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BRE Client Report

Calculation of summertime solar shading performance for MicroLouvre

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BRE
Watford, Herts
WD25 9XX

Customer Services 0333 321 8811

From outside the UK:
T + 44 (0) 1923 664000
F + 44 (0) 1923 664010
E enquiries@bre.co.uk
www.bre.co.uk

Prepared for:
Smartlouvre
18 The Tanneries
Brockhampton Lane
Havant
Hampshire
PO9 1JB

Prepared by

Name Dr Paul Littlefair

Position Associate Director, Environment

Date 21 December 2017

Signature PJ Littlefair

Checked by

Name Stephanie King

Position Senior Consultant

Date 21 December 2017

Signature

1 Introduction

BRE have been commissioned by Smartlouvre to determine the solar radiation transmittance of their MicroLouvre system. This is a sheet of very small louvres, usually applied to the outside of windows to reduce solar heat gain.

The usual way to assess the solar gain performance of a system is to calculate the total solar transmittance. This is the fraction of incoming solar radiation that passes through a window and/or shading system. In Europe it is often called the g value.

The total solar transmittance includes both radiation that is transmitted directly through the window, and radiation that is absorbed and then re-radiated, convected or conducted into the room.

For most glazings, the total solar transmittance is measured at normal incidence (ie with the sun directly opposite the window). However when the sun hits the window at an oblique angle, less radiation will be transmitted. This is particularly important for a shading device like MicroLouvre, which is designed to block high angle sun. It will transmit much less solar gain when the sun is high in the sky than a simple measure at normal incidence would indicate.

The effective g value (refs 1, 2) is a better metric for the performance of angle dependent shading devices such as MicroLouvre. It allows for the effects of radiation coming in from different angles, throughout a sunny day in summer. It is defined as:

Effective g value =

$$\frac{\text{Solar gain in period of potential overheating through window with shading device}}{\text{Solar gain through unshaded, unglazed aperture for the same period}}$$

The period from May-August has been chosen as the basis for the calculation of solar protection. The whole day has been taken, but only peak days (the 2.5% centile of radiation availability) are included as solar overheating is most likely to occur on clear days with uninterrupted sun.

This means that the effective g value will vary with the orientation of the window. To simplify things slightly, the data have been averaged so that east and west facing windows give the same value; for UK weather conditions this leads to only a very small difference.

2 Details of the effective g value calculation

The effective g value of a shading system is calculated using the following approach.

CIBSE (in their Guide A) have tabulated the radiation available on peak summer days (the 2.5% centile of radiation availability) and these values have been used as the basis for calculation, together with the sun positions for that period and a model of the radiance of the sky (ref 1).

This enables data to be calculated to allow for the different amounts of radiation received from different directions. This has been carried out for a series of sky patches at 2° intervals in altitude and 5° in azimuth, a total of 3240 data points. Sun and sky radiation are combined, so if the sun is located in a particular sky patch at any time during the summer period its direct radiation is added on. Since the MicroLouvre is intended to be used with glazing, the data are weighted according to the variation of angular transmittance of a typical window (a double glazed low emissivity window). This means that radiation which comes at a glancing angle to the window is given less weight because most of it would be reflected by the glazing anyway, in the absence of MicroLouvre.

The data can then be coupled with the angular transmittance of the shading device to give an overall value of shading performance. For vertical glazing, ground reflected radiation needs to be taken into account. Ground reflected radiation can reduce the effectiveness of devices like MicroLouvre because they do not block it as much as they do sky and sun radiation. Consequently a fairly detailed model of ground reflected radiation has been assumed. A ground albedo of 0.2 has been assumed. The obstruction of the ground by the building itself has been taken into account, assuming that the window is halfway up the façade. The façade is taken to be of infinite width, with an albedo of 0.2.

No external obstruction (for example a building opposite) has been included in the calculation. External obstructions would tend to increase the relative effectiveness of the MicroLouvre, because it has a lower transmittance for radiation coming from higher up.

For both ground reflected and sky and sun radiation, the data are coupled with the angular transmittance of the shading device and glazing to give the effective g value.

A BRE publication ‘The summertime solar performance of windows with shading devices’ (ref 1) gives full details of the way the calculation is carried out.

The Microlouvre is modelled as a series of louvres tilted at a 17° angle to the horizontal. Figure 1, taken from Smartlouvre’s product specification, shows its geometry.

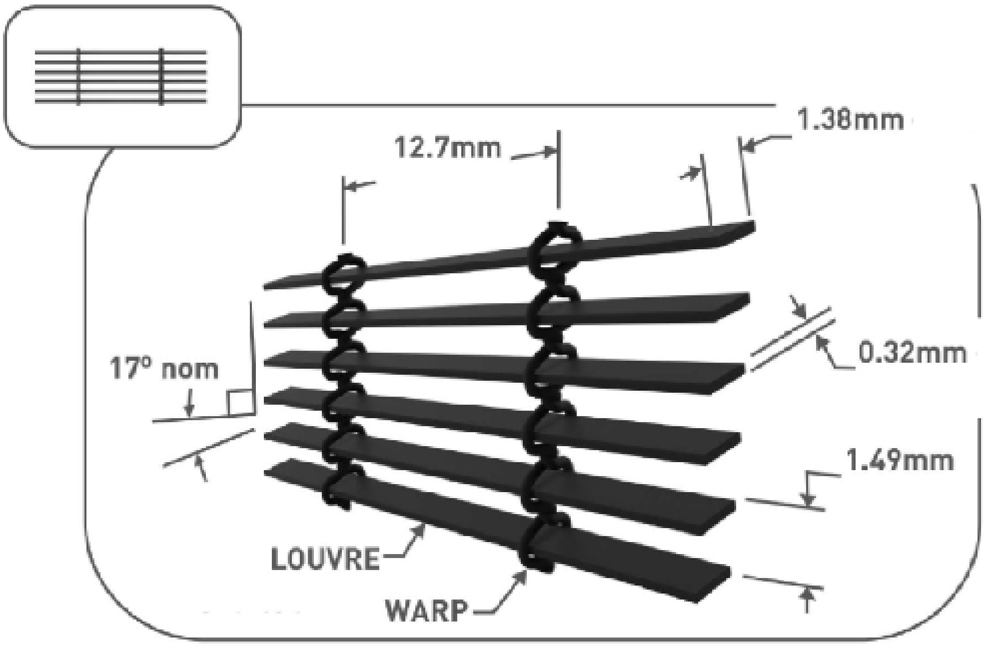

Figure 1. Geometry of MicroLouvre (based on specification by Smartlouvre)

The vertical spacing between adjacent louvres was 1.49mm, and each louvre blade was 1.38mm wide. The thickness of the louvre blade was taken to be 0.32mm. The blades were assumed to be rectangular in cross section. The spacer wire was taken to be straight and an average of 0.257mm wide spaced at 12.7mm intervals.

Reflection of radiation between the blades was included. The solar reflectance of the material used to make black MicroLouvre was taken to be between 0.05-0.10 (5-10%). Only the black MicroLouvre has been modelled.

3 Results

The second column of Table 1 gives the effective g value (solar transmittance) of MicroLouvre alone. This is does not include radiation that is absorbed by the MicroLouvre and then re-radiated, but it does include radiation reflected inwards from the MicroLouvre. The third and fourth columns give the fraction of radiation that is absorbed and reflected back out.

Table 1. Effective g value (solar transmittance, absorptance and reflectance of MicroLouvre alone.

r=0.05	Effective g value	Absorptance	Reflectance
North	0.29	0.69	0.02
NE/NW	0.23	0.75	0.02
E/W	0.18	0.80	0.02
SE/SW	0.12	0.85	0.02
South	0.12	0.85	0.03
r=0.1	Effective g value	Absorptance	Reflectance
North	0.29	0.67	0.04
NE/NW	0.24	0.72	0.04
E/W	0.19	0.77	0.05
SE/SW	0.13	0.82	0.05
South	0.13	0.82	0.05

The total effective solar energy transmittance g can be determined for a window plus blind combination using the methods given in EN 13363-1 (ref 3).

The effective g value g_{tot} for a glazing and **external shading** combination is given by:

$$g_{tot} = g_B \,.\, g + \alpha_B \frac{\Lambda}{\Lambda 2} + g_B\,(1-g)\,\frac{\Lambda}{\Lambda 1}$$

where g is the effective g value of the glazing, g_B is the effective g value of the MicroLouvre alone (second column of table 1), and the absorptivity of the MicroLouvre α_B is given in the third column of table 1.

$$\Lambda = \frac{1}{1/U + 1/\Lambda 1 + 1/\Lambda 2}$$ with $\Lambda 1 = 5$ W/m^{2}K; $\Lambda 2 = 10$ W/m^{2}K

where U is the thermal transmittance of the glazing.

(Note: $\Lambda 1$ and $\Lambda 2$ are notional parameters which are mathematically fitted).

This analysis assumes that the external shading is in thermal contact with the window, and mounted fairly close to it. If the MicroLouvre is mounted some distance from the window, and there is good ventilation of the space in between, $g_{tot} = g_B \,.\, g$

The total solar energy transmittance g_{tot} for a glazing and an **internal shading** combination is given by:

$$g_{tot} = g \,.\, (1 - g.\, \rho_B - \alpha_B \frac{\Lambda}{\Lambda 2})$$

$$\Lambda = \frac{1}{1/U + 1/\Lambda 2}$$ with $\Lambda 2 = 30$ W/m^{2}K

ρ_B, the solar reflectance of the MicroLouvre, is given in the fourth column of table 1.

The effective g value g_{tot} for **shading between two glass panes** (a mid-pane shading device) is given by:

$$g_{tot} = g_B \,.\, g + g.\, (\alpha_B + (1-g)\, \rho_B\,). \frac{\Lambda}{\Lambda 3}$$

$$\Lambda = \frac{1}{1/U + 1/\Lambda 3}$$ with $\Lambda 3 = 3$ W/m^{2}K

Table 2 gives values for the overall effective g values of MicroLouvre (reflectance 0.05) coupled with four different glazing types. These are the reference glazings in BS EN 14501:2005 (ref 4).

1. Reference glazing A. Single glazing, U=5.8 W/m^{2}K, normal incidence transmittance g=0.85.

2. Reference glazing B. Double clear glazing, U=2.9 W/m²K, normal incidence transmittance g=0.76.

3. Reference glazing C. Double low emissivity glazing, U=1.2 W/m²K, normal incidence transmittance 0.59.

4. Reference glazing D. Double soft coat low emissivity glazing, U=1.1 W/m²K, normal incidence transmittance 0.32.

Table 3 gives the values for MicroLouvre with a material reflectance of 0.1. The values for the two reflectances are very similar.

Table 2. Effective g values (solar transmittances) for MicroLouvre/glazing combinations. Slat reflectance 0.05.

r=0.05	A. Single glazing		B. Double clear glazing			C. Double low emissivity glazing			D. Double soft coat low emissivity glazing		
	Internal	External	Internal	Mid pane	External	Internal	Mid pane	External	Internal	Mid pane	External
North	0.62	0.39	0.58	0.39	0.32	0.45	0.23	0.22	0.23	0.11	0.16
NE/NW	0.67	0.36	0.62	0.41	0.30	0.49	0.23	0.20	0.25	0.11	0.15
E/W	0.68	0.33	0.64	0.40	0.27	0.51	0.22	0.18	0.27	0.11	0.14
SE/SW	0.65	0.29	0.62	0.37	0.23	0.49	0.19	0.15	0.25	0.09	0.12
South	0.61	0.28	0.57	0.34	0.22	0.45	0.17	0.14	0.22	0.08	0.11

Table 3. Effective g values (solar transmittances) for MicroLouvre/glazing combinations. Slat reflectance 0.1.

r=0.1	A. Single glazing		B. Double clear glazing			C. Double low emissivity glazing			D. Double soft coat low emissivity glazing		
	Internal	External	Internal	Mid pane	External	Internal	Mid pane	External	Internal	Mid pane	External
North	0.61	0.38	0.57	0.39	0.32	0.45	0.23	0.22	0.23	0.11	0.16
NE/NW	0.66	0.36	0.61	0.40	0.30	0.49	0.23	0.21	0.25	0.12	0.15
E/W	0.67	0.33	0.63	0.40	0.27	0.51	0.22	0.18	0.27	0.11	0.14
SE/SW	0.64	0.29	0.61	0.37	0.23	0.48	0.19	0.15	0.25	0.09	0.12
South	0.60	0.28	0.56	0.34	0.22	0.44	0.17	0.14	0.22	0.08	0.11

For comparison, Table 4 gives the effective solar transmittances of the glazing alone, without MicroLouvre.

Table 4. Effective g values for glazing on its own

	A. Single	B. Double clear	C. Double low emissivity	D. Double soft coat low emissivity
North	0.71	0.62	0.47	0.24
NE/NW	0.77	0.68	0.51	0.26
E/W	0.80	0.70	0.53	0.28
SE/SW	0.77	0.68	0.51	0.26
South	0.72	0.63	0.47	0.23

The values in Tables 2 and 3 include heat that is absorbed by the MicroLouvre and then transferred inside the window. For the low transmittance reference glazing D, the equations in EN13363-1 predict higher transmittance with externally mounted Microlouvre than with a mid-pane installation. This is because the externally mounted Microlouvre will heat up in the sun and the method assumes that some of this heat is conducted or convected indoors. The extent to which this actually happens will depend on the way the Microlouvre is installed, and the amount of ventilation between it and the window. With a mid-pane installation, most of the incoming solar radiation is reflected away by the outer pane of the reference glazing D, which means that the Microlouvre does not warm up as much and less heat is predicted to enter the room.

Overall, the results show that:

- Mounted externally or mid pane, MicroLouvre makes a substantial difference to the solar transmittance of the window. This can be seen by comparing the values in Tables 2 and 3 with those in Table 4, which gives the effective solar transmittances of the glazing alone, without MicroLouvre.

- The performance of the MicroLouvre does vary with orientation, although it has a significant effect for all orientations. Mounted externally, it is best for E/W, SE/SW and South facing windows.

- When the MicroLouvre is mounted internally, it makes only a relatively small reduction in transmittance compared to an unshaded window. The calculations have been carried out for black MicroLouvre, and nearly all the radiation is either transmitted or absorbed. Most of this absorbed radiation is then trapped in the room if the MicroLouvre is inside, unless there is some form of ventilation such as a trickle vent. White MicroLouvre would be expected to reflect more radiation and therefore to have a bigger impact when mounted internally.

4 References

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