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BRE Client Report

Aging of light pipe materials (4000 hours artificial ageing)

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Introduction

This report assesses the efficiency of light pipe materials in the transmission and reflection of light. Samples of dome and inner light pipe material had their transmittance and reflectance calculated respectively. The samples were then artificially aged by exposure to 4000 hours of UV radiation in a specialist chamber at BRE. This is broadly equivalent to four years' exposure on a horizontal surface. The transmittance and reflectance calculations were repeated after 1000, 2000, 3000 and 4000 hours to investigate how ageing impacts the efficiency of the materials. During the ageing process some samples of inner light pipe material were placed behind the dome samples in the chamber in order to compare with those subjected to direct UV exposure.

The materials tested were samples of Monodraught and Solatube products. Four samples of Monodraught and four samples of Solatube inner light pipe materials were measured for reflectance before and after artificial ageing. Monodraught acrylic, Monodraught polycarbonate and Solatube polycarbonate dome samples were measured for transmittance before and after artificial ageing.

The project was undertaken for Monodraught Ltd. All the samples were provided by Monodraught and had been cut from domes and reflective light pipe material. Samples which were bent or visibly abraded were rejected.

Methodology

Reflectance measurements

The reflectance of a material is the ratio of the amount of reflected light from a surface to the amount of incident light to that surface. This gives a percentage, with a value of 100% meaning all incident light is reflected.

Reflection from a surface may be either diffuse or specular (Figure 1). In specular reflection each incoming ray is reflected mirror-like in a single direction. With diffuse reflection, incoming light is scattered in all directions. For a light pipe material, a high specular reflectance is important, because then light from the top continues to travel down the pipe.

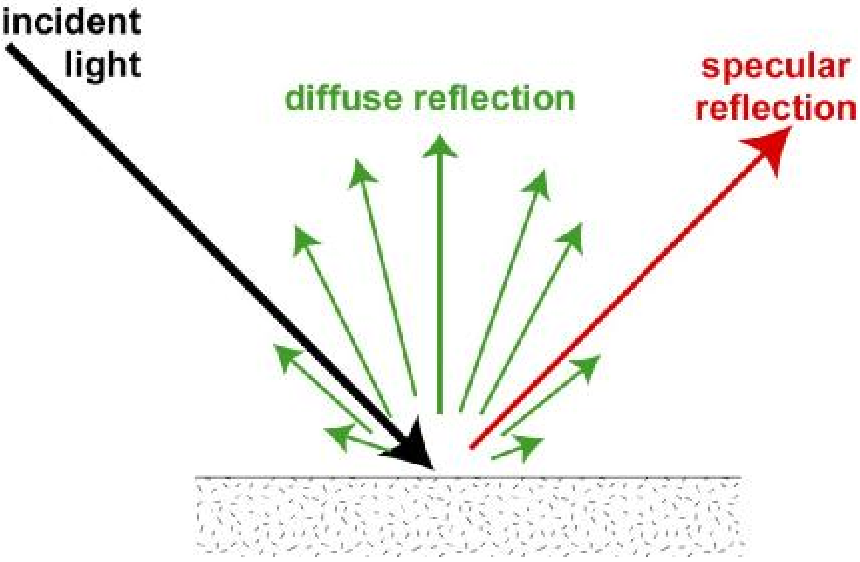

Figure 1. Specular reflection from a material.

Reflectance measurements for samples of inner light pipe material were undertaken in BRE’s photometry laboratory (figure 2). A reflective magnesium block was illuminated to create a “source”. The luminance of the block and the luminance of the specular reflection of the block from each sample were measured and the reflectance calculated. The position of the sample and luminance meters were arranged so the measurement of luminance, either directly to the block or reflected in the sample, was at the same distance in each case. The samples were clamped in a small frame to ensure that they were as flat as possible. The measurements were repeated four times for each sample. The reflectance values presented in the results are the average of these four measurements.

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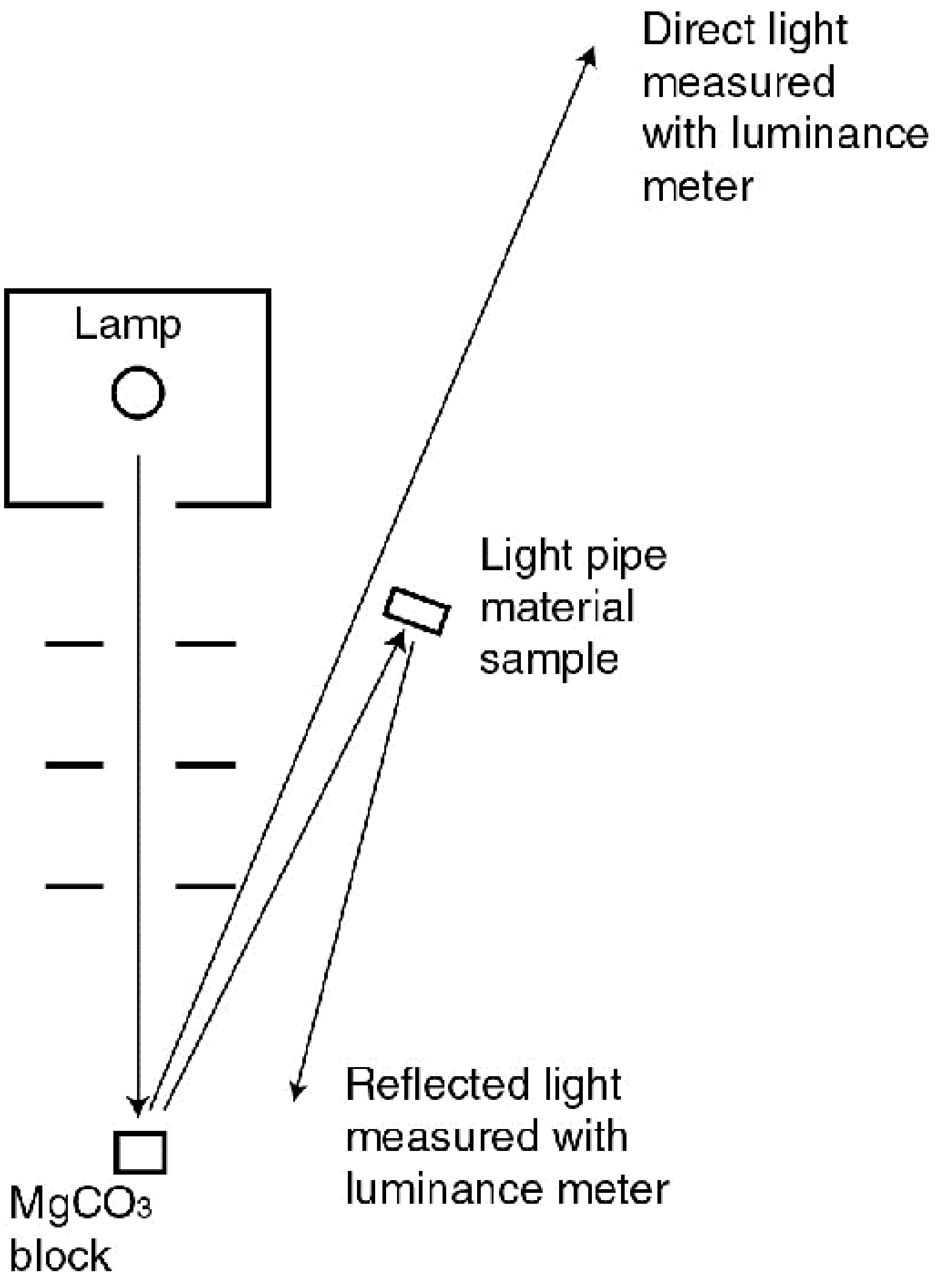

Figure 2. Plan view of reflectance measurement setup. Both lamp and magnesium carbonate block are mounted on the BRE photometric bench, not shown. Baffles between lamp and block reduce stray light.

Transmittance measurements

The transmittance of a material is the ratio of the amount of light that has passed through a material, compared with the amount of light that is incident on the material. This gives a percentage, with a value of 100% meaning all incident light is transmitted through the material.

Transmittance measurements for samples of light pipe dome material were undertaken using BRE's artificial sky and integrating box (figure 3). Light inside the box 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 photocell illuminance is first measured with the top aperture open. Then the dome sample is placed over the aperture and the illuminance remeasured. The sample transmission is the ratio of the illuminance with the sample divided by the illuminance without the sample. 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'. The measurement was made under an electrically lit simulated sky (an 'artificial sky') to ensure stability of illumination.

A special aperture was cut to fit the samples. The measurements were taken at least five times for each sample and the transmittance calculated. The transmittance value in the results is the average of the measured values for each sample.

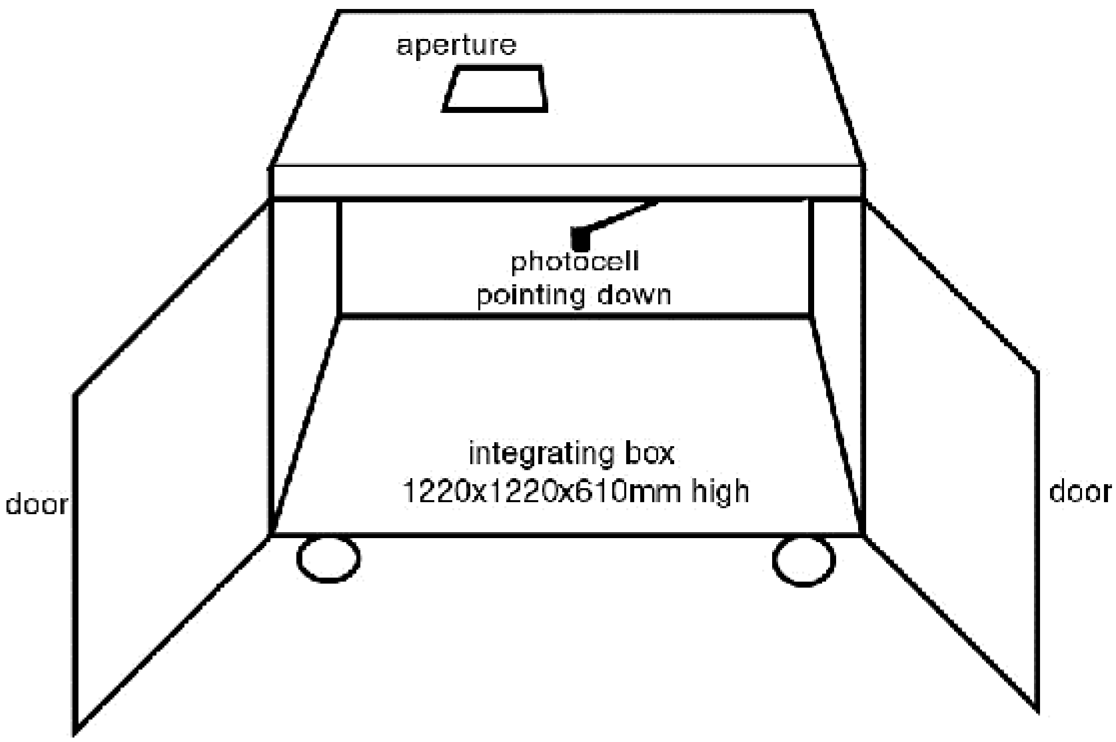

Figure 3. Integrating box used for the measurements. The doors are shut when in use.

Artificial ageing process

Artificial weathering conditions consisted of exposure under fluorescent UVA lamps (340 nm) in a dry condition at a temperature of 50 °C. These conditions are as detailed in EOTA Technical Report TR10 – Exposure procedures for artificial weathering, with the exception that water spray was not used on the samples. All samples were exposed for a total period of 4000 hours. Samples were aged in four 1000 hour periods. The samples had their reflectance / transmittance measured before ageing and after each 1000 hour period.

EOTA TR 10 considers that a period of exposure of 1000 hours is broadly equivalent to one year's exposure on a horizontal surface.

Findings

Reflectance measurements

Four Monodraught and four Solatube inner light pipe samples had their reflectances measured before and after artificial ageing via UV exposure. The results are shown in Table 1. Relative reflectance loss compared to before ageing is shown in Table 2.

Monodraught sample 1 was placed in the artificial ageing chamber behind the Monodraught acrylic dome sample, Monodraught sample 3 was behind the Monodraught polycarbonate dome sample and Solatube sample 1 was behind the Solatube polycarbonate dome sample. All the other samples were exposed directly to the UV radiation.

Table 1: Reflectance of inner light pipe material before and after artificial ageing for 1000, 2000, 3000 and 4000 hours (equivalent to one, two, three and four years' exposure on a horizontal surface).

Inner light pipe sample	Reflectance before ageing (%)	Reflectance after 1000 hours artificial ageing (%)	Reflectance after 2000 hours artificial ageing (%)	Reflectance after 3000 hours artificial ageing (%)	Reflectance after 4000 hours artificial ageing (%)
Monodraught sample 1 (aged behind Monodraught acrylic dome sample)	93.5%	93.2%	93.2%	93.4%	92.8%
Monodraught sample 2	93.6%	92.5%	91.4%	91.5%	90.8%
Monodraught sample 3 (aged behind Monodraught polycarbonate dome sample)	93.3%	93.5%	92.8%	93.0%	93.3%
Monodraught sample 4	92.9%	92.2%	91.5%	91.0%	91.1%
Solatube sample 1 (aged behind Solatube polycarbonate dome sample)	98.4%	98.3%	97.9%	97.5%	97.6%
Solatube sample 2	98.7%	94.6%	87.6%	66.0%	16.0%
Solatube sample 3	98.8%	94.7%	86.3%	57.0%	13.9%
Solatube sample 4	98.8%	94.6%	86.9%	67.6%	21.0%

Table 2: Relative reflectance loss of inner light pipe samples compared with before ageing for 1000, 2000, 3000 and 4000 hours

Inner light pipe sample	Relative loss of reflectance from original after 1000 hours artificial ageing	Relative loss of reflectance from original after 2000 hours artificial ageing	Relative loss of reflectance from original after 3000 hours artificial ageing	Relative loss of reflectance from original after 4000 hours artificial ageing
Monodraught sample 1 (aged behind Monodraught acrylic dome sample)	-0.3%	-0.3%	-0.1%	-0.7%
Monodraught sample 2	-1.2%	-2.3%	-2.2%	-2.9%
Monodraught sample 3 (aged behind Monodraught polycarbonate dome sample)	+0.3%	-0.5%	-0.2%	0.0%
Monodraught sample 4	-0.8%	-1.5%	-2.0%	-2.0%
Solatube sample 1 (aged behind Solatube polycarbonate dome sample)	-0.2%	-0.5%	-0.9%	-0.8%
Solatube sample 2	-4.2%	-11.2%	-33.2%	-83.8%
Solatube sample 3	-4.2%	-12.7%	-42.3%	-85.9%
Solatube sample 4	-4.2%	-12.0%	-31.6%	-78.8%

Before artificial ageing, the four Monodraught samples had average measured reflectances of between 92.9% and 93.6%. The four Solatube samples had measured average reflectances of between 98.4% and 98.8%.

After 1000 hours artificial ageing (equivalent to one year’s exposure)

After artificial ageing, the reflectances of the two Monodraught inner light pipe samples which were in the ageing chamber behind the two Monodraught dome samples (samples 1 and 3) were very similar to those measured before ageing. The two Monodraught samples which were artificially aged with direct UV exposure (samples 2 and 4) showed a slight reduction in reflectance compared to before. The measured average reflectances were 92.5% and 92.2% after ageing, 1.2% and 0.8% lower (in relative terms) than those measured before ageing. This is on the borders of being attributed to experimental error.

The reflectance of the Solatube sample which was exposed to artificial ageing behind the Solatube dome sample was very similar when measured before and after ageing. The Solatube samples which were aged with direct UV exposure (samples 2 – 4) had measured average reflectances of 94.6% and 94.7% after ageing. This is a decrease of reflectance compared with the initial values of 4.2%.

After 2000 hours artificial ageing (equivalent to two years' exposure)

After 2000 hours ageing, the reflectances of the two Monodraught inner light pipe samples which were in the ageing chamber behind the two Monodraught dome samples (samples 1 and 3) were very slightly lower than those measured before ageing, but the difference was within the bounds of experimental error. The two Monodraught samples which were artificially aged with direct UV exposure (samples 2 and 4) showed a slight reduction in reflectance compared to before. The measured average reflectances were 91.4% and 91.5% after ageing, 2.3% and 1.5% lower than those measured before ageing.

The reflectance of the Solatube sample which was exposed to artificial ageing behind the Solatube dome sample was very slightly lower after ageing, but the difference was within the bounds of experimental error. The Solatube samples which were aged with direct UV exposure (samples 2 – 4) had measured average reflectances of 87.6%, 86.3% and 86.9% after ageing. This is a decrease of reflectance compared with the initial values of 11.2%, 12.7% and 12.0%. These latter samples appeared to have a dull haze covering them.

After 3000 hours artificial ageing (equivalent to three years' exposure)

After 3000 hours ageing, the reflectances of the two Monodraught inner light pipe samples which were in the ageing chamber behind the two Monodraught dome samples (samples 1 and 3) were still only very slightly lower than those measured before ageing, within the bounds of experimental error. Monodraught sample 2, exposed to direct UV radiation, showed a reduction in reflectance compared to before aging, but the reflectance was similar to that measured after 2000 hours. The reflectance of Monodraught sample 4, also exposed to direct UV, was similar, 2% lower than before aging. This represents a small decrease in reflectance compared to 2000 hours, on the borders of experimental error.

The reflectance of the Solatube sample which was exposed to artificial ageing behind the Solatube dome sample was about 1% lower than before aging. There was a small difference between this and the 2000 hours reflectance value, within the bounds of experimental error. The Solatube samples which were aged with direct exposure show a significant drop of reflectance after 3000 hours. Samples 2 and 4 hade a relative loss of reflectance compared to before ageing of just over 30%. Sample 3 had a relative loss of reflectance of over 40%. The surfaces of these samples were visibly "stained" as the surface appears to be clouded over in a non-uniform way.

After 4000 hours artificial ageing (equivalent to four years' exposure)

After 4000 hours ageing, the reflectances of the two Monodraught inner light pipe samples which were in the ageing chamber behind the two Monodraught dome samples (samples 1 and 3) were still similar to those measured before ageing. Monodraught sample 3 had the same measured reflectance as before ageing and Monodraught sample 1 had a relative loss of 0.7% reflectance, within the bounds of experimental error. Monodraught sample 2, exposed to direct UV radiation, showed a relative reduction in reflectance compared to before aging of around 3%, a small worsening from 3000 hours. The reflectance of Monodraught sample 4, also exposed to direct UV, was 2% lower than before aging, the same as measured after 3000 hours.

The reflectance of the Solatube sample which was exposed to artificial ageing behind the Solatube dome sample was about 1% lower than before aging, within the bounds of experimental error. The result was very similar to that measured after 3000 hours. The Solatube samples which were aged with direct exposure show a further very significant drop of reflectance after 4000 hours. Sample 4 had a relative loss of reflectance compared to before ageing of just under 80%. Samples 2 and 3 were measured at over 80% relative reflectance loss compared with before ageing. The surfaces of samples 2 - 4 appear further clouded and stained as the surface has broken up and lost its reflective properties.

Transmittance measurements

Three samples of light pipe dome material had their transmittance measured before and after three stages of artificial ageing. Figure 4 shows the samples. The samples were Monodraught acrylic, Monodraught polycarbonate and Solatube polycarbonate. Each was cut using the same process from an actual dome.

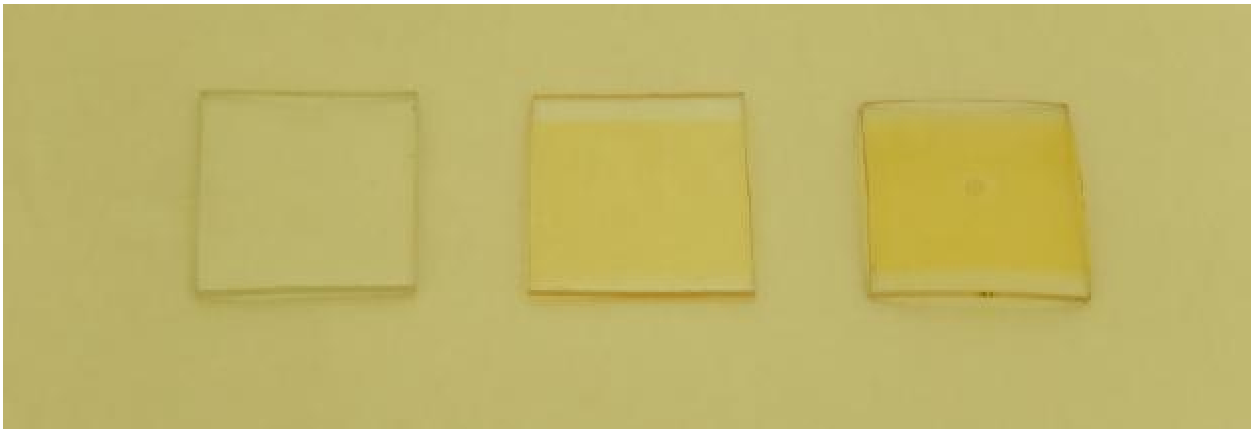

Figure 4. Samples of light pipe domes after 2000 hours ageing. From left to right: Monodraught acrylic, Monodraught polycarbonate and Solatube polycarbonate.

The transmittance results for the samples before and after 1000, 2000, 3000 and 4000 hours ageing are given in Table 3 below. Table 4 shows the relative transmittance loss compared to before ageing. The transmittance values shown are the average of at least five measurements taken for each sample, as outlined in the methodology section.

Table 3: Transmittance of light pipe dome material before and after artificial ageing for 1000, 2000, 3000 and 4000 hours (equivalent to one, two, three and four years' exposure on a horizontal surface).

Dome sample	Transmittance before ageing (%)	Transmittance after 1000 hours artificial ageing (%)	Transmittance after 2000 hours artificial ageing (%)	Transmittance after 3000 hours artificial ageing (%)	Transmittance after 4000 hours artificial ageing (%)
Monodraught Acrylic	87.6%	87.2%	87.4%	87.1%	86.6%
Monodraught Polycarbonate	86.6%	85.5%	83.5%	81.8%	79.6%
Solatube Polycarbonate	83.5%	80.6%	78.2%	77.1%	75.1%

Table 4: Relative transmittance loss of dome samples compared with before ageing for 1000, 2000, 3000 and 4000 hours.

Dome sample	Relative loss of transmittance from original after 1000 hours artificial ageing	Relative loss of transmittance from original after 2000 hours artificial ageing	Relative loss of transmittance from original after 3000 hours artificial ageing	Relative loss of transmittance from original after 4000 hours artificial ageing
Monodraught Acrylic	-0.5%	-0.2%	-0.6%	-1.2%
Monodraught Polycarbonate	-1.3%	-3.6%	-5.6%	-8.1%
Solatube Polycarbonate	-3.5%	-6.3%	-7.7%	-10.1%

Before artificial ageing the Monodraught acrylic and polycarbonate samples had similar initial transmittance of 87.6% and 86.6% respectively. The Solatube had a lower transmittance (83.5%) before artificial ageing, however this may be because the sample had to be cut from the centre of the dome which contains a small 'pimple' in the plastic. Overall, all three domes might be expected to have a different transmittance, because the domes also contain prismatic elements which were not included in the sample we studied.

After 1000 hours artificial ageing (equivalent to one year's exposure)

After 1000 hours artificial ageing (equivalent to one year on a horizontal surface) the Monodraught acrylic sample had an average measured transmittance of 87.2%, 0.5% lower (in relative terms) than measured before ageing. This difference could be down to experimental error.

The Monodraught polycarbonate sample had a transmittance of 85.5% after artificial ageing, 1.3% lower than before. The sample was visibly slightly yellowed.

The Solatube polycarbonate sample had a measured average transmittance after ageing of 80.6%, 3.5% lower than before ageing. The sample was noticeably yellowed.

After 2000 hours artificial ageing (equivalent to two years' exposure)

After 2000 hours artificial ageing (equivalent to two years' exposure on a horizontal surface) the Monodraught acrylic sample had an average measured transmittance of 87.4%, 0.2% lower than measured before ageing.

The Monodraught polycarbonate sample had an average transmittance of 83.5%, 3.6% lower than before ageing and 2.3% lower than after 1000 hours ageing. It was noticeably yellowed (see figure 4).

The Solatube polycarbonate sample had an average transmittance of 78.2%, 6.3% lower than before ageing and 3% lower than after 1000 hours ageing. It was a darker yellow (see figure 4).

After 3000 hours artificial ageing (equivalent to three years' exposure)

After 3000 hours artificial ageing (equivalent to three years' exposure on a horizontal surface) the Monodraught acrylic sample had an average measured transmittance of 87.1%, 0.6% lower than measured before ageing. The differences in the measured values for this sample at the four stages are within the region of experimental error.

The Monodraught polycarbonate sample had an average transmittance of 81.8%, 5.6% lower than before ageing and 2% lower than after 2000 hours ageing. It was noticeably yellowed and part of the surface appeared to be roughened.

The Solatube polycarbonate sample had an average transmittance of 77.1%, 7.7% lower than before ageing and 1.4% lower than after 2000 hours ageing. It was a darker yellow and part of the surface appeared to be roughened.

After 4000 hours artificial ageing (equivalent to three years' exposure)

After 4000 hours artificial ageing (equivalent to four years' exposure on a horizontal surface) the Monodraught acrylic sample had an average measured transmittance of 86.6%, 1.2% lower than measured before ageing, still on the borders of experimental error.

The Monodraught polycarbonate sample had an average transmittance of 81.8%, 8.1% lower than before ageing and a further decrease of 2.5% over that measured at 3000 hours.

The Solatube polycarbonate sample had an average transmittance of 75.1%, 10.1% lower than before ageing, a further decrease of 2% from 3000 hours.

Conclusions

Samples of light pipe materials used for the inner reflective surface and dome covering were tested for reflectance and transmittance respectively. Measurements were taken before and after the samples being artificially aged. The artificial ageing process involved exposure to UV radiation, via fluorescent UVA lamps, for a total of 4000 hours. This is broadly equivalent to two years' exposure on a horizontal surface. Measurements were taken after 1000, 2000, 3000 and 4000 hours exposure.

Reflectance of inner light pipe materials and artificial ageing

The results of the reflectance measurements show that the Solatube inner light pipe material sample had higher values of reflectance (98.4-98.8%) before artificial ageing, compared with Monodraught samples (92.9-93.6%).

For samples artificially aged with direct UV exposure, after 1000 hours the reflectances of Monodraught inner light pipe samples decreased by around 1%. The reflectances of the Solatube samples with direct UV exposure decreased by around 4%.

After 2000 hours the reflectances of Monodraught samples were around 2% lower than the initial values. The reflectance of the Solatube samples with direct UV exposure was around 12% lower than the initial values.

After 3000 hours the Monodraught samples had similar reflectance values to those after 2000 hours. The Solatube samples exposed to direct UV had significantly lower reflectances than measured before ageing (two samples around 30% relative loss of reflectance, one sample around 40%). The surfaces of the Solatube samples appeared to be clouded over.

For the samples exposed to direct UV, after 4000 hours the Monodraught samples still had similar reflectance values to those after 2000 hours and 3000 hours, with a 2% – 3% relative loss of reflectance. The Solatube samples had a very significant drop in reflectance as the surface appears to be losing its reflective properties. The three samples had a relative loss of around 80% compared to before ageing

For samples of both manufacturers which were in the artificial ageing chamber behind dome samples, the measured reflectances for before and after ageing at the four stages were similar. These results suggest that in a real world setting where the inner light pipe material would be behind a dome, loss of reflectance would not be an issue, as the dome would protect the inner surface from UV radiation, at least over a period of up to four years.

Transmittance of light pipe dome materials and artificial ageing

Three samples of light pipe dome material had their transmittance measured using the BRE integrating box and artificial sky before and after artificial ageing. They were cut from actual domes using the same process in each case. The samples were Monodraught acrylic, Monodraught polycarbonate and Solatube polycarbonate. Results from average transmittance measurements show that before the ageing process the Monodraught acrylic and polycarbonate samples had similar initial transmittances of 87.6% and 86.6% respectively. The Solatube sample had a lower transmittance (83.5%) before artificial ageing, however this may be because the sample contains a small 'pimple' in the plastic. Overall, all three domes might be expected to have a different transmittance, because they also contain prismatic elements.

After artificial ageing, results suggest the Monodraught acrylic sample lost around 0.5% relative transmittance after 1000 hours, 0.2% after 2000 hours, 0.6% after 3000 hours and 1.5% after 4000 hours. The differences between the five measurements are within the bounds of experimental error (it would be unlikely that ageing would increase the transmittance, as seen after 2000 hours).

The Monodraught polycarbonate sample lost around 1% transmittance after 1000 hours, and was visibly slightly yellowed. After 2000 hours the sample lost a further 2% transmittance. This is a relative loss of 3.6% compared to the initial transmittance. After 3000 hours this increased to a relative loss of 5.6%, and after 4000 hours there was an 8.1% relative loss. The sample was noticeably yellowed and part of the surface appeared roughened.

The Solatube polycarbonate dome sample lost around 3% transmittance due to artificial ageing for 1000 hours and was noticeably yellowed. After 2000 hours, the sample further lost around 3% transmittance. This is a relative loss of 6.3% compared to the initial transmittance. After 3000 hours this had increased to a relative transmittance loss of 7.7%, and after 4000 hours was 10.1% less compared to the initial transmittance. The sample was a darker yellow and part of the surface appeared roughened.

Appendix A Experimental errors

The five sets of measurements (before and after 1000, 2000, 3000 and 4000 hours ageing) were carefully controlled in order to eliminate experimental errors. These are discussed below.

Reflectance measurements

Where possible, errors were eliminated by using the same geometry for every set of measurements. This included using the same luminance meter for both incident and reflected light to eliminate calibration errors and errors in the way the meter deals with off axis light. Stray light was minimised by having black painted surfaces throughout the laboratory.

The reflectance of specular materials can vary with angle of incidence. Because of the setup of the experiment a near normal incidence could not be achieved, and the measured reflectances may therefore be less than those measured at near normal incidence. However the same geometry was used each time to give consistency in the measurements before and after ageing.

Similarly the magnesium carbonate block used as a source for the light is not a perfect diffuser and its luminance varied slightly with angle of measurement. This error was reduced by measuring the luminance from either side of the reflectance sample.

The most important error is due to distortion of the sample itself. The samples are made of flexible film and are therefore subject to bending and distortion. A bent sample gives an indistinct reflected image, usually of reduced luminance. The samples were held within a specially made frame to reduce this problem. Great care was taken not to bend or distort the samples when installing or removing them from the UV exposure machine.

Overall errors of 1-2 % can be expected in absolute measurements of reflectance, and 0.5-1% in comparison of two measurements of the same sample.

Transmittance measurements

Once again, errors were eliminated by using the same geometry for every set of measurements. Light meter calibration is not an issue because the same cell is used for the measurements with and without the dome sample. Screening of the box eliminates stray light.

Box measurements of this type can introduce errors from light reflected from the dome material. This slightly increases the internal reflectance of the box and results in the transmittance being over-estimated. However in this case the samples are very small and of low reflectance, so this error is negligible.

The artificial sky can vary in its output over short periods as the fluorescent tubes warm up. This error was reduced by carrying out the measurements as quickly as possible.

Because the box is not a perfect sphere, and the photocell inside it blocks some light, the measured transmittance can depend slightly on the exact location of the aperture. The alignment of the sample is also important as the samples are not flat. Care was taken to retain the same geometry for every measurement.

Overall, errors of 1-2 % can be expected in absolute measurements of transmittance, and 0.5-1% in comparison of two measurements of the same sample.

In addition, the dome samples as provided to BRE may not have been wholly representative of complete domes. To fit in the UV exposure machine small samples had to be cut from the centre of the domes. In particular the Solatube sample included the small ‘pimple’ at the centre of the dome, and the Solatube dome also includes prismatic elements which were not present in our sample.

Report Ends

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BRE Client Report

Measurements of dome transmittance

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Introduction

This report assesses the efficiency of light pipe domes in the transmission of light. The domes tested were two Monodraught domes (acrylic and polycarbonate) and one Solatube dome (polycarbonate). All the domes were single skin. Domes were tested ‘as new’ without any ageing or weathering.

The measurement was undertaken in the BRE artificial sky and represents the overall diffuse transmittance of the dome under overcast sky conditions.

The project was undertaken for Monodraught Ltd. All the dome samples were provided by Monodraught.

Methodology

The transmittance of a material is the ratio of the amount of light that has passed through a material, compared with the amount of light that is incident on the material. This gives a percentage, with a value of 100% meaning all incident light is transmitted through the material.

Transmittance measurements for samples of light pipe dome material were undertaken using BRE's artificial sky and integrating box (Figure 1). Light inside the box 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 photocell illuminance is first measured with the top aperture open. Then the dome sample is placed over the aperture and the illuminance remeasured. The sample transmission is the ratio of the illuminance with the sample divided by the illuminance without the sample. 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'. The measurement was made under an electrically lit simulated sky (an 'artificial sky') to ensure stability of illumination.

A special aperture was used to fit the samples. This was of similar size to the light pipe diameter, so the Monodraught samples had a 310mm aperture and the Solatube one a 360mm aperture. The measurements were taken at least five times for each sample and the transmittance calculated. The transmittance value in the results is the average of the measured values for each sample.

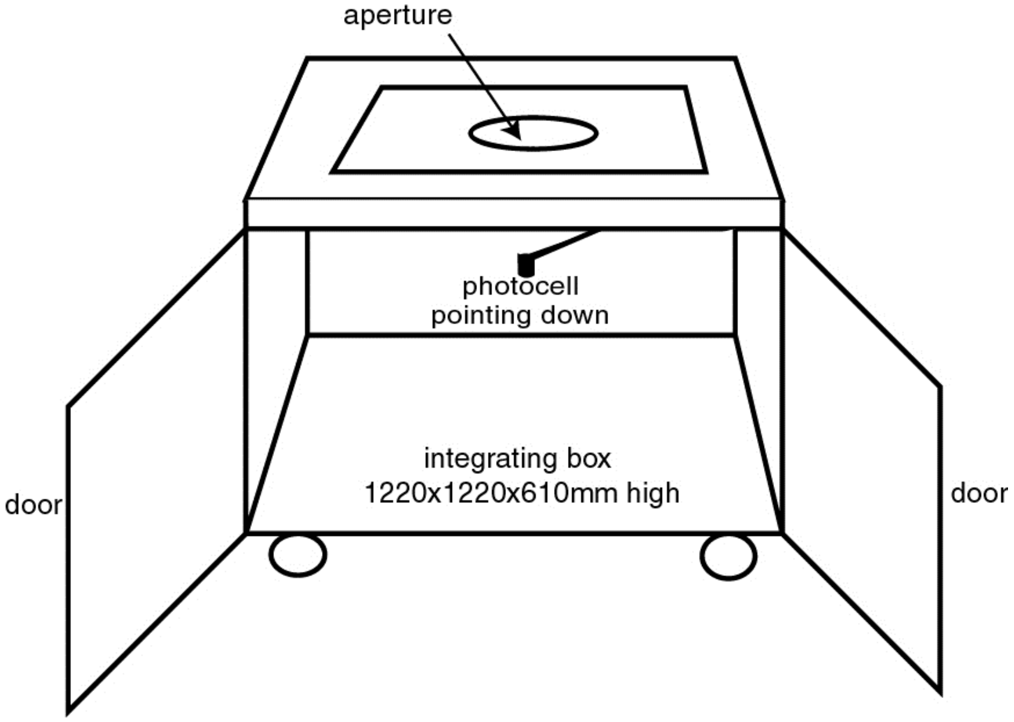

Figure 1. Integrating box used for the measurements. The doors are shut when in use.

Findings

Table 1 gives the results of the dome transmittance measurements.

Table 1: Transmittance of light pipe domes.

Dome sample	Transmittance (%)
Monodraught Acrylic	90.2%
Monodraught Polycarbonate	85.4%
Solatube Polycarbonate	74.2%

The Monodraught acrylic dome had the highest transmittance followed by the polycarbonate dome. Both domes had exactly the same design, so the difference would be expected to be due to the different material used.

The Solatube dome had a lower transmittance. This may be due to the different design of the Solatube dome; it contains bands of louvres which would be expected to reduce the transmittance under the diffuse conditions of the test.

Appendix A Experimental errors

The measurements were carefully controlled in order to eliminate experimental errors. These are discussed below.

Where possible, errors were eliminated by using the same geometry for every set of measurements. Light meter calibration is not an issue because the same cell is used for the measurements with and without the dome sample. The design of the box eliminates stray light.

Box measurements of this type can introduce errors from light reflected from the dome material. This slightly increases the internal reflectance of the box and results in the transmittance being over-estimated. However in this case the samples are of low reflectance, and so this error is negligible.

The artificial sky can vary in its output over short periods as the fluorescent tubes warm up. This error was reduced by allowing it to warm up for at least five minutes before doing the test, and then by carrying out the measurements as quickly as possible.

Because the box is not a perfect sphere, and the photocell inside it blocks some light, the measured transmittance can depend slightly on the exact location of the aperture. The location of the sample over the aperture is also important. Care was taken to retain the same geometry for every measurement.

Overall, an error of 1% can be expected in absolute measurements of transmittance.

Report Ends