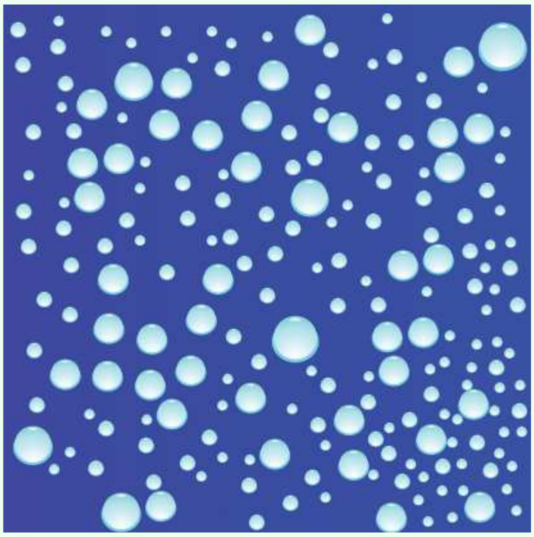
CONDENSATION

Pleasures and Curses: A brief outline



A cold drink presented with beads of condensation on the outside of the glass is one of life's simple pleasures. The same effect on domestic windows, walls and floors is unwelcome but arises from similar circumstances – put simply, a cool surface in a humid atmosphere. Yet even with an air temperature of 50^{o} C at 50% relative humidity, condensation will occur on surfaces and objects whose surface temperature is 36^{o} C or below – think 'steamy jungles'.

Cooks will notice on placing a cold but dry plate into a hot gas oven (say at 200^{o}C) that a film of condensation will be deposited on the cold surfaces from humid air in the oven until the plate heats up above a defined temperature.

In the case of buildings, the challenge for Surveyors is devising mechanisms for control of moisture whilst at the same time maintaining comfort of occupants, and minimising remedial cost.

Complex causes

Dampness and a high level of absolute humidity within a dwelling can have severe consequences; partly by facilitating growth of moulds/spores which can induce asthma attacks or aggravate the condition in susceptible individuals; partly by affecting the balance of oxygen per unit volume of air by its partial pressure effect.

Condensation, its causes and effects, can be difficult to explain convincingly to a client who is running a de-humidifier in their home and disposing of more than six litres of water a day, seemingly with little effect. Consideration of 'first principles' can often help, and the following may be of assistance.

Sources of moisture

Water vapour is invisible and behaves like a true gas constituent of air. The vapour, at atomic level, is derived from evaporation of water in liquid form; rainfall, rivers, lakes, puddles, wet surfaces; transpiration from plants; grass, trees and other vegetation; and from bodily functions of living organisms; breathing, excreting and sweating. Other sources include end products from combustion of organic fuels, and, in relation to dwellings, from domestic activities including cooking and bathing/showering. A human body alone releases c. 1.25 litres of water into the atmosphere per day from respiration alone, depending on the level of physical activity engaged in; damp earth in sub-floor voids will contribute to problems of high humidity when water vapour enters the habitation via gaps in the floor, and so on.

Difficult to control

The amount of moisture in environmental air is limitless, and a modest dwelling of 100 m^2 floor area (volume 240m^3), at air temperature 20^0 C and relative humidity of 50%, contains over two litres of water vapour, before any moisture is contributed by the occupants themselves. Introducing fresh air from the outside environment ('air change') will introduce moisture-containing air, and will only favour the drying-out process when its absolute humidity (water-mass per unit volume of air) is less than that within the dwelling. Thus, on a warm summer's day, the absolute humidity is usually higher than that of the cooler air inside. Opening the windows, whilst providing a feeling of well-being, will contribute little to drying out the structure. Conversely, in depth of winter, outside temperature hovering around freezing, even if the air is saturated with moisture, its absolute humidity (moisture content) will be lower than air inside the building at 20^0 C. Wafting air from the garden through the house will be beneficial to a drying-out process. Discomfort to occupants of the building maybe, but that is a different issue.

Several terms and definitions are helpful in understanding the theory behind condensation:

Terms and definitions

Absolute humidity: Amount of water expressed as gm/m^3 held as mass of water vapour per cubic metre of air. This means the total weight of water which could be extracted from a cubic metre of air.

Relative humidity: Amount of water in gm/m^3 (i.e. the absolute humidity) expressed as a percentage of the mass of water which a cubic metre of air is capable of holding as vapour at the same temperature and atmospheric pressure when it is saturated (saturated air having a relative humidity of 100%).

When air is unsaturated, if its absolute humidity (gm/m^3) remains the same but the air temperature changes, the relative humidity also changes. For example, by reference to tables*****, air at 25^0C and relative humidity 60% has an 'absolute humidity' of 13.8 g/m^3. If the air temperature drops to 20^0C, the absolute humidity remains the same but its relative humidity increases to 80%. Saturation is reached at 16^0C and thereafter, with further cooling, condensation occurs either as 'misting' in the air or on surfaces at or below 16^0C. This scenario might occur during cold weather when room heaters are used during the evening to keep the place warm, and then turned off at bed-time and the building cools down.

The 'relative humidity' value is useless without knowledge of the ambient temperature

Air Temperature: A critical measurement which must be assessed at the same time as measuring 'relative humidity'. This is simply that air, as it becomes warmer, is capable of containing a greater mass-weight of water in its vapour form, to the point of saturation, than air that is cooler. It follows that, if saturated warm air is cooled, the excess will be deposited as condensation either as droplets in suspension (misting) or on surfaces at or below 'dew-point' as explained above. Knowing the relative humidity but not the air temperature is a similar analogy to knowing your speed on a motorway, but not the distance to reach your destination. To illustrate the point, a cubic metre of air at a relative humidity 90% will contain 75 grams of water at 50^0C but merely 11.5 grams at 15^0C.

Micro-climate effects and 'Dew-point'

Dew-point: The critical temperature at which a volume of air becomes saturated, essentially where the vapour/liquid state is in dynamic balance (i.e rate of evaporation = rate of condensation). Surfaces and objects at or below the critical 'dew-point' absorb heat from the surrounding air, in effect developing a micro-climate and allowing the surrounding air to become saturated so that moisture is released as condensation on the surface. The process of condensation continues (heat lost = heat gained), until the temperature of the object or surface rises above the 'dew-point' value and evaporation (drying) occurs. The phenomenon is encountered by spectacle-wearers when entering a warm building after a period in the cold air outside where their lenses steam up until the temperature of the glass warms up. The process will be favoured in still air (e.g. behind furniture, under carpets etc).

A dehumidifier uses this principle: Air is circulated over a coil cooled below the dew-point of the air; moisture condenses on the coil, and drops into a bucket or is piped to waste. The process of drying-out a building by dehumidification following a flood uses two principles: The first; that warm air holds more mass of moisture per unit volume than cold; the second, that passing warm humid air over a cooling coil causes moisture to be condensed at a faster rate than from cooler air with a lower absolute humidity. This is the reason why effective drying out requires both heaters and dehumidifiers in combination, and why flues and other sources of outside air should be sealed to prevent entry of fresh moisture from the external environment.

Examples of micro-climate effect

Micro-climates develop within a building structure where physical conditions affect a discrete zone, with conditions which cause condensation locally but not elsewhere. An example can be the enclosed void within a flat decked roof when this has been incorrectly constructed as a 'cold-roof' with insufficient ventilation above the insulation, or without insulation and where the construction is not protected with a vapour barrier to prevent moisture permeating into the void. When the roof warms up by solar gain, air within the void can attain a high absolute humidity. When cooling takes place (e.g. at night-time) when the deck-temperature falls to 'dewpoint,' condensation is given up on the underside. Many 1960s roofs fitted with chipboard decks suffer effects of condensation, softening as a result of moisture absorption and losing structural strength. Although not so frequently encountered as a few years ago, the matter is still one of which a surveyor should be aware when carrying out surveys.

Un-insulated solid floors under porous floor coverings will also provide conditions for the micro-climate effect, particularly around the outer perimeter of rooms. This is where the floor slab lacks insulation at lower level and at the side, and frequently cools below the dew-point. Condensation will arise from water vapour in the ambient air permeating through the porous carpet, but where the surface is prevented from warming up due to the insulation effect of the coverings. The result is condensation on the surface of the floor under the carpet. In this case moisture often goes unnoticed and is absorbed by the carpet, but can be detected by staining on the underside if looked for on survey. Situations are often encountered where condensation has been noticed by the householder who, convinced there is 'rising-damp', will lay plastic sheeting under the carpet to protect it. Moisture will continue to condense on the upper surface of the sheet against the carpet rather than on the screed itself. The presence of plastic sheeting under a carpet is often a tell-tale sign of an ineffective remedy to combat condensation.

Poorly ventilated gaps behind furniture, particularly against un-insulated, or poorly insulated walls, under beds against un-insulated solid floors, or inside cupboards, provide further examples of micro-climate effects where condensation frequently occurs.

Alleviating condensation

Remedial work to mitigate condensation has to be designed for the particular building concerned, but usually one or more of the following will be helpful:

1. Provision of **mechanical ventilation** for areas where high water usage takes place e.g kitchens and bathrooms. Extractor fans fitted with humidistats are usually recommended.
2. **Insulation of solid floors** will usually assist. A damp-proof membrane is laid over the floor surface, followed by insulation board and a 'floating floor, integrated with the walls, skirtings, doorways etc. The process can be expensive when kitchen and bathroom fittings need to be dismantled and re-fitted. In many instances plumbing (radiators) need to be re-positioned, and occasionally electric wiring/fittings re-routed within the scope of a comprehensive scheme.
3. **Insulation of outside walls** will need to be considered, particularly in older houses. Insulation applied externally is often preferable if there are no particular features of the building which need to be preserved. Care should be taken before installing fibre-fill in wall cavities to ensure that the cavity is suitable; that wall ties and damp-proof courses are not bridged or otherwise compromised. A comprehensive endoscopic inspection is regarded as an essential pre-requisite.
4. **Positive ventilation systems** can be helpful to introduce air into the building with a lower absolute humidity, particularly when the outside air temperature is cold, but there is a conflict between reducing condensation and keeping the dwelling warm. The system is unlikely to be effective unless positive air flow occurs in all parts of the accommodation affected by condensation, and should only be considered when no other options are feasible or economically viable.

5. **Furnishings should be limited** to avoid clutter so far as possible, avoiding placement against external walls, and maintaining clear, unrestricted gaps where air movement can take place to avoid development of the micro-climate effect described.
6. **Dehumidifiers** can be of assistance in controlling air-moisture in rooms of small volume, particularly where natural ventilation is a problem. Note: we have used dehumidification successfully in controlling condensation in armouries to prevent corrosion of firearms, and in file-storage rooms.
7. **Roof voids** susceptible to condensation can be addressed by improvement of ventilation, ensuring a good cross flow, equivalent in ventilation area to a continuous gap of 10mm measured along the eaves. Air-porous roof-membranes are of assistance but roof claddings which are tight-fitting reduce the ventilation effect. Attention should be given to ensure that open channels are maintained above insulation at eaves lines and up-grading of insulation should be planned at the same time.
8. **Suspended timber floors in older buildings** frequently lie over an unprotected sub-site which is saturated with moisture, and allows moist air to penetrate into the living accommodation. Unless the floors are to be replaced with damp-proofed insulated construction, a pragmatic solution can often be achieved by opening up the floor at intervals to lay a damp-proof membrane, weighted down with sand. Benefit can usually be gained by improving the sub-floor ventilation at the same time.
9. Consideration should always be given to **removing and replacing mould-contaminated plaster-work** and affected soft-furnishings, particularly carpets, which will contain spores.

Useful Guidance

Useful References:

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