

**GENERAL DIRECTORATE OF HIGHWAYS**  
ROAD IMPROVEMENT AND TRAFFIC SAFETY PROJECT  
**TRAFFIC SAFETY PROJECT**

**REFLECTIVE MATERIALS FOR  
VERTICAL SIGNS**

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## **1 Introduction**

### **1.1 Background**

There are many different reflecting materials for vertical signs on the market, types as well as brands. New products are coming on the market all the time. The companies making the reflecting sheetings are marketing their products on central, regional and local level at the road administration and at the municipalities. Depending of the interest from the persons in different responsible positions, the choice of standard for the reflective material varies a lot along the roads. For the road users (the drivers), this is not a good situation. Sometimes the signs can hardly be seen, depending on low (or even lack of) retroreflection from the signs. In some other areas the signs have even too strong retroreflection and there are risks for blindings of the drivers.

### **1.2 Cost effectiveness**

The cost for different reflective materials varies a lot. In Turkey there are problems with stealing and destroying signs – the average lifetime for many signs are therefore not so long. This means that in areas where destroying and stealing signs are frequent, it is not a good idea to make calculations on the longer lifetime for the more expensive reflective materials, as they may have disappeared a long time before the reflective sheetings are worn out. In other places, like on motorways and in gantries, the signs can be kept alone and the possible lifetime of the signs can be included, when making the choice of reflective material.

### **1.3 The task**

The aim with this report is to suggest a manual with a standard, valid for all Turkey, for the retroreflection from vertical signs. The retroreflective standards are chosen to achieve good traffic safety at reasonable costs. The suggestion is made in an uncomplicated way, so that the manual could be used as a simple handbook for all levels around Turkey.

In many cases, which will be shown later in this report, the normal performance reflective materials are fully acceptable for a good traffic safety. One of the problems in this matter in Turkey, as well as in other countries, is that the standards and the costs are gradually increased without responsible calculations. The result is sometimes therefore a standard that is higher than needed.

## **2 Studies and experiences in this matter**

There have been many studies about reflective materials during the late 1990-s. Some of these results can be interesting for Turkish circumstances.

### **2.1 Sign function**

To control the function of the signs, measurements have been made on a huge number of signs of different quality, age and with different reflective materials. The measurements have been carried out with the instrument RetroSign. The instrument is held directly on the sign,

and the values are corresponding to what a driver can see on a distance of 100 meters, with an observation angle of 0.33 degrees if the sign is turned away from the driver with 5 degrees.

If a sign shall have a good readability from a vehicle under dark conditions, the reflective sheeting should have a retroreflection that is high enough, to give an acceptable luminance. However, if you have very high retroreflection, you get too high a luminance from the white and yellow material and this makes the sign hard to read (the luminance from white and yellow is "taking over").

The result from the study shows that the reflective materials on the market often have enough retroreflection, for the sign to have acceptable readability for vehicles with dipped headlights. With full headlights you often get too high luminance, which gives reading problems. The study also shows, that the aging of the signs is very slow, and there is no reason to measure signs younger than 10 years, if the signs have not been damaged in any way.

There have been a lot of studies on the subject when signs should be exchanged. Summarized, these studies give a needed value for the luminance of 1-2  $\text{cd/m}^2$ . The sign is then readable even with glare from oncoming traffic. This corresponds to a minimum retroreflexion of 10-20  $\text{cd/m}^2 \cdot \text{lx}$  for a sign on right hand, located on the ground. The value for signs located on the left hand on the ground is 15-30  $\text{cd/m}^2 \cdot \text{lx}$ . For a gantry-mounted sign, the minimum value is 25-50  $\text{cd/m}^2 \cdot \text{lx}$ .

The study includes signs with an age up to 15 years. The only group, where you can find values below acceptable luminance, is signs with normal performance reflective sheeting mounted in gantries. The recommendation is therefore always to have high performance reflective material or better on signs in gantries.

## 2.2 Probable lifetime for the signs

A special Swedish investigation has been carried out lately, to find probable lifetime for different reflective materials, and also give values of the retroreflection, when the sign has to be exchanged. The results of the studies correspond to the ones mentioned above. Signs up to 18 years old have been measured.

The studies showed that all signs with an age not more than 15 years, gave a luminance over 1  $\text{cd/m}^2$  for vehicles with dipped head-lights.

The result from the investigation has resulted in a Swedish regulation with retroreflection values when signs should be exchanged. There are some small differences in the needed figures for signs located on the right hand and on the left hand, but to make an uncomplicated regulation these signs have been collected into one group.

**The following values for retroreflection should be used:**

<b>Ground mounted signs:</b>	<b>Minimum 20 <math>\text{cd/m}^2 \cdot \text{lx}</math> for white color.</b>
<b>Gantry mounted signs:</b>	<b>Minimum 30 <math>\text{cd/m}^2 \cdot \text{lx}</math> for white color.</b>

**For the other colours, the following coefficients should be used:**

<b>Yellow</b>	<b>0,7</b>
<b>Red</b>	<b>0,2</b>
<b>Blue</b>	<b>0,06</b>
<b>Green</b>	<b>0,14</b>

The figures are meant for normal dark and also illuminated traffic environment, and give a certain margin for somewhat dirty signs. In the cases, where the traffic environment includes a great deal of disturbing light sources, like for instance in city centres, the figures have to be raised.

In SweRoads earlier report about Signs and Markings for Pilot Roads, somewhat higher values were mentioned. However with the knowledge from these new studies, SweRoad recommend the values above to be valid also for Turkey.

Several different reflective materials have been investigated in Sweden. The following materials were approved for use on the Swedish roads (early year 2000). There are three groups:

- C1 = Class 1 = Normal performance reflective materials
- C2 = Class 2 = High performance reflective materials
- C3 = Class 3 = Microprismatic reflective materials.

<b>Material</b>	<b>Supplier</b>	<b>Calculated lifetime Years</b>	<b>Group</b>
Kiwalite EG	Kiwaflex	12	C1
Scotchlite EG	3M	12	C1
Nikkalite EG ser. 81	Nippon Carbide	12	C1
Nikkalite EG ser. 71	Nippon Carbide	12	C1
Kiwalite SEG	Kiwaflex	15	C1
Nikkalite SEG ser 180	Nippon Carbide	15	C1
Nikkalite SEG ser 170	Nippon Carbide	15	C1
Scotchlite HI	3M	18	C2
Nikkalite ULG ser 8	Nippon Carbide	18	C2
Nikkalite ULG ser 7	Nippon Carbide	18	C2
Stimsonite 6200	Stimsonite	18	C3
Diamond G 3990	3M	*	C3
Scotchlite FDG 3951	3M	*	C3
Scotchlite DG 3970	3M	*	C3
Scotchlite DG 3991	3M	*	C3

\*/ Rather new products – no lifetime calculated yet

### **2.3 Ageing of reflective sheetings**

A large project has been carried out in Nordic co-operation (Finland, Norway, Denmark, Iceland and Sweden). All reflective sheetings for road signs on the Nordic market in 1997 were mounted on identical test signs, which have been exposed to traffic at 9 test sites. These test sites were chosen to cover a large variation in climate.

After measurements on the new test signs upon mounting them at the test sites in 1997, measurements of retroreflection on all the test samples, after cleaning, were carried out in the period August – September every year. In 2000 these measurements were complemented with measurements of color on seven test signs in Denmark and three test signs in Sweden.

The result of the 3-year period 1997 – 2000 are presented in a report. The results show a small reduction in retroreflection for most of the reflective sheetings. But there were also some sheetings which show a large loss in retroreflection over these first three years in traffic (30 – 40 %).

The result of the color measurements shows that a relatively large proportion of the measurement values did not fall inside the limits specified for the signal colours. The only color for which all measurements fulfil the requirements was blue.

The results for the tested types of reflective sheetings and for the colors do not constitute a good basis for the prediction of further changes of the reflective sheetings in future years.

The project continues with annual measurements of retroreflection and colour.

## **3 Suggestion for the manual and comments**

The aim has been to make a suggestion for the choice of reflective sheetings on the vertical signs, that is as simple as possible. The idea is that the final manual shall be possible to print on a simple leaflet, that can be kept in the pocket and be well used under all different circumstances. The traffic safety aspects and cost effectiveness has been balanced as well as possible, taken into account present knowledge (available materials and price indications for reflective sheetings).

The suggestion for manual is presented in Appendix 1. The reflective sheeting materials are divided into the three groups C1, C2 and C3 mentioned under chapter 2.2.

### **3.1 Specifications**

The specifications for the two groups C1 (Normal performance retroreflection) and C2 (High performance retroreflection) can be found in the CEN (European committee for standardisation) document prEN 12899-1 (See Appendix 2). This is a draft, but the work with the creation has been in progress for a long time. The specification will probably be ratified by the member states early next year. There are only minor details still under discussion, so the document is already now possible to use, when it comes to color and retroreflection.

For the third group, C3 (microprismatic retroreflection), there is no official European specification yet. 3M company has made a suggestion for a standard. However, it is unclear at this moment, if the standard is accepted by the other companies producing microprismatic material. (On the Swedish market, Stimsonite and Nikkalite can be found). This suggestion for specification can be found in Appendix 3.

### 3.2 Cost situation

The cost for the different reflective sheetings varies from country to country. This is of course depending upon the purchased volumes and the competition situation. In Sweden there has been a good competition for materials in the C3 group, which has led to that the cost difference between the two groups C2 and C3 has become very small. As an example, 3M-s listed prices for Sweden can be mentioned:

C1	Engineer Grade	10,50 US\$/m <sup>2</sup>
C2	High Intensity	29,80 US\$/m <sup>2</sup>
C3	Diamond Grade	32,40 US\$/m <sup>2</sup>

A normal variation for Europe, is, according to 3M, that C3 (Diamond Grade) is 20% more expensive than C2 (High Intensity). As Turkey has bought very small volumes of the prismatic material, the cost has been very high. When volumes are increasing, the prices will approach those mentioned above.

The suggested manual is prepared from an overall price situation.

### 3.3 Comments on the suggested table

#### 3.3.1 General comments

At a first look at the table, it seems as if normal performance materials are very rarely suggested. In fact the situation is the opposite. Most of the signs belong to the group for signs located on not illuminated highways, and, as mentioned before, several reports show that normal performance materials are good enough for these situations.

There are some differences for luminance from signs mounted on left side of the road and from signs mounted on right side, but these minor differences are not separated in the suggested manual.

For over-head signs in gantries, the luminance at night time is considerably lower, and because of this, the manual shows higher demands for these groups. The local price situation for retroreflecting sheetings of course must be reflected in such a manual. If the difference between C2 and C3 is very high, only the gantry-mounted signs with the most problematic locations should have C3 sheetings. On the other hand, with only a price difference of 10% from C2, as in Sweden, all gantries can have sheetings from the C3 group. What you now can see in western parts of Europe, is that most countries uses the prismatic materials in gantries, as this gives substantially better luminance values.

The table does not make any difference for signs in rural and urban environment. According to our opinion these differences are taken care of through differences in illumination and/or

disturbing external light sources. In the table there are higher demands for illuminated environments. In urban areas with dark environments, the normal performance materials should be good enough. It is important to avoid too bright, glaring signs, while looking out for vulnerable road users.

### 3.3.2 Signs, which need special attention

#### 3.3.2.1 Stop, give way

This group of signs is most important to be seen for a good traffic safety. They shall always have sheetings from C2, and in special circumstances from C3.

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#### 3.3.2.2 Pass this side

These signs are located on center islands, and some other islands separating the traffic. Sometimes they are located in a position, which give a bad luminance. Hitting islands can cause serious accidents, so the suggestion is to use C2 or C3 on these signs.

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#### 3.3.2.3 Signs for railway crossings

This is another important group of signs, which need extra attention. In Turkey there are several open unguarded level crossings. They often appear on unexpected places, and accidents that happen are normally serious. The lowest class recommended for these signs is also C2.

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#### 3.3.2.4 Pedestrian crossings

This group includes, besides the normal sign for pedestrian crossings also the three warning signs for pedestrian crossings, children and bicycles. The vulnerable road-users are almost always a problem, when mixed with the cars, trucks and buses. Level crossings should only be signed on roads with maximum speed 50 km/h or less. C2 is recommended for this group.

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#### 3.3.2.5 Markers for bends, gore areas, obstacles and limited access

To show the geometry of the road in a good way is very important. First of all this is done with roadside delineators, widely used in Turkey. However, when sharp bends, obstacles along the roadside, gore areas and in some other cases, you have to add markers of different kinds.

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These signs are even more important for the speed adaptation, than the speed limit signs themselves. For a good speed adaptation, these signs often should be seen at a long distance and in big side angles from the headlamps of the vehicles.

Lowest class for this group is also suggested to be C2.

#### 3.3.2.6 Road works

Both reconstruction and maintenance works on the roads create dangerous situations. The road works often appear on unexpected locations. Both for the road users and the workers in the work zones it is very important with visible signs. Signs for road works should always have C2 or C3.

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#### 3.3.2.7 Fluorescent signs

Fluorescent reflective sheetings have been introduced on the market in different colors. While daylight, signs with these sheetings have extremely good visibility. In western parts of

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Europe, the use of these materials is increasing a lot, mainly in connection with road works, but also on dangerous sections which need special attention, such as black spots.

The suggestion for Turkey is to use fluorescent sheetings in connection with road works and black spots. How widely they shall be used, must of course be adjusted to the price situation.

#### **4 The future**

The development of reflective materials is continuing all the time. The production of microprismatic materials will probably be more and more rationalised, and there will be more actors on the market, producing such sheetings of good quality. This will result in reduced prices.

However, as mentioned before, it is important to balance the retroreflection for the actual situation, so that the luminance is not too high.

The future will most probably include microprismatic materials with different retroreflection levels for different circumstances at good prices.

The Turkish manual for the use of reflective sheetings must be adjusted regularly in the future, with adaptation to the market.

**Appendix 1**

<b>Choice of reflecting material for vertical signs</b>					
Type of sign	Location	Environment			
		Roads with none or little illumination and without disturbing external light sources		Road illumination of good quality and/or seriously disturbing external light sources	
		Motorways (1)	Other roads	Motorways (1)	Other roads
All, except those mentioned below	Ground	C2	C1	C2	C2
	Gantry	C2 (3)	C2 (3)	C3	C3
Stop		C2	C2	C2 (3)	C2 (3)
Give Way		C2	C2	C2 (3)	C2 (3)
Pass this side, located in center of road		C2	C2	C2 (3)	C2 (3)
Signs for railway crossings		-	C2	-	C2 (3)
Pedestrian crossings (2)		-	C2	-	C2
Markers (for bends, gore areas, obstacles and limited access )		C2	C2	C2 (3)	C2 (3)
Road Works (4)		C2	C2	C2 (3)	C2 (3)

C1 = Class R1, according to prEN 12899 specification (Normal performance reflective material)

C2 = Class R2, according to prEN 12899 specification (High performance reflective material)

C3 = Class R3, according to suggested specification for Microprismatic reflective material (see Appendix 3)

(1) This group also include other roads with 2 or more lanes in the same direction.

(2) This group also include the three warning signs: pedestrian crossing, children and cyclists.

(3) In specially exposed illuminated roads and/or on roads with heavy traffic volumes, class 3 should be preferred.

(4) This group include all signs for road construction and maintenance works.

**Fluorocent reflecting material should be used:**

a. On signs at Black-Spots with severe accidents, if there are no plans for reconstruction in the near future.

b. On signs for road works, if the traffic volumes are high and/or if there are other special dangerous circumstances.