Preferable luminous intensity of a yellow flashing arrow

Kai Sørensen and Torben Holm Pedersen, DELTA, 28 March 2008

Foreword and conclusions

The test described in this note test is part of 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 persons at DELTA helping to run the experiment, taking part as test persons and contacting other 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 a yellow flashing arrow. Section 1 describes the equipment and the test persons, section 2 the test results, while section 3 provides a discussion and conclusions.

There is an indication that the luminous intensity of lights forming a yellow flashing arrow could be reduced a bit compared to other applications of yellow flashing lights – which is logical in view of the number of lights forming the flashing arrow.

However, the tests are taken to demonstrate that the preferred luminous intensity of flashing lights varies little with the application, and that the same level of luminous intensity should be applied for practical reasons.

1. Equipment and test persons

Figure 1 illustrates a yellow flashing arrow placed 100 m in front of two passenger vehicles.

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 arrow was made available by Multi Afspærring ApS, Ølandsvej 2, 8800 Viborg together with a special control box that allows setting of the luminous intensity in a fairly large number of steps.

An additional light identical to the lights forming the flashing arrow was also made available. This light was also supplied by the control box and was used to determine the luminous intensity in the reference direction as a function of the setting.

The additional light and the pattern formed by nine lights in the arrow are also shown in figure 1. A light has a powerful LED behind a 20 cm lens. The lights emit 1 flash per second of 0,5 second duration. The lights were used with settings of approximately 31, 52, 104, 166 and 307 cd.

> NOTE: The intention was to use settings of 30, 55, 100, 173 and 300 cd; the above-mentioned settings were the closest allowed by the control box.

The passenger cars were placed at a position in a distance of 100 m in front of the arrow, and the arrow was aligned so that the beams of light were aimed towards the cars. The distance of 100 m is intended to represent conditions on a motorway.

The test took place after dark from approximately 20 hours until approximately 21:30 hours on 27 March 2008. A total of 13 test persons took part, some of them persons working at DELTA, and some taking part for a modest fee.

The two passenger cars had room for four test persons at a time in the driver and passenger seats. The test persons were instructed to imagine that they were driving towards the arrow and they were asked to rate the yellow flashing arrow for its ability to draw attention without causing nuisance or glare.

The five settings of the flashing arrow were presented in a random sequence three times in each session. The test persons were allowed time on their own request for the ratings.

Accordingly, each test person provided a rating of each luminous intensity setting of the flashing arrow with three repetitions. A 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.

2. Test results

The rating marks were converted into values by means of the signed distances in millimetres 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.

The average values for the three repetitions are shown in table 1. The standard deviation between repetitions was 14 as an average for the test persons.

An inspection of the values shows that the test persons have different preferences for luminous intensity. This variation between test persons is a strong factor and highly significant. Experiments of this nature do invariably show this feature – perhaps because individual persons define different criteria for the evaluation by themselves in spite of having all received the same instruction.

Some of the variation between 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 the test persons. These were calculated for the different intensities and are illustrated in figure 2.

The luminous intensity is seen to be a strong factor and its influence is highly significant. The most preferable intensity (closest to 0 for suitable) of the three is 104 cd. However, the trend line added in figure 2 indicates that the most preferable intensity is approximately 80 cd (it indicates a rating of 0 for suitable at this intensity).

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. Other previous tests indicate that the preferred intensity of yellow flashing lights on retroreflective road signs in the same conditions is approximately 100 cd.

This test points to a somewhat lower preferred intensity of approximately 80 cd for yellow flashing lights forming a flashing arrow.

It seems natural that the preferred intensity should actually be somewhat lower, as the flashing arrow is formed by several flashing lights sitting fairly close together. Therefore, it might be considered to graduate the intensity of yellow flashing lights with the application:

- approximately 120 cd for single and as sequential running light
- approximately 100 cd for a pair of flashing lights on road signs
- approximately 80 cd for flashing lights forming a flashing arrow.

However, it is uncertain if these tests really prove that preferred luminous intensity varies with the application. Additionally, the variation is small in terms of both ratings supplied by test persons and the production variability of flashing lights.

Therefore the tests should rather be taken to demonstrate that the preferred luminous intensity of flashing lights varies little with the application, and that for practical reasons the same level of luminous intensity of approximately 100 cd should be the target.

Figure 1: A flashing yellow light (top left), the pattern of nine lights forming a flashing yellow arrow (top right) and two passenger cars at a distance of 100 m in front of the flashing arrow.

Table 1: Average rating values.

Test person	Luminous intensity 31 cd	52 cd	104 cd	166 cd	307 cd
1	-13	-9	17	22	50
2	-54	-42	-14	21	54
3	-37	-23	-2	6	46
4	-65	-60	6	23	21
5	-25	-14	20	35	55
6	-30	-7	11	29	61
7	-14	0	13	24	53
8	-16	1	9	29	51
9	-57	-19	1	56	58
10	-21	0	12	21	44
11	-40	0	11	44	55
12	-18	18	0	37	55
13	-31	-12	4	18	44
average	-32	-13	7	28	50

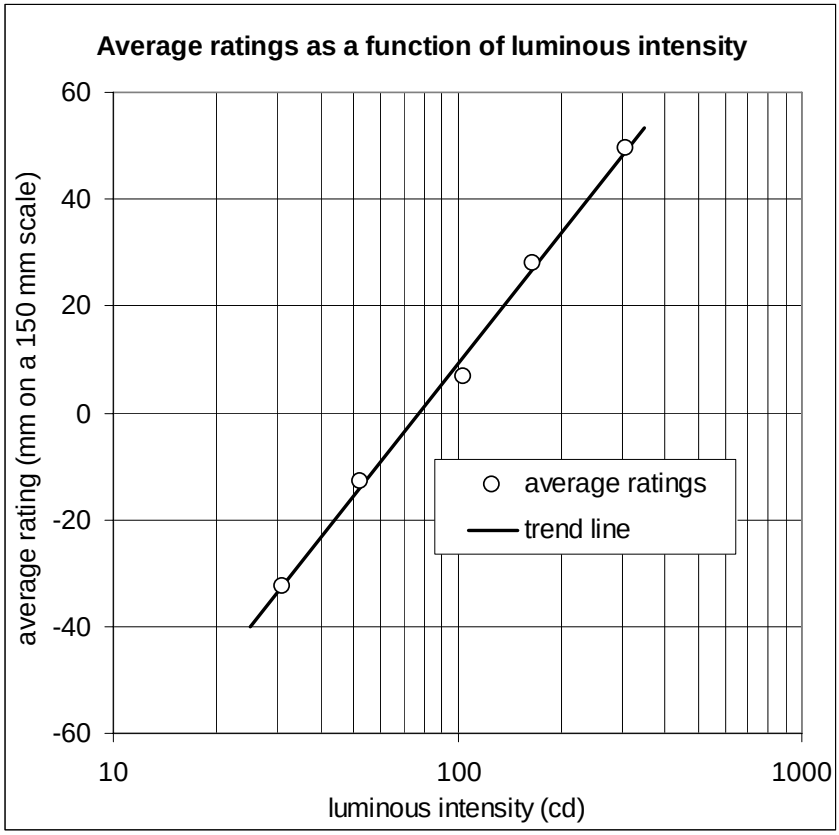

Figure 2: Average ratings as a function of luminous intensity.