

Photo-luminescent tread edge products: are they safe enough?

Rod A. Hunter

Photo-luminescent, “glow in the dark” products are promoted as enhancements for way-finding and safety in unlit spaces. One application is for the leading edge of steps and stair treads and their top landings, with a common focus being on their role in emergency egress, at times of power failure, and when viewing distance is minimal such as in smoke. The benefit appears obvious but, do such products sufficiently facilitate or, even compromise safe negotiation of steps and stairs?

Photo-luminescent products incorporate inorganic phosphor compounds that are able to accumulate and maintain ultraviolet energy from light and then, in darkness, gradually release it as luminescence. Photo-luminescent products for treads are available in the form of paints, tapes, sheets, cast or moulded plastic sections, and extrusions of metal such as aluminium. For some products, the photo-luminescence material is also slip-resistant; for other products, the slip resistance is achieved by material adjacent to the photo-luminescence material. Slip-resistant materials are available in many colours, with pale green being the most common colour of photo-luminescent material because of its greater luminescence.

In Australia there is no standard that deals with the configuration of photo-luminescent strips at steps and stairs, nor is there a building or other code that requires the provision of such strips. However, Australian Standard AS1428.1-2001 ‘Design for Access and Mobility Part 1: General requirements for access – New building work’ stipulates the required configuration and luminance contrast of strips on stair treads.

The objective of AS1428.1 is to enable access for people with disabilities, but this does not preclude its use as a code of good design, regardless of disability, as the title by itself suggests. Furthermore, AS1428.1 is called up by the Building Code of Australia (BCA) which requires the application of AS1428.1 to its stairways. The proposed Disability (Access to Premises — Buildings) Standards 2009 (DAPBS) will do the same. In other words, provision for people with disabilities is and will serve as a minimum criterion for the design of stairways for users generally.

To facilitate visibility of tread edges and hence safer ascent and descent of stairs, AS1428 stipulates that there be a strip of width 50 mm to 75 mm at the leading edge of each tread and that it have a luminance contrast of at least 30% with its background. AS1428 was possibly intended only for lit conditions, but it seems logical that in principle these conditions also apply to unlit conditions.

For products having subsidiary strips of photo-luminescent material, or photo-luminescent material and non-photo-luminescent material, compliance with AS1428 is not as easy to establish as for products comprised of a single strip of the one material. Nevertheless, it seems reasonable to suggest that the subsidiary strips intended for luminance contrast during lit conditions (regardless of whether they are photo-luminescent) should have the following properties:

- a) Their combined width is 50 mm to 75 mm.
- b) Each subsidiary strip has at least 30% luminance contrast with the tread. For multiple strips of different materials (photo-luminescent and non-photo-luminescent), it can be deduced that there should be less than 30% luminance contrast between them and between them and any exposed parts of the metal extrusion. Far preferably, there should be little or no luminance contrast between the subsidiary elements; in other words, the strip as a whole should preferably be homogeneous in terms of light reflectivity.

Additionally, and irrespective of whether products are comprised of single or multiple strips, for the dual purpose of luminance contrast in lit conditions and luminescence in unlit conditions, the strip or strips should start at the leading edge of the tread.

Many installed instances of products, and many products having subsidiary strips of photo-luminescent and non-photo-luminescent material do not satisfy these conditions.

Contrast and polarity

In many cases, products that are easily visible in lit conditions are not easily visible in unlit conditions, and vice versa. This is illustrated by the following sample swatch of tread segments (the going dimension of each tread is indicated by the arrows).

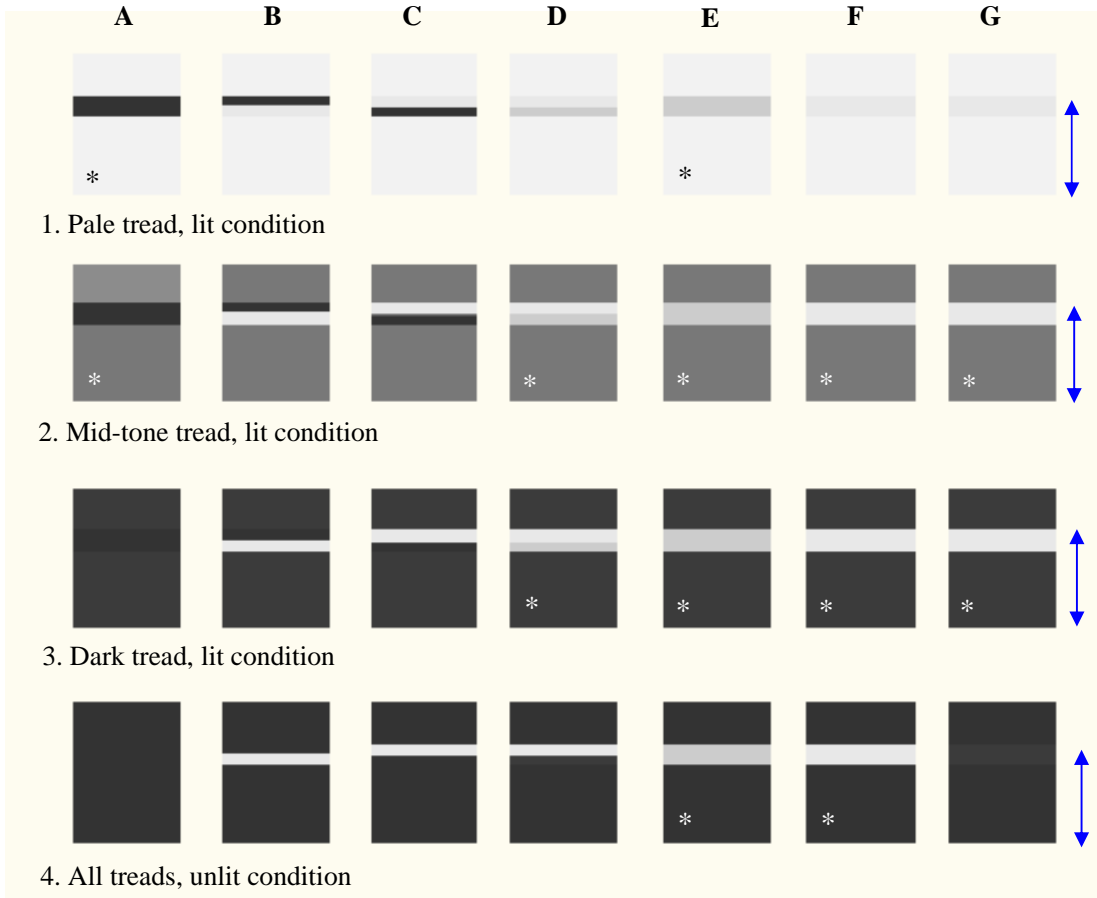


Fig. 1

Legend to Figure 1

- A Single: dark non-photo-luminescent strip
- B Dual: dark non-photo-luminescent strip with photo-luminescent strip
- C Dual: photo-luminescent strip with dark non-photo-luminescent strip
- D Dual: photo-luminescent strip with pale non-photo-luminescent strip
- E Single: photo-luminescent strip (granulated for slip-resistivity)
- F Single: photo-luminescent strip (not granulated for slip-resistivity)
- G Single: pale non-photo-luminescent strip

The samples marked with an asterisk are effective because they have: a) simplicity - they are a single strip or, if a dual strip, there is little contrast between the subsidiary strips; b) contrast with the tread of at least 30%. The sample that is effective in all conditions is “E”. The tread that is most versatile in lit conditions is “2” (mid-tone).

The following examples from on-line promotional material further illustrate the variation in effectiveness in lit and unlit conditions.

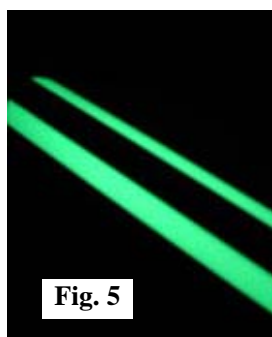


Stair descent

In unlit conditions, the photo-luminescent strip highlights the leading edge of the treads, but it does this inaccurately because it is set back from the edge, as Fig. 3 shows (the photo-luminescent strip appears as a grey strip in Fig. 3). Whilst the luminescence may be sufficient for the set-back to be noticeable by people without vision impairment, it may be insufficient for people with vision impairment.

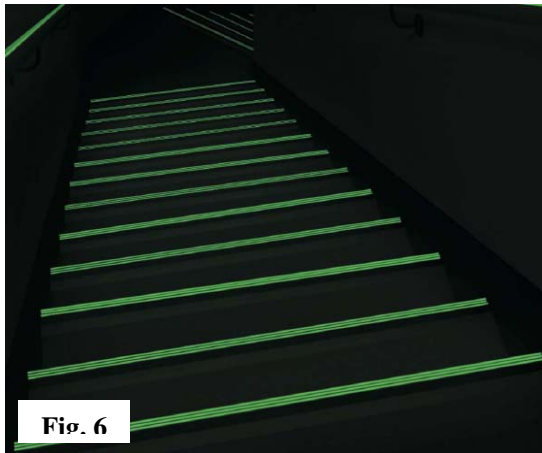


In lit conditions, the excessive width of the overall strip and its luminance contrast with the tread could confuse people with vision impairment about the extent of the going dimension of the treads. Confusion predisposes towards mis-steps and retardation of evacuation traffic. A solution is for the tread strip to be narrower or else part of its width provided in a material similar in appearance to that of the tread.



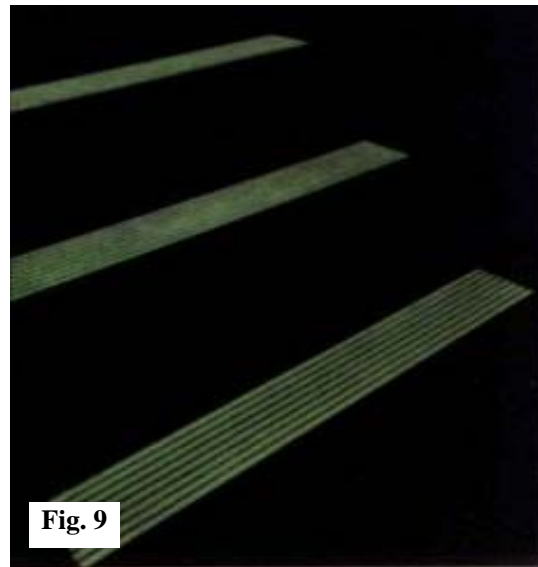
Stair ascent

Discernment of the leading edge of treads fitted with this product (shown here as samples of the product shown in Figs. 2 and 3) would tend to be hindered in lit conditions (Fig 4) and especially in unlit conditions (Fig 5).



Stair descent

In this example, the photo-luminescent strip more accurately indicates the leading edge of the tread in the unlit condition than does that of the previously illustrated product because it is closer to the leading edge. However, in the lit condition, the strip that best satisfies the luminance contrast requirement - the black strip - is too far from the leading edge of the tread for accurate discernment of the edge and hence, especially for people with vision impairment, may compromise safe descent of the stairway.



Stair ascent and descent

The excessive width of this photo-luminescent tread strip could be confusing, especially for people with vision impairment during ascent and descent of the stairway during lit and especially during unlit conditions. The open risers (which do not comply with AS1428) and the blackness of the tread finish (neither of which features are due to the product) would contribute to the confusion.

AS1428 limitations

Establishing the compliance of products and their installation with AS1428 and, on this basis, their contribution to safety is made difficult by the silence of AS1428 in relation to several matters.

Strip width

The strip width of 50 mm to 75 mm in AS1428 is for visibility in lit conditions, but it is unclear whether these would be the dimensions also required for the performance of photo-luminescent material in unlit conditions. In suddenly unlit conditions, the brightness of fully charged photo-luminescent material is pronounced and the strip width therefore could or possibly should be narrower than that required for luminance contrast in lit conditions, although the diminution of luminescence with time might invalidate such a proposition.

Guidance on the required width of photo-luminescent strips can be found in the New York City Building Code Reference Standard RS 6-1 (RS6-1). Applicable to exit paths in high-rise office buildings, the code stipulates that the width of photo-luminescent strips be 25 mm to 50 mm. Some tread products having subsidiary photo-luminescent and non-photo-luminescent strips do not satisfy this.

It is not mandatory in the City of New York for buildings that are not tall office buildings to have photo-luminescent features as outlined in RS6-1 but, if they do, the features must comply with RS6-1.

If the RS 6-1 requirement were incorporated with that of AS1428.1 or the proposed revision of it (DR04019), a strip or composite of strips would need to be at least 50 mm to 75 mm wide, with a portion of at least 25 mm to 50 mm being of photo-luminescent material. Many tread products having subsidiary photo-luminescent and non-photo-luminescent strips would not satisfy this.

Radius of tread edge

Neither AS1428.1 nor DR04019 refer to any radius or chamfer of the junction of the tread with the riser or the nosing. In comparison, AS1428.2 – 1992 ‘Design for access and mobility Part 2: Enhanced and additional requirements – Buildings and facilities’ recommends that the junction have a radius of between 10 mm and 15 mm. Reference to radius in codes and standards in other countries is similarly varied. In the United Kingdom, BS8300:2001 ‘Design of buildings and their approaches to meet the needs of disabled people — Code of practice’ makes no statement and its diagrams are ambiguous, whereas the City of London’s 2007 Facility Accessibility Design Standards stipulates a radius of 6 mm to 10 mm. In the United States, the Americans with Disabilities Act and Architectural Barriers Act Accessibility Guidelines (ADA/ABA Guidelines) stipulate a maximum radius of 13 mm, whereas the RS6-1 is silent. New Zealand’s Compliance Document for its building code in relation to access routes stipulates a radius of 5 mm to 10mm.

Stipulation of a radius is significant for the visibility of leading edges of treads (and top landings) because it determines the proximity of strips to the edges.

Proximity to leading edge

AS1428.1 and DR04019 stipulate that the luminance contrasting strip be ‘at’ the leading edge of the tread (‘nosing’), but do not quantify this. BS8300 and the ADA/ABA Guidelines make the same kind of statement, although in the form of recommendations only.

In contrast, RS6-1 stipulates a set-back distance for photo-luminescent strips of 0 mm to 13mm (and up to 25 mm for pre-2006 buildings) from the leading edge of treads. The United States' National Fire Protection Authority Code 101 of 2006 is even more specific: it refers to the leading *vertical* edge.

AS1428.2 is also specific: it proposes that there be nil set-back distance from a vertical plane tangential to the junction of the tread and riser. In other words, for a radiused tread edge, the strip needs to include the radius. Most products do not satisfy this.

In relation to a downwards extension of the strip, RS6-1 stipulates, notwithstanding its diagrams, that the edging strip must not extend down ('overlap') the vertical face of the tread ('step') more than 13 mm. For a tread with a leading edge having a radius of 13 mm as allowed by the ADA/ABA Guidelines, the strip can therefore extend vertically downward from the horizontal plane of the tread by 26 mm. Applying this to the radius of 10 mm recommended as the maximum by AS1428, the downward vertical distance from the horizontal plane of the tread would be 23 mm.

In relation to the position of the strip on the tread, if the RS6-1 requirement were incorporated with that of AS1428.2, the 50 mm to 75 mm wide strip or composite of strips would need to start at the vertical tangential plane, as would also the 25 mm to 50 mm wide portion of photo-luminescent material. Many tread products having subsidiary photo-luminescent and non-photo-luminescent strips would not satisfy this.

AS1428.2 currently does not and in the future will not be the criteria for statutory compliance in Australia because it is not referenced by the BCA nor will be by the DAPBS. Nevertheless, AS1428.2 serves as guidance for good design of edge strips beyond the minimum statutorily required. Or does it?

Is compliance with AS1428.2 better than compliance with AS1428.1?

AS1428.2 was published prior to the current AS1482.1 (and DR04012) and views about access and safety have changed over the past seventeen years. For example, AS1428.2 stipulates a contrasting strip on risers, whereas AS1428.1 and DR04012 do not. It is conceivable, and many credible people assert, that a strip on the riser of the same visible characteristics as the strip on the tread hinders discernment of the leading edge of the tread and therefore contributes to more hazardous stair ascent. Whatever the case, AS1428.1 stipulates that there be luminance contrast of the tread strip with its 'background'. Taken literally, "background" during ascent includes the riser. This therefore suggests that AS1428.1:- a) considers a strip on the riser as unnecessary or undesirable or, b) avoided stipulating strips on risers thus leaving such provision to the discretion of designers. Hence, it cannot be concluded in this instance that AS1428.2 necessarily represents *enhanced* requirements compared with AS1428.1.

The same comments apply to the relationship of the strip with a radius at the tread edge: it is unclear whether the strip on the tread *can* or whether it *should* start at the horizontal plane of the tread or whether it *can* or *should* start at the vertical plane tangential to its edge (in other words, at the bottom of any radius).

Homogeneity of strip

It has been suggested above that strips should be maximally visually homogenous, that is, that there be little or no luminance contrast of material within them. RS6-1 is more specific:

it advises that the whole of its stipulated photo-luminescent strip must be of photo-luminescent material, not interspersed with non- photo-luminescent material. Many products do not satisfy this.

Length of strip and location at top landings

AS1428.1, AS1428.2-1992 'Design for access and mobility Part 2: Enhanced and additional requirements – Buildings and facilities' and DR04019 make no reference to the length of strips. Nor do they refer to strips at the leading edge of top landings, possibly on the assumption that the need is self-evident. This silence is also found in BS8300 and in New Zealand's Compliance Documents for its building code in relation to access routes and visibility in escape routes.

In relation to photo-luminescent strips, the RS6-1 is not so silent. It stipulates that they must extend for the full breadth of each tread (with some concession being allowed for pre-2006 buildings) and be provided at the leading edge of top landings.

It would be better for safety if, for photo-luminescent and non-photo-luminescent strips, standards and codes were specific about the length of strips and installation of strips at top landings rather than rely upon assumption about these.

The hazard

Increased visibility of leading edges of treads and top landings decreases the chances of mis-steps. Mis-steps, which have been reported as contributing most to injurious falls on steps and stairs, commonly occur in the form of tripping during ascent or slipping off the leading edge of treads or top landings during descent. Human factors predisposing to mis-steps are vision impairment, lapses in concentration, and difficulties of balance, whether occupational in nature or inherent to the individual.

Tread and landing edges that are more visible facilitate:- a) discernment of edges with peripheral vision, b) discernment of edges by people with vision impairment and, c) attention to edges and thus greater concentration on negotiation of steps and stairs.

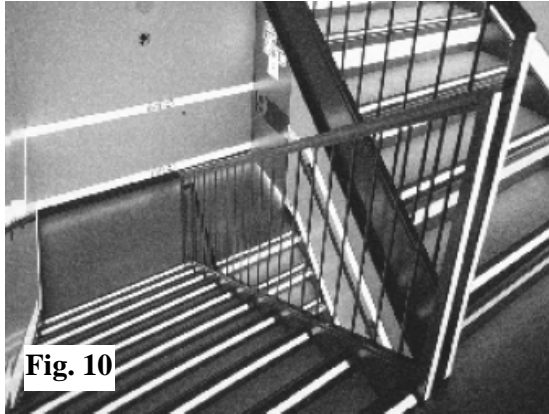
Emergency egress

A significant ramification of insufficiently visible tread and landing edges is the retardation of emergency egress; the fall of even one person on a stairway can disrupt the egress flow and thus increase the hazard of evacuation.

It is common experience that people tend to slow down when they cannot clearly see where they are going; confusion or doubt about the location of tread edges could have a similar effect, as has been borne out by recent research in relation to ascent of steps by people with blurred vision. The possible slowing of evacuation traffic is particularly significant for tall buildings with many stair flights.

The risk

Establishing the cause of accidents can be extremely difficult in relation to the sort of environmental detail discussed here. The literature search undertaken for this article revealed no research on the contribution of tread edge visibility to safe step and stair navigation. A Canadian study was conducted in 1999 to assess the performance during an evacuation drill of a photo-luminescent way-finding system in stairwells, including photo-luminescent strips at tread edges.



The study involved a single occasion with approximately 500 occupants of a three-storey office building. Approximately 5% of the occupants had a disability, including vision impairment (this figure compares with approximately 20% of the population in Australia who have a disability). The effectiveness of the system overall was concluded as being successful. What is interesting is that the photo-luminescent strips, placed between existing slip-resistant strips on each tread and landing, were set considerably further back from the tread and

landing edge than the maximum since stipulated by RS6-1 (See Figure 10). Also interesting is that no difference in speed of descent was recorded between the fully-lit, dimly-lit and unlit conditions.

Notwithstanding the apparent lack of firm evidence about the contribution of tread and landing edge visibility to safety on steps and stairs, prudence warrants that products be designed, chosen and installed on the basis of their maximum contribution to the visibility of tread and landing edges in both lit and unlit conditions. Many products and the application of many products can be assessed as falling short of this.

Examples of edge strips

The following products exemplify the issues discussed above.

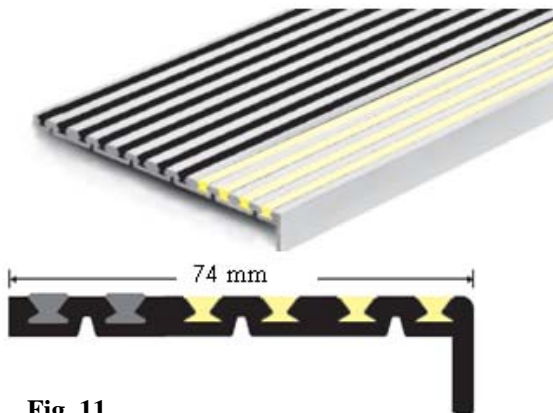


Fig. 11

The product in Figure 11 has the virtue of its photo-luminescent material being at the very leading edge of the tread (even though it is set back slightly from the face of the aluminium section), and of the negligible protrusion of the front face of the tread..

To satisfy AS1482 and DR04019, the two grey strips in the bottom example, or two of the black strips closest to the photo-luminescent material in the top example, would

need to be replaced with material that has similar light reflectance and preferably also colour as the photo-luminescent material.

In the top example of Figure 11, the other black strips would need to match the tread finish.

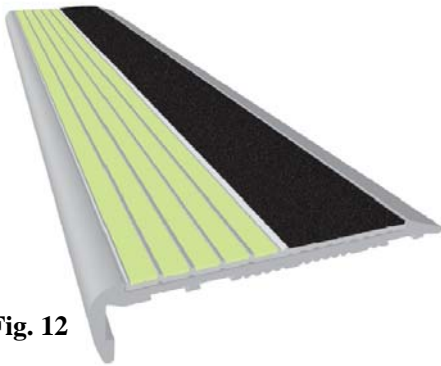
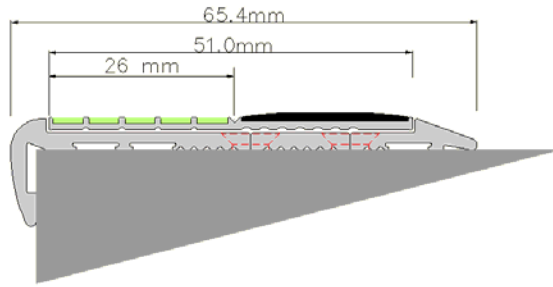


Fig. 12



To satisfy AS1428 (and DR04019) for lit conditions, the black subsidiary strip would need to be replaced with material similar in light reflectance and preferably also colour to the photo-luminescent subsidiary strip. Of the overall width, at least 75 mm, but no more, would need to contrast in luminance (light reflectance) with the tread..

For descent, the photo-luminescent subsidiary strip has the virtue of being almost exactly at the leading edge of the tread, (even though it is approximately 6 mm back from the leading edge of the aluminium section).

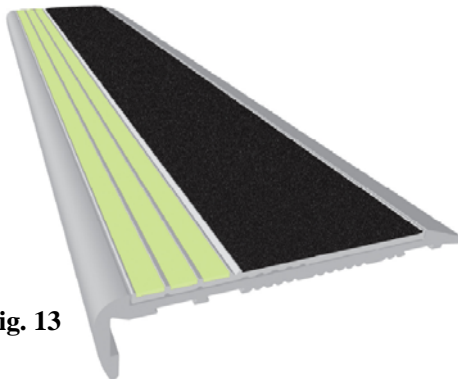


Fig. 13

The version of the product in Figure 12 satisfies RS6-1 for width but the version in Figure 13 does not because the photo-luminescent strip is too narrow (it is approximately 16 mm). The photo-luminescent subsidiary strip is not fully homogeneous, but it is probably sufficiently so because of the narrowness and slightly reflectivity of the aluminium ribs as to satisfy RS6-1.

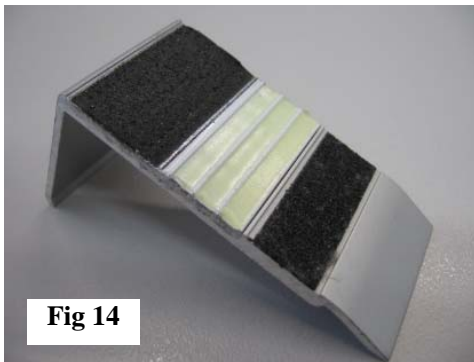


Fig 14

To satisfy AS1428 (and DR04019) for lit conditions, the black subsidiary strip of the product in Figure 14 would need to be replaced with material similar in light reflectance and preferably also colour to the photo-luminescent subsidiary strip. Of the overall width, at least 75 mm, but no more, would need to contrast in luminance (light reflectance) with the tread.

In its current form for many tread finishes in lit conditions, the product would hinder accurate perception of the leading edge of the tread.

In unlit conditions, and regardless of the appearance of the strips at each side of the photo-luminescent strip, the product would not satisfy RS6-1 because it is too narrow (it is approximately 16 mm) and, for buildings after 2006, it is slightly too far back from the leading edge of the tread (approximately 16 mm). For pre-2006 buildings, the set-back satisfies RS6-1.

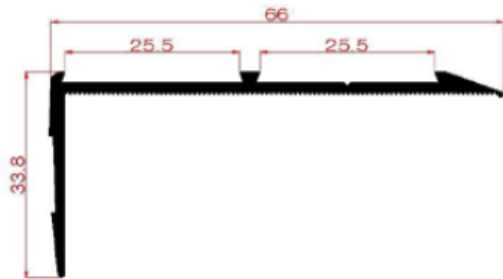
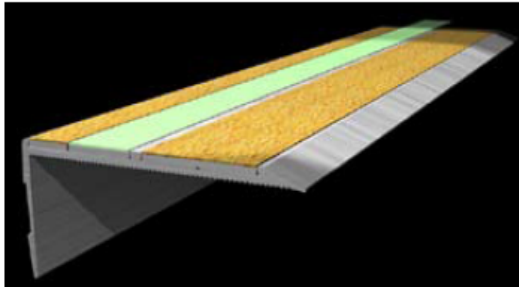


Fig. 15

This product would better satisfy AS1428.1 and DR04019 if there were less luminance and colour contrast between the photo-luminescent material and the adjacent yellow material.

The whole assembly would also need to contrast in luminance with the tread

To satisfy RS6-1, the whole of the first channel would need to be occupied by the photo-luminescent material, otherwise it would prevent accurate discernment of the leading edge of the tread.

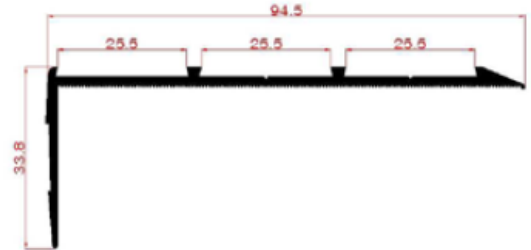
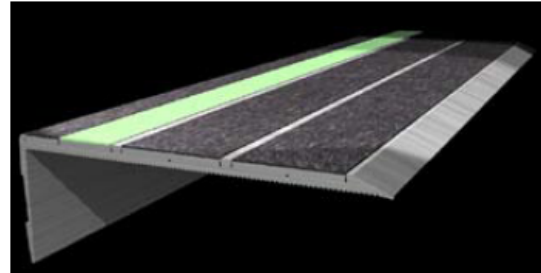


Fig. 16

This version of the product in Figure 14 would better satisfy AS1428.1 and DR04019 if there were less luminance and colour contrast between the photo-luminescent material and the immediately adjacent grey material. The two channels closest to the leading edge of the tread would need to contrast with the outer-most strip of material – which would need to be visibly similar to the tread.

To satisfy RS6-1, the whole of the first channel would need to be occupied by the photo-luminescent material, otherwise it would prevent accurate discernment of the leading edge of the tread.

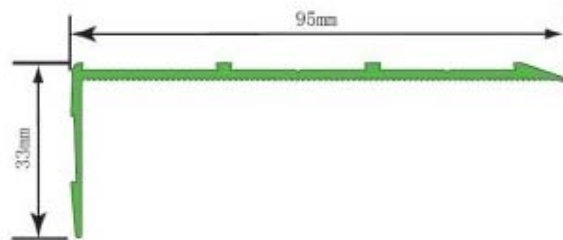
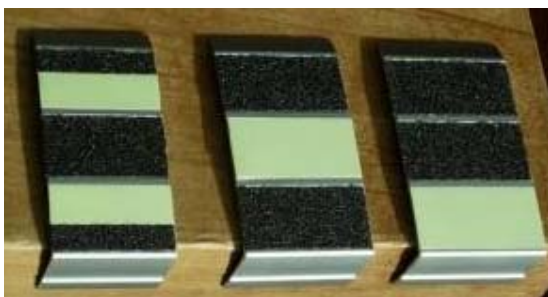
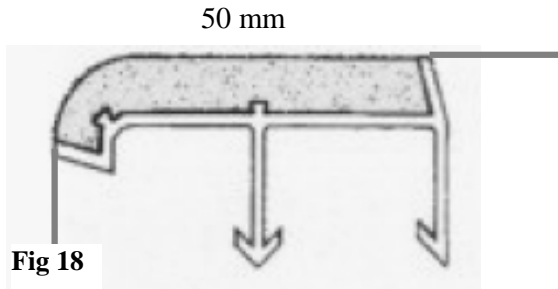


Fig 17

Of the three versions of this product, the one at the right is the only one most accurately indicates the leading edge of the tread and best satisfies RS6-1. For compliance with AS1428.1 (and DR04019), the slip resistant strip farthest from the tread edge would need to contrast with the other two and be similar in appearance to the tread.

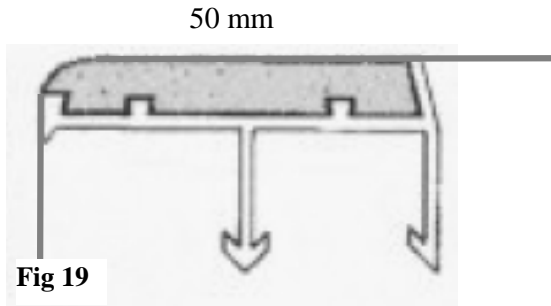


Of the products reviewed, those in Figures 18 and 19 are the only ones whose configuration satisfies AS1428.1 (and DR04019), AS1428.2 and RS6-1. For ascent and descent, the product facilitates accurate perception of the leading edge of the tread

The products are intended for embedment in new concrete steps and stairs, but a version is also available as a two part assembly whose design could be readily modified for other materials or for application to existing stairs.

The product integrates photo-luminescence and slip resistivity

There would need to be luminance contrast with the tread finish.



Note:

The illustrations above, with the exception of Figure 1, have been obtained from the on-line promotional material of various companies operating in Australia and overseas. Minor graphical editing of many of them has been made for purposes of simplicity. The promotional material was reproduced in order to impart a case study characteristic to the article. Names of firms and descriptors of their products have not been indicated in order to focus on design principles.

About the author:

Rod Hunter, principal of Hunarch Consulting, has 35 years experience in research, design and compliance appraisals for building and product usability, safety, accessibility, egress, and people with disabilities. Rod is a registered architect, ACAA-accredited access consultant, and member of Standards Australia drafting committees.