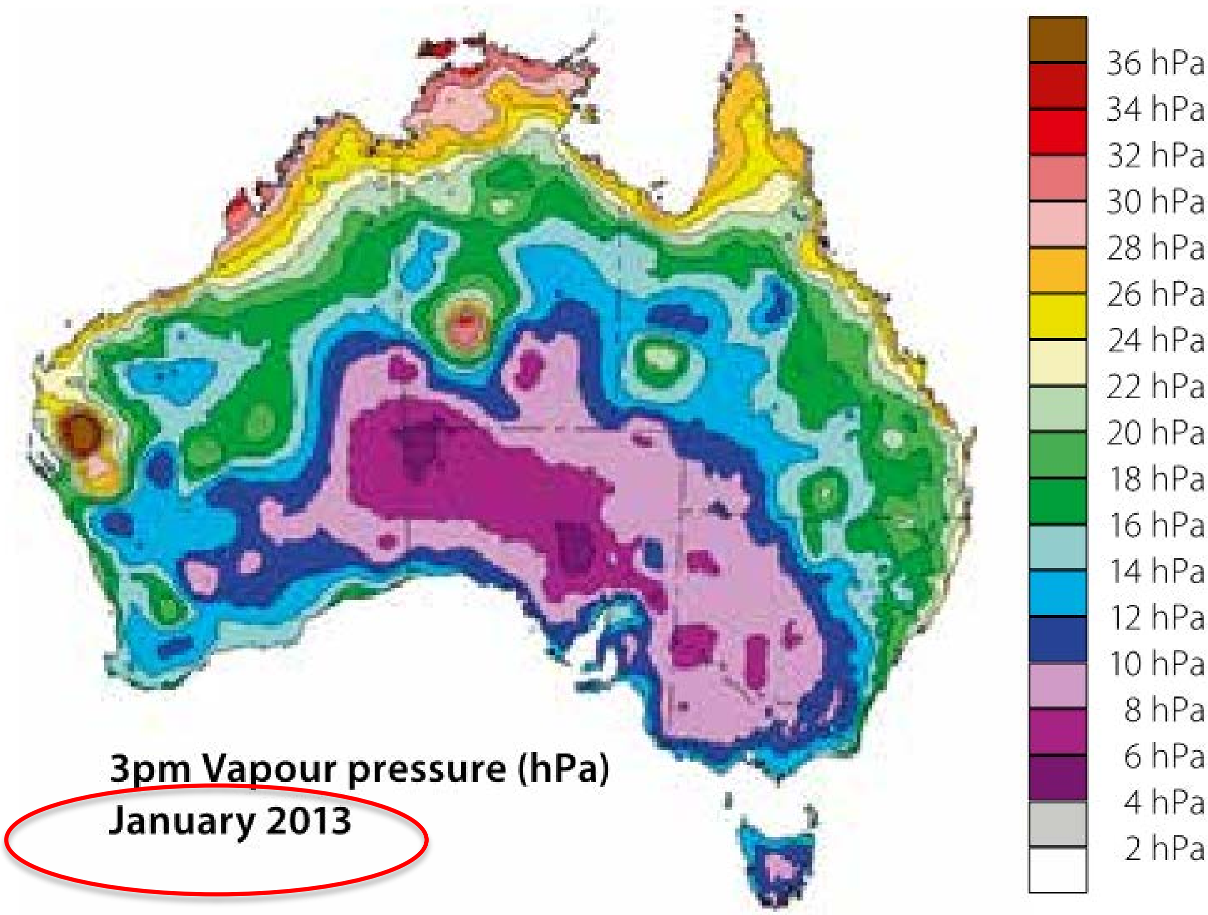

24.1 ^{0}CDP
23.0 ^{0}CDP

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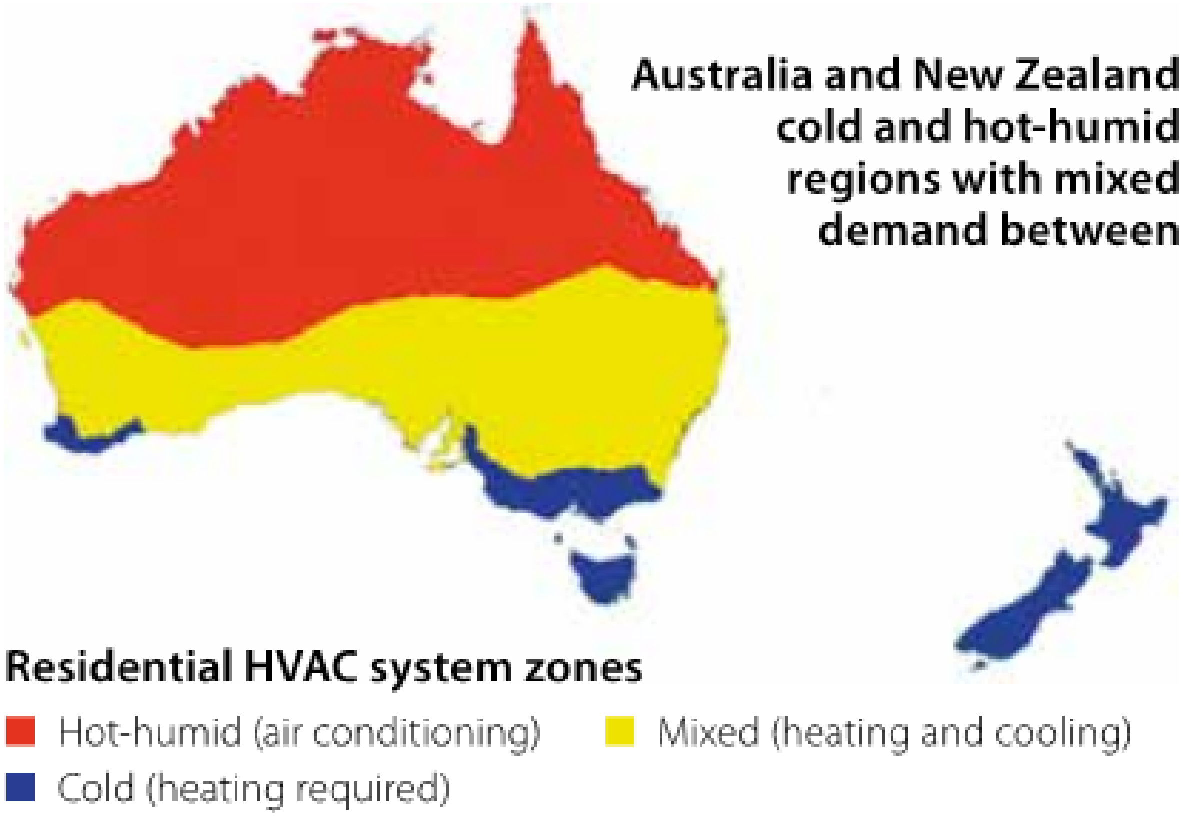

Figure 2.3: Three zone heating/cooling regions map.

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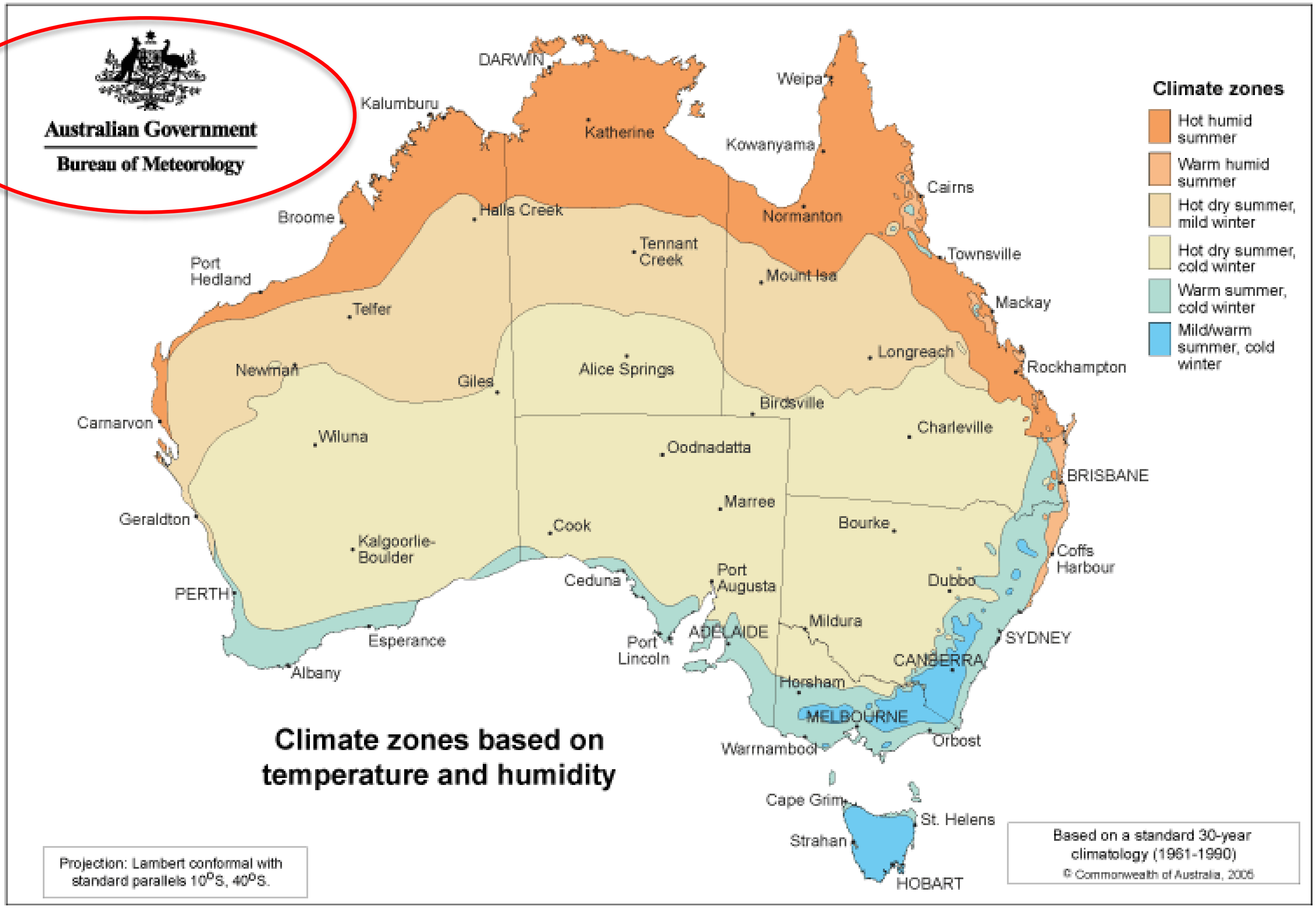

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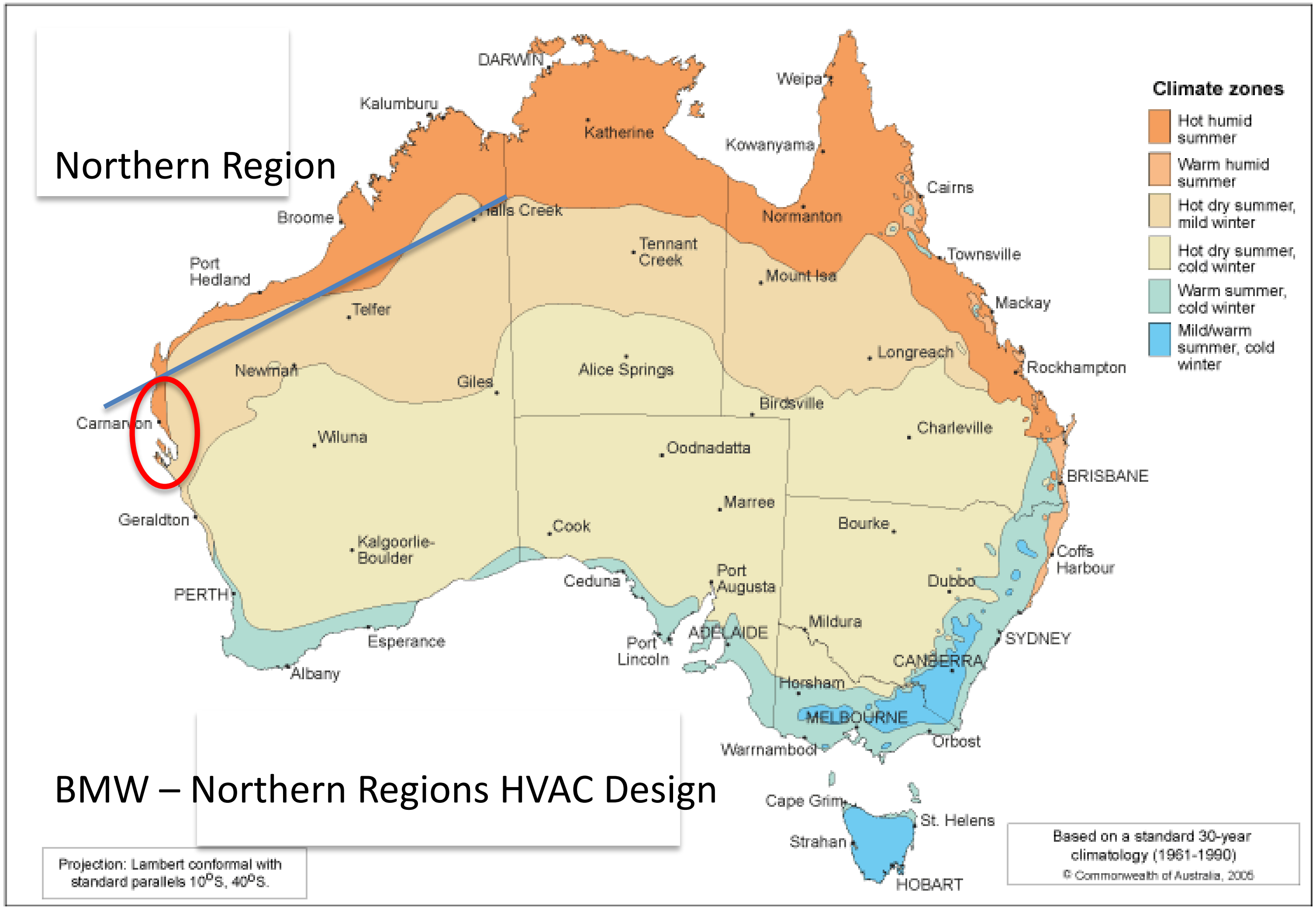

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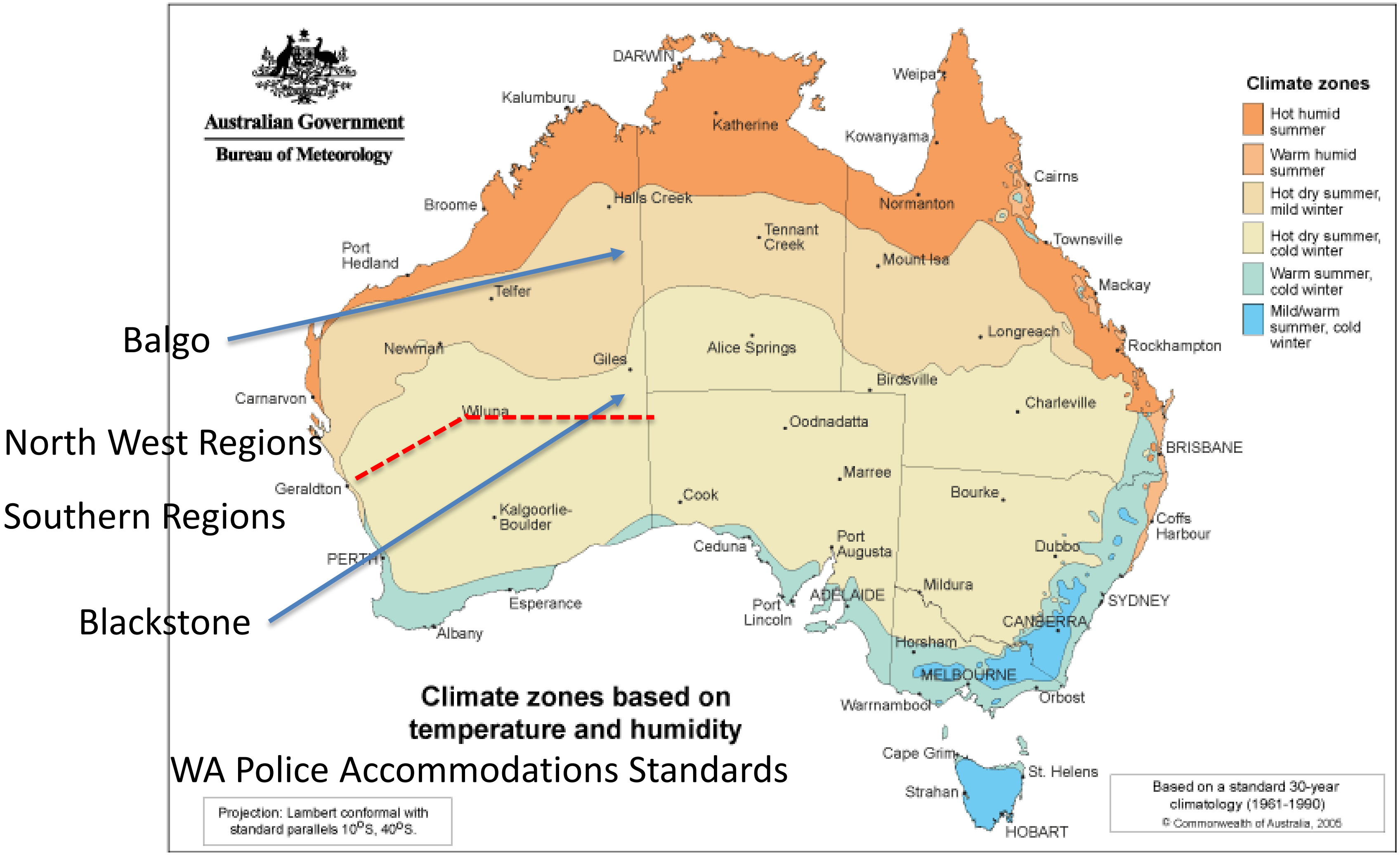

WA Police Accommodations Standards

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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

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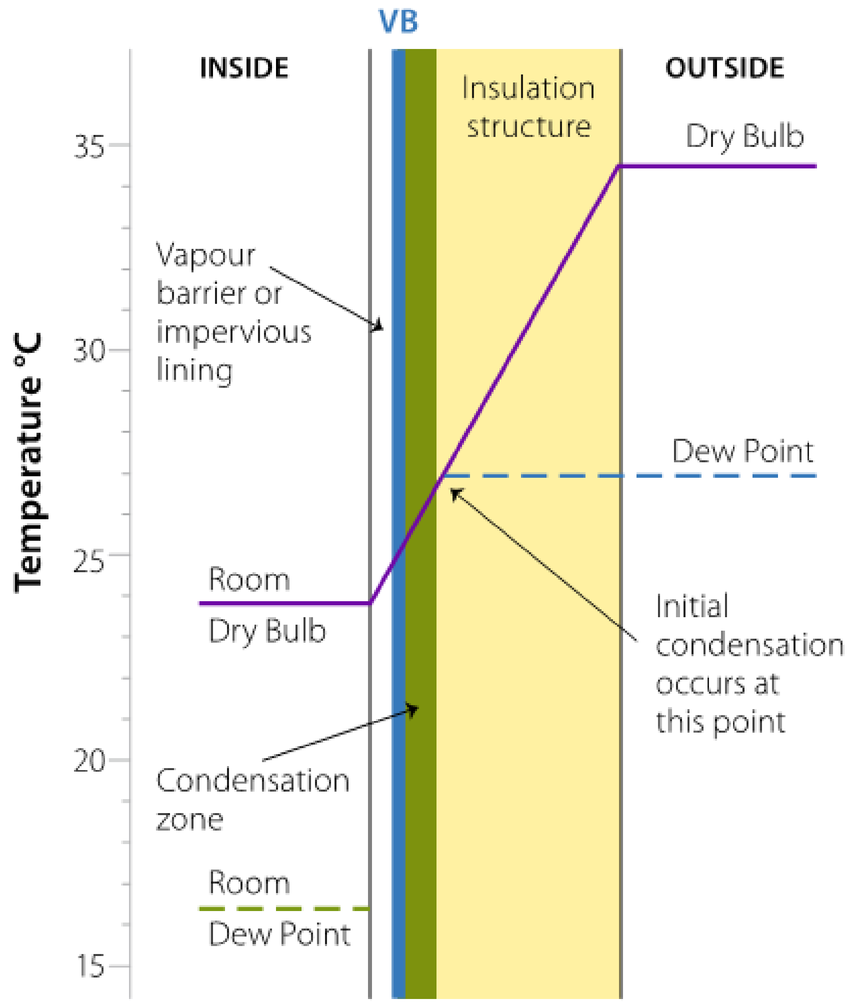

CASE 2: Vapour barrier in wrong location

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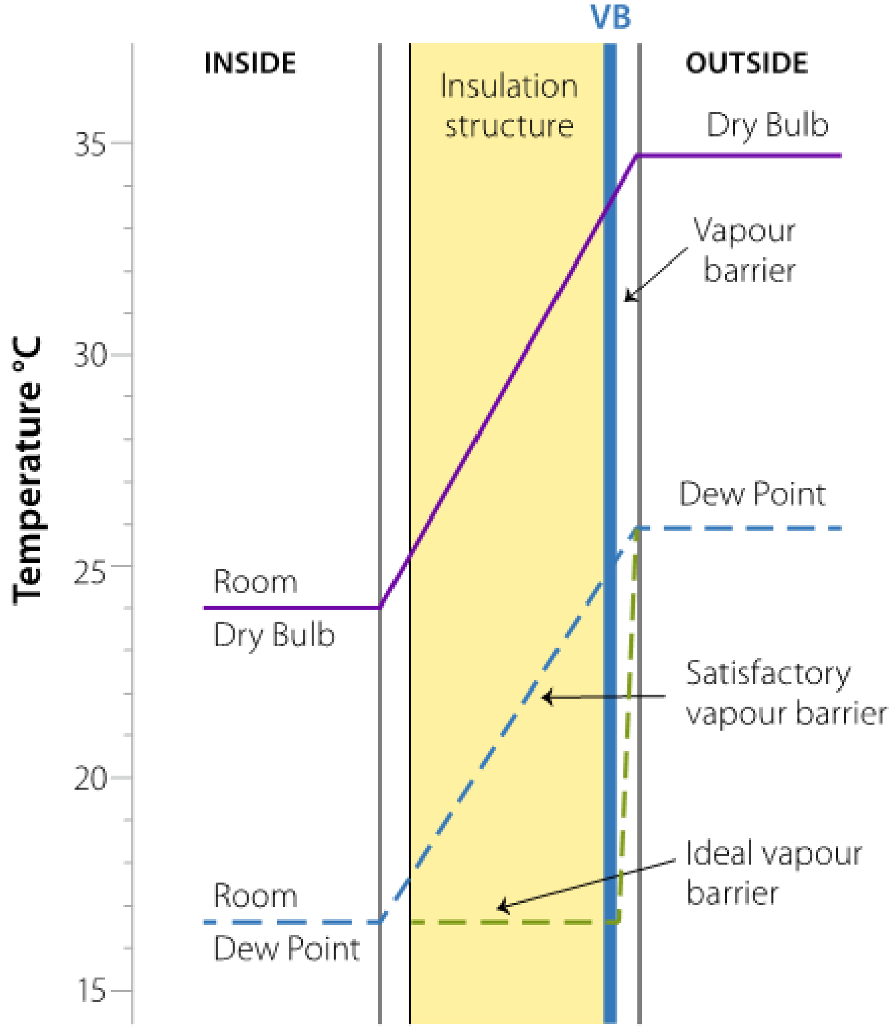

CASE 1: Good Practice

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Mould formed in wall sheeting saturated by concensation

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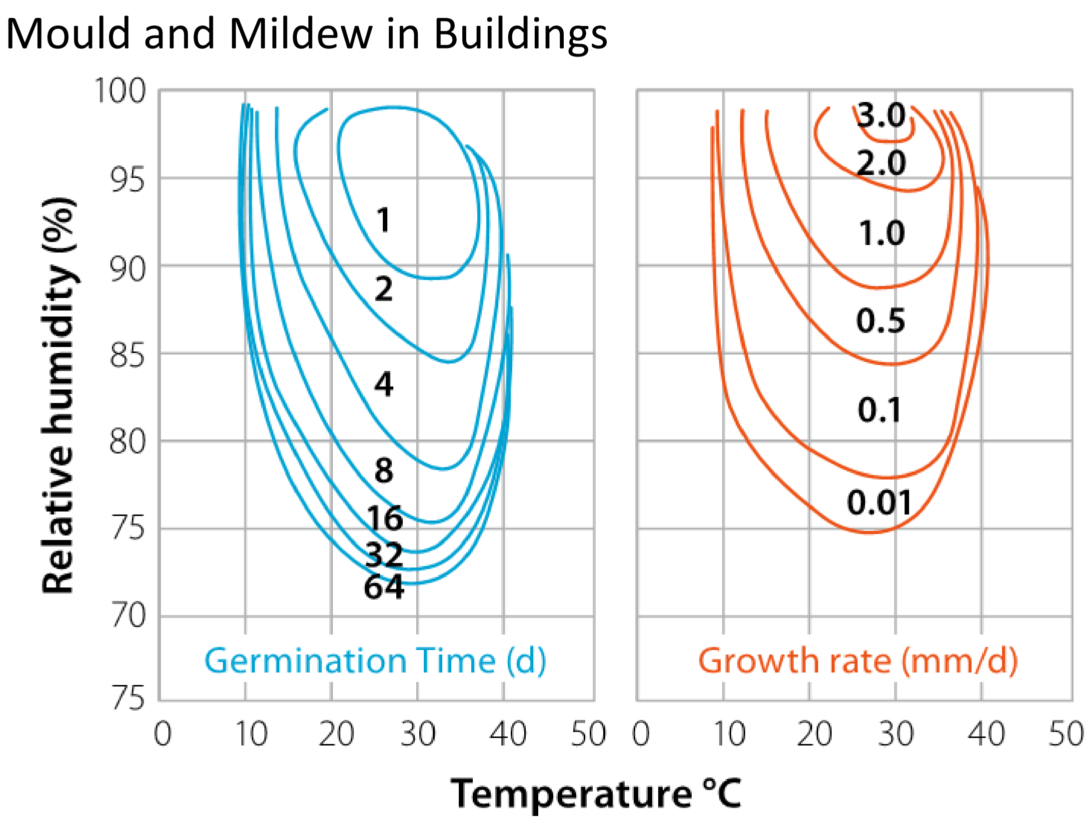

- Mould spore
- Food (dust)
- Moisture / water

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.

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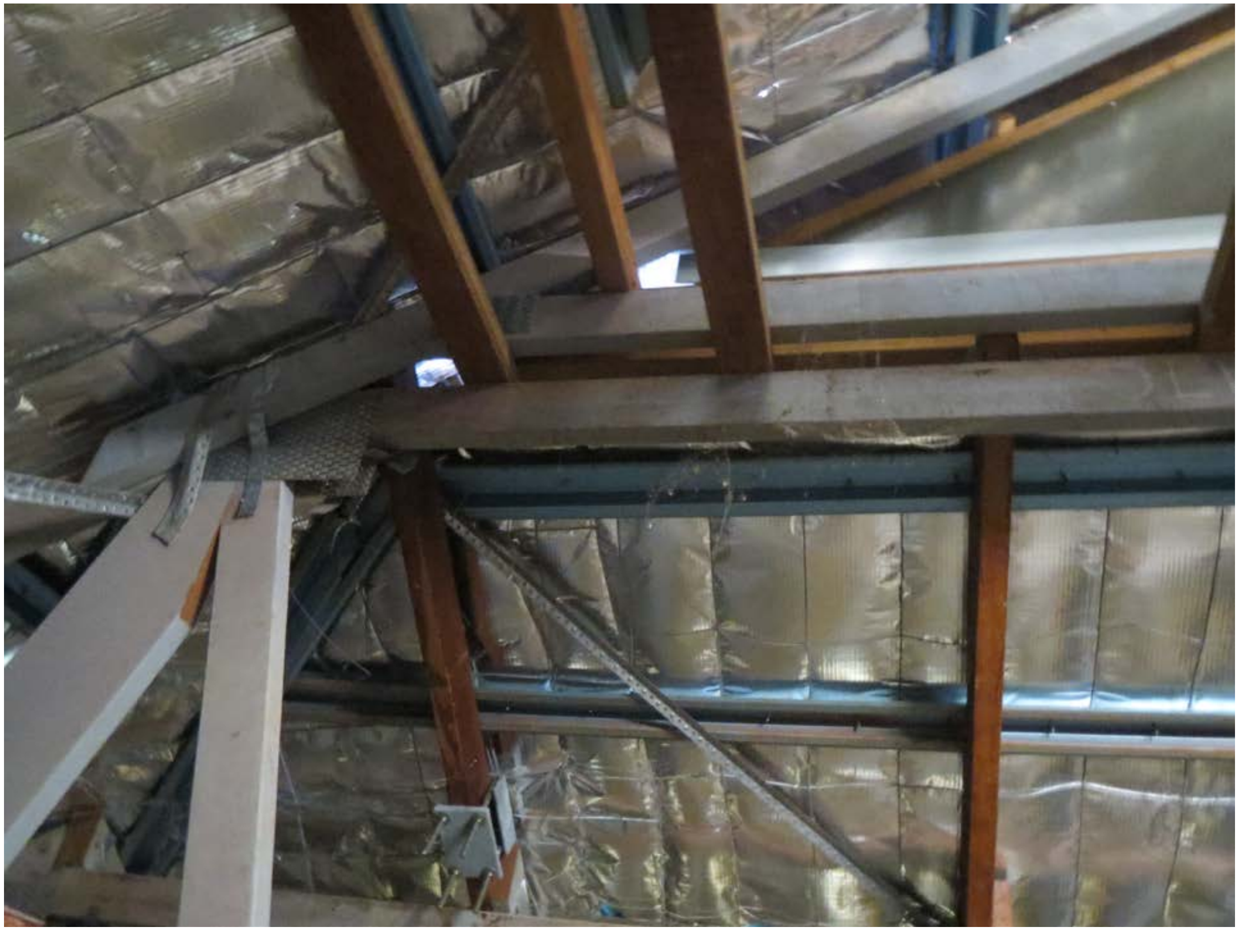

Failure of vapour barrier

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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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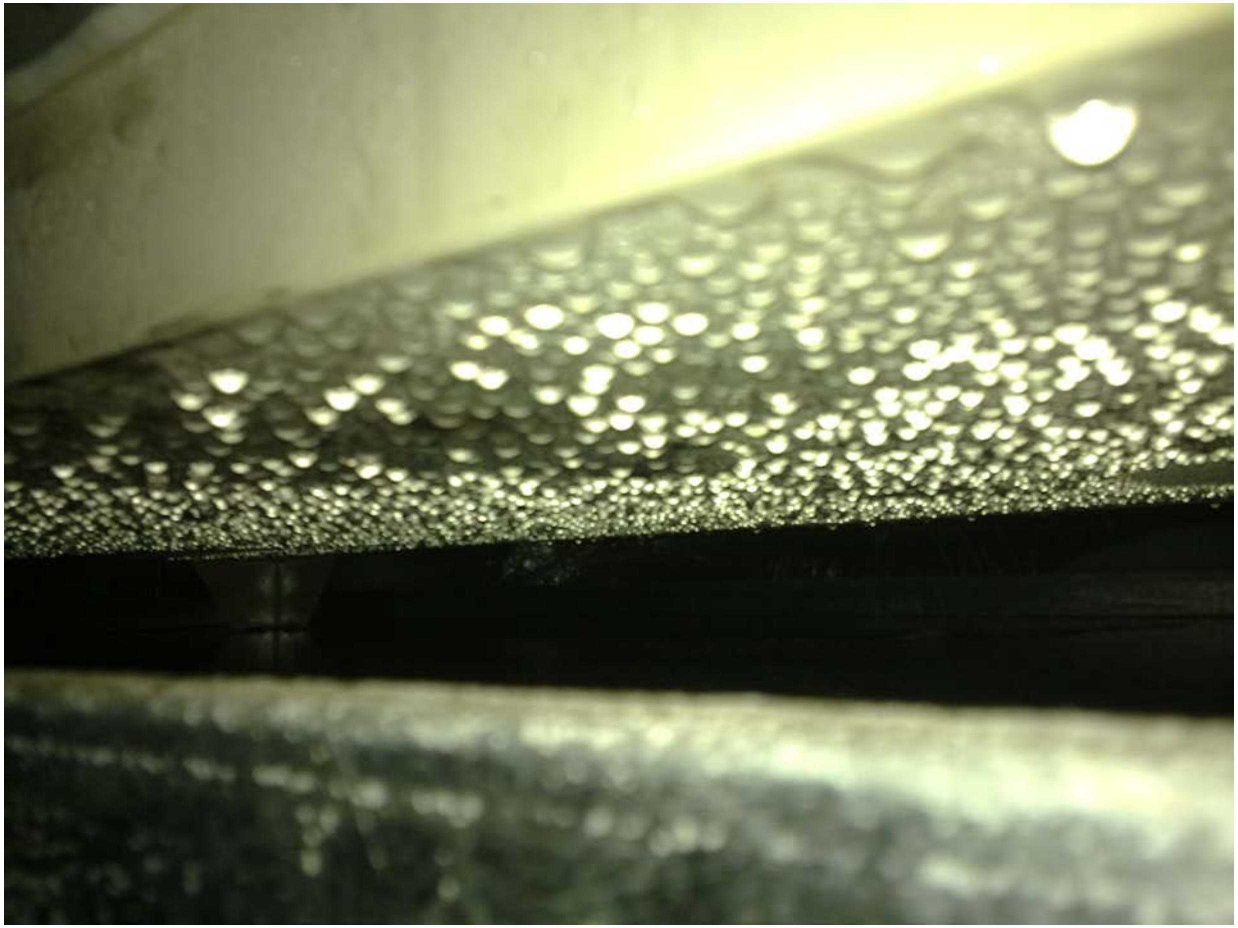

Underside of A/C unit drip tray.
Insufficient insulation between tray and casing.

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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

No DB / CWB
No WB / CDB

Map | Location: Western Australia | PERTH RO

Design Conditions based on climatic data: before (●) 1990 ( ) after

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
3pm °CDB	36.6	36.6	36.6	31.9	28.1	24.7	22.9	24.1	27.6	32.2	35.4	36.5
3pm °CWB	22.4	22.4	22.4	20.6	19.5	18.2	16.2	16.9	17.7	19.0	20.6	22.4

Years on which Design Conditions based 1979-1988

Map | Location: Western Australia | PERTH METRO

Design Conditions based on climatic data: before ( ) 1990 (●) after

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
3pm °CDB	36.7	36.7	36.7	33.6	28.7	23.4	23.1	23.6	26.9	31.7	35.3	36.7
3pm °CWB	22.1	22.1	22.1	20.9	19.2	17.3	16.5	17.0	17.0	18.9	20.2	21.9

Years on which Design Conditions based 1994-2013

Map | Location: Western Australia | BROOME AMO

Design Conditions based on climatic data: before (●) 1990 ( ) after

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
3pm °CDB	36.8	37.4	37.4	37.4	35.6	33.3	32.7	34.2	37.4	37.4	37.4	37.4
3pm °CWB	28.5	28.5	28.5	28.3	25.5	23.0	22.5	22.7	25.0	26.2	27.3	28.5

Years on which Design Conditions based 1979-1988

Map | Location: Western Australia | BROOME AIRPORT

Design Conditions based on climatic data: before ( ) 1990 (●) after

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
3pm °CDB	35.7	36.4	37.3	37.3	36.5	33.4	32.8	34.9	37.3	37.3	37.3	37.0
3pm °CWB	27.9	27.9	27.9	27.4	25.0	23.7	22.6	22.8	24.4	26.6	27.4	27.9

Years on which Design Conditions based 1990-2012

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ASHRAE (Appendix B)

BROOME AIRPORT, Australia

WMO#: **942030**

Lat: **17.95S** Long: **122.23E** Elev: **17** StdP: **101.12** Time Zone: **8.00 (AUW)** Period: **86-10** WBAN: **99999**

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
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)
(1)	7	10.9	12.4	-6.1	2.3	26.9	-3.2	2.9	25.2	9.4	20.9	8.7	21.4	1.3	110

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
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)
(2)	1	5.7	37.2	20.9	35.8	21.6	34.6	22.6	28.2	31.8	27.8	31.3	27.5	31.1	4.5	140

	Dehumidification DP/MCDB and HR									Enthalpy/MCDB						Hours 8 to 4 & 12.8/20.6
	0.4%			1%			2%			0.4%		1%		2%		
	DP	HR	MCDB	DP	HR	MCDB	DP	HR	MCDB	Enth	MCDB	Enth	MCDB	Enth	MCDB	
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)
(3)	27.2	23.1	30.5	26.9	22.6	30.4	26.5	22.0	30.1	91.3	32.0	89.3	31.4	87.7	31.2	80

Extreme Annual Design Conditions

	Extreme Annual WS			Extreme Max WB	Extreme Annual DB				n-Year Return Period Values of Extreme DB							
					Mean		Standard deviation		n=5 years		n=10 years		n=20 years		n=50 years	
	1%	2.5%	5%		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)
(4)	8.8	8.0	7.3	30.6	7.9	40.8	1.6	1.5	6.8	41.9	5.9	42.8	5.0	43.6	3.9	44.7

Monthly Climatic Design Conditions

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- AIRAH Handbook

Comfort Conditions (Cooling)

	CWB	DB	WB	CDB
Perth	20.1	36.6	22.4	31.8
Broome	23.2	37.8	29.1	33.5

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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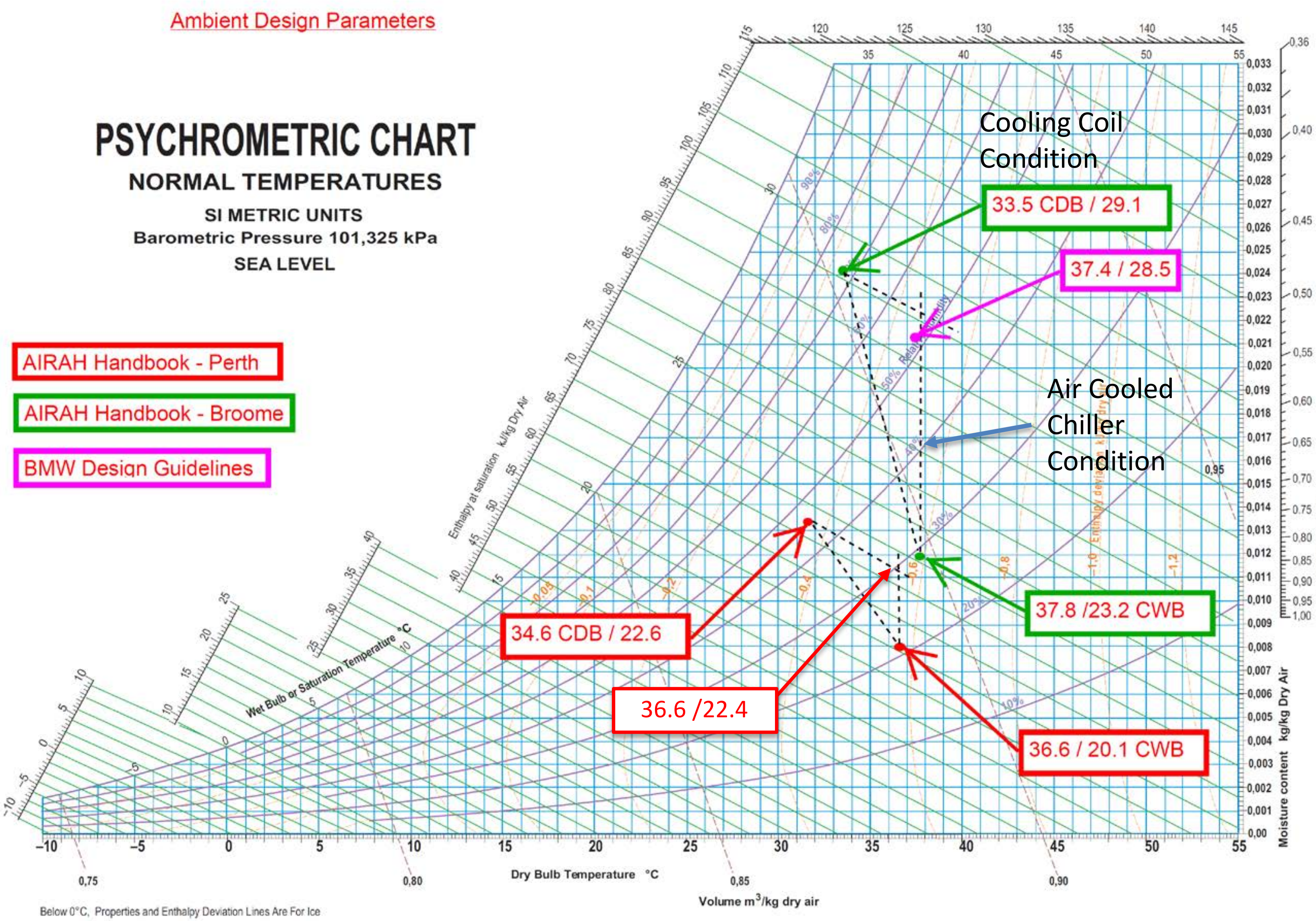

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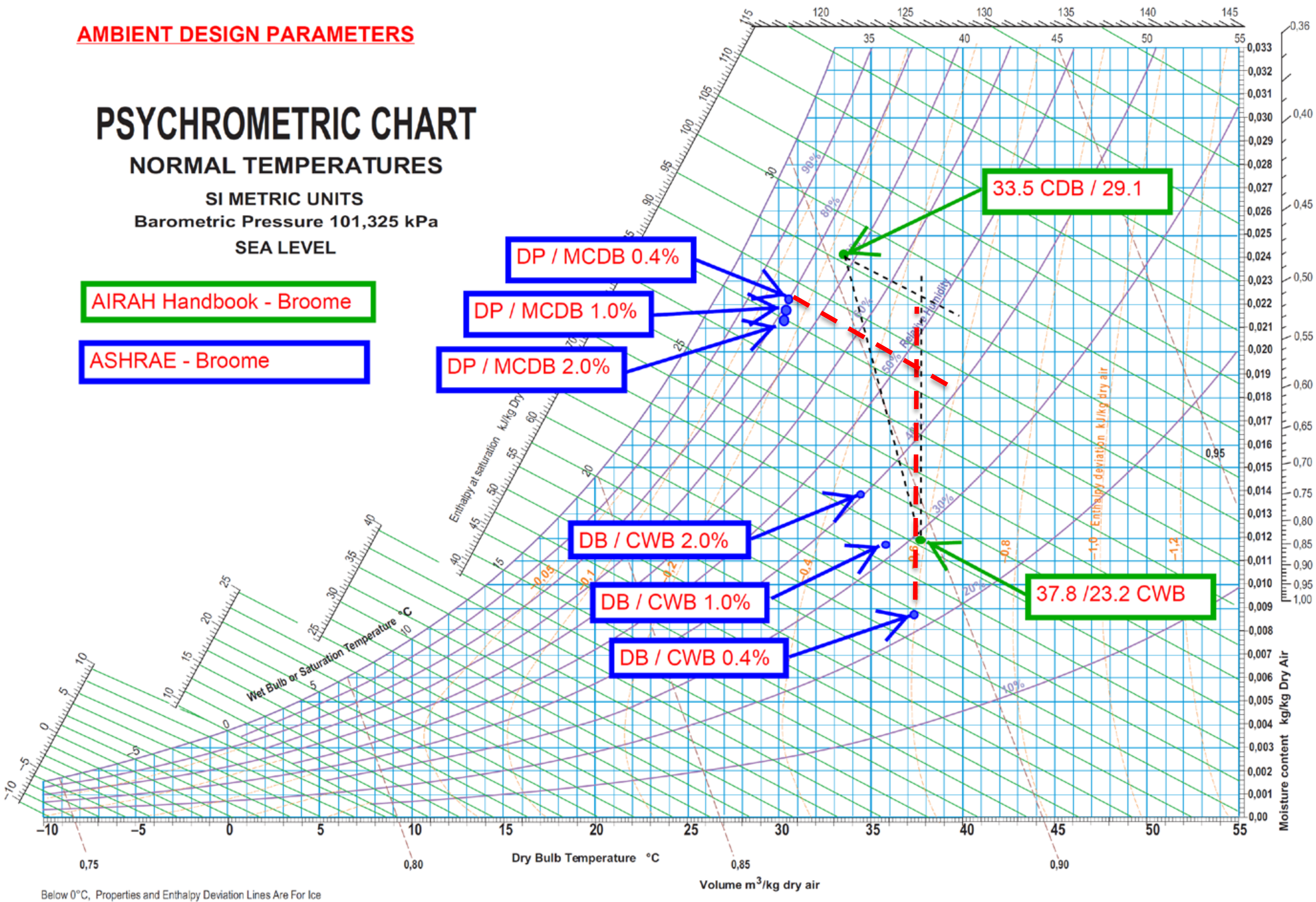

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If, for Perth, the actual ambient conditions(dry bulb) exceed design, what are the consequences?

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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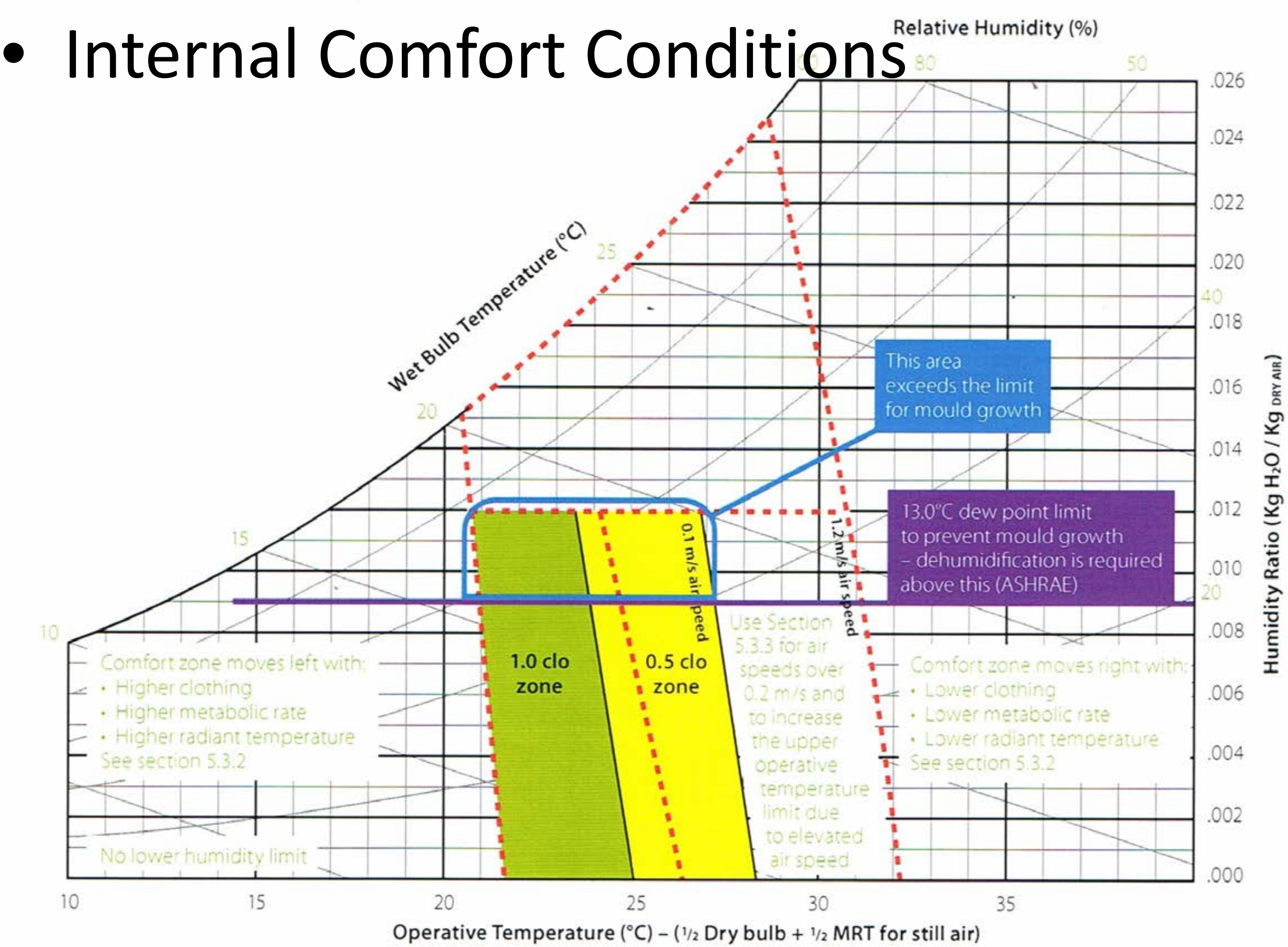
- Internal Comfort Conditions



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 ^{0}C DP to prevent mould growth

DP	22.5 ^{0}CDB	23.0 ^{0}CDB	23.5 ^{0}CDB	24.0 ^{0}CDB
13.0 ^{0}CDP	54.9 %RH	53.3 %RH	51.7 %RH	50.2 %RH
DP	24.5 ^{0}CDB	25.0 ^{0}CDB	25.5 ^{0}CDB	26.0 ^{0}CDB
13.0 ^{0}CDP	48.7 %RH	47.3 %RH	45.9 %RH	44.6 %RH

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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)

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DX Systems

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. Lets 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 ^{0}C (Broome)

Return air temperature at 24.5 ^{0}C

% of Outside Air / Supply Air Varies

Mix Entering Air on Coil Condition

% O/A	20%	25%	30%	35%
^{0}CDB EAT	27.2	27.9	28.5	29.1

Some A/C units can incorporate hot gas bypass and operate upto 31 ^{0}C – 33 ^{0}C EAT

What happens when Ambient > 37.8 ^{0}C ?

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DX Systems

Evaporator Coil Entering Air Limitations

A classroom of 20 primary school students (population rate at 1 person / 2 m^2),

Classroom area = 40 m^2

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 / m^2 = 400 l/s

Evaporator Mix EAT Condition = 29.5 ^{0}C

To achieve EAT < 28.0 ^{0}C, increase supply air to 580 l/s (increase 45%), 14.5 l/s / m^2

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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 ^{0}C DB / 28.0 ^{0}C WB
- Leaving Air Condition – 18.0 ^{0}C DB
- Equivalent Length of Refrigerant Piping – 7.5 m horizontal

What happens when Ambient > 33.0 ^{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