Standard Thermal Modelling Assumptions, Windows and Curtain Walls

The Wright Consultancy

Introduction

This sheet addresses the issues surrounding the calculation of condensation risks assessments (CRA) and heat loss (U-values, Psi-values and Chi-values) in regard to windows and glazed curtain walling.
Given the variations in the approach to thermal modelling employed by many consultancies, there is often confusion about the appropriate assumptions to be made when thermally modelling. This document is designed to be submitted to clients, especially the overseeing facade consultants, whose task it is to check and comment on the suitability of any thermal calculations to be submitted. It is hoped that the basic modelling assumptions for a project can be examined, and either accepted or altered in line with the client's wishes, before the modelling starts.

Assumptions

Boundary Conditions

<u>Surface Resistance</u>
For thermal transmission calculations, boundary conditions are clearly stated in BS EN ISO 6946:2007 Table 1 (and in 10211 and 10077-2).
However, with regard to condensation risk calculations, there is an apparent conflict between the boundary conditions stipulated for thermal models in two standards, -

- EN ISO 13788:2012
  '*Hygrothermal performance of building components and building elements – Internal surface temperature to avoid critical surface humidity and condensation – Calculation methods*'
- EN ISO 10077-2:2012
  '*Thermal performance of windows doors and shutters - Calculation of thermal transmittance –*
  Part 2: Numerical method for frames'

'Annex-B'

Since EN ISO 13788:2012 declares itself to be focussed on 1D, and explicitly refers to EN ISO 10077-2:2012 with regard to complex window frames (5.4.f, esp. Note 2), then the detailed description of boundary conditions in 10077-2 (5.3 and Appendix B) is to be taken to supersede the broad definitions in 13788, especially with regard to sheltered areas by the glazing.

Curtain Walling and Condensation

In addition, there is the issue that curtain wall structures are not directly addressed with regard to condensation, (see BS EN ISO 12631:2012.) This means a professional judgement must be used over where boundary conditions for “corners, furniture curtains or suspended ceilings”(4.4.1), or for “low thermal inertia elements such as windows and their frames” (4.2.2), should be applied.
Therefore, areas with similar properties as windows or doors, such as spandrel areas, or large metal structures, shall have the boundary conditions specified for 'windows or doors', as being part of a curtain wall scheme. Areas with plasterboard, timber or carpet, as higher risk areas, shall be considered, 'opaque surfaces', in the terms of 13788:2012. This is both physically realistic and within the spirit of the regulations as presently set out.

Thus, for condensation risk assessments –

- Windows, default surface resistance, as 6946 (Up / Horiz. / Down) R_{si} = 0.10 / 0.13 / 0.17 m^2.K/W
- Windows, internal corner, 30mm onto glazing (Annex B) R_{si} = 0.20 m^2.K/W
- Curtain wall, spandrels other similar non-porous, as 6946 R_{si} = 0.10 / 0.13 / 0.17 m^2.K/W
- Non-'window' areas, porous surfaces R_{si} = 0.25 m^2.K/W

<u>Temperature and Humidity</u>
The client must specify the internal and external temperatures, as well as the internal relative humidity for the CRA test. This must be single valued (e.g. ***not*** RH>30%, ***nor*** 22-24 °C). If no values are supplied, or they are not single valued, then the CWCT values may be taken.*

CWCT, Standard for specifying and assessing for condensation risk, 2nd ed. 2.4.1

External	Air Temperature, °C	Relative Humidity, %	Dew-point, °C
Summer	18	65	11.3
Winter	-5	90	-6.3

Internal	Air Temperature, °C	Relative Humidity, %	Dew-point, °C
Houses and flats	20	55	10.7
Offices	20	40	6.1
Schools	20	50	9.3
Factories and warehouses	15	35	-0.4
Textiles	20	70	14.4
Swimming pool halls	25	70	19.2

**If the client specifies the a range of humidities and temperatures, the ones most likely to cause a condensation risk failure will be taken for a worst-case scenario, as is best practice. In many cases, this causes a predicted condensation fail in an unrealistic manner. Therefore, providing environmental condition specifications as a range is impractical for this purpose.*

<u>Mould</u>
Mould risk calculations are performed as requested. Mould, according to BS 5250, forms when the relative humidity at a porous surface exceeds 80% at internal surfaces, for several days (BS EN ISO 13788). Worst-case risk assessments are made by checking the interior temperatures given the specified 10 year low external temperature, and standard checks by using the monthly average.

Model Elements

<u>Materials</u>
Material conductivities are set by standard values unless advised of product or design values in a specific project.
The standards used are generally –

- BS EN ISO 10456:2007
- BS EN 12524:2000
- BS EN ISO 10077-2:2012
- CWCT '*Guide to good practice for assessing heat transfer and condensation risk for a curtain wall, 2nd ed. Table 1*'

Other sources for material values from competent 3rd parties, such as the software suppliers Builddesk and Physibel, will be used if other data is not available.

<u>Air Spaces</u>
Cavities in Building Elements and Window Frames -

The 'equivalent material' method of modelling airspaces is used, as set out in BS EN 10077-2:2012 and BS EN ISO 6946:2007, except where it is found to significantly deviate from results using the 'radiosity' methodology. The radiosity method separates the convection and conduction components from the infra-red transmission. This more accurate method is required by the BFRC (as being more accurate), recommended by Physibel (the software provider) and is the expected direction of revision for BS EN ISO 10077-2. *(The BFRC is the only UK moderator and forum for thermally modelling windows.)*

Cavities in Glazing

The equivalent conductivity (λ_{equ}) of the air space can be calculated by BS EN 673:2011. This standard requires the exact gas mix, the conductivity of the glass, the orientation and the hemi-spherical emissivity of the glass sheet surfaces. However, the centre pane U-value is often the only readily available data with regard to the glazing thermal values. The practical solution is to manually set the thermal conductivity of the glazing gas cavity to reproduce the centre pane U-value in the thermal model, which, in turn, produces robust values.

Fixings, Brackets and Rails

The general treatment of brackets and other fixings can be variable.

Small fixings such as nails and small bolts are generally ignored –

- Screws have no effect fixing between rails and continuous metal elements in modelling, and so are ignored.
- Pressure plate screws in curtain walls are included, as per BS EN ISO 12631:2012, (6.2.2.1 and Annex C).
- In EN ISO 10211:2008, (5.3.3.3), fixings can be incorporated into the conductivity (λ) of a penetrated layer, when certain conditions are met. The upper limit for this increase in λ is 0.0015 W/K.m.**
- For non-insulating layers, the increase in λ is insignificant and is therefore ignored.
- For insulation layers, the increase in λ is still small, the affected layer is slim, so the affect is also ignored.
- The exception to these observations are fixings through insulation, such as wall ties or rain-screen brackets. These may either have a significant, but small, affect on the layer insulation, or do not conform to 5.3.3.3.

***The fundamental condition is that the fixings have a combined area no more than 30 x 10^{-6} m^2 per m^2 of wall (1 x M6 fixing or 2.3 x M4 fixings per m^2). This would easily be met for nails, and quite easily for screws or smaller bolts. If the upper limit of the of the area is 30 x 10^{-6} m^2/m^2, and the fixings are steel (λ=50 W/K.m), the area weighted increase in the conductivity for this layer is a maximum of 0.0015 W/K.m.*

Other fixings and brackets

- 'Toggle' fixings on structural glazings are not included, as they are not included in 12631:2012 Annex C. The screw formula is neither appropriate, nor physically necessary, and if applied to toggles, is not worst-case. Toggles can significantly affect heat flow. If metallic, they can also affect condensation risk. This means that an appropriate view must be taken on toggle fixings in respect to each project and junction calculated.
- In the case of masonry cavity wall ties, all experience to date shows no change in CRA or Psi-values.
- Rain-screen and similar brackets have no significant effect when sufficiently removed from complex metallic structures, and attached to structural boards that are well insulated behind. However, along critical path lengths, attached to window junctions and metal structures, the effect of these brackets is noticeable.
- At a thermal bottle neck (e.g. a large bolt in a 3D model of a bracket fixing) the bolt or similar fixing is included.
- Rails are always included.

Since the **inclusion or exclusion of rail brackets requires professional judgement**, these may be **included or excluded in deference to the opinion of the facade consultants**. In lieu of firm guidance, brackets are often treated as continuous at element junctions at details such as window jambs. This is because the inclusion of brackets is nearly always worst-case and as such may be required for condensation calculations cold spots. However, these are often be excluded from 2D heat loss models, the bracket heat loss being treated as a Chi-loss in a broader calculation.