Angle – dependent Light and Solar Transmittance

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Measurements of MicroLouvre K700 / 17 Fabric

EN 14501:2005
EN 52022-1:2017

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EN 14501:2005 & EN 52022-1:2017

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1 Introduction

Fraunhofer ISE sates that MicroLouvre fabric is an angle-selective product, therefore angle-dependent transmittance and reflectance values have been tested at positive and negative angles of incidence. The defined standards of EN14501 specify reporting results only at normal incidence and thus do not adequately indicate true performance at other, highly relevant angles of incidence. This report gives technical values for a MicroLouvre solar shading screen without glazing and in combination with reference glazing types A, B, C and D according to EN 14501:2008 and EN 14501:2005 (single, double, low-e and solar-control glazing). According to EN 14501:2005, for general product labelling (independent of the installation conditions), the technical values calculated with reference glazing C, specified in Annex A of EN 14501:2005, shall be used.

MicroLouvre K700 – 17 fabric was tested in a complete screen assembly format

2 Summary

BASIC PRINCIPLES (EN 14501) Thermal and visual performances of solar protection devices are characterised by the European Standard EN 14501 "Blinds and shutters – Thermal and visual comfort – Performance characteristics and classification".

This standard defines performance classes on:

The thermal comfort, covering the following characteristics:
- The solar factor,
- The secondary heat transfer factor,
- The direct solar transmittance.

The visual comfort, covering the following characteristics:
- The opacity control,
- The night privacy,
- The visual contact with the outside,
- The glare control,
- The daylight utilisation,
- The rendering of colours.

The standard EN 14501 defines the following classification.

Total solar factor classification (according to EN 14501)

Class	gtot	Evaluation
4	gtot < 0.10	Very good effect
3	0.10 ≤ gtot < 0.15	Good effect
2	0.15 ≤ gtot < 0.35	Moderate effect
1	0.35 ≤ gtot < 0.50	Little effect
0	gtot ≥ 0.50	Very little effect

Total solar factor "glazing + textile" The total solar factor gtot takes into account the textile performance but also the performance of the glazing to which it is associated. Therefore, the standard EN 14501 has defined four reference glazing to make calculations of the total solar factor.
The performances of these glazing are presented below.
Reference glazing properties (according to EN 14501)

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Glazing	U2	g3
A : clear single glazing	5.8	0.85
B : clear double glazing	2.9	0.76
C : low emission double glazing	1.2	0.59
D : reflective double glazing with a low emission layer	1.1	0.32

2 Thermal transmittance of the glazing alone (W/m²K)
3 Solar factor of the glazing alone

Direct solar transmittance classification (according to EN 14501)

Class	τe, n-n	Evaluation
4	τe, n-n < 0.05	Very good effect
3	0.05 ≤ τe, n-n < 0.10	Good effect
2	0.10 ≤ τe, n-n < 0.15	Moderate effect
1	0.15 ≤ τe, n-n < 0.20	Little effect
0	τe, n-n ≥ 0.20	Very little effect

The visual comfort:

The standard EN 14501 specifies a classification for the following visual performances.

Glare control: It is the capacity of a textile to control the luminance level of windows (disruptive luminosity) and to reduce the luminance contrasts between different zones within the field of vision.

Visual contact with the outside: It is the capacity of a textile to allow an exterior view when it is fully extended.

Daylight utilisation: It is the capacity of a textile to optimise the available daylight.

Night privacy: It is the capacity of a textile to protect persons from external view, at night, in normal lighting conditions.

Opacity control: It is the capacity of a textile to preclude the vision of outside light. The performance of products is expressed by the level of illuminance (in lux) under which no light is perceivable by an observer behind the device, the textile being illuminated.

3 Scope of Test

To establish Angle-Dependent (AD) characterisation of MicroLouvre® metal fabric and g value determination when used in combination with Class A,B,C,D Glazing Units and Angle-Dependent
(AD), Spectral Transmittance and Reflectance measurements (UV-vis-NIR)

Testing was to establish performance characteristics at angles in addition to the 0º stipulated in EN 14501-2008 as 0º which equates to a sunrise / sunset parameter wheras solar shading, like the sun, is angular relevant.
Angles tested were -70 ° to +70 ° measured in steps of 10 °.
Measurements tested to include

Spectral Transmittance and Reflectance
- Direct-hemispherical spectral transmittance and reflectance
- Hemispherical-hemispherical spectral reflectance incident diffuse radiation
- Spectral normal-hemispherical reflectance
- Normal-diffuse transmittance reflectance
- Spectral near-normal-hemispherical reflectance

Solar, Light and Solar Thermal characteristics
- Light and Solar Transmittance and Solar Reflectance values
- Normal-normal transmittance
- Normal-diffuse transmittance
- Diffuse-hemispherical transmittance
- Colour Rendering Index (CRI)

Note: The angle-dependent reflectance measurements (“RHOWIN”) are not yet included in the TestLab accreditation. However, all instruments are included in the quality management system of Fraunhofer ISE, which is certified according to ISO 9001:2015. The instruments are calibrated regularly against traceable standards.

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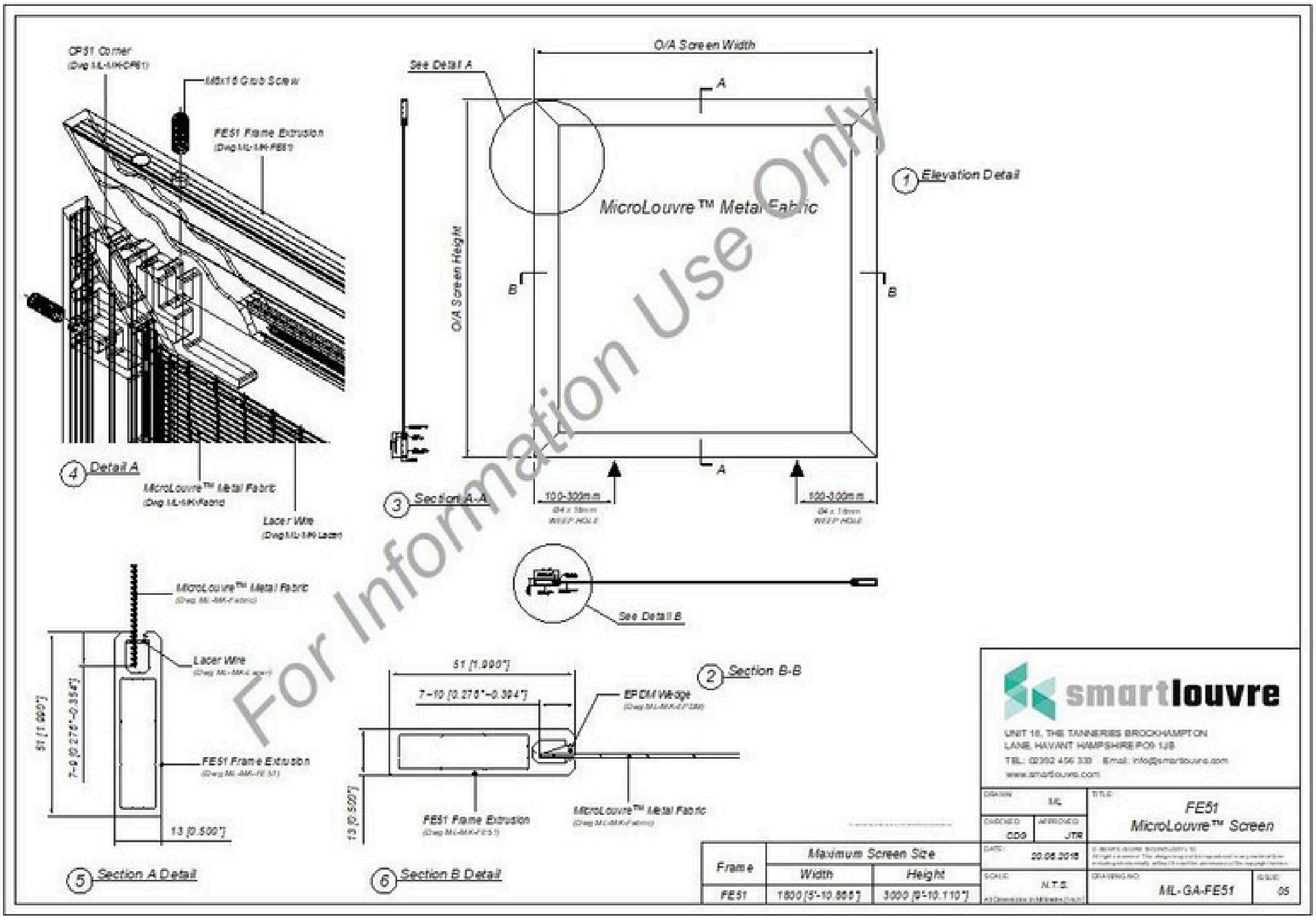
4 Description of Test Specimen (Fig 1)



(Fig 1)

VS393001	K700 – 17	Test Screen	200 mm x 300 mm
VS393002	K700 – 17	Test Screen	400 mm x 400 mm

Metal Fabric	Standard MicroLouvre K700 – 17
Frame	FE 25 extruded aluminium
Corner Posts	CP 25 machined aluminium corner posts
Lacer Wire	lateral tensioning system (top and bottom)
EPDM	Anti Vibration system (sides)

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5 Test Methods

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Angle-dependent light and solar transmittance measurements of a MicroLouvre solar shading screen

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The results in this report refer to the tested samples. Fraunhofer ISE did not have any influence on the selection of samples.

Fraunhofer Institute for Solar Energy Systems ISE
Energy-Efficient Buildings Department
TestLab Solar Façades

Freiburg, 14th December, 2018

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1 Preliminary note

MicroLouvre solar shading screen is an angle-selective product, so angle-dependent transmittance and reflectance values have been provided at positive and negative angles of incidence. The defined standards specify reporting results only at normal incidence and thus do not adequately indicate performance at other, highly relevant angles of incidence.

This report gives technical values for a MicroLouvre solar shading screen from Smartlouvre Technology Limited without glazing and in combination with reference glazing types **A, B, C and D** according to EN 14501:2008 and EN 14501:2005 **(single, double, low-e and solar-control glazing)**. According to EN 14501:2005, for general product labelling (independent of the installation conditions), the technical values calculated with reference glazing C, specified in Annex A of EN 14501:2005, shall be used.

We present the results according to the European annexes of EN 52022-1:2017, which was published in January 2018, and is thus the currently valid standard. It replaces EN 13363-1:2009, which is the equivalent standard that is still referenced in the current versions of EN 14501:2008 and EN 14501:2005.

1.1 A note on terminology

"Facteur solaire", "g-Wert", "Gesamtenergiedurchlassgrad", "Solar factor", "g value", "Solar Heat Gain Coefficient SGHC" and "total solar energy transmittance TSET" are synonyms used in different standards for the same physical quantity. As the standards specify different boundary conditions, the numerical values determined for this physical quantity may vary according to the standard used.

2 Description of samples

The investigated samples of a MicroLouvre solar shading screen are characterised in Table 1. Samples were provided with two different areas, because samples of different dimensions are required for the different spectrometers. Except for the external dimensions, the samples should be identical. They were delivered to Fraunhofer ISE on 16th November 2018.

For the results, we note the Fraunhofer ISE identifier (e.g. VS393001) and the description from Smartlouvre Technology Limited.

Table 1 Sample descriptions

Fraunhofer ISE ID	Smartlouvre description	area
VS393001	MicroLouvre solar shading screen in frame	200 mm x 300 mm
VS393002	MicroLouvre solar shading screen in frame	400 mm x 400 mm

3 Description of angle-dependent measurements of spectral transmittance and reflectance

The TestLab Solar Façades was first accredited for testing windows, façades and other products according to DIN EN ISO/IEC 17025:2005 in 2006. The accreditation encompasses the determination of the g value (total solar energy transmittance), transmittance, reflectance and U value by measurement and calculation. The flexible accreditation also includes procedures developed at Fraunhofer ISE which go beyond the state of the art documented in standards.

The DAkkS registration number for the accreditation is D-PL-11140-03-01.

The angle-dependent reflectance measurements ("RHOWIN") are not yet included in the TestLab accreditation. However, all instruments are included in the quality management system of Fraunhofer ISE, which is certified according to ISO 9001:2015. The instruments are calibrated regularly against traceable standards.

3.1 Angle-dependent measurements of spectral transmittance and reflectance

The angle-dependent direct-hemispherical spectral transmittance $\tau_{dir-h}(\lambda, \theta)$ was determined with the so-called TAUWIN integrating sphere of diameter 620 mm using a diode-array spectrophotometer (Figure 1 to Figure 3). The angle of incidence θ was varied from -70 ° to 70 ° in steps of 10 °, except that -10° and 10° were replaced by -8° and 8°, respectively. The hemispherical-hemispherical spectral reflectance $\rho_{h-h}(\lambda)$ of the back of the samples for incident diffuse radiation (originating from the integrating sphere) was determined for the sample with the so-called Diffuse Radiation Source DRS using a sample port aperture of 10 cm diameter; this value is used for the second order correction for the change of sphere throughput caused by the sample at the measurement port.

The angle-dependent direct-hemispherical spectral reflectance $\rho_{dir-h}(\lambda, \theta)$ was determined with another integrating sphere (RHOWIN) of diameter 620 mm using a diode-array spectrophotometer (Figure 4 and Figure 5). The angle of incidence θ was varied from -70 ° to -20 ° and 20 ° to 70 ° in steps of 10 °; measurements were also made at -8 ° and 8 °. In this case, the sample is mounted within the sphere in a rotatable sample holder. A piece of black cardboard with a direct-hemispherical visible reflectance between 0.02 and 0.03 was mounted within the rotatable sample holder approximately 8 mm behind the sample. The back surface of the sample holder is made of sintered PTFE and is used as the reflectance reference.

Measurements were made with the micro-louvres running parallel to the axis of rotation. The light was incident on the surface which had been labelled by Smartlouvre Technology Limited as the outside surface.

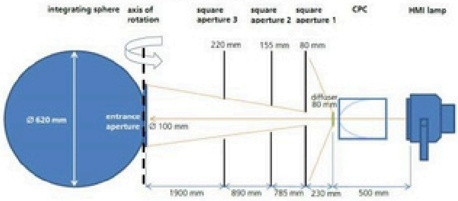

Figure 1 "TAUWIN" equipment for measuring angle-dependent spectral direct-hemispherical transmittance $\tau_{dir-h}(\lambda, \theta)$.

Figure 2 "TAUWIN" equipment for measuring angle-dependent spectral direct-hemispherical transmittance $\tau_{dir-h}(\lambda, \theta)$, showing the illuminated, empty sample holder and the entrance aperture to the integrating sphere.

Figure 3 "TAUWIN" equipment for measuring angle-dependent spectral direct-hemispherical transmittance $\tau_{dir-h}(\lambda, \theta)$, showing the MicroLouvre solar shading screen mounted on the sample holder and the entrance aperture to the integrating sphere. The visible Moiré effect is an artefact of the digital camera image.

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Angle-dependent light and solar transmittance measurements of a MicroLouvre solar shading screen

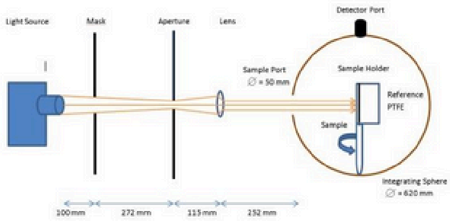

Figure 4 "RHOWIN" equipment for measuring angle-dependent spectral direct-hemispherical reflectance $\rho_{dir-h}(\lambda, \theta)$.

Figure 5 View of opened "RHOWIN" sphere for measuring angle-dependent spectral direct-hemispherical reflectance $\rho_{dir-h}(\lambda, \theta)$, displaying the mounted MicroLouvre solar shading screen.

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Angle-dependent light and solar transmittance measurements of a MicroLouvre solar shading screen

The spectral normal-hemispherical and normal-diffuse transmittance and the spectral near-normal-hemispherical reflectance of the samples were also measured using a Perkin-Elmer Lambda-900 spectrometer and a 220 mm integrating sphere coated with sintered PTFE. These spectra were used to complete the spectra described above to cover the range from 280 nm to 2500 nm. The near-normal-hemispherical reflectance measurements with the Lambda-900 spectrometer were made using a white standard that can be traced to a PTB calibration as the reference. The reported sample reflectance results do not include the reflectance due to the black cardboard behind the sample.
The angle of incidence was 0 ° for the transmittance measurements and 8 ° for the reflectance measurements for the (near-)normal measurements.

3.2 Calculation of the solar, light and solar thermal characteristics

The light and solar transmittance and reflectance values for the samples were calculated according to EN 410:2011 on the basis of the transmittance and reflectance spectra, using an internally written and validated program.
The solar factors presented in this report have been calculated according to EN 52022-1:2017, in accordance with EN 14501:2005 and EN 14501:2008.

The normal-normal transmittance τ_{n-n} was determined by calculating the difference between the normal-hemispherical transmittance τ_{n-h} and normal-diffuse transmittance τ_{n-dif} measured with the Perkin-Elmer Lambda-900 spectrometer and the 220 mm integrating sphere.

In accordance with EN 14501:2008, Annex B, the value of normal-normal transmittance τ_{n-n} is used as an approximation for the openness coefficient.

The diffuse-hemispherical transmittance τ_{d-h} has been calculated according to the simplified formula given in EN 14501:2008.

An internally written and validated program was also used for these calculations.

(Fig 6)

The colour rendering index (CRI) in transmission was calculated according to EN 410:2011 using the WIS program (Window Information System), that was developed during the EU-funded WinDat project.

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6 Test Evidence

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Angle-dependent light and solar transmittance measurements of a MicroLouvre solar shading screen

4 Results

The measurements were carried out between 19th November and 6th December 2018.

4.1 Light, solar and g-value characteristics for normally incident radiation

The following tables list the values for $\tau_{e,n-h}$ (normal-hemispherical solar transmittance), $\tau_{v,n-h}$ (normal-hemispherical light transmittance), $\tau_{v,n-n}$ (normal-normal light transmittance), $\tau_{v,n-dif}$ (normal-diffuse light transmittance), $\tau_{v,d-h}$ (diffuse-hemispherical light transmittance), $\rho_{v,n-h}$ (normal-hemispherical light reflectance), $\rho_{e,n-h}$ (normal-hemispherical solar reflectance) and $\alpha_{e,n-h}$ (normal-hemispherical solar absorptance) of the MicroLouvre solar shading screen alone (as a blind, subscript "B"), and the values of g_{tot} (total g value of blind and glazing) according to EN 52022-1:2017 for the MicroLouvre solar shading screen together with glazing types A, B, C and D as specified by EN 14501:2005.

Please note that "normal incidence" is equivalent to an incidence angle of 0°, as listed e.g. in Table 3. The transmittance values at 0° incidence from Table 3 are also found in Table 1. For geometrical reasons (the detector blocks the incident beam), "normal-hemispherical reflectance" is not usually determined at 0°. Instead, the averages of the reflectance values measured at +8 ° and -8 ° from Table 3 have been reported in Table 1.

The openness factor is 0.67 for the sample.

The sample has a colour rendering index (CRI) in transmission of 100.

Table 1 [illegible]
τ = transmittance, ρ = reflectance, α = absorptance [illegible]
[illegible]

MicroLouvre solar shading screen				Solar characteristics			Light characteristics				
Fraunhofer ISE ID	Smartlouvre ID	Colour of surface toward beam	Surface toward beam	$\tau_{e,B,n-h}$	$\rho_{e,B,n-h}$	$\alpha_{e,B,n-h}$	$\tau_{v,B,n-h}$	$\tau_{v,n-dif}$	$\tau_{v,n-n}$	$\tau_{v,d-h}$	$\rho_{v,n-h}$
VS393001 / VS393002	MicroLouvre solar shading screen	black	outdoor surface	0.678	0.002	0.320	0.682	0.008	0.674	0.505	0.001

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Angle-dependent light and solar transmittance measurements of a MicroLouvre solar shading screen

Table 2 g_{tot} values for samples VS393001 and VS393002 with glazing **types A, B, C and D** according to EN 14501:2008 and EN 14501:2005 calculated according to EN 52022-1:2017. "g_{tot} exterior" refers to the total g value for an exterior blind and glazing unit; "g_{tot} interior" refers to the total g value for an interior blind and glazing unit. τ = transmittance, ρ = reflectance, α = absorptance, subscript e = (solar) energy, subscript B = blind, U_g = U-value in W/(m²K) of the reference glazing without blind, g = g value of the reference glazing without blind. Three decimal places are used for the solar characteristics only to indicate small differences between similar values. Only two decimal places are significant. According to EN 14501:2005, for general product labelling (independent of the installation conditions), the technical values calculated with reference glazing C shall be used.

MicroLouvre solar shading screen				Solar characteristics			Glazing A / Glazing B				Glazing C / Glazing D			
							g_{tot} exterior		g_{tot} interior		g_{tot} exterior		g_{tot} interior	
							U_g = 5.8	U_g = 2.9	U_g = 5.8	U_g = 2.9	U_g = 1.2	U_g = 1.1	U_g = 1.2	U_g = 1.1
							g = 0.85	g = 0.76	g = 0.85	g = 0.76	g = 0.59	g = 0.32	g = 0.59	g = 0.32
Fraunhofer ISE ID	Smartlouvre ID	Colour of surface toward beam	Surface toward beam	$\tau_{e,B,n-h}$	$\rho_{e,B,n-h}$	$\alpha_{e,B,n-h}$	g_{tot}	g_{tot}	g_{tot}	g_{tot}	g_{tot}	g_{tot}	g_{tot}	g_{tot}
VS393001 / VS393002	MicroLouvre solar shading screen	black	outdoor surface	0.678	0.002	0.320	0.69	0.62	0.80	0.74	0.48	0.32	0.58	0.32

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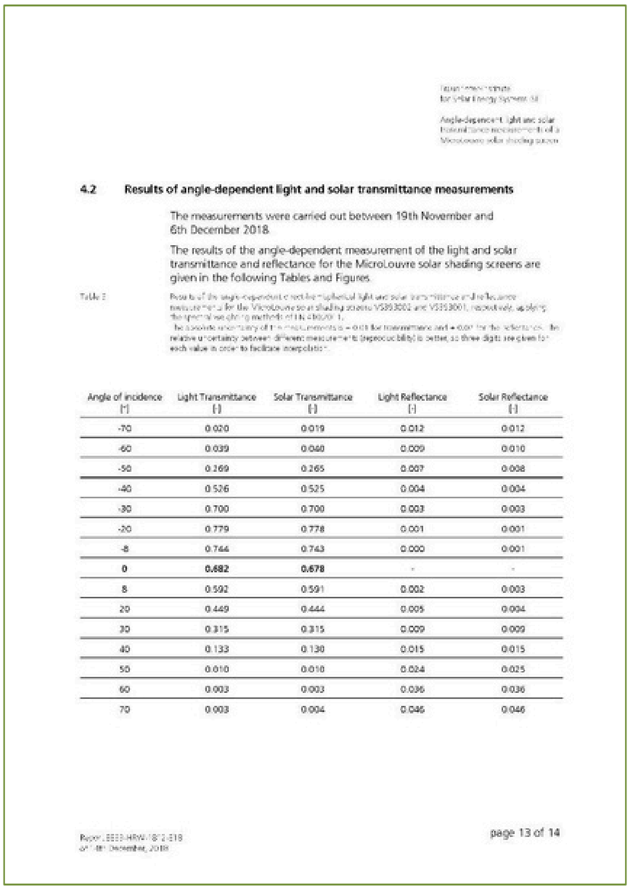

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Angle-dependent light and solar transmittance measurements of a MicroLouvre solar shading screen

4.2 Results of angle-dependent light and solar transmittance measurements

The measurements were carried out between 19th November and 6th December 2018.

The results of the angle-dependent measurement of the light and solar transmittance and reflectance for the MicroLouvre solar shading screens are given in the following Tables and Figures.

Angle of incidence [°]	Light Transmittance [-]	Solar Transmittance [-]	Light Reflectance [-]	Solar Reflectance [-]
-70	0.020	0.019	0.012	0.012
-60	0.039	0.040	0.009	0.010
-50	0.269	0.265	0.007	0.008
-40	0.526	0.525	0.004	0.004
-30	0.700	0.700	0.003	0.003
-20	0.779	0.778	0.001	0.001
-8	0.744	0.743	0.000	0.001
0	**0.682**	**0.678**	-	-
8	0.592	0.591	0.002	0.003
20	0.449	0.444	0.005	0.004
30	0.315	0.315	0.009	0.009
40	0.133	0.130	0.015	0.015
50	0.010	0.010	0.024	0.025
60	0.003	0.003	0.036	0.036
70	0.003	0.004	0.046	0.046

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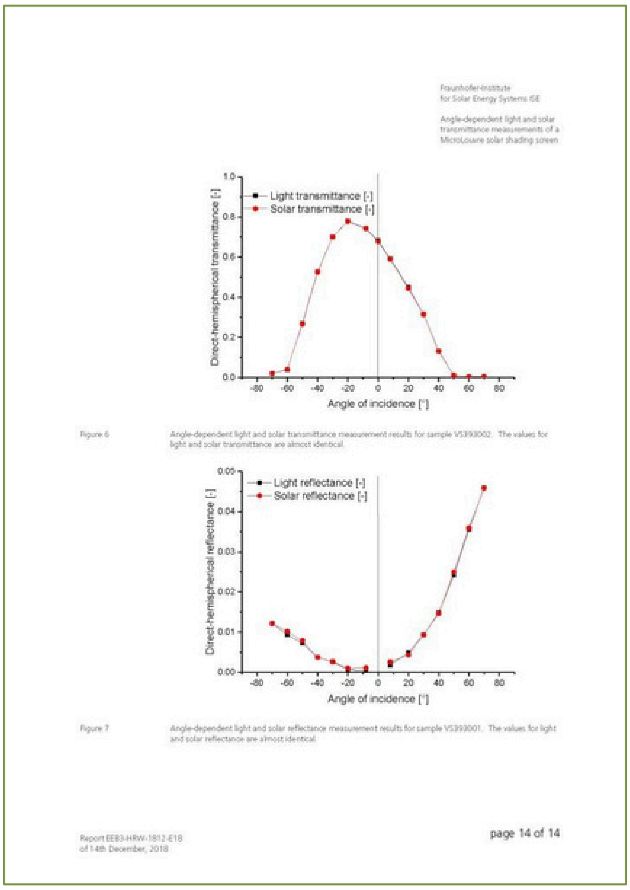

Figure 6 Angle-dependent light and solar transmittance measurement results for sample VS393002. The values for light and solar transmittance are almost identical.

Figure 7 Angle-dependent light and solar reflectance measurement results for sample VS393001. The values for light and solar reflectance are almost identical.

7 Conclusion

Angle of incidence [°]	Light Transmittance [-]	Solar Transmittance [-]	Light Reflectance [-]	Solar Reflectance [-]
-70	0.020	0.019	0.012	0.012
-60	0.039	0.040	0.009	0.010
-50	0.269	0.265	0.007	0.008
-40	0.526	0.525	0.004	0.004
-30	0.700	0.700	0.003	0.003
-20	0.779	0.778	0.001	0.001
-8	0.744	0.743	0.000	0.001
0	**0.682**	**0.678**	-	-
8	0.592	0.591	0.002	0.003
20	0.449	0.444	0.005	0.004
30	0.315	0.315	0.009	0.009
40	0.133	0.130	0.015	0.015
50	0.010	0.010	0.024	0.025
60	0.003	0.003	0.036	0.036
70	0.003	0.004	0.046	0.046