



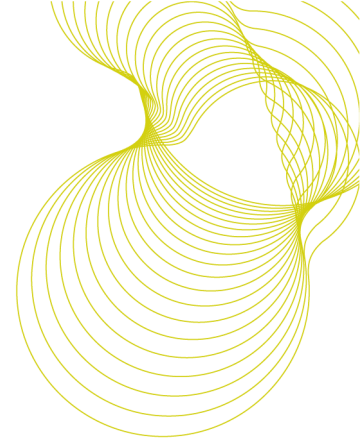
bre

Testing of light tubes

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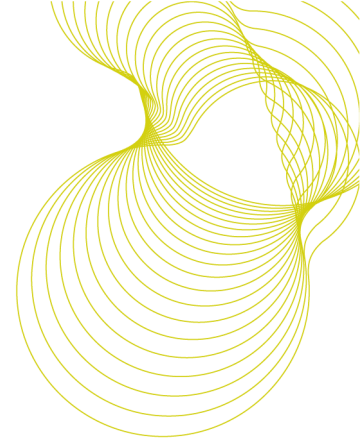
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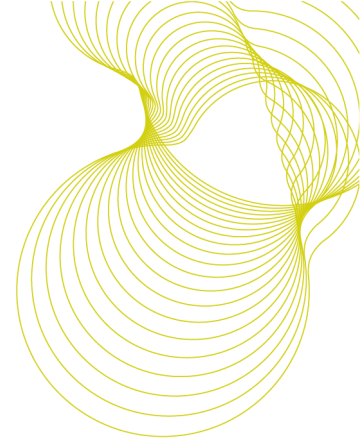
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1 Introduction

BRE were commissioned by Syneco to measure the light transmittance of four different light tubes. The tubes are listed in Table 1.

Sample	Make	Type	Diameter	Actual length
1	Solarspot	Solarspot D-38, double glazed top dome, Convax lens	380mm	2.28m
2	Solarspot	Solarspot D-38, single glazed top dome, no Convax lens	380mm	2.28m
3	Monodraught	Sun Pipe 450, double glazed diffuser	450mm	2.28m
4	Solatube	Brighten Up 290 DS, double glazed diffuser and dome reflector	350mm	2.28m

Table 1. List of tubes tested

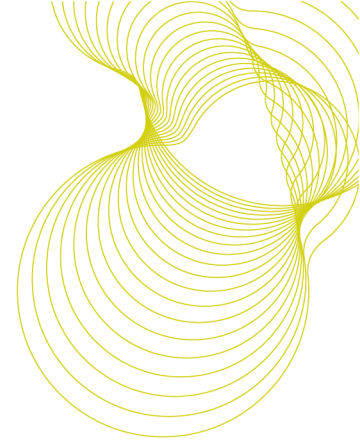
All the tubes had a single glazed dome except where stated. The Solarspot tubes had a single glazed diffuser.

The light tubes were to be measured under overcast conditions.

All the light tubes were provided and assembled by Chris Taffs of Syneco. The length of each tube was 2.28 metres long, which is the length of the visible silvered surface not including the portions protruding through the dome and diffuser units. Each tube was measured with the top dome and bottom emitter/diffuser in place, so the transmission factors given are those for the entire system.

The Solarspot tubes had integral RIR reflectors designed to pick up more light at low sun angles. The Sun Pipe system was fit with a diamond shaped dome, and the Solatube system had a roof dome with Fresnel lenses and integral Light Tracker reflector.

The transmission factor T is defined as the light emitted from the light tube system divided by the light entering it. The total light F emerging from the system in lumens is given by $F = E \times T \times A$, where A is the aperture area (πr^2 for a circular tube) and E is the illuminance at the top of the tube (the global horizontal daylight illuminance for a vertical tube). Thus under given weather conditions the total light output from the tube depends upon the tube area as well as the transmittance. A 380mm diameter tube would therefore transmit more light in total than a 350mm diameter tube of the same transmittance, for example. Use of the transmittance as a parameter allows the effects of tubes of different radii to be compared objectively.



2 Details of tests carried out

2.1 Use of the integrating box

Light can exit the light tube in a range of directions. To ensure all the light is collected and accounted for, a photocell inside an integrating box is used (the 'BRS Integrating Sky Photometer'). Figure 1 shows the box, which is painted matt white inside.

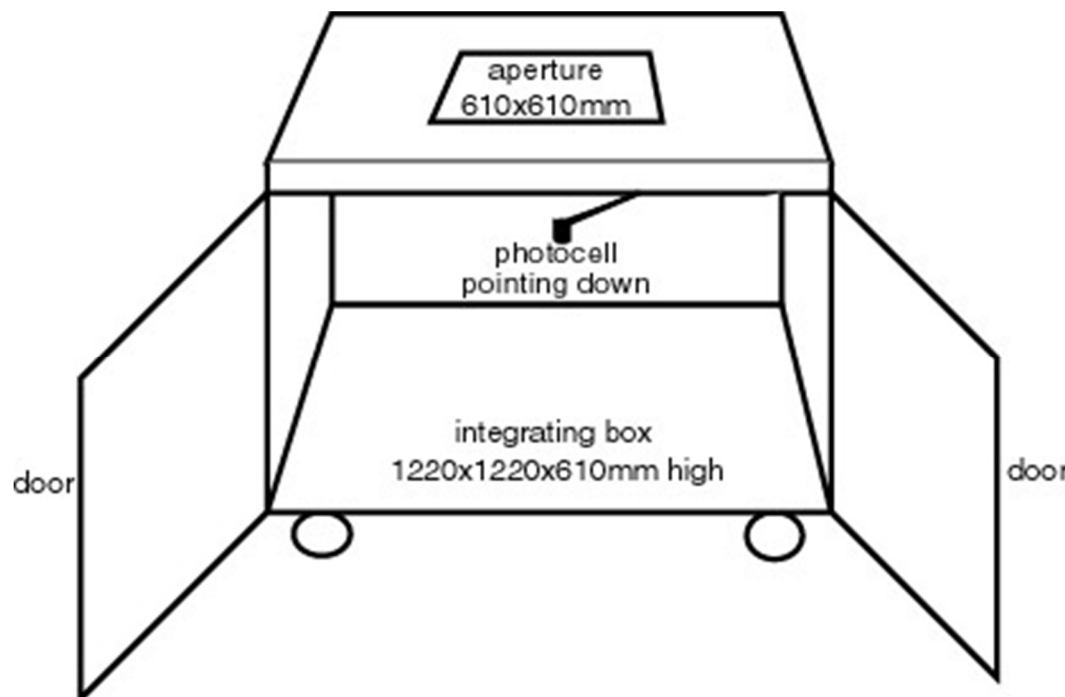
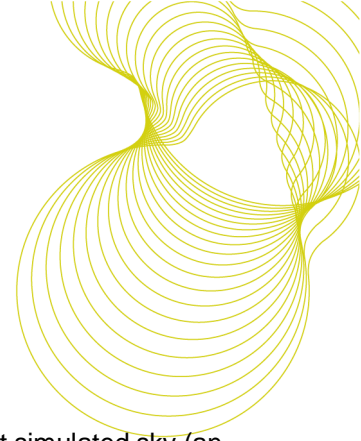


Figure 1 Integrating box used for the measurements. The doors are shut when in use.

During use, the doors to the box are shut and the light inside is measured using a colour and cosine corrected photocell attached to an LMT Lichtmesstechnik Pocket Lux illuminance meter. The photocell points downwards so it receives light from all directions, diffusely reflected inside the box.

The box is usually used to measure the diffuse transmittance of rooflight glazing. The photocell illuminance is first measured with the top aperture open. Then the rooflight sample is placed over the aperture and the illuminance re-measured. The rooflight transmission is the ratio of the illuminance with the rooflight divided by the illuminance without the rooflight. Hopkinson, Petherbridge and Longmore describe the technique on page 352 of their book 'Daylighting' (Heinemann, London, 1966). A similar procedure is recommended in BS EN1013-1 1998 'Light transmitting profiled plastic sheeting for single skin roofing: general requirements



and test results'. For rooflights the measurement is usually made under an electrically lit simulated sky (an 'artificial sky') to ensure stability of illumination.

For light tubes, two modifications were required to the procedure. The diameter of the tubes is smaller than the normal aperture, so special aperture plates were constructed with a circular hole approximately equal to the diameter of the tube. The ratio of the illuminance in the box with the tube (Figure 2) to that with the aperture plate (Figure 3) then corresponds to the transmittance of the tube system.

Because of the length of all the tubes tested, the overcast sky measurements could not be carried out under the BRE artificial sky and were instead undertaken under the real sky (see next section).

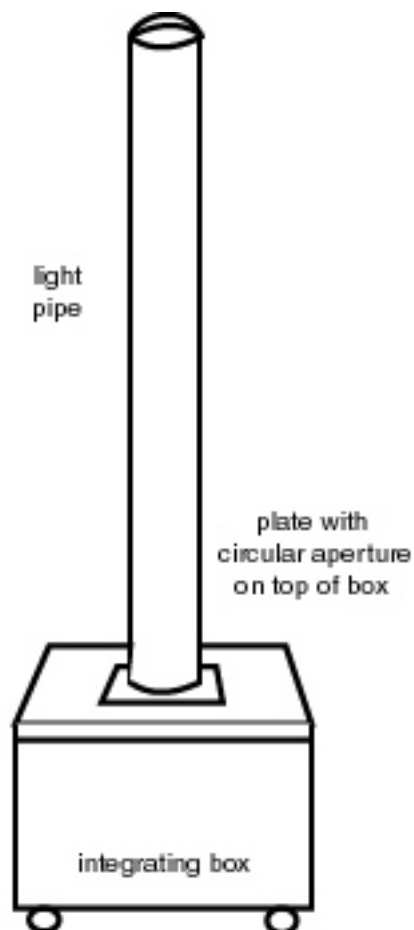


Figure 2 The light tube seated on the integrating box.

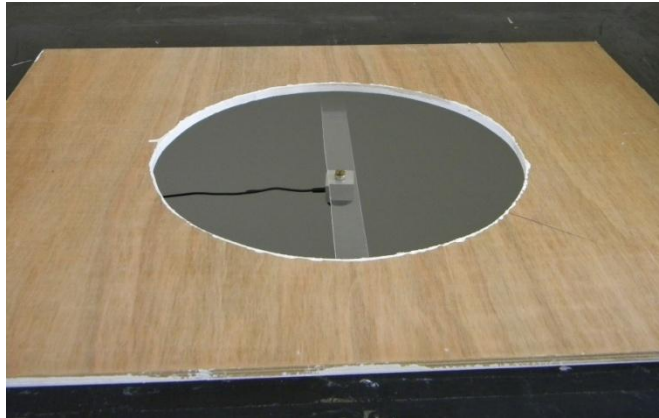
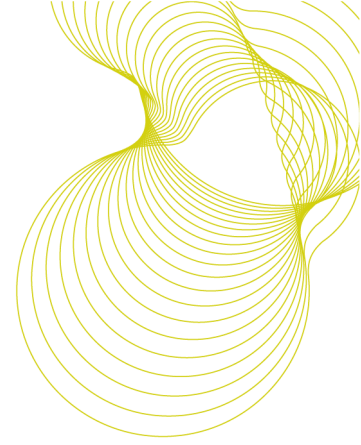


Figure 3 The aperture plate on top of the integrating box. The back of the photocell is visible through the aperture. The underneath of the plate is painted matt white.

2.2 The overcast sky measurements

These measurements were made on Monday 16th July 2012 on the roof of building 9 at BRE. The roof is almost completely unobstructed. During the measurements the sky was completely covered in cloud, with occasional light drizzle, and the solar disk was invisible.

Alternate measurements were taken with the sample present and absent. The illuminance was first measured in the integrating box with the aperture plate and no tube. This was repeated with the tube in place (Figure 4), then with the aperture plate and no tube again. Three measurements with the sample present were taken. Therefore, the typical set of measurements for each sample was:

No sample, **sample (1)**, no sample, **sample (2)**, no sample, **sample (3)**, no sample

The samples are then averaged to give a single value for no sample present, a single value for sample present, and a single value for the corresponding unobstructed sky measurements in each case.

The measurements were taken as quickly as possible to ensure that the sky conditions are as consistent as possible across the measurement set. However during the time taken to lift the tube on and off the box the illuminance from the sky could change. This was corrected for by monitoring the unobstructed global horizontal illuminance using a separate LMT Lichtmesstechnik illuminance meter at the other end of the roof (Figure 5).

The transmittance of the light tube was then taken as

$$T = \frac{\text{Illuminance in box with tube}}{\text{Illuminance in box no tube}} \times \frac{\text{Unobstructed illuminance for no tube measurement}}{\text{Unobstructed illuminance for tube measurement}}$$

Measurements were repeated for the four different tubes.

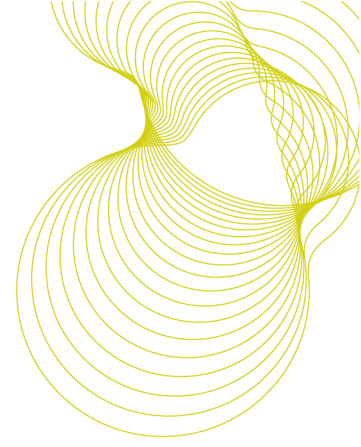
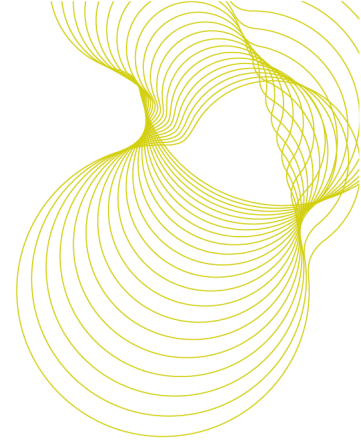


Figure 4 Light tube (Solarspot D-38, single glazed top dome, no Convax lens) under test on roof



Figure 5 Simultaneous measurement of external horizontal illuminance using a separate light meter.



3 Test results

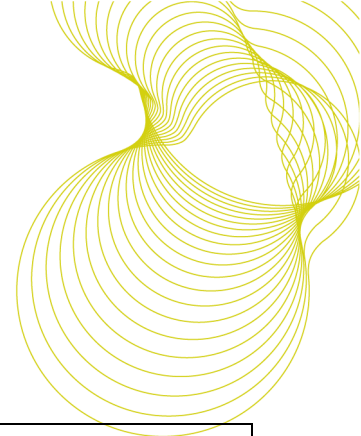
The values of the illuminances measured during the tests are given in Tables 2 to 5 below.

Measurement no.	Position 1 (integrating box)		Position 2 (unobstructed sky)	
	No tube	With tube	No tube	With tube
1	2447		16310	
2		1699		20280
3	2919		19130	
4		1719		19950
5	3294		21250	
6		1966		21840
7	2855		18670	
Average value	2879	1795	18840	20690

Table 2. Measured illuminances for sample 1 - Solarspot D-38, double glazed top dome, Canvas lens

Measurement no.	Position 1 (integrating box)		Position 2 (unobstructed sky)	
	No tube	With tube	No tube	With tube
1	1710		11190	
2		1052		10910
3	2275		14750	
4		1386		14220
5	2246		14570	
6		1340		13880
7	1971		12960	
Average value	2051	1259	13368	13003

Table 3. Measured illuminances for sample 2 - Solarspot D-38, single glazed top dome, no Canvas lens



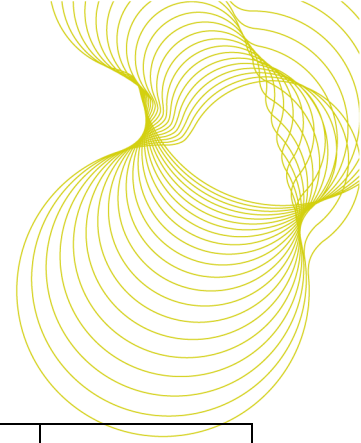
Measurement no.	Position 1 (integrating box)		Position 2 (unobstructed sky)	
	No tube	With tube	No tube	With tube
1	5212		25870	
2		3491		39370
3	8363		40020	
4		3951		43700
5	10105		47240	
6		3724		41420
7	7137		33180	
Average value	7704	3722	36578	41497

Table 4. Measured illuminances for sample 3 – Monodraught Sun Pipe 450mm, double glazed diffuser

Measurement no.	Position 1 (integrating box)		Position 2 (unobstructed sky)	
	No tube	With tube	No tube	With tube
1	3681		27080	
2		1355		25130
3	3148		23250	
4		1157		21900
5	2959		21990	
6		1190		22180
7	2755		20340	
Average value	3136	1234	23165	23070

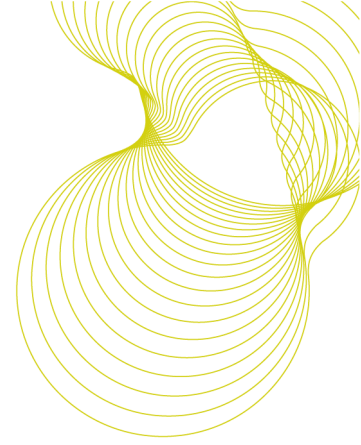
Table 5. Measured illuminances for sample 4 – Solatube Brighten Up 290 DS, double glazed diffuser and dome reflector

Based on the measured values, the results of the tests were calculated and these are given in Table 6.



Sample	Make	Type	Diameter	Transmittance
1	Solarspot	Solarspot D-38, double glazed top dome, Convax lens	380mm	0.57
2	Solarspot	Solarspot D-38, single glazed top dome, no Convax lens	380mm	0.63
3	Monodraught	Sun Pipe, double glazed diffuser	450mm	0.43
4	Solatube	Brighten Up 290 DS, double glazed diffuser and dome reflector	350mm	0.40

Table 6. Light tube transmittances under overcast sky conditions

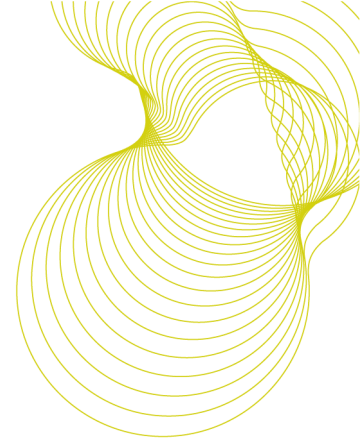


4 Conclusions

These tests covered four different light tube products. Three of these (Solarspot with Convas lens, Monodraught, Solatube) were broadly comparable, because they combined a double glazed element with a single glazed one. For the Monodraught and Solatube, the diffuser was double glazed and the dome single glazed; for the Solarspot with Convas lens, the dome was double glazed and the diffuser single glazed. The Solarspot without Convas lens would be expected to have a higher transmittance, because it only had a single glazed dome and diffuser. This proved to be the case; its transmittance of 0.63 was the highest in the test, 11% (in relative terms) higher than for the similar product with the double glazed dome.

The transmittance T of a light tube is the proportion of the light that reaches the top of the tube that emerges from the bottom. It is a measure of the effectiveness of the tube in transporting and emitting light. The total amount of light F (in lumens) a tube transmits is given by $F = E \times T \times A$, where A is the aperture area (πr^2 for a circular tube) and E is the outside illuminance at the top of the tube (the global horizontal daylight illuminance for a vertical tube).

Taking the three double/single glazed tubes, the Solarspot with Convas lens product had the highest transmittance, 0.57, compared to 0.43 for the Monodraught and 0.40 for the Solatube. In relative terms, it was 33% more effective than the Monodraught at transmitting light, and 44% more effective than the Solatube.



Appendix A – Measurement errors

For the overcast sky tests there is one principal source of error. This is that the sky luminance distribution could depart from that of a standard overcast sky. A light tube has its highest transmittance at the zenith, so if the zenith is brighter than expected the measured transmittance will be higher. This error was reduced by repeating the measurements. From experiences with different tests, it is estimated to be $\pm 5\%$.

Obstruction caused by the greenhouse on top of the roof, the other light tubes, and trees is relatively small. It affects the measurement of light in the box without the tube, but has no impact on the measurement with the light tube. It is estimated that the illuminance in the box could be underestimated by 0.1%, so the measurements of transmittance could be too high by this amount.

Levelling of the tube is an issue, but under overcast conditions even if the tube is tilted by 2 degrees the error is less than 0.1%.

To measure transmittance accurately, the aperture plate has to be exactly the same size as the light tube. This has been corrected for, but some residual errors may remain. A 1% error in the diameter of the aperture would lead to an error of 2%.

Other errors are negligible. Light meter calibration is not an issue because the same cell is used for the measurements with and without the tube. Screening of the box eliminates stray light.

Overall an error of $\pm 6\%$ is expected for these measurements. This is a relative error, so a transmission of 0.4 could be labelled 0.40 ± 0.024 .

=====REPORT ENDS=====