LARGE SCALE EXPERIMENT OF CONTOUR MARKING FOR TRUCKS

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1 INTRODUCTION

During the last 10 years several large scale experiments were made on behalf of introducing a contour marking for trucks for better conspicuity. The results comparing the accident rates of marked and unmarked trucks always showed a reduction of the number of accidents. This was the reason for preparing a new ECE-Draft Regulation:

Uniform provisions concerning the approval to retroreflective marking of heavy and long vehicles and their trailers as an annex to the agreement:

Concerning the adoption of uniform conditions of approval and reciprocal recognition of approval for motor vehicle equipment and parts. Within this Draft Regulation several requirements were made on behalf of

- geometrical dimensions
- coefficients of retroreflection
- chromaticity co-ordinates

and others.

In a large scale experiment restricted to Germany it was allowed by only special permission to equip trucks and trailers with logos, graphics, letters, and characters of different material types and colours. The geometrical data and the coefficients of retroreflection of the marking of trucks and trailers were measured during the procedure of giving the special permission for installation of the markings.

2 MEASUREMENTS

The coefficient of retroreflection was measured by a special retrometer in the geometry:

$$\alpha = 20', \beta_2 = 5°.$$

The data is given in $R'/cd \cdot m^{-2} \cdot lx^{-1}$ in the following descriptions abbreviated to R'/U. No colour-measurements were made because of the lack of a portable equipment giving reproducible results.

The coefficient of retroreflection was measured following the below described procedure for the contour marking:

Driver's cabin:	1 measuring area
Side of the truck/trailer:	1 measuring area at the front, the middle, and the rear of the vehicle body
Rear of the truck/trailer:	1 measuring area at the left, middle, and right part of the vehicle body.

The measurements were carried out at the horizontal part of the lower contour.

The measurements for the logos, distinctive marks, letters, and characters were carried out in a typical area of the marking. Always three single measurements were made within every single area, the linear average value was calculated. During the course of the measurements the retrometer was calibrated to standard-materials.

3 REQUIREMENTS AFTER THE DRAFT REGULATION

The Draft Regulation differs between 3 material classes:

Class C:	materials for contour marking
Class D:	materials for logos/distinctive marks and others
Class E:	materials for logos/distinctive marks and others for extended areas $A > 2m^2$

The photometric requirements for a measuring geometry $\alpha = 20'$, $\beta_2 = 5°$ for these three types are

Class C:	white:	$R' \geq 450U$,
	yellow:	$R' \geq 300U$
Class D:	any colour	$R' \leq 150U$
	area	$A \leq 2m^2$
Class E:	any colour	$R' \leq 50U$
	area	$A > 2m^2$

For lettering and characters the requirements are

- number of letters $N \leq 15$
- height of letters $H = 30...100cm$.

There are several other requirements which are not discussed here because it was not within the task for this large scale experiment.

4 RESULTS - GEOMETRICAL REQUIREMENTS

4.1 Numbers of Letters and Characters

In figure 1 the frequency distribution f of the numbers of letters and/or characters is plotted.

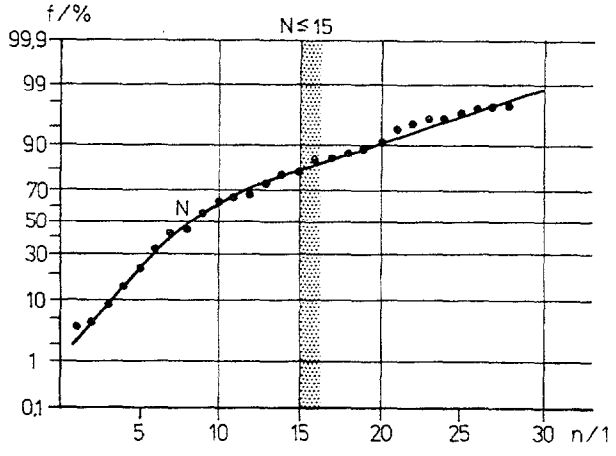

Fig. 1: Frequency distribution f of the numbers n of letters and/or characters within contour markings
N ≤ 15: Maximum limit for the number of letters and/or characters

These results represent the lettering of 344 different trucks and trailers. The borderline $N \leq 15$ shows the requirement after the Draft Regulation. Roughly 80% of the lettering are fulfilling this requirement.

4.2 Thickness of Lines and Width of Lettering

Figure 2 shows the frequency distribution f of the width (W) of letters and the thickness (T) of lines of letters.

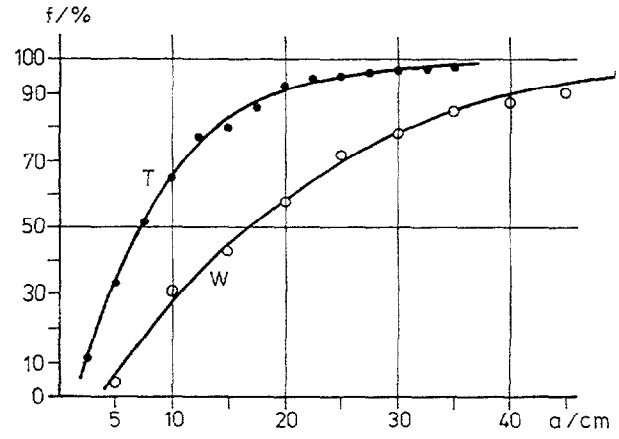

Fig. 2: Frequency distribution f of dimensions of letters and/or characters
T: Thickness of lines
W: Width of letters and/or characters

For 80% of the lettering the results are

width:	$W \leq 31cm$
thickness of line	$T \leq 14cm$.

4.3 Height of Lettering

For the height of lettering the requirements are

$$30cm \leq H \leq 100cm.$$

According to figure 3 in which the frequency distribution f for the lettering height is plotted

45% of lettering are smaller than H = 30cm

8% of lettering are larger than H = 100cm.

Therefore roughly 53% of the lettering are not performing this requirement.

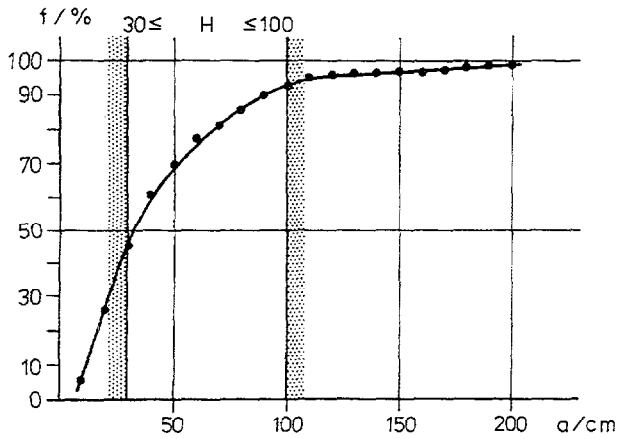

Fig. 3: Frequency distribution f of heights a of letters and/or characters
30 ≤ H ≤ 100: Limits for the height of letters and/or characters

4.4 Area of Logos or Distinctive Marks

In the requirements the class of used material is depending on the size of the logo, distinctive mark etc. For areas A ≤ 2 m² class D materials are permitted, for larger areas the class E material should be used. In figure 4 the frequency distribution of the height (H) and width (W) of logos or distinctive marks is shown.

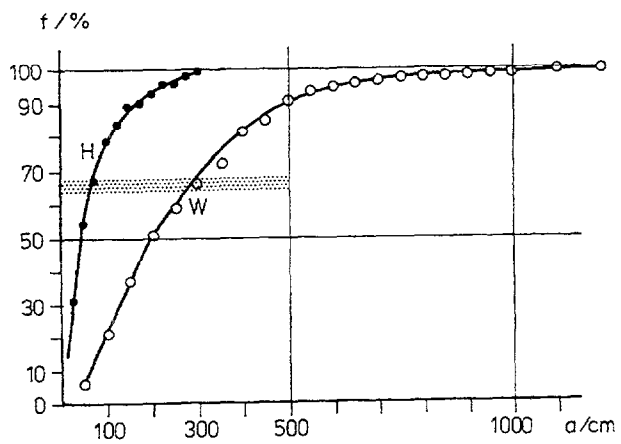

Fig. 4: Frequency distribution f of widths W and heights H of logos or distinctive marks

The dotted area represents in approximation A ≈ 2 m². Based on these results one can expect that ≈ 70% of the logos or distinctive marks will fulfil the requirement A ≤ 2 m² and can consist of material class D. This value is only an estimation because the effective area was not measured but only the all over size. So the value of f ≈ 70% is even higher.

5 RESULTS - PHOTOMETRIC REQUIREMENTS

5.1 Contour Marking

In the figures 5 and 6 the photometric measuring results for contour markings are plotted for different situations. In figure 5 the frequency distribution f for clean rear contour marking of retroreflective material type 3 is shown.

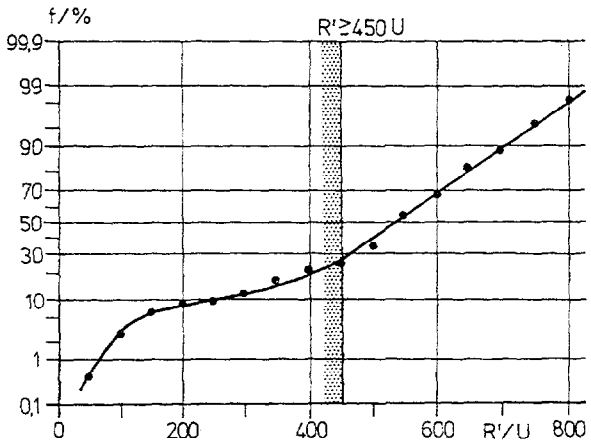

Fig. 5: Frequency distribution f of the coefficients of retroreflection R' of contour markings at the rear of trucks and trailers
R' ≥ 450U: Minimum requirement (class C) for the coefficient of retroreflection R' for white materials

The dotted borderline shows the minimum photometric requirement R' = 450U. The contour marking was measured after the area for measuring had been cleaned carefully. The results show that f ≈ 27% of the contour markings are not fulfilling the photometric requirements.

For different areas the results measured are shown in figure 6.

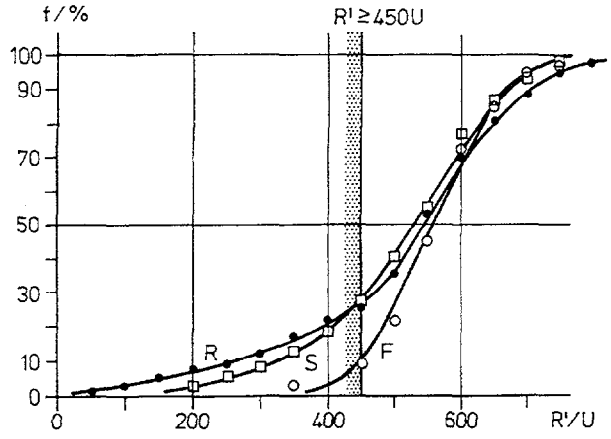

Fig. 6: Frequency distribution f of the coefficient of retroreflection R' of contour markings at different places of trucks and trailers

F:	*Side of driver's cab*
S:	*Side of the truck or trailer*
R:	*Rear of the truck or trailer*
R' ≥ 450U:	*Minimum requirement for the coefficient of retroreflection R' for white materials for contour marking (class C)*

Again the frequency distributions f for the photometric values R' for contour markings of clean material of type 3 are shown. The results for side marking (S) and rear marking (R) are differing not too much whilst the results gained from the contour marking of driver's cabin (F) are different. The material mounted at the driver's cabin seemed to be stressed less than at other positions.

Roughly f = 27% of rear and side contour markings are not fulfilling the minimum photometric requirements of R' ≥ 450U for white materials. For materials mounted at driver's cabin this value is reduced to f ≈ 10%.

5.2 Reducing of Photometric Performance by Dirt

During all measurements the photometric data were gained first for dirty marking and then after cleaning for clean marking.

The influence of dirt can be shown in figure 7 for contour marking, and in figure 8 for logos or distinctive marks.

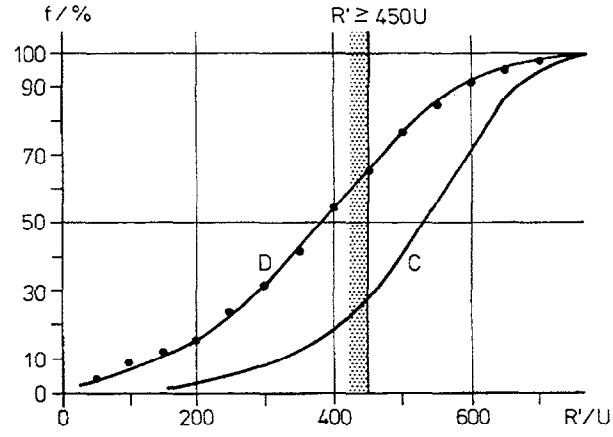

Fig. 7: Frequency distribution f of the coefficient of retroreflection R' of clean (C) and dirty (D) contour markings at the side of trucks and trailers

D:	*Dirty contour marking*
C:	*Contour marking after cleaning*
R' ≥ 450U:	*Minimum requirement for the coefficient of retroreflection for white materials for contour marking (class C)*

In figure 7 the results of figure 6 are plotted (C) adding the results for dirty (D) contour markings. These results were found for contour marking of material type 3 at the side of the truck or trailer. The dotted borderline shows the minimum requirement of photometric performance for contour markings. For the value f = 50% the reduction of photometric performance by dirt is about $\Delta R' \approx 30\%$.

In figure 8 similar to figure 7 the frequency distribution f is shown for the coefficient of retroreflection R' for clean (C) and dirty (D) logos or distinctive marks of white material of type 1.

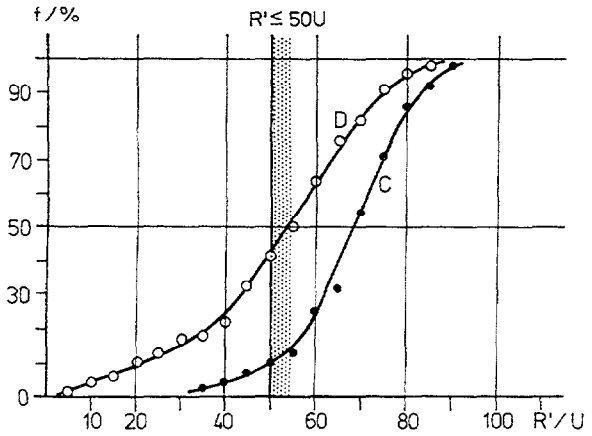

Fig. 8: Frequency distribution f of the coefficient of retroreflection R' of clean (C) and dirty (D) logos or distinctive marks at the side of trucks or trailers

D: Dirty logo or distinctive mark

C: Logo or distinctive mark after cleaning

R' ≤ 50U: Maximum for the coefficient of retroreflection R' for logos or distinctive marks of any colour and of class E materials

The dotted borderline shows the maximum for the coefficient of retroreflection R' for material of class E, the borderline of class D (R' ≤ 150U) is not plotted. For clean materials only f = 10% are fulfilling the requirements for class E in contrary to class D where 100% of the materials are performing the maximum value of R' ≤ 150U. The reduction of the photometric performance by dirt is for f = 50% nearly ΔR' ≈ 25%.

5.3 Contour Marking and Colour of Materials

During the large scale experiment, for the contour marking different types of materials and colours were used. In figure 9 the coefficient of retroreflection R' is plotted for different colours of clean (C) and dirty (D) materials of type 1.

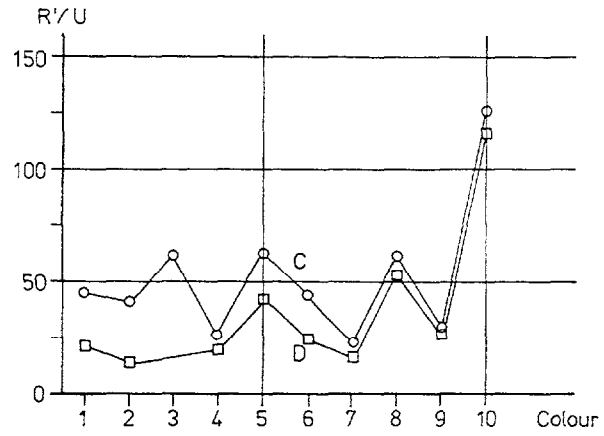

Fig. 9: Mean values of the coefficient of retroreflection R' of clean (C) and dirty (D) contour markings of type 1 material with different colours

1: yellow 6: white/yellow

2: gold 7: red

3: orange 8: silver

4: black 9: green

5: white 10: pink

D: Dirty contour marking

C: Contour marking after cleaning

None of those materials fulfil the minimum requirement of R' ≥ 450U (white) or R' ≥ 300U (yellow). In addition in figure 10 the results for the materials of type 2 and type 3 are shown.

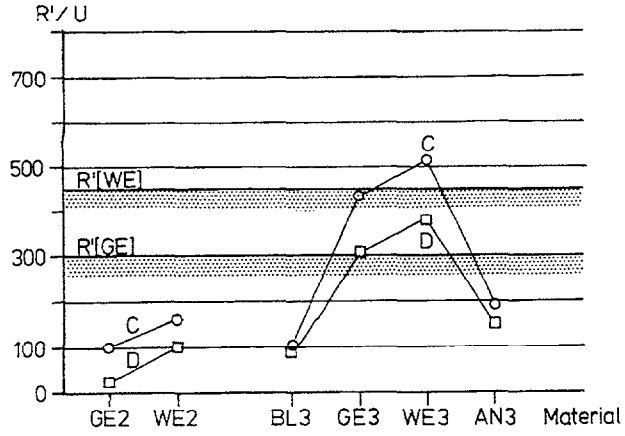

Fig. 10: Mean values of the coefficient of retroreflection R' of clean (C) and dirty (D) contour markings of different type of material and of different colour

GE2:	*yellow*	*type 2*
WE2:	*white*	*type 2*
BL3:	*blue*	*type 3*
GE3:	*yellow*	*type 3*
WE3:	*white*	*type 3*
AN3:	*anthracite*	*type 3*
R'(WE):	*Minimum requirement for the coefficient of retroreflection R' for white materials for contour marking (class C)*	
R'(GE):	*Minimum requirement for the coefficient of retroreflection R' for yellow materials for contour marking (class C)*	

Only the materials: type 3 - white and type 3 - yellow are performing the minimum photometric requirements (dotted borderlines) for contour marking (class C).

5.4 Logos/Distinctive Marks and Colours of Materials

For clean logos or clean distinctive marks the mean values of the coefficient of retroreflection R' are shown in figure 11.

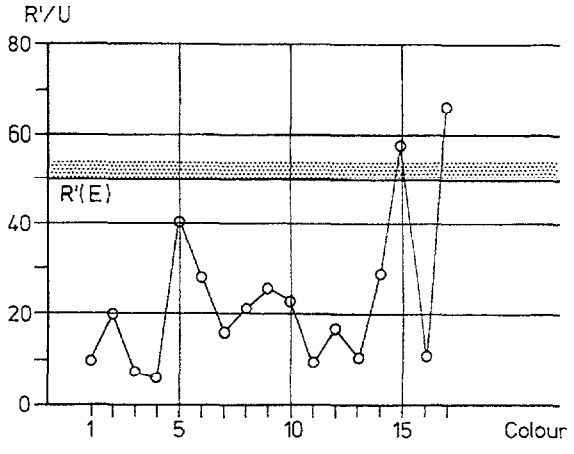

Fig. 11: Mean values of the coefficient of retroreflection R' of clean logos or distinctive marks of different colours

1:	*blue*	*9:*	*light green*
2:	*brown*	*10:*	*orange*
3:	*dark blue*	*11:*	*red*
4:	*dark green*	*12:*	*pink*
5:	*yellow*	*13:*	*red/violet*
6:	*gold*	*14:*	*black*
7:	*green*	*15:*	*silver*
8:	*light blue*	*16:*	*violet*
		17:	*white*

R'(E): Maximum for the coefficient of retroreflection R' for logos or distinctive marks of class E (areas A>2m²)

The dotted borderline R'(E) describes the maximum value for the coefficient of retroreflection for materials class E R' ≤ 50U. Except the materials of the colours white or yellow all the other materials perform the class E-requirement, they can be used without size limitation. The materials with the colour white or yellow have to be restricted to sizes A ≤ 2 m2.

The influence of dirt layer on material for logos or distinctive marks can be derived from figure 12 where the mean values of the coefficient of retroreflection for dirty (R'(D)) and clean (R'(C)) materials are plotted for the different colours as in figure 11.

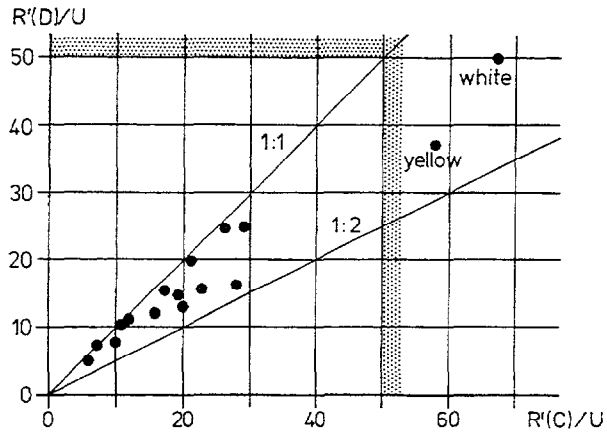

Fig. 12: Mean values of the coefficient of retroreflection R' of clean materials (R'(C)) and dirty materials (R'(D)) of logos or distinctive marks of different colours
1:1, 1:2: Ratio of the values of coefficient of retroreflection before (R'(D)) and after cleaning (R'(C))

The dotted borderline describes the performance limits for the class E-material. Again the colours white and yellow are not fulfilling these requirements. The reduction of the coefficients of retroreflection R' of materials in use by dirt is roughly between 10% and 50%.

6 CONCLUSIONS

The performance requirements for geometric and photometric values as described in the Draft Regulation for

- Retroreflective Markings -

can be fulfilled by materials available today for the contour marking as for logos, distinctive marks, letters and characters.

There are some reductions in the numbers of letters and characters necessary. Also a reduction of the limits of heights of letters and characters should be strived for.

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