# Condensation in Buildings

## Condensation principles

### What is condensation?

Air contains invisible water vapour. The higher the air temperature, the more water vapour it can hold. The lower the air temperature, the less water vapour it can hold. Where warm air contacts a cold surface, it cools. When the air cools below a temperature known as the 'dew point', invisible water vapour condenses to visible water droplets on the cold surface. The water that is formed is known as condensate and the process is called condensation. If more water vapour is present, further condensation occurs which may lead to a trickle of condensate. However, the process is reversible – if the surface is warmed above the dew point, the condensation will evaporate and may leave the surface dry.

Common examples of surface condensation include:

E.g. 1 Condensation upon a glass of cold beer as a result of the reduced temperature of the glass in the warm environment

E.g. 2 Condensation upon a bathroom mirror as a result of increasing the moisture levels within the room.

### Condensation in buildings

Condensation within a building can form as visible surface condensation or can form on surfaces within the building fabric, known as interstitial condensation. In cold weather, interstitial condensation is caused when water vapour inside a building is able to move outward via diffusion through permeable building fabrics or air movement and reach a surface within the building cavity that is below the dew point. That surface may be smooth such as sheet metal, or fibrous, such as glasswool insulation. A cold surface that condenses vapour absorbs the heat of vapourisation, raising its temperature slightly. Thus condensation can be most rapid on a metal frame, and less rapid on an insulation material. But given time, both might condense a considerable amount of water.

Interstitial condensation can be far more damaging to the building than surface condensation. Interstitial condensation can go unnoticed and if the building fabric has not been designed to allow moisture to dry from within it can become trapped and compromise the durability of the building and the health of the occupants.

The factors that contribute to condensation in buildings are essentially one or more of the following:

- the presence of moisture levels which are too high;
- the presence of temperatures in the building fabric which are too low; and
- uncontrolled flow of water vapour from a source to a region of cold temperature.

Moisture levels within buildings are often higher than outdoors. The main cause of high indoor moisture levels is the generation of warm moist air by domestic activities. Heaviest loads are produced by:

- cooking
- bathing/ showering
- clothes drying
- high occupancy
- high indoor plant concentrations
- uncontrolled moisture ingress.

All of these factors contribute to raising the indoor relative humidity (RH). An increase in RH increases the dew point temperature for the same air temperature. This increases the risk of condensation should the water vapour come into contact with a surface below dew point.

### The psychrometric chart

Condensation will form on a surface when its temperature drops to the dew point temperature of the surrounding air. The dew point temperature of the air depends upon the air temperature and the humidity of the air. This relationship is illustrated using a psychrometric chart (See Figure 1 on next page).

Figure 1 is read as follows:

- dry bulb temperature (air temperature) – vertical lines (values along the bottom)
- relative humidity – curved lines (values along the top and right hand side)
- dew point temperature – represented by the 100% relative humidity line (values along the 100% humidity line)
- wet bulb temperature – lines sloping upward to the left (values along the 100% humidity line)
- moisture content – horizontal lines (values not shown when it is expressed as a fraction)

The chart shows that the higher the air temperature, the more moisture that can be held in the air. An example of how to use the chart to determine dew point temperature is shown. For 30°C air temperature and 50% relative humidity, the dew point temperature is 18.3°C. For 30°C air temperature and 71% relative humidity, the dew point temperature is 24.2°C, which is within the range of indoor air temperatures in air-conditioned space in Darwin.

Dew point values have been used to generate Figure 2 (page 17), which provides an approximate relationship between the surface temperature drop from the air temperature to the relative humidity of the air. If the relative humidity and air temperature is known, then the dew point temperature of the surface is easily estimated. For example, at 50% relative humidity the surface can be about 10.5˚C below the air temperature without condensation forming. At 90% relative humidity the surface need only be about 1.5˚C below the air temperature if condensation is to be avoided.

### The influence of building materials

Controlling condensation upon and within the building fabric requires an understanding of the movement and storage of moisture. Transport of moisture into the building fabric can be via diffusion of water through linings or via air movement.

- Vapour diffusion through linings occurs as a result of vapour pressure difference between indoor and outdoor linings. The rate of diffusion depends upon the vapour permeability of the linings that make up the building fabric and is referred to as the water vapour transmission rate (WVTR).
- Air movement through the fabric occurs as a result of gaps within the building fabric that are not fully sealed.

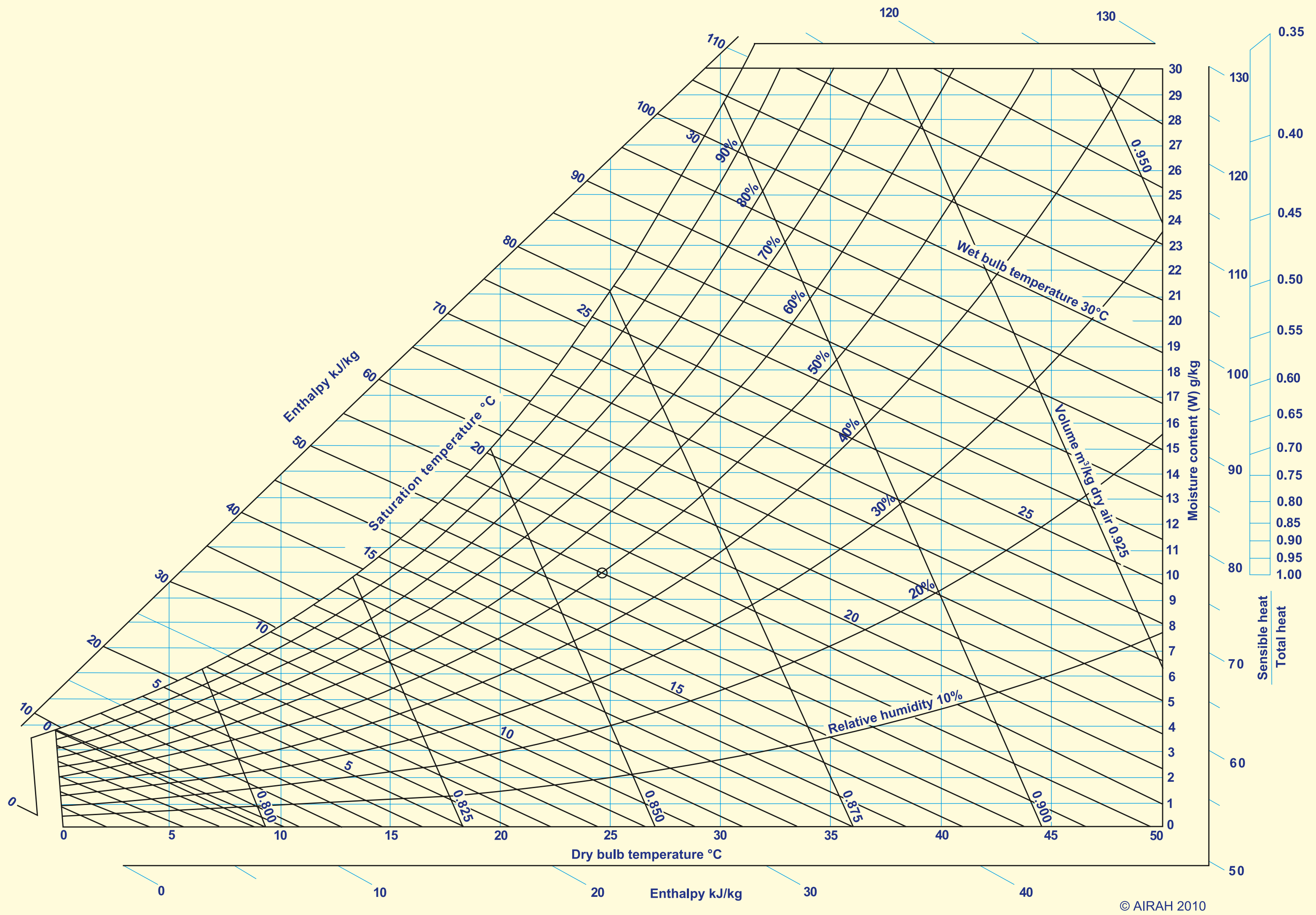


*Figure 1: The psychrometric chart*

The latter is far more critical and is why it is important that the internal wall lining (plasterboard) be installed at the edges to be as airtight as physically possible (providing a quality air barrier) to limit unintended infiltration of warm moist internal air into the cavity. Use of external sarking for walls also helps to limit air movement across the wall.

Membranes that are water vapour permeable while still being impermeable to liquid water can assist in providing for water vapour egress from the construction.

The use of absorbent building materials also influences moisture movement and the consequences of any condensation that may form. Some materials such as wood and brick have a capacity to absorb and store moisture while other materials such as steel and glass do not. For example, in a bathroom, although beads of condensation form on the surface of the mirror, the window or plastic shower curtain, they do not form on the surface of the timber frame around the mirror, the toilet paper or textile curtains. Although at the same surface temperature the latter materials are absorbing moisture.

Absorbent materials can store moisture and hold condensation until such time that drying conditions prevail, which can protect other materials from becoming wet. Of course the absorbent material must be able to accommodate higher moisture levels without damage. Use of absorbent building materials can also result in locked in construction moisture, which may create issues if drying is impeded.

## The influence of climatic conditions

The direction of the predominant flow of moisture vapour can be determined from an understanding of the vapour pressure conditions inside and outside a building.

Vapour pressure is related to the temperature of the air and the amount of moisture contained in the air. For the same relative humidity, higher temperatures result in higher vapour pressure. For the same temperature, higher relative humidity results in higher vapour pressure.

Generally the direction of vapour flow can be classified as follows:

**Cold climates:** The vapour pressure is usually lower outside due to the fact that indoor temperatures are well above those outside. In addition to this we tend to generate moisture within our homes, which often results in higher indoor vapour pressure. Therefore in cold climates the vapour flow is typically outward.

**Temperate climates:** Other than during seasonal extremes, the vapour pressure difference is not great because the difference between indoor and outdoor temperatures and vapour pressure levels is less.

**Tropical climates:** Tropical climates typically have high outdoor temperatures combined with high relative humidity, resulting in high outdoor vapour pressure. This creates a slight inward vapour flow. For an air-conditioned building in a tropical climate the indoor vapour pressure

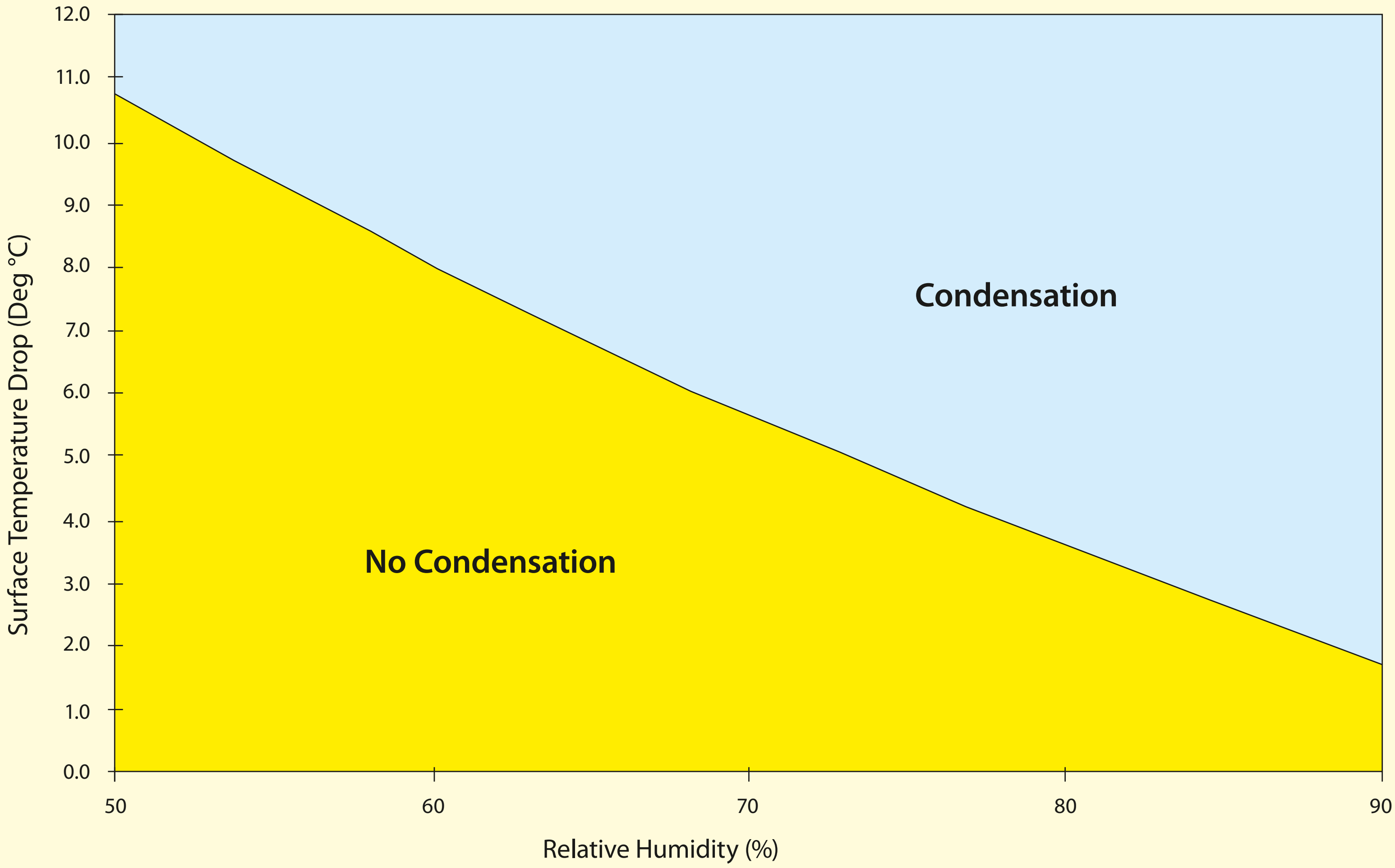


*Figure 2: Relative humidity vs Surface temperature*



is reduced as both the indoor temperature and humidity is reduced. This results in a large vapour pressure difference, creating a much greater inward vapour flow.

### The influence of local climate

Understanding the local climate that the building is exposed to is important to ensure that appropriate principles are applied and that suitable climate data is used in any risk assessment that is undertaken.

The BCA energy efficiency measures divide Australia into eight distinct climatic zones. The broad principles to control condensation in each of these zones will often be common. However, while each climatic zone has similar temperatures; the humidity and rainfall that exists within each of the zones can create a variety of sub-climates. In addition, many factors may influence the local micro climate to which the building is exposed. Examples of local factors include: exposure to weather, shade, flooding, cyclones, vegetation, orientation, proximity to water, concentrations of groundwater, elevation and terrain.

In addition to having an understanding of the local outdoor environment some buildings have indoor environments that require special consideration. Examples of special use buildings include, refrigerated buildings, buildings containing pools or spas, museums, etc.

### Key moisture management principle

The key principle of moisture management in building cavities is to:

Design to keep moisture out of the building envelope, but when it does get in – and it is likely it will get in, allow for it to escape.

Not adhering to the latter part of this principle is the cause of many moisture related building problems.

The premise is often that a vapour barrier (or impermeable cladding) will provide adequate protection. However, once moisture gets in behind a vapour barrier, the barrier acts to trap the moisture, stopping the building fabric from drying and leading to decay.

Inappropriately placed materials acting as cold side vapour barriers also contribute to moisture related building problems.

As a result of previous experience New Zealand now advocates the following principles to control external moisture:

- **Deflection:** shed water by a cladding system, including deflecting devices such as eaves and 'weathering' deflectors
- **Drainage:** a back-up system to direct water that may bypass the cladding back to the outside
- **Drying**: remove remaining moisture by ventilation or diffusion
- **Durability:** use materials with appropriate durability within the life expectancy of the building. ■

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