Evaluations of sequential running lights at Værløse airport

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Foreword and preliminary conclusions

The evaluations were carried out as a part of a pilot project of the Nordic project termed 'Lysgéner ved vejarbejder om natten' carried out on a runway at Værløse airport on 28 and 29 March 2006.

The preliminary conclusions of the evaluations are:

- an on-time of the lights of 0,2 second is preferable to 0,111 second
- a very short on-time - as with xenon flash lamps - makes it difficult to perceive the direction of the sequence, unless the lights have a steady background level
- an on-time of 0,5 second combined with a delay time of 0,2 second from one light to the next is confusing because more than one light is on at a time
- the method of individual on-times (turning lamps on one after the other, and leaving them on until the last lamp has been turned on during its on-time) received good marks
- the effective luminous intensities have been set according to previous experiments for individual lights, and seemed to be suitable also for sequential running lights - perhaps with a trend towards lower levels.

The delay-time between lights in the sequence was set to 0,2 seconds in all cases. Such a delay time is found in commercially available sequential running lights and seems to be suitable.

1. The experimental arrangement

The experimental arrangement is according to drawing 4.1 of the Danish road standards for marking of road works "Afmærkning af vejarbejder - tegninger", Vejdirektoratet 2002 (see www.vejregler.dk), except that those parts of the arrangement which were to be placed at the left-hand side of the road were unnecessary and therefore omitted. The central parts of the arrangement are shown in the photo in figure 1.

Five yellow signal lights are seen in the foreground. These lights were made at DELTA for use in experiments with yellow signal lights. The lights can be controlled in terms of a period consisting of an on-time and an off-time, and the intensity of light during the on-time. Additionally, a 'background level' of intensity can be set for the off-time.

The lights have been used previously in an individual manner for experiments with suitable effective intensities and flashing sequences, refer to the report "Gule blinksignaler - statusrapport august 2005".

Additionally, the lights can be used as sequential running lights, in which a delay-time determines the rate of the sequence. This can be done by two methods:

I each light turns on in its specified on-time and then goes off

II each light, after being turned on, stays on until the last light has been on in the specified on-time.

The experiments described below uses the lights as sequential running lights by the above-mentioned methods.

Five additional signal lights are seen in the background of the photo in figure 1. These are commercially available sequential running lights working by the above-mentioned method I. The delay time is approximately 0,2 second and the on-time is approximately 0,1 second (the lights use halogen incandescent lamps). This corresponds to the settings #1 or 2 mentioned later for the experimental yellow lights.

> NOTE: All the lights seem to be on simultaneously in the photo of figure 1 due to the long exposure of the photo.

The two sets of sequential running lights are intended to lead drivers to the left around a work zone and back again behind the work zone. When the photo was taken, the work zone was illuminated by three floodlights on a pole, each with a 1500 W halogen incandescent lamp. When the evaluation of the yellow signal lamps was carried out, these flood lamps had been replaced with two flood lamps with flat, horizontal glass covers, each with a 150 W high pressure sodium lamp.

The evaluations were carried out in the way that a group of observers (participants in the pilot project) were standing at a distance of 50 m in front of the experimental running lights and successively evaluated a number of settings of the lights. The distance of 50 m is intended to be relevant for a driving speed of 50 km/h.

The age of the observers was between 30 and 65 years; the opinions of eldest observers were weighted the most.

Figure 1: Central parts of the experimental arrangement.

2. Daylight evaluation

A daylight evaluation was carried out in conditions of an overcast sky with a daylight illumination level of approximately 8 000 lx on the horizontal.

The settings are all based on effective luminous intensities of 400 cd, as found most suitable in previous experiments. The suitability of this level was confirmed in setting #1 and, therefore, the adjustment of the level intended in setting #2 was not carried out.

The settings are described in table 1, while the evaluations are provided in table 2.

Table 1: Settings used for daylight evaluation.

Setting #	On-time (second)	Effective luminous intensity (cd) *)	Comment
1	0,111	400	method I
2	(this setting was not used)		
3	0,200	400	method I
4	0,500	400	method I
5	0,020	400	method I
6	as setting #5 with an background level of 30 cd		
7	1,0/0,8/0,6/0,4/0,2	400 **)	method II
*) the effective luminous intensity is according to the Blondell-Rey formula **) the effective intensity of the last light in the sequence with an on-time of 0,2 second			

Table 2: Evaluations for daylight conditions.

Setting #	Evaluations
1	OK.
3	Better than 1.
4	Not good. First light is on before the last is off. Confusing.
5	Too short light pulse. Difficult to find direction
6	Better to have a weak background together with the short pulse.
7	Nice and clear.
The daylight favourites are settings #3, 6 and 7.	

3. Night-time evaluation

Night-time evaluations were carried out in late dusk, a bit before total darkness with an ambient luminance level of approximately 1 cd/m^2.

The setting #1 assumes that the most suitable effective intensity in darkness at 50 m distance is 100 cd. This was the result for inexperienced observers (employees at DELTA) in previous experiments. However, experienced observers preferred an effective intensity of 30 cd in these conditions, and therefore setting #2 is introduced in order to decide which of the two levels is preferable for sequential running lights.

As the lower of the two levels of luminous intensity was actually preferred in these evaluations, the other settings were used with this level. As an exception, however, setting #7 was repeated in setting #7b with a lower effective luminous intensity of 20 cd. This is sensible, as four of the five yellow lights are operated in this setting with a longer on-time

than 0,2 second and therefore has a higher effective intensity than the intensity set for the on-time of 0,2 second.

The evaluations were carried out twice; first with no disturbing lights (other than the second sequential running light) and with the work place lighting turned off; and next with a VTI van placed in the work zone with blinking warning lights turned on - and also with the work zone lighting turned on.

For the two cases, the settings are described in tables 3 and 5 respectively, while the evaluations are provided in tables 4 and 6 respectively.

Setting 3, 6 and 7 were filmed from the VTI instrumented car.

Table 3: Settings used for evaluation in dusk/night without disturbing lights.

Setting #	On-time (second)	Effective luminous intensity (cd) *)	Comment
1	0,111	100	method I
2	0,111	30	method I
3	0,200	30	method I
4	0,500	30	method I
5	0,020	30	method I
6	as setting #5 with an background level of 8 cd		
7	1,0/0,8/0,6/0,4/0,2	30 **)	method II
7b	1,0/0,8/0,6/0,4/0,2	20 **)	method II
*) the effective luminous intensity is evaluated by the Blondell-Rey formula **) the effective intensity of the last light in the sequence with an on-time of 0,2 second			

Table 4: Evaluation of dusk/night settings without disturbing lights.

Setting #	Comments
1	Too short pulses. A bit too strong.
2	Better than 1. Not too bright. Could have been even less light (but remember that we were standing at 50 m)
3	Good.
4	Too long pulses. Comments that something in between 0,2 and 0,5 second would be ideal (mix of 3 and 4).
5	Too short pulses. Direction difficult to perceive.
6	Background level too bright. Short pulses are easier to perceive with a little background light in addition.
7	A little too bright.
7b	OK light level.
The dusk/night favourites without disturbing lights are 3 and 7(b). Setting 1 which was “OK” at daylight, was not well received at dusk/night.	

Table 5: Settings used for evaluation in dusk/night with disturbing lights.

Setting #	On-time (second)	Effective luminous intensity (cd) *)	Comment
2	0,111	30	method I
3	0,200	30	method I
6	as setting #5 with an background level of 8 cd		
7	1,0/0,8/0,6/0,4/0,2	30 **)	method II
7b	1,0/0,8/0,6/0,4/0,2	20 **)	method II
*) the effective luminous intensity is evaluated by the Blondell-Rey formula **) the effective intensity of the last light in the sequence with an on-time of 0,2 second			

Table 6: Evaluation of dusk/night settings with disturbing lights.

Setting #	Comments
2	Not good. Confusing with the blinking warning lights on the van, which had almost the same frequency as the sequential running lights.
3	OK.
6	Too many blinks at different places. Same problem as in 2.
7	Not very different from 7b, might be better to draw attention away from blinking warning lights of the van.
7b	OK
The dusk/night favourites with disturbing lights are 3 and 7.	