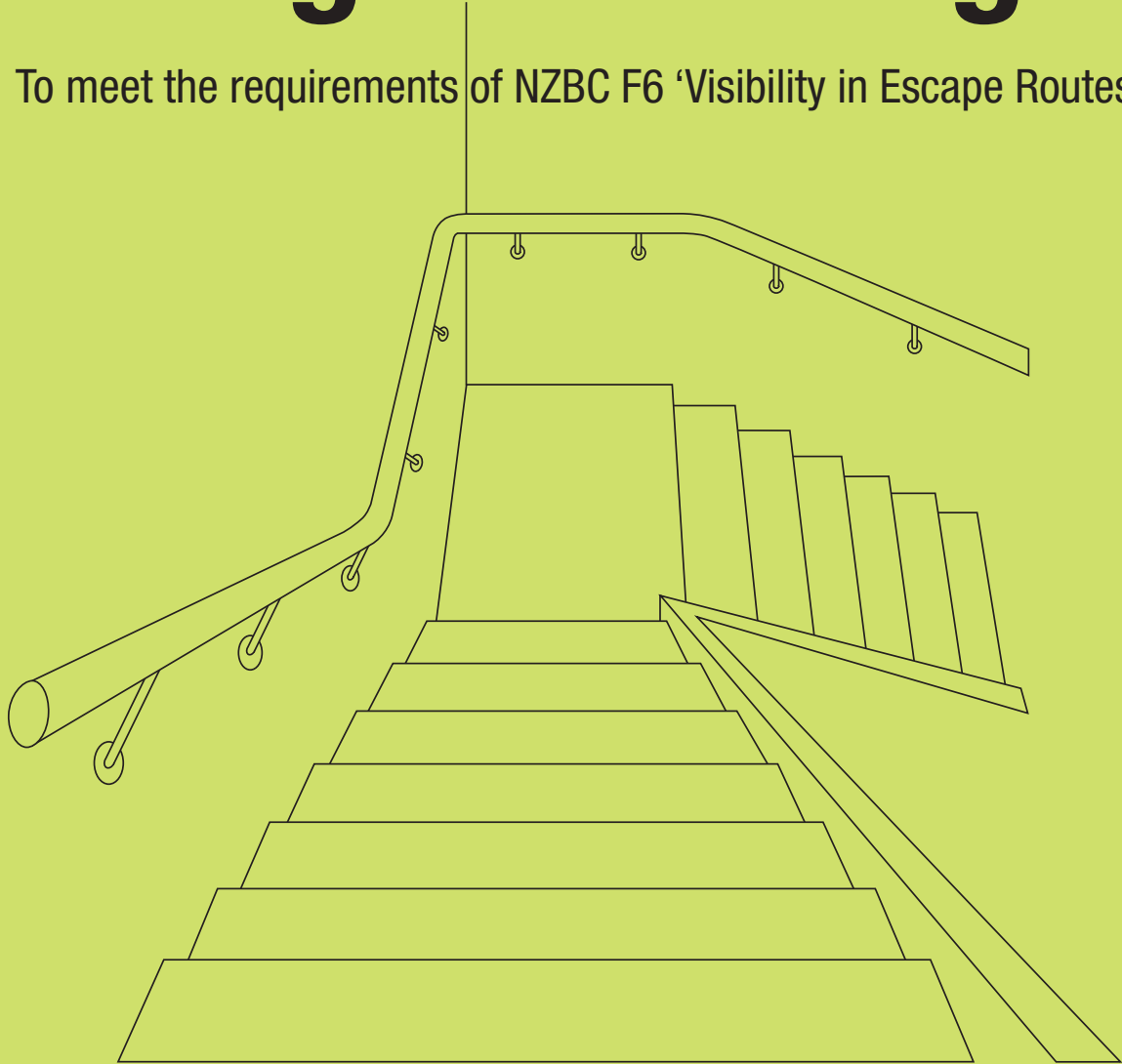


Technical Justification for Ecoglo Markings

To meet the requirements of NZBC F6 'Visibility in Escape Routes'



VISIBLY BETTER

This report provides the technical justification for the product performance specification and design of Ecoglo photoluminescent markings to meet the requirements of NZBC Clause F6 'Visibility in Escape Routes'.

For the most current solution documents refer to:

www.ecoglo.co.nz

(from the Home Page select Technical then F6 Compliance)

Introduction

This document examines the requirements of the New Zealand Building Code Clause F6 Visibility in Escape Routes, then shows how Ecoglo markings can be used to meet F6, via the following methodology:

- The markings can be sufficiently bright to be reasonably visible;
- The markings can be located in such a way to make sure that the specified

features in an escape route can be made reasonably visible;

- Charging requirements can be prescribed to ensure the markings can be charged sufficiently to maintain sufficient brightness for the duration specified in F6;
- A verification process can be defined to ensure ongoing compliance with Clause F6.

New Zealand Build Code, Clause F6

Clause F6 has the following objective, functional requirement and performance requirements:

Objective

F6.1 The objective of this provision is to help safeguard people from injury in escape routes during failure of the main lighting.

Functional requirement

F6.2 *Specified features* in escape routes must be made reasonably visible by lighting systems, other systems, or both, during failure of the main lighting.

Performance

F6.3.1 Specified features in escape routes must, when the systems for visibility are at their design level, be reasonably visible.

F6.3.4 The systems for visibility must operate continuously in buildings or parts of buildings in the following risk groups for the following periods after failure of the main lighting:

- (a) risk group A, until restoration of the main lighting system;
- (b) risk group B, 90 minutes;
- (c) risk group C, 30 minutes.

Clause F6 provides the following definitions:

Reasonably visible, in relation to a specified feature, and for the purposes of Clause F6, means that the specified feature is visible to a person who-

- (a) is 10 metres from it, or the greatest distance from it that it is possible to go in the open space surrounding it, whichever is the lesser; and
- (b) has sight that is not defective, or is corrected (for example, by an optical appliance).

Specified features for the purposes of Clause F6, means the following:

- (a) building elements that may act as obstructions;
- (b) safety features required under clauses of the Building Code other than Clause F6 (for example, handrails required under Clause D1);
- (c) changes in direction;
- (d) stairs and ramps;
- (e) escape doors;
- (f) entries to a safe place.

Note: F6.3.2 The systems for visibility must operate to specific percentages of their design levels within specified 'Start-up times.' Ecoglo markings meet all of the requirements because they are already at 100% of design level before the lighting fails.

Luminance of Ecoglo Photoluminescent Markings to Ensure Reasonable Visibility

The Ecoglo products have been tested by two independent laboratories, Intertek and QUT (Queensland University of Technology) to prove visibility at 10 metres after more than 90 minutes of darkness (see Appendices A and C). The Ecoglo products tested by Intertek (G3-001, H3-001, E2-071, E3-071) all utilise a 15mm wide strip of Ecoglo photoluminescent material, while the products tested by QUT include E14-075 which utilises a 10mm strip of Ecoglo photoluminescent material. The testing carried out by both Intertek and QUT was specified to be the same as the UL1994 test "Luminous Egress Path Marking Systems", except that:

- Instead of being observed from a viewing distance of 25ft (7.6m), Ecoglo requested a viewing distance of 10m.
- Instead of testing the products at 90 minutes, tests were carried out when the Ecoglo products had a luminance of 5mcd/m².

Both tests required observers to correctly identify the randomly selected orientation (horizontal, vertical or at 45deg) of 3 replicate markers, 300mm long, within 15 seconds.

The Ecoglo products passed the test at all four times, which means they meet the visibility requirement from 10m at a luminance of 5mcd/m².

UL1994 is ratified by NIST (the Federal US body responsible for ratifying standards as being applicable nationally) and is specified in US building codes such as the NFPA codes and the International Building Code. For example, IBC 2012 Section 1024 Luminous Egress Path Markings mandates non-electrical (either self luminous or photoluminescent) markings that meet UL1994 (or have a luminance no less than 5mcd/m² after 90 minutes of darkness) for most new multi-storey buildings, supplementary to electrical emergency lighting.

The fact that UL1994 is ratified by NIST and is used by the US building codes confirms that it is a rigorous and industry-accepted code, and therefore confirmation that Ecoglo markings pass the UL1994 standard at 5mcd/m² is sufficient justification to say that such markings meet the "sufficient level of visibility to be identified" criterion.

Therefore, Ecoglo products having a length of 300mm or more and a width of 10mm or more meet the requirement for "sufficient level of visibility to be identified" at or above a luminance of 5mcd/m².

Visual adaptation

The observation testing carried out in UL1994 is carried out when the observer's eyes have been conditioned to about 550 lux (about 50% brighter than typical office lighting) for at least 5 minutes followed by complete darkness for 5 minutes. The 5 minute dark time was chosen by the UL1994 Standards Technical Panel pragmatically, because in the first 5 minutes the eye's dark adaptation is changing very rapidly, so it would be very difficult to develop a repeatable test method using a shorter dark time.

So what about that first 5 minutes of dark adaptation?

In almost all escape scenarios where occupants need to leave the building quickly for their safety, Ecoglo S10 material will be at a much brighter luminance at the start of an emergency, to allow for its decreasing luminance not to drop below 5mcd/m² before 30 minutes (Risk Group C building) or 90 minutes (Risk Group B building) has elapsed.

There is no available scientific data that indicates what luminance would be required to ensure no dark adaptation time is needed, but Ecoglo's in-house testing

indicates about 15mcd/m² works for people with normal vision.

Ecoglo S10 material, when charged to a minimal level to just meet 5mcd/m² after 30 minutes will be above 15mcd/m² for at least the first 5 minutes after the lights fail. In the vast majority of situations¹ Ecoglo S10 material will be above 15mcd/m² for at least 30 minutes after the lights fail.

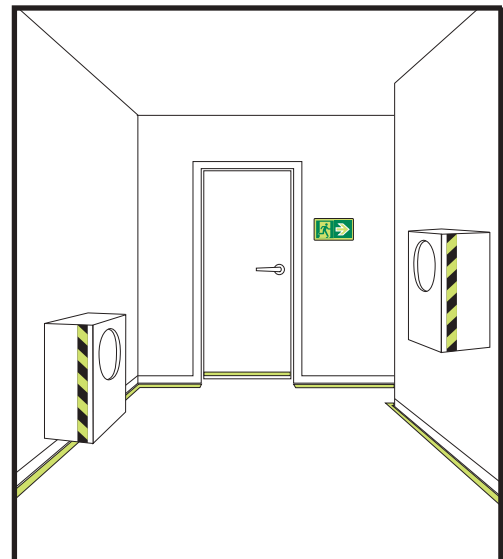
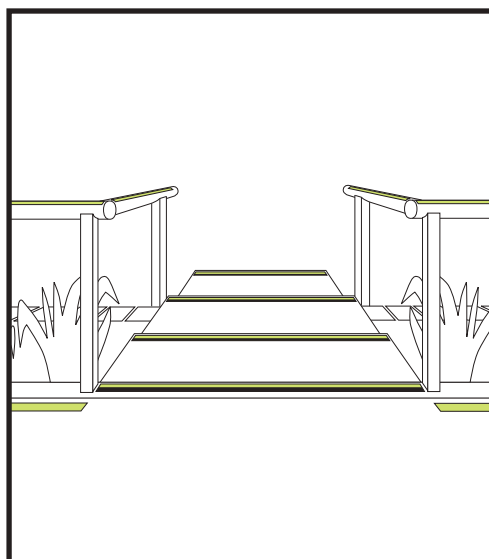
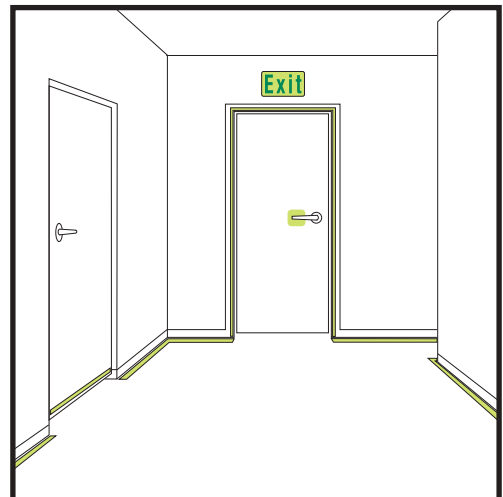
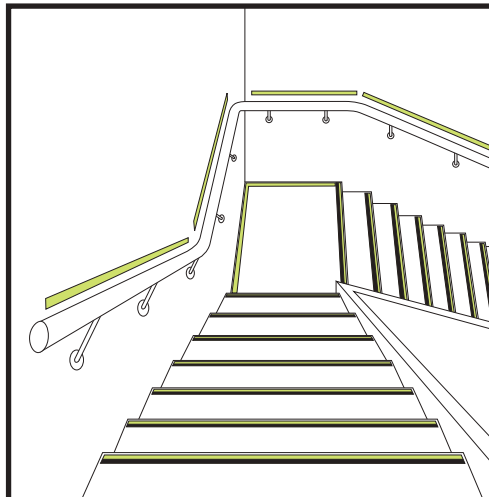
Therefore, in almost all foreseeable escape scenarios there will be no need for an escaping person to wait for their eyes to dark-adapt before the markings become reasonably visible.

However, it is important for system designers to be aware of this issue. For example if charging lights are to be used on a timer system, re-charging should time on before the markings drop below 15 mcd/m².

System Design to Ensure Reasonable Visibility of Specified Features

A literature review carried out by Hughes Associates² teaches that the stress caused by an emergency situation reduces people's

ability to make decisions when navigating in a building space, and that conventional signs do not alleviate any disorientation. Navigating by landmarks (whether visual, tactile, or



1. Five minutes of charging at 60 lux, 10 minutes charging at 40 lux, or 15 minutes at 20 lux is sufficient.

2. Literature Review on WAYFINDING AND THE USE OF PHOTOLUMINESCENT MATERIALS TO AUGMENT WAYFINDING, July 30, 2004, Dave Tomecek, John Cuttonilli, Hughes Associates Inc.

audio) and follow-the-leader (ie guidance in the form of continuous linear strips to follow) is recommended.

A literature review carried out by the University of Iowa Operator Performance Laboratory³ shows that long rectangular targets (lines) are detected very easily by the eye, and one-to-one correspondence (eg parallel lines of equal length) enables stable interpretation of perspective.

This therefore is the basis on which Ecoglo prescribes marking step edges, handrails, floor/wall intersections and exit doors, as illustrated in the examples above.

Handrail strips and step edge markings provide both visual and tactile landmarks, door surround strips provide visual landmarks, and handrail strips, step edge markings and wall/floor perimeter markings provide landmark and follow-the-leader information.

Additionally, hazard markings provide visual landmarks for obstacles in the escape route.

The International Building Code 2012, Section 1024 Luminous Egress Path Markings, prescribes the same system for marking the essential features of an escape path, viz:

- Solid continuous markings along step edges and landing edges (the leading edge to be within 13mm of the leading edge of the step);
- Solid continuous markings along handrails, with gaps no more than 100mm;
- Solid continuous perimeter demarcation markings for landings and corridors within 100mm vertically or horizontally of the floor-wall intersection, with gaps no more than 100mm;
- Alternating diagonal bands of glowing material/black to mark obstacles in the pathway.

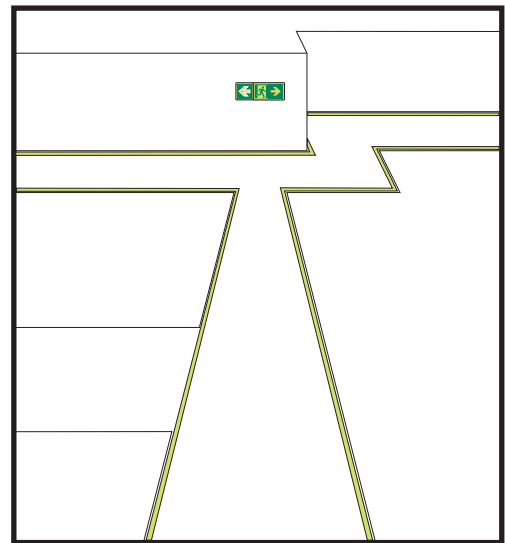
The above shows that both science and existing building codes concur with this

system for marking the specified features of the escape route to make sure they are reasonably visible.

Additional features, options

Open spaces

Follow-the-leader perimeter marking is also suitable for marking escape paths through open spaces. This is effectively the same as marking a corridor, as indicated above, except that the sides of the marked path are open rather than being solid walls.

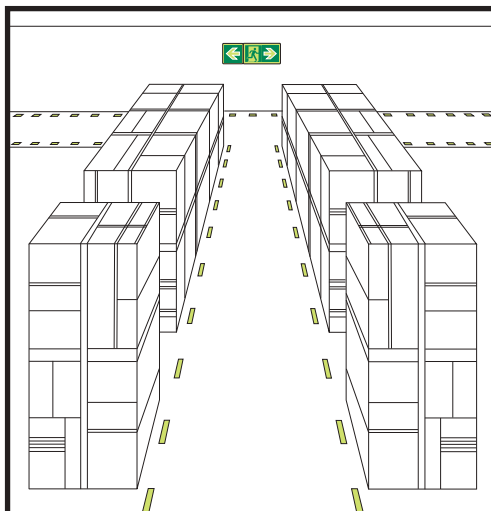


While all the above highlights the importance of continuous lines as the ideal way to create stable perspective and easy follow-the-leader egress, Ecoglo considers it acceptable to use discontinuous markings in open spaces in the following circumstances:

- where it is not practical to install continuous markings (for example because of uneven ground or floor surfaces, or the presence of working forklifts);
- where all occupants are familiar with the escape route and the escape path markings, so that they are pre-programmed to carry out follow-the-leader navigation;
- where the minimum marker length is 100mm, and the minimum frequency of markers is 1 per metre (this meets the requirements of UL1994 6.1.2b for marker spacing).

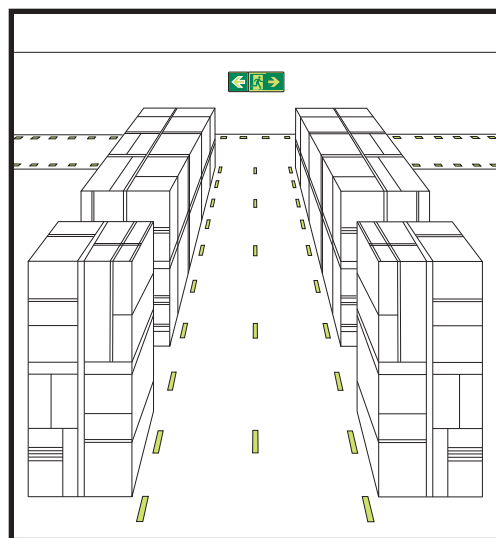
3. Determination of the state-of-the-art in the visibility of extended rectangular targets under dark conditions, August 2004, Fuat Atkan, Thomas Schnell, Shaowei Yang, Operator Performance Laboratory, Centre for Computer Aided Design, University of Iowa.

From practical experience, Ecoglo recommends that where the escape route has many changes in direction and few straight runs of 10 metres or more, the markings should provide 30% cover or more (eg 100mm markers at 3 per metre or 300mm markers at 1 per metre).



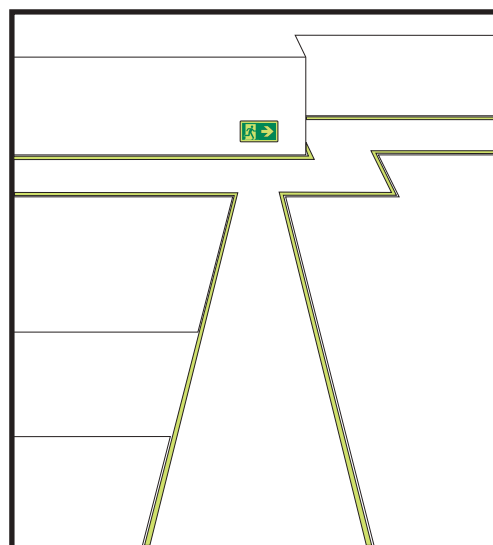
Wide paths

Where the escape route is required to be 3m wide or greater, Ecoglo recommends lane markers to enable people in the middle of the path to navigate via follow-the-leader markings. The lane markers are recommended to be 300mm long, with a frequency of 1 per 3m, and spaced to ensure that no lane is wider than 3m.



Unexpected direction changes, merging routes

Where there are direction changes which might seem surprising or sudden to someone escaping, or intersections where one way is a dead end, directional exit signs should be installed. To provide the best response from a stressed evacuee with reduced peripheral vision, (navigating in follow-the-leader mode by following the floor markings), they should be mounted on a vertical surface, the top of the signs no more than 450mm above floor level. *Note that this is in addition to the requirements under Clause F8 for exit signs.*



Handrails

Where it is deemed unacceptable to apply handrail strips to handrails in the escape route, an alternative solution is to provide a continuous marking adjacent to the handrail on the closest wall.

The system designer should be aware that this solution no longer provides a tactile landmark.

It is recommended that the marking be a minimum of 25mm of a higher luminance specification to compensate for the absence of tactile feedback.

Combined electrical lighting and stairway markings

In public assembly crowd areas where there are steps or stairways a combined electrical

emergency light and stairway marking solution may be applicable.

F6/AS1 specifies a higher illuminance for changes in level than for horizontal travel, but in this instance, Ecoglo step edge markings (with or without handrail markings) can provide failsafe illumination of the step edges, no matter how dense the crowding, while the electrical emergency lighting (at the horizontal travel illumination level) provides lighting continuity between the horizontal concourse areas and the stairways.

Design limitations

Obstructions

NZBC Clause C requires escape routes to be unobstructed. Notwithstanding Clause C, it is foreseeable that obstructions may be inadvertently left in an escape route.

Where the escape route consists of stairs, the likelihood is that an obstruction large enough to cause a trip hazard would be highlighted by the step edge markings.

On a level escape route, where the markings are only on the sides of the path, there

is potential for an obstruction to remain unseen. It is important for the system designer to be aware of this risk, and consider factors such as public access, familiarity of the users with the escape route, and likelihood of obstructions.

Dangerous Machinery

If it can be foreseen that in the event of failure to the normal lighting, machinery or equipment could present an unseen danger to people in the area, and that hazard marking would not alleviate that danger, then emergency electrical lighting should be used to illuminate the danger.

Open Spaces

Where an escape route is required through an open space, the perimeter of the escape path can be marked, as described above.

If the open space acts like a concourse, with the multiple routes rather than one or more clear paths through it, path marking is not appropriate. Egress science suggests that overall lighting is the best option, with illuminance sufficient for people to readily read all landmarks, signs and other cues to enable effective navigation decision-making.

Charging Requirements to Ensure Specified Features Remain Reasonably Visible for the Duration Required

Building Risk Groups

NZBC F6.3.4 specifies the duration that the specified features must remain reasonably visible.

To ensure that Ecoglo markings meet the required duration, they must be charged with natural or electric lighting at a sufficient brightness and for sufficient time.

Risk Group C buildings require a 30 minute duration.

Risk Group B buildings require a 90 minute duration.

Risk Group A buildings

require an open-ended duration, which cannot be met with Ecoglo markings. However Ecoglo may provide useful fail-safe instant strike while the main back-up system is firing up.

Outdoor use (that part of an escape route between the building shell and a safe place) Luminance testing by Ecoglo shows that Ecoglo S10 material maintains a luminance greater than 5mcd/m² when installed outdoors in Christchurch⁴, and practical experience confirms that it meets people's visibility

4. Testing carried out in Christchurch, 10th-15th June 2007. Ecoglo S10 material mounted vertically, South facing (no direct sunlight), maximum illuminance from daylighting 5000lx. Luminance measured 13.75 hours after sunset, before first light (6.45am).

expectations 24/7, even when installed in permanently shaded places.

In the very south of the South Island there is about 20 minutes extra night length than Christchurch. Based on various luminance tests carried out by Ecoglo, Ecoglo S10 material would still be expected to remain at or above 5mcd/m² at this latitude.

Therefore, for outdoor use throughout New Zealand, there is no need for charging with any electric lighting: Ecoglo S10 material will meet the charging requirements to ensure compliance with Clause F6 for all building risk groups.

Indoor use: how to ensure charging is at sufficient brightness and for sufficient time to meet the durations specified in F6.3.4:

As determined earlier in this document, the Ecoglo markings need to be at or above 5mcd/m² to ensure the markings are reasonably visible.

What light sources can be used?

Ecoglo markings are charged by wavelengths between 315nm and 475nm.

Wavelengths between 315nm and 400nm are classified as long-wave UV or UVA (the part of the UV spectrum that goes through normal window glass).

Wavelengths between 400nm and 475nm span violet to blue in the visible light spectrum.

Most current technology white electric lights provide sufficient light in the 315-475nm range to provide good charging.

White electric lights are specified by “colour temperature”. A low colour temperature (2700K-3500K) produces noticeably yellow light, often called “warm white”. A medium colour temperature (3500K-5000K) produces less yellow light, often called “cool white”. A high colour temperature (5000K-6500K) produces a non-yellow light, often

called “daylight” (the sun in the middle of the day provides light at around 6500K).

Low colour temperature lights usually do not have as much emission in the 315-475nm range as medium and high colour temperature lights, so are not as good at charging Ecoglo.

International standards such as ASTM E2073 Standard Test Method for Photopic Luminance of Photoluminescent Markings, and UL1994 specify a fluorescent charging light of approximately 4000K colour temperature.

This is typical of most office, commercial, and industrial lighting, so can be used as a benchmark colour temperature for electric light sources in regard to Clause F6.

If the installed lighting has a colour temperature greater than 4000K, the Ecoglo markings can be expected to charge more than specified. Conversely, if the installed lighting has a colour temperature less than 4000K, the Ecoglo markings can be expected to charge less than specified, so should not be used without further investigation.

Ecoglo has carried out lamp testing with fluorescent lamps, metal halide lamps, and LED lamps all rated at 4000K colour temperature. This testing indicates that the Metal Halide lamps provide greater charging than fluorescent lamps, and the LEDs are sometimes greater and sometimes similar to the fluorescent lamps.

It should be noted that LED lamp technology is developing rapidly, and that other lamp technologies may enter the market. Testing to date indicates that as long as the lamp is rated at 4000K or more, it will charge at least as well as the test reports indicate for a 4000K fluorescent lamp. Specifiers of Ecoglo markings should be aware that future lamp technologies may behave differently.

It is safe to conclude that current electric light sources having a colour temperature of

4000K or more are suitable light sources.

How long do Ecoglo markings need to be charged for?

Ecoglo has had testing carried out based on a 5 minute charge time. The reasons for this are:

- Some lamp types (eg most fluorescent and metal halide) take 1-3 minutes to get to near-normal operation, so a charge time less than 5 minutes would not be reliable in practice;
- It would generally be impractical to require that charging lights be turned on before first occupation of a building.

It is considered acceptable to enter and occupy a space that has been dark then turn on the lighting. The lighting will start charging the Ecoglo markings and the markings will not have the full duration of visibility (as specified in F6.3.4) until, at worst, 5 minutes after entering the space.

This is similar to the current acceptance of lock management plans which allow a building's exit doors to be locked in a manner which does not comply, but be unlocked soon after initial occupation.

Ecoglo has consulted extensively with building officials, who have all accepted this as a pragmatic solution for this issue.

Ecoglo markings will almost always achieve full operational charge sooner than 5 minutes in real life because of residual charge from previous use (the test method requires the markings to be fully discharged before test charging is started).

In daylight spaces the Ecoglo markings will often be at full operational charge when the building is first entered.

Assuming the worst case where the building is first entered while it is still dark, or the markings are in a room with no windows, for every second that the lights have been turned on, the markings will accumulate several seconds of operational charge. So

the time the markings will remain reasonably visible is greater than the time since first occupation, which allows for safe evacuation.

Designers should be aware of scenarios where this rationale may not be appropriate, such as a tall building with elevators which can rapidly take someone to an upper floor, from where their escape time could be much more than the time since first occupancy.

In crowd occupancies, it is recommended that the public not be allowed entry to the building until the markings have full operational charge.

What illuminance is needed to charge Ecoglo markings?

NZBC Clause F6 Risk Group C:

Independent testing confirms that Ecoglo S10 material will remain above 5mcd/m² for the specified period of 30 minutes when charged with 20 lux for a period of 5 minutes.

NZBC Clause F6 Risk Group B:

Ecoglo in-house testing⁵ confirms that Ecoglo S10 material will remain above 5mcd/m² for the specified period of 90 minutes when charged with 60 lux for a period of 5 minutes.

Note that an illuminance of 20 lux is the minimum amount of light allowed by Clause G8.3 (Artificial Light) in an occupied space of a building. In most practical situations there is a lot more than 20 lux or even 60 lux and therefore the Ecoglo markings obtain full operational charge more quickly, and remain reasonably visible for a lot longer than F6.3.4 specifies.

5. Ecoglo runs an in-house luminance test facility, which is validated by comparative testing with independent test laboratories. The in-house test facility enables the efficient testing of multiple charging brightness, time, lamp type, and product variations. Ecoglo has carried out over 2000 in-house tests over the last 10 years.

Ongoing Verification Requirements

What process is needed to ensure the installed Ecoglo markings continue to meet the requirements of Clause F6?

Verification of ongoing luminance

On site measurement is impractical for the following reasons:

- Sufficiently accurate luminance measuring equipment is very expensive (more than \$10,000);
- Repeatable testing can only be carried out once the markings have been kept in complete darkness for at least 48 hours, and testing is carried out in a temperature-controlled environment.

Therefore another approach is required.

The strontium aluminate based photoluminescent pigments used in Ecoglo markings have inherent long term stability.

All photoluminescent products utilise photoluminescent pigments embedded in a clear carrier. With some manufacturing techniques these carriers can age and discolour over time due to UV exposure, especially exposure to unfiltered sunlight.

Any discolouration of the carrier will inhibit both the charging and discharging of the pigments and lead to deteriorating luminance over time. Therefore a suitable test needs to subject the markings to UV through real or simulated outdoor exposure.

Ecoglo markings have been subjected to independent accelerated weathering (UV) testing, in accordance with the only building code that specifies a test for photoluminescent markings to confirm long term stability, suitable for outdoor use: New York City Building Code, Reference Standard 6.1.

Section 6 specifies:

1000 hours exposure in accordance with ASTM G 155-2004 Standard Practice for

Operating Xenon Arc Light Apparatus for Exposure of Nonmetallic Materials

See Appendix B for the independent test report that confirms that Ecoglo markings meet this requirement (less than 10% reduction in luminance after exposure).

It is very difficult to translate exposure hours in an accelerated weathering test with real-life outdoor use because UV intensity, air temperature, rainfall, etc vary widely from place to place. However a rule of thumb equates 1000hrs of ASTM G155 exposure with between 2.5 yrs and 10 years outdoor use.

Ecoglo in-house testing has also been carried out on Ecoglo markings following 6000 hours exposure in accordance with ASTM G-155. This resulted in a 5%-8% reduction in luminance after exposure.

Ecoglo in-house testing has also been carried out on product removed from long term outdoor use. Ecoglo markings installed at the former Jade Stadium, (also former AMI stadium), Wilsons Rd, Christchurch have been removed and replaced annually for a period of 10 years.

This has resulted in a flat trend line (no change in luminance after exposure).

The conclusion drawn from all this data is that Ecoglo markings are very stable to long term outdoor exposure and can be expected to remain reasonably visible for at least 15 years.

Indoors, where UV is usually negligible, Ecoglo markings can be expected to remain reasonably visible for much longer: it seems reasonable to expect this to be at least 30 years.

Therefore there is no need for ongoing luminance verification.

Furthermore NZBC Clause B2 specifies durability requirements of building elements. Path marking products required by Clause F6 are required to meet Clause B2.3.1: They must continue to meet the Building Code for (the lesser of) the life of the building, or:

5 years if they are easy to access and replace, and failure would be easily detected during normal use of the building;

or

15 years if they are easy to access and replace, but failure would go undetected during normal use of the building (but be easily detected during normal maintenance).

Given that the normal use of a building does not involve occupants being in a lights-out

condition, failure could go undetected during normal use of the building, so the markings need to continue to meet F6 for 15 years. Testing has shown the Ecoglo markings will meet this requirement therefore there is no need for ongoing luminance verification.

Inspection requirements

It has been established that ongoing luminance verification is not required, but inspection is still warranted to make sure that the markings as installed have not been damaged or removed, that any electrical light needed to charge the markings is still functioning as intended, and that the marked escape route is still an appropriate path.

The following inspections are recommended to ensure ongoing compliance with Clause F6:

6 Monthly Maintenance Check

(to be carried out by the Owner or their appointed agent)

Action	Complete
There has been no change in the configuration of the building which renders the marked escape routes unusable.	
All products are still configured as at installation and there is no material damage to any of these products.	
All products are clean from general dust build up and any other specific obscuring deposits.	
All products are clearly visible and have not been covered up by carpet or other materials.	
All products mark a clear path and have not been obstructed by physical hazards such as trolleys, machinery, partitions, etc.	
All lights checked that the positions have not altered from design.	
All lights are in working order and clean.	
All automated lighting control systems are operational as per design.	

Annual Inspection (to be carried out an IQP)

Action	Complete
There has been no change in the configuration of the building which renders the marked escape routes unusable.	
All products are still configured as at installation and there is no material damage to any of these products.	
All products are clean from general dust build up and any other specific obscuring deposits.	
All products are clearly visible and have not been covered up by carpet or other materials.	
All products mark a clear path and have not been obstructed by physical hazards such as trolleys, machinery, partitions, etc.	
All lights checked that the positions have not altered from design.	
All lights are in working order and clean.	
All automated lighting control systems are operational as per design.	

Conclusion

The above has shown that:

- The markings can be sufficiently bright to be reasonably visible;
- The markings can be located in such a way to make sure that the specified features in an escape route can be made reasonably visible;
- Charging requirements can be prescribed to ensure the markings

can be charged sufficiently to maintain sufficient brightness for the duration specified in F6;

- A maintenance process can be defined to ensure ongoing compliance with Clause F6.

In this way Ecoglo markings can be used to meet the requirements of Clause F6.

APPENDIX A

Test of Ecoglo Photoluminescent Material in accordance with UL1994 Test Standard.

This is the test report by Intertek annotated by Ecoglo with metric equivalent values.
For a copy of the original report (imperial units only), contact Ecoglo.

REPORT

3933 US ROUTE 11
CORTLAND, NEW YORK 13045

Revised Issue Date: April 2, 2009

Order No. 3161519 Original Issue Date:
October 22, 2008

REPORT NO. 3161519CRT-002A

TEST OF PHOTOLUMINESCENT MATERIAL

RENDERED TO

ACCESS PRODUCTS, INC.
55 ROBERTS AVENUE
BUFFALO, NY 14208

Revision Note:
Corrected typographical errors.

DATA REQUESTED

Luminance measurements after activation
tests and visibility observation tests on
photoluminescent material,
model nos. G3001, H3001, E2071, E2061,
E2051, E3071, E3061 and E3051
in accordance with UL 1994
Test Standard.

AUTHORISATION

This test service was authorized by signed
quote number 500104953.

DEVICES SUBMITTED

The client submitted photoluminescent ma-
terial samples of Models G3001, H3001,
E2071, E2061, E2051, E3071, E3061
and E3051. The samples were received
by Intertek on May 7, 2008 in undamaged
condition, and tested as received.
The sample designations are M08Z301
through M08Z309.

DATE OF TESTS

May 21, 2008 through October 22, 2008

TEST SUMMARY

UL 1994 Models G3001, H3001, E2071,
E2061, E2051, E3071, E3061 and E3051
Brightness Rating – Client's Criteria Com-
ply for duration of 195 minutes
**Visibility Observation Tests Comply for
the duration of 195 minutes at 33 feet
[10.05 metre] distance**

EQUIPMENT LIST

Equipment Used	Model Number	Control Number	Calibration Due Date
Optronic Luminance Standard	455-6-2	Y174	11/15/09
Optronic based Luminance Meter consisting of:			
Optronic Photometer	730C	E2900	6/14/08
Optronic Direct Viewing Module	600	-	-
Optronic Amplified Photodetector	730-5H-LED	-	-
Fisher Scientific Stopwatch	-	N8530	6/15/08
UDT Illumination	MeterS371R	L0600	1/16/09

TEST AND TEST METHOD

Luminance Measurements

The luminance measurements were made on the photoluminescent test samples with the Intertek License Plate Test Apparatus. The center of each test sample was measured at normal (0°) viewing angle. The aperture of the Optronic based luminance meter was adjusted in order to view the maximum area on the test sample.

The Intertek License Plate Test Apparatus consists of an Optronic based luminance meter and a horizontal and vertical movement system. The luminance calibration of the luminance meter is traceable to the National Institute of Standards and Technology through the calibration of the Optronic Luminance Standard.

The tests were conducted on May 21, 2008.

The test samples were conditioned for at least 16 hours at zero footcandle (zero lux) illumination. The photoluminescent material samples were then conditioned for 60 minutes (one hour) by 1 footcandle (10.8 lux) illumination from a 4100K fluorescent light source.

Luminance measurements were reported at ninety minutes after conditioning.

Conditioning of Samples for Observation Visibility Test

The samples were conditioned for a minimum of sixteen hours at zero footcandles [zero lux] illumination.

The samples were then conditioned for 60 minutes by 1 footcandle illumination footcandle (10.8 lux) from a fluorescent light source.

Then, the exit signs were illuminated with zero footcandle (zero lux) illumination for 90 minutes. Then, the observations were performed. This conditioning was performed before each test.

Selections of Observers

Three observers, having the visual acuity and color vision as specified in Paragraph 40.1.2 of UL 924 were selected for the observations performed at Intertek.

Observational Visibility Test

Each observer made observations for each model under an ambient light conditions of 0 footcandle (zero lux) at 25 feet (7.6 metres) distance after the samples were conditioned in accordance with UL 1994. For the observations for each model in ambient conditions of 0 footcandle (zero lux) illumination, three test samples were placed at floor level. Each sample was placed in one of three orientations: horizontal, vertical or at 45 degrees to vertical.

The conditions in the test ranges were in accordance with UL 1994. Observations were also made at 33 feet (10.05 metres) at three additional time durations (zero footcandles [zero lux] illumination period).

Each observer recorded his observations for the three samples.

The observations were made within 15 seconds. All observers must have all correct observations for compliance.

This process was repeated for two additional time durations. The three time durations were 90 minutes, 135 minutes and 195 minutes.

RESULTS OF TEST

Luminance Measurements after One Hour Activation Period (mcd/m²)
 Model Nos. G3001, H3001, E2071, E2061, E2051, E3071, E3061 and E3051
 Intertek Sample Nos. S08Z815, S08Z816 and S08Z817

Time After Exposure	Sample S08Z815	Sample S08Z816	Sample S08Z817	Average	Specified Minimum
2 min	90.0	96.0	88.0	91.3	
15 min	42.8	45.0	43.5	43.8	
30 min	27.2	27.9	27.8	27.6	
45 min	20.4	20.9	20.8	20.7	
60 min	15.5	16.3	16.0	15.9	
75 min	13.1	13.2	13.2	13.2	
90 min	10.7	11.0	11.0	10.9	5.0
105 min	9.30	9.50	9.70	9.50	5.0
120 min	8.25	8.40	8.50	8.38	5.0
135 min	7.10	7.25	7.40	7.25	5.0
150 min	6.55	6.75	7.10	6.80	5.0
165 min	5.90	6.15	6.15	6.07	5.0
180 min	5.40	5.60	5.50	5.50	5.0
195 min	4.90	5.00	5.00	4.97	5.0
210 min	4.40	4.70	4.70	4.67#	5.0

- Indicates non-compliance

Observational Visibility Test

Observer Number	Number of Correct Responses							
	Ambient Illumination Level: 0 Footcandle (0 lux)							
	Model G3001				Model H3001			
	90 min 25 ft (7.6m)	90 min 33 ft (10.0m)	135 min 33 ft (10.0m)	195 min 33 ft (10.0m)	90 min 25 ft (7.6m)	90 min 33 ft (10.0m)	135 mi 33 ft (10.0m)	195min 33 ft (10.0m)
1	3	3	3	3	3	3	3	3
2	3	3	3	3	3	3	3	3
3	3	3	3	3	3	3	3	3
Percentage of Correct Observations	100	100	100	100	100	100	100	100
Specified Minimum Percentage	3	3	100	100	3	3	100	100

In Charge of Tests:
David Ellis
 Senior Project Engineer
 Lighting Division

Report Reviewed By:
Jacki Swiernik
 Project Engineer
 Lighting Division

APPENDIX B

Test of Ecoglo Photoluminescent Material
Certifying that the material meets NYC RS6.1 Section 6.



REPORT
Intertek ETL SEMKO
3933 US ROUTE 11 CORTLAND, NEW YORK 13045

Order No. 3078911

Date: November 15, 2005

REPORT NO. 3078911CRT-006

TEST OF FOUR PHOTOLUMINESCENT MATERIAL MODELS

RENDERED TO

ECOGLO LTD.
77 KINGSLEY ROAD
CHRISTCHURCH, NEW ZEALAND 8002

DATA REQUESTED

Luminance measurements after activation tests on four photoluminescent material models after UV exposure in accordance with New York City Building Code Reference Standards RS 6-1 and RS 6-1A: Photoluminescent Low-level Exit Path Markings.

AUTHORIZATION

This test service was authorized by signed quote number 18761099.

DEVICES SUBMITTED

The client submitted three photoluminescent material samples each of four Models: G3001C/E2071C, and G5001C/H5001C. The samples were received by Intertek on June 18, 2005 in undamaged condition, and tested as received. The sample designations are E2218Z through E2223Z.

DATE OF TESTS

June 28, 2005 through November 13, 2005.

TEST SUMMARY

NYC Building Code RS 6-1A Photoluminescent Low-level Exit Path Markings	Model G3001C/E2071C	Model G5001C/H5001C
Clause 1.0 Brightnes Rating Post UV Exposure	Complies	Complies

An independent organization testing for safety, performance, and certification.

This report is for the exclusive use of Intertek's Client and is provided pursuant to the agreement between Intertek and its Client. Intertek's responsibility and liability are limited to the terms and conditions of the agreement. Intertek assumes no liability to any party, other than to the Client in accordance with the agreement, for any loss, expense or damage occasioned by the use of this report. Only the Client is authorized to copy or distribute this report and then only in its entirety. Any use of the Intertek name or one of its marks for the sale or advertisement of the tested material, product or service must first be approved in writing by Intertek. The observations and test results in this report are relevant only to the sample tested. This report by itself does not imply that the material, product, or service is or has ever been under an Intertek certification program. Measurement uncertainty budgets have been determined for applicable test methods and are available upon request.

EQUIPMENT LIST

Equipment Used	Model Number	Control Number	Calibration Date
Optronic Luminance Standard	455-6-2	Y174	09/30/04
Optronic based Luminance Meter consisting of:			
Optronic Photometer	730C	E290	06/23/05
Optronic Direct Viewing Module	600	---	---
Optronic Amplified Photodetector	730-5H-LED	---	---
Fisher Scientific Stopwatch	---	N853	05/05
UDT Illumination Meter	S371R	L060	09/02/04

TEST AND TEST METHOD

Selective Process

After evaluation at Intertek, it was determined that Models G3001C and E2071C are identical in regards to luminance performance and that Models G5001C and H5001C are identical in regards to luminance performance.


Luminance Measurements Before and After Weathering Test

The luminance measurements were made on the photoluminescent test samples with the Intertek License Plate Test Apparatus. The center of each test sample was measured at normal (0°) viewing angle. The aperture of the Optronic based luminance meter was adjusted in order to view the maximum area on the test sample. The Intertek License Plate Test Apparatus consists of a Optronic based luminance meter and a horizontal and vertical movement system. The luminance calibration of the luminance meter is traceable to the National Institute of Standards and Technology through the calibration of the Optronic Luminance Standard.

The test samples were conditioned for at least 16 hours at zero footcandle illumination. The photoluminescent material samples were then conditioned for 120 minutes (two hours) by 2 footcandle illumination from a 4100K fluorescent light source. Luminance measurements were made on each test sample at two minutes intervals after conditioning for a period of one hour and at ninety minutes after conditioning. Luminance measurements were reported for ten minutes, sixty minutes and ninety minutes after conditioning.

Weathering Tests

The test samples were sent to Canesis Network Limited for 1000 hours exposure to Xenon Arc light apparatus per ASTM G155 Cycle 1. The samples were returned to Intertek for the post UV luminance measurements. Average post UV luminance measurements must be at least 90% of the initial average luminance measurements at each time interval.

Checked by: 

Intertek ETL SEMKO

RESULTS OF TEST

Luminance Measurements After Two Hours Activation Period

Model No. G5001C/H5001C
Intertek Sample Nos. E2220Z, E2218Z, E2219Z
Luminance (mcd/m²)

Time After Exposure	Sample One	Sample Two	Sample Three	Average	Specified Minimum
<u>Pre UV Exposure</u>					
Ten Minutes	41.1	40.8	42.3	41.4	30
One Hour	9.96	9.66	10.25	9.96	7.0
Ninety Minutes	6.56	6.37	6.78	6.57	5.0
<u>Post UV Exposure</u>					
Ten Minutes	37.6	37.5	36.9	37.3	37.3*
One Hour	10.09	9.54	10.19	9.94	8.96*
Ninety Minutes	6.97	6.41	7.02	6.80	5.91*

Model No. G3001C/E2071C
Intertek Sample Nos. E2222Z, E2221Z, E2223Z
Luminance (mcd/m²)

Time After Exposure	Sample One	Sample Two	Sample Three	Average	Specified Minimum
<u>Pre UV Exposure</u>					
Ten Minutes	105.6	104.7	107.3	105.9	30
One Hour	29.0	28.5	29.2	28.9	7.0
Ninety Minutes	20.2	19.7	20.1	20.0	5.0
<u>Post UV Exposure</u>					
Ten Minutes	99.1	97.2	100.0	98.8	95.3*
One Hour	27.3	28.4	27.6	27.8	26.0*
Ninety Minutes	18.1	19.4	18.4	18.6	18.0*

* Specified minimum is 90% of average initial luminance value at each time interval

In Charge Of Tests:

David Ellis

David Ellis
Project Engineer
Photometric Testing

Report Reviewed By:

Ernest Dykeman

Ernest Dykeman
Senior Project Engineer
Photometric Testing

Attachment: None



APPENDIX C



Queensland University of Technology

PHOTOMETRIC LABORATORY

REPORT NO: 3661-1

CLIENT: Ecoglo International Ltd

Visibility Measurements of Photoluminescent Materials to modified requirements of UL1994

NATA Accreditation No: 4819
TFI No: T3899
Accredited for compliance with ISO/IEC 17025

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The results of the tests, calibrations and/or measurements included in this document are traceable to Australian national standards.

The name or logo of the Queensland University of Technology may not be used in any form on publicity material that may be generated as a result of this report.

Initials



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Tel (07) 1138 5073
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PHOTOMETRIC LABORATORY

TEST REPORT

REPORT No: 3661-1 DATE OF TEST: 19th August 2015

CLIENT: **Ecoglo International Ltd**
77 Kingsley St
Christchurch 8023
New Zealand

TEST: **Visibility Measurements of Photoluminescent Materials to Modified Requirements of UL1994**

ITEM DESCRIPTION: **Three sets of each sample.**
Sample 1 – E14-075 Batch 2653-1552 Dated 23/04/2015
Dimensions: 300 mm long x 63 mm wide x 2mm thick
2 only photoluminescent strips approx. 5 mm wide along length

Sample 2 – G8-011 Batch 2302-1424 Dated 23/07/2014
Dimensions: 100 mm wide x 100 mm high x 2 mm thick
photoluminescent strips approx. 5 mm wide along length over full width

Information taken from Client ID markings on rear of samples
(See photographs on Page 5)

TESTS REQUIRED: 2 samples to be exposed to an illumination of 10.8 lux for 1 hour using fluorescent lamp of CCT 4000K, then Visibility Test as per Sections 34.2.3 and Section 35.1 of UL1994 but with modifications of visibility measurements undertaken when luminance is 5 mcd m⁻² and at a viewing distance of 10 m.

RESULTS: **The two samples passed the Visibility Test conducted in accordance with UL1994, with the modifications described above.**

Approved Signatory

A/Prof. Ian Cowling

Date of issue: 27th June 2014

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TEST REPORT

Report No: 3661-1

Test: Visibility Measurements of Photoluminescent Materials to modified requirements of UL1994

NOTES ON PROCEDURE:

The preparation of the supplied samples was undertaken using the procedures set out in ASTM 2073-10 *Standard Test Method for Photopic Luminance of Photoluminescent (Phosphorescent) Markings*.

The samples were kept in a dark location for several days to ensure the luminescence was below threshold measurements levels. After this period the three sets of each of the two samples were mounted by the Senior Laboratory Technician in a vertical line with one sample horizontal (lengthwise), one vertical and the third at 45° either sloping downward or upward left to right. These three orientations were in random order, and the order was different between the two samples.

The samples were exposed to a 1200 mm 36W/840 fluorescent lamp (CCT = 4000 ± 20K) for 1 hour at an exposure of 10.8 ± 0.3 lux.

CCT was measured using the laboratory Konica Minolta CL-500A colour and illuminance meter (Serial No 10001295). The illuminance on the exposure plane was measured using a calibrated laboratory Topcon IM-3 Illuminance meter (Serial No 90160485).

After the exposure lamp was switched off, the luminance of each sample was monitored and the time taken for the luminance to reduce to 5 mcd m⁻² was recorded.

This procedure was repeated for both samples.

The luminance was measured normal to the surface off the samples with a laboratory Konica Minolta LS-100 luminance meter (Serial No 79413025) which has been calibrated against our laboratory primary standard lamp which itself has been calibrated by the National Measurement Institute (NMI) in Sydney.

In accordance with UL1994, the three observers remained in a room with a vertical illumination of 500 lux at eye level for 5 minutes. The observers then remained in the darkened test room for 5 minutes with backs to the samples. After adaptation the observers turned to view the samples and had to record the orientation of each sample within 15 seconds.

Approved Signatory



A/Prof. Ian Cowling

Date of issue: 20th August 2015

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TEST REPORT**Report No: 3661-1****Test:** Visibility Measurements of Photoluminescent Materials to modified requirements of UL1994**RESULTS:**Laboratory conditions:
Temperature: 24.0 ± 0.5 °C

Light Source: 36W/840 1200 mm (4000 K) fluorescent tube

Illumination: $E_{av} = 10.8$ lux for 1 hour; $E_{max}:E_{min} = 1.02$ **Time taken for luminance to reduce to 5 mcd m⁻² (from end of excitation)**


Sample 1	E14-075	147 minutes
Sample 2	G8-011	140 minutes

Results of Visibility Test

Observer 1:	Order and orientation correct within 15 seconds
Observer 2:	Order and orientation correct within 15 seconds
Observer 3:	Order and orientation correct within 15 seconds

Overall Result of Visibility Test: Pass**UNCERTAINTIES:**

Measured values of luminance have an uncertainty of ± 0.001 cd m⁻²
(95% confidence level, coverage factor k=2).
Measurements were taken within 10 seconds of the specified time.

Approved Signatory 
A/Prof. Ian Cowling

Date of issue: 20th August 2015

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TEST REPORT

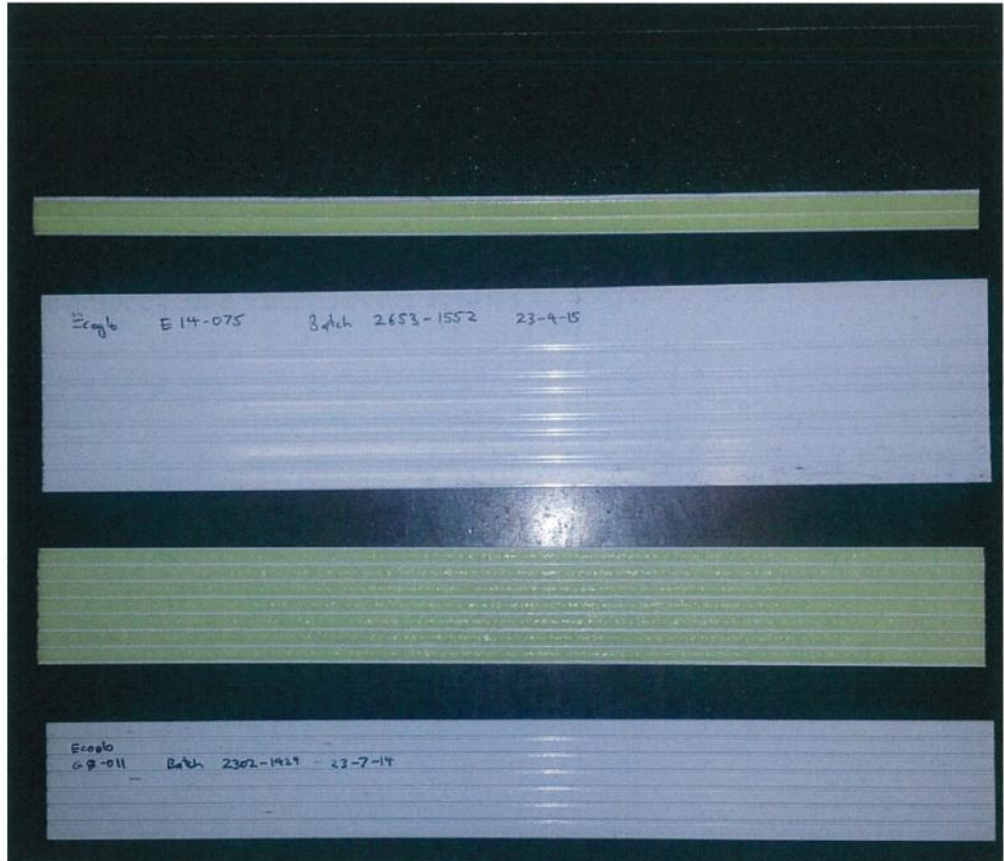
Report No: 3661-1


Test: Visibility Measurements of Photoluminescent Materials to modified requirements of UL1994

PHOTOS OF SAMPLES SUPPLIED FOR TESTING

Sample 1 E14-075 at top: showing photoluminescent surface above and rear surface below it, with clients identification details

Sample 2 G8-011 at bottom: showing photoluminescent surface above and rear surface below it, with clients identification details



Approved Signatory  A/Prof. Ian Cowling

Date of issue: 20th August 2015

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