**Thermal Insulation and Condensation**

**LEGISLATION AND GUIDANCE**

Technical Guidance Document L, Conservation of Fuel and Energy is divided into two sections, one specifically relevant to Dwellings and the other which addresses Buildings other than dwellings. Both are published by the Department of the Environment, Heritage and Local Government as part of a series of documents forming the Building Regulations. The document specifies a range of minimum and maximum criteria related to energy efficiency.

**REDUCING HEAT LOSS**

Any building with an internal temperature higher than the external temperature will lose heat. The type of structure and its materials will contribute towards the rate of heat loss. The introduction of thermal insulation into a structure helps to reduce the rate of heat loss, conserve energy and subsequently reduce heating costs.

Building Regulations specify minimum levels of thermal performance for external walls, roofs and floors of almost all building types. Suitable levels of insulation must also be provided for hot water heating services, pipes, warm air ducts and hot water storage vessels.

Therefore, when specifying the insulation systems for a particular building it is important to consider both the heating regime and the pattern of usage of the building.

**Infrequently heated buildings**

If a building is only infrequently heated, thermal insulation materials are most effectively located as near as possible to the internal surface of the building fabric. This helps to provide a quick thermal response to heating input. It is also essential in such conditions to reduce internal surface condensation during the warm-up period, when the maximum amount of water vapour is often present within the atmosphere. It will also ensure that comfortable room temperatures are quickly achieved.

**Regularly heated buildings**

In many frequently occupied buildings, the heating regime is usually fairly consistent with relatively equal periods of heating activity and non-activity i.e. a domestic dwelling during winter months. In this situation, traditional forms of high mass construction, such as double leaf cavity walls, can effectively exploit the ‘heat store’ concept when insulation is located within the cavity. The thermal mass of the internal fabric located inside the insulation envelope helps to subdue excessive temperature fluctuations within the building. Heat that is stored within the internal building fabric whilst the heating is on, dissipates back into the building. Further benefits are often observed due to the reduced size and complexity of space heating equipment necessary to maintain room temperatures.

**Airtightness**

The air leakage characteristics of a building are described by the term ‘airtightness’. In respect of the Irish Building Regulations, it is measured by the rate at which the internal volume of air contained within a building is replaced at an artificially induced pressure (usually 50Pa). The lower the air leakage rate, the greater the airtightness.

The current building regulations sets an upper limit of air permeability of $10 \text{m}^3/\text{hr.m}^2$, although this level is expected to be reduced in future revisions to Technical Guidance Document L. In practice designs will need to be significantly better than this. When correctly applied, the airtightness of a building can offer significant contributions towards its efficient energy performance.

Although prescribed air leakage can occur directly via designed ventilation provision, the majority of leaks occur indirectly. Air leakage paths are often complex and difficult to trace and seal effectively. The following is a list of some typical unprescribed air leakage paths.

- Cracks, gaps and joints in the structure
- Timber floors
- Joist penetrations of external walls
- Windows and doors
- Loft hatches
- Skirting boards
- Chimney and flues
- Service entry points
- Permeable building materials

It is therefore important to adopt appropriate detailing at the areas identified above to overcome the weaknesses they may present.

Significant improvements to the airtightness of the building fabric can be achieved by utilising Gyproc plasterboard internal dry lining systems or Gyproc plasters. Gyproc Airtite can be used to successfully seal airpaths in blockwork, and provide excellent improvements to the airtightness of same prior to applying a dry lining system to the wall. Gyproc plasters i.e. Airtite can also be utilised to help seal permeable blockwork.
THERMAL TERMINOLOGY

Thermal conductivity ($\lambda$)
Expressed as W/mK, this is a measure of a single material's ability to transmit heat, measuring heat flow in watts per metre thickness of material for a temperature gradient of one degree Kelvin (K).

Generally, dense materials have a high thermal conductivity and are inefficient thermal insulants. Lightweight materials tend to have a low thermal conductivity and can be efficient thermal insulants. The lower the $\lambda$ value of a material the better its insulating efficiency.

Thermal resistance (R)
Expressed as m$^2$/K/W, this is the measure of the resistance to the passage of heat offered by the thickness of one or more materials. The thermal resistance of a single material is obtained from the following calculation.

$$ R = \frac{t}{\lambda} $$

Where $t$ = thickness in metres and $\lambda$ = thermal conductivity (W/mK).

Thermal transmittance (U-value)
U-values are used as the common basis for comparing different constructions and for meeting prescribed performance criteria. The lower the U-value of the element, the better its thermal insulation.

Expressed as W/m$^2$K, this is a property of the whole construction, including air spaces and surfaces. It is a measure of the constructions ability to transmit heat under steady state conditions. The U-value of a construction build up is calculated by taking the reciprocal of the sum of all the individual thermal resistances. Consideration should also be taken to the effects of any thermal bridging.

When calculating U-values, thermal resistances for the inside and outside surfaces of a building element, and for any cavities within it, have to be taken into account. This is an additional factor to the thermal resistances directly relating to the actual thickness of the materials.

The R-value of inside and outside surfaces and of any cavities will vary according to their emissivity. Emissivity is typically taken as high for all normal building materials other than polished or metal surfaces, which are regarded as low.

When calculating the U-value of some constructions the effect of components that repeatedly bridge the insulation layer, i.e. studs roof joists and wall ties etc, should be taken into account. This is achieved by calculating the U-value of the thermal bridge and relating it as a proportion of the overall area. More insulation may therefore be needed to compensate for the thermal bridging. The additional heat loss for non-repeating thermal bridges, such as at windows and doors, is determined separately.

CONDENSATION CONTROL IN BUILDINGS

Harmful effects of condensation
Condensation can be one of the worst problems that designers, owners and occupants of a building may experience. Dampness and mould growth caused by surface condensation can not only be distressing to the occupants of a building, but can eventually lead to damage to the building fabric itself.

Designers should take care to eliminate all problems caused by condensation, particularly in refurbishment projects on existing buildings, which may not be covered by current regulation.

Reducing the risk
Due to changes in building design, occupancy patterns and increased thermal requirements, all buildings tend to be more sensitive to condensation now than in previous years. Thermal insulation, correctly positioned within specific building elements, combined with adequate heating and, where appropriate, the necessary water vapour control and ventilation, should ensure trouble-free design.

How condensation occurs
At any given temperature, air is capable of containing a specific maximum amount of water in invisible vapour form. The warmer the air, the greater the amount of water vapour it can contain. Conversely, the lower the temperature, the smaller the amount.

Where moisture-laden air comes into contact with cold surfaces it will cool. As it cools, the amount of water it can hold in vapour form reduces until, at a specific temperature called the dew point temperature, it becomes saturated. Water is then deposited in the form of condensation.

Surface condensation
Surface condensation occurs when air containing water vapour comes into contact with highly vapour resistant surfaces, which are at, or below, the dew point temperature. It is usually evidenced by beads of water, damp patches, and where the problem persists, mould growth.
Interstitial condensation
Warm moist air will also diffuse through building elements to reach colder, lower pressure conditions outside. If the building materials have a low water vapour resistance, it is possible for condensation to occur within the building element. This will occur on the first cold surface, at or below the dew point temperature, which is encountered by the moisture vapour on its passage through the structure.

**DESIGNING TO REDUCE CONDENSATION RISK**

**Thermal insulation**
Thermal insulation helps to reduce the risk of surface condensation by maintaining surfaces above the dew point temperature subject to adequate heating being provided. Gyproc Thermal laminated plasterboards and insulated cavities help to maintain temperatures on the internal side of a construction. They will also help to reduce the thermal bridge effects in a building.

With some construction types the potential problem may be one of interstitial condensation. Gyproc plasterboard products are available with integral vapour control to minimise the risk, of vapour migration through a building element, but must be used in conjunction with the appropriate construction build-up to eliminate any potential risk.

**Heating**
Adequate heating helps to keep the temperature of the internal surfaces above the dew point. Ideally, an air temperature above 10°C to 12°C should be maintained in all parts of the building.

**Ventilation**
Ventilation removes the water vapour produced within a building to the outside air. Adequate ventilation will help to reduce harmful condensation and mould growth. Ideally, ventilation, whether provided naturally or mechanically, should control the internal air to between 40% and 70% relative humidity (RH) for human occupation.

Condensation can occur in roof spaces of pitched roofs, and in timber joist flat roofs with insulation, unless adequate ventilation is provided.

**Vapour control layer**
A vapour control layer, usually in the form of a membrane, is used to substantially reduce the transfer of water vapour through a building element in which it is incorporated.

A vapour control layer, positioned on the warm side of the thermal insulation within a building element, helps to reduce the risk of interstitial condensation occurring within that element. However, other suitable precautions may also be necessary, either in combination with, or as an alternative to, a vapour control layer.

Vapour control layers should be as airtight as possible. Any penetrations should be suitably sealed and detailed to prevent localised condensation.