Preferable luminous intensity of a pair of yellow flashing lights on road signs

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Foreword and conclusions

The test described in this note test has been requested by the Danish Road Directorate, but is related to a joint Nordic research project on the use of light and problems caused by light at road works at night.

The test has been carried out with assistance from several persons at DELTA helping to run the experiment and taking part as test persons.

Some tests of yellow flashing lights have already been carried out within the above-mentioned project at various locations.

This particular test concerns yellow flashing light mounted on road signs in order to draw attention. Section 1 describes the equipment and the test persons, section 2 the test results while section 3 provides a discussion and conclusions.

It is concluded that the luminous intensity of a pair of yellow flashing lights on a road sign can be approximately the same as for flashing lights used in isolation or in a group of sequential running lights. However, there is an indication that the luminous intensity of yellow flashing lights on a road sign should be reduced a bit – which is also logical in view of the need to read the road sign.

The actual retroreflectivity of the road sign was varied in three levels and did not show a significant influence on the preferred luminous intensity. Hwever, there is an indication of a weak influence in the direction of a lower intensity for road signs of low retroreflectivity.

In order to complete the basis for establishing national regulations for yellow flashing lights at road works it is being considered to carry out an additional test of this nature involving yellow flashing lights used as flashing arrows of crosses.

1. Equipment and test persons

Figure 1 illustrates a road sign with a pair of yellow flashing lights placed 100 m in front of a passenger vehicle. This distance is intended to represent conditions on a motorway.

The location is the road from Venlighedsvej onto the location of DHI at the Scion – DTU Science Park. The road is fairly dark except for some spill light from office windows and a low level of lighting by a few lanterns. The lighting level is lower than on a motorway with road lighting, but higher than on an unlit motorway.

The yellow flashing lights are conventional 20 cm diameter lights with front lenses that have been refitted by DELTA so as to be adjustable in terms of intensity, frequency and duration of the flashes and some other matters.

The yellow flashing lights were directed towards the passenger car and set to 1 flash per second of 0,5 second duration. The flashes of the two lights were set to be simultaneous instead of

alternating as is sometimes seen at road works. The lights were used with three intensities of 30, 100 and 300 cd.

In one additional experiment, the duration of the flash was set to 0,2 second.

In order to include the level of retroreflectivity of the sign as an independent parameter of the test three signs were used with different retroreflective sheeting materials:

- EG, enclosed lens known as Engineering Grade
- HI, encapsulated lens known as High Intensity
- HIP, a microprismatic sheeting material produced by 3M.

The passenger car was a Peugeot type 408.

With this car, the luminance created by the headlamp illumination and as seen from the driver seat was 1,4; 2,5 and 9,0 cd/m^2 for the three signs respectively. The luminance does actually vary across the sign faces, but the above-mentioned luminance values were measured at a central location and taken to be representative of the general luminance level.

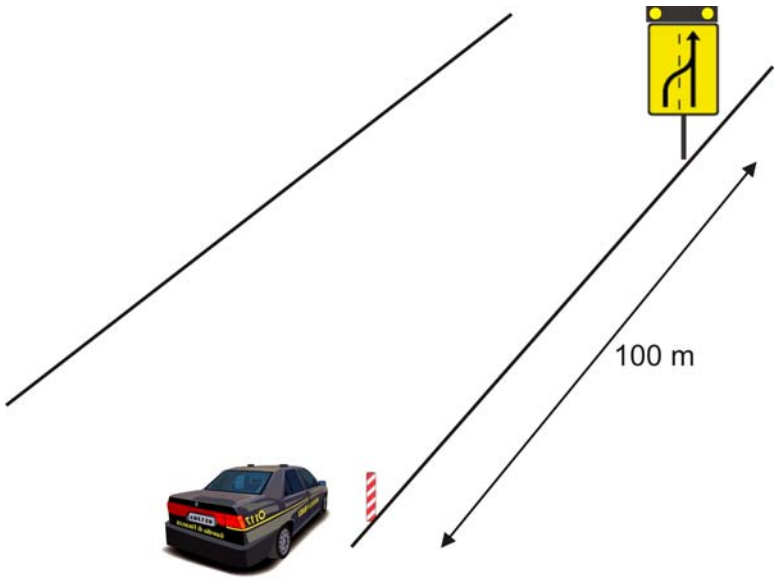

Figure 1: Road sign with a pair of flashing lights placed 100 m in front of a passenger car.

Figure 2 illustrates the three luminous intensity values of the flashing lights for one of the road signs.

The tests took place after dark from approximately 16:20 hours until approximately 18:00 hours on 7, 8 and 9 January 2008 using respectively the HIP, EG and the HI signs. Persons working at DELTA, as they were leaving work, were asked to take part and offered soup in order to make them wait for their turn.

Some persons took part on only one of the three nights, some two out of three nights and some all three nights. In total approximately 30 persons took part each of the nights.

A test person was asked to enter the driver seat of the passenger car. In case of a queue, one more test person was asked to enter the passenger seat.

The persons were instructed to imagine that they were driving towards the sign on a motorway and asked to rate the yellow flashing lights for their ability to draw attention without making it difficult to read the sign or causing glare.

The test persons saw the three luminous intensities presented in random order and were allowed time on their own request.

Each rating was indicated by a mark on a 150 mm long horizontal line equipped with an indication of ”suitable” in the middle, ”too weak” at about ¾ to the left end and ”too strong” at about ¾ to the right. The marks could be placed outside of the indications of ”too weak” or ”too strong” as well as inside.

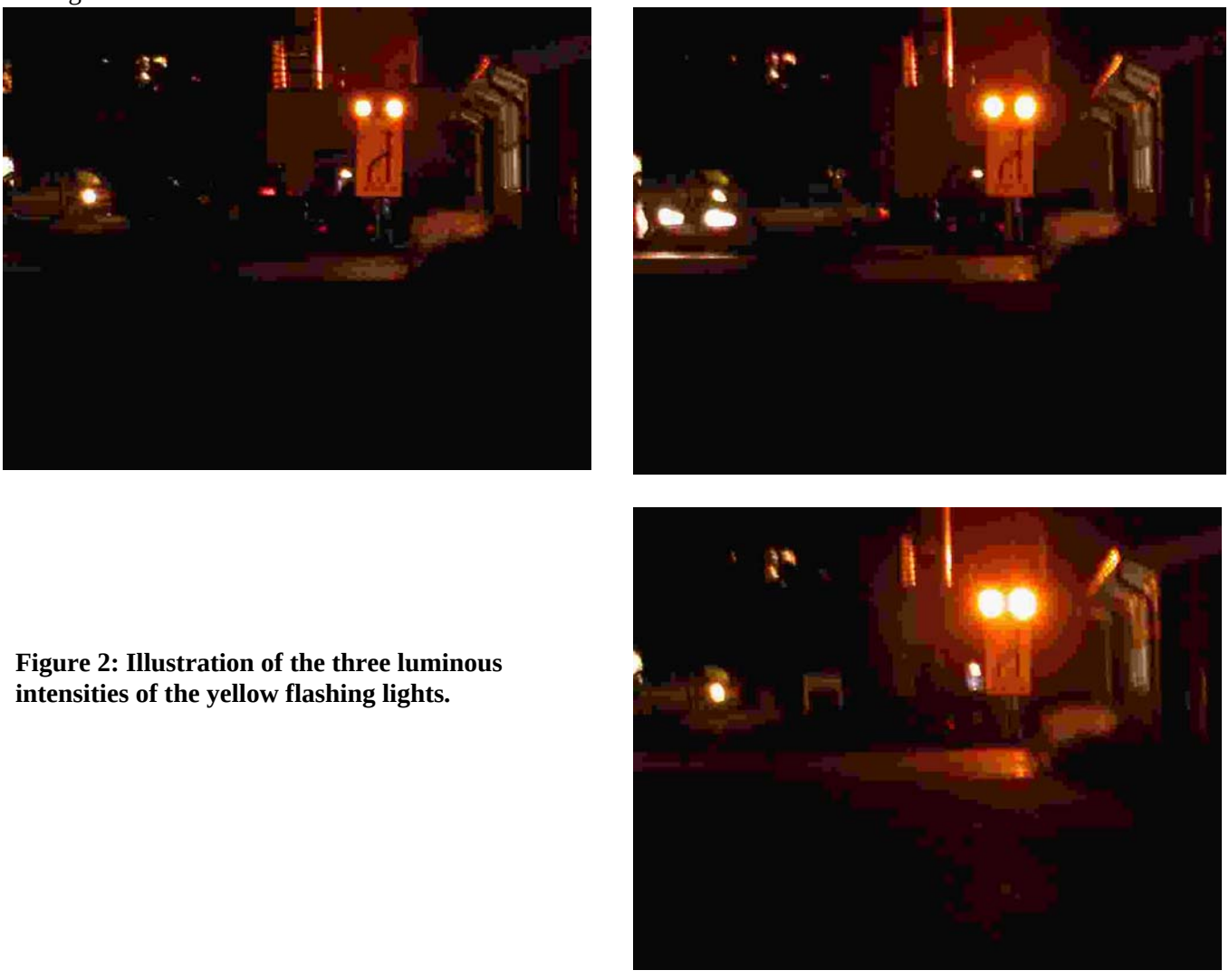

Figure 2: Illustration of the three luminous intensities of the yellow flashing lights.

2. Test results

The marks were converted into rating values by means of the signed distances from the indication of ”suitable” to the marks. The distance is negative for marks to the left and positive for marks to the right. ”Too weak” corresponds to -55, ”suitable” to 0 and ”too strong” to 55.

These values are shown in annex A. An inspection of the values shows clearly that the test persons have different preferences for luminous intensity – for instance the rating 0 for suitable is given to all three intensities by different test persons. This variation between test persons is a strong factor and highly significant.

The variation among test persons shows that it is not possible to satisfy all test persons with the same intensity. Experiments of this nature do invariably lead to such conclusions – perhaps because different persons define different criteria for the evaluation by themselves in spite of having all received the same instruction.

Some of the variation among test persons may be due to physiological factors such as more or less sensitivity to glare. This, on the other hand, could be linked to the age of each test persons which was recorded and ranges from 20 to 60 years. However, there is no correlation between the level of the ratings and the age of the test persons.

The normal thing to do is to base the analyses on the average ratings of observers. These were calculated for the different intensities and signs and are illustrated in figure 3.

The luminous intensity is seen to be a strong factor and its influence is highly significant. The most preferable intensity of the three is 100 cd, but should perhaps be as little less.

The sheeting material seems also to be a factor. At the intensity of 100 cd, the average rating decreases - as if the lights seems less strong – when the luminance of the road sign increases in the order of the EH, HI and HIP materials. However, this factor is not strong, it is not apparent for the other two intensities and its influence is not significant.

The additional test with 0,2 second flash duration was carried out by mistake on the first evening until the error was noted and the flash duration was corrected to 0,5 second. However, this mistake gives an opportunity to compare the average values for the two flash durations for the sign with HIP material.

This comparison is illustrated in figure 4. It is seen that the 0,2 second flash duration leads to lower rating values than the 0,5 flash duration. This applies for all three intensities and is highly significant.

The effect of the flash duration is as if the effective luminous intensity is lower for the 0,2 flash duration than for the 0,5 second flash duration. This, on the other hand, agrees with the calculation of the effective luminous intensity according to the 'Blondell-Rey' method used in EN 12352:2000 'Traffic control equipment - Warning and safety light devices'.

The result of such a calculation is that the effective luminous intensity of the 0,2 second flash duration is 30% lower than for the 0,5 second flash duration – for the same nominal intensity. The effect on the rating values should be approximately one third of the effect of changing from one intensity level to the next. That is not unreasonable in view of figure 4.

3. Discussion and conclusions

Previous tests of a similar nature indicate that the preferred luminous intensity of yellow flashing lights used both single and as sequential running light is approximately 30 cd in dark surroundings when observed at 50 m distance.

> NOTE 1: This intensity applies for a long flash duration of 0,5 second. A comparison to shorter flash durations requires a conversion to effective luminous intensities according to the 'Blondell-Rey' method used in EN 12352:2000 'Traffic control equipment - Warning and safety light devices'.
>
> NOTE 2: Comparison to other distances than 50 m requires scaling according to the square distance as the stimulus is the illuminance at the observer's eye.
>
> NOTE 3: In situations with daylight, the preferred luminous intensity is much higher depending on the daylight level.

At 100 m distance the above-mentioned intensity of 30 cd at 50 m distance corresponds to 120 cd, which is not far from the preferred intensity in this test of 100 cd or perhaps a bit less.

It is concluded, therefore, that the luminous intensity of a pair of yellow flashing lights on a road sign can be approximately the same as for flashing lights used in isolation or in a group of sequential running lights. However, there is an indication that the luminous intensity of yellow flashing lights on a road sign should be reduced a bit – and this is logical in view of the need to read the road sign.

The actual retroreflectivity of the road sign was varied in three levels and did not show a significant influence on the preferred luminous intensity – there might be a weak influence in the direction of a lower intensity for road signs of low retroreflectivity.

The additional test with 0,2 second flash duration compares well to those with 0,5 second flash duration, when taking effective luminous intensities into account.

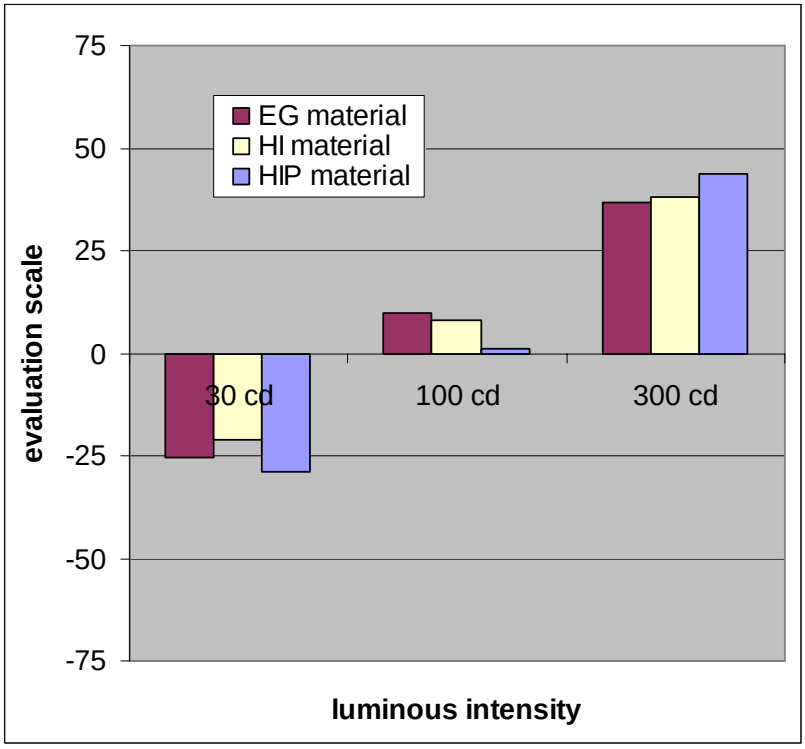

Figure 3: Average rating values for three luminous intensities of 30, 100 and 300 cd and three road signs with EG, HI and HIP materials.

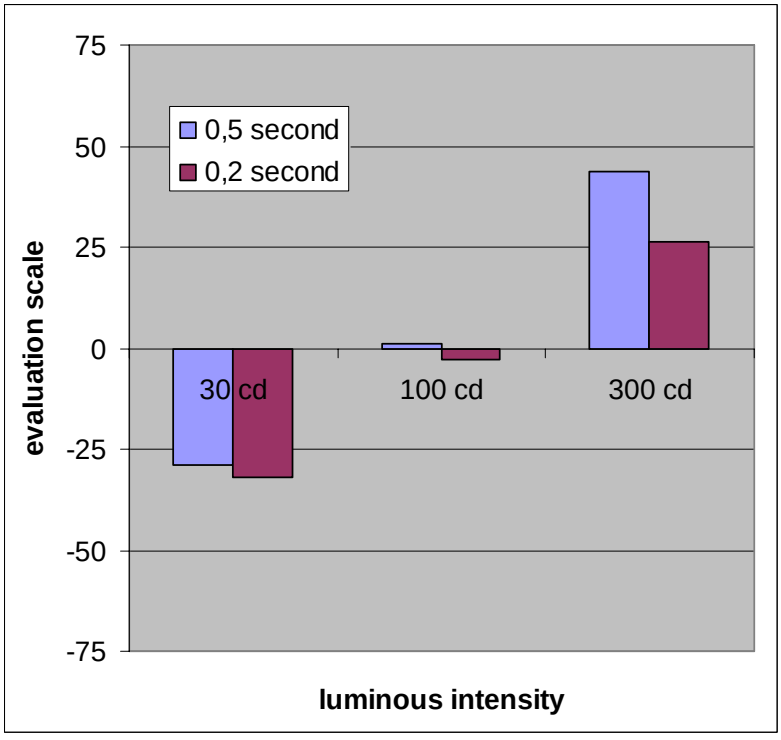

Figure 4: Average rating values for three luminous intensities of 30, 100 and 3000 cd and duration of the flash of either 0,2 or 0,5 second.

Annex A: Rating values for a pair of yellow flash lights on road signs

The rating values are derived from marks set by test persons on a 150 mm line equipped with indications of ”too weak”, ”suitable” and ”too strong”.

The rating values are signed distances of the marks from the indication of ”suitable” . The distance is negative for marks to the left and positive for marks to the right. ”Too weak” corresponds to -55, ”suitable” to 0 and ”too strong” to 55.

The evaluations were carried out for three road signs with EG, HI and HIP retroreflective materials. The rating values are provided in tables A.1, A.2 and A.3 respectively.

For the road signs with EG and HI materials the flash duration was 0,5 second while for the road sign with HIP material flash durations of both 0,5 and 0,2 second were used. Accordingly, table A.3 has been split into two sub-tables.

Table A.1: Rating values for the road sign with EG material.

test person	luminous intensity (candela)		
	30 cd	100 cd	300 cd
1	-12	28	55
2	3	37	53
3	-23	-2	31
4	-15	0	0
5	-48	-2	22
6	0	21	28
7	-42	0	44
8	26	50	59
9	-14	8	20
10	-37	7	30
11	-37	13	55
12	-54	34	58
13	-52	-6	44
14	-56	-2	34
15	-8	27	55
16	32	7	48
17	-31	21	55
18	-39	-16	39
19	-20	19	5
20	-4	17	61
21	-42	-14	0
22	-49	8	52
23	-48	-4	-4
24	-17	-10	62
25	0	35	57
26	-55	0	0
27	0	-11	22

Table A.2: Rating values for the road sign with HI material.

test person	luminous intensity (candela)		
	30 cd	100 cd	300 cd
1	-2	19	56
2	-10	11	50
3	-6	0	28
4	-41	20	55
5	-23	19	50
6	-53	0	12
7	15	41	69
8	0	28	55
9	-55	0	30
10	0	22	48
11	0	9	47
12	-48	-13	51
13	-11	3	13
14	-7	1	27
15	-9	31	53
16	8	44	57
17	-2	15	44
18	-4	12	48
19	-60	-21	21
20	-28	12	44
21	-22	-4	23
22	-31	4	17
23	-44	12	49
24	-32	-1	14
25	0	19	39
26	0	6	18
27	-52	-48	-1
28	-44	1	30
29	-56	-2	54
30	-33	0	38
31	0	11	37

Table A.3: Rating values for the road sign with HIP material
- upper table: flash duration of 0,5 second
- lower table: flash duration of 0,2 second.

test person	luminous intensity (candela)		
	30 cd	100 cd	300 cd
1	13	9	42
2	-35	-20	0
3	-11	8	65
4	-6	8	48
5	-50	-9	42
6	-38	0	40
7	-55	-33	55
8	-35	12	48
9	-28	-5	40
10	-33	0	25
11	-39	44	75

test person	luminous intensity (candela)		
	30 cd	100 cd	300 cd
1	-20	3	33
2	-2	29	55
3	-39	0	36
4	-55	0	55
5	-66	25	50
6	-46	-46	0
7	-41	-24	0
8	-41	17	16
9	0	-15	37
10	-9	11	29
11	-43	-8	10
12	-55	0	4
13	-55	-17	24
14	0	0	29
15	-55	-23	0
16	-11	0	27
17	0	0	55
18	-26	4	48
19	-32	6	28
21	-46	-16	-8