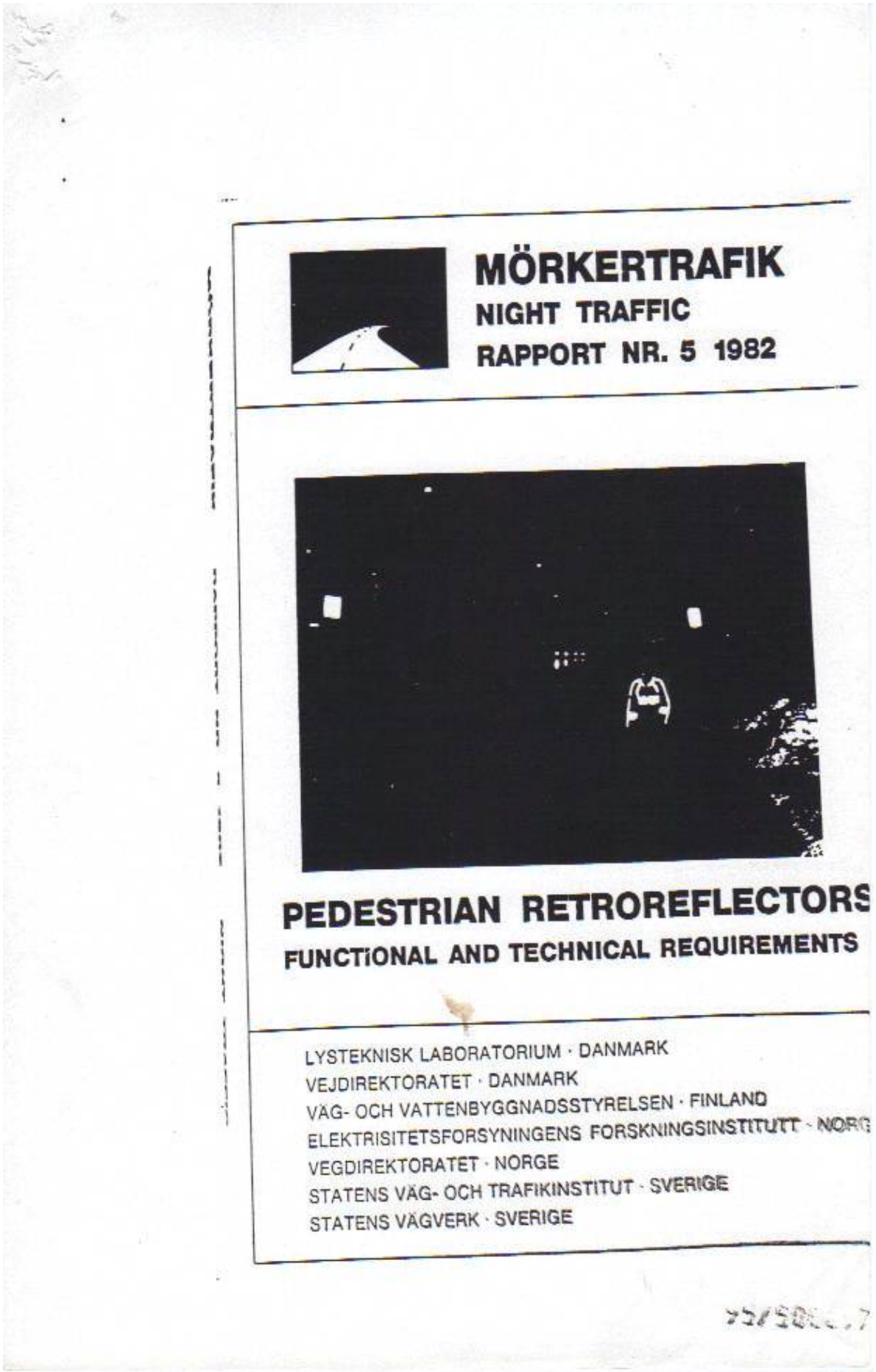

[Linköping, Sweden : National Swedish Road & Traffic Research Institute]
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- Matti Koivurova,
  Central Organization for Traffic Safety, Finland
- Kåre Rumar,
  VTI, Sweden
- Bjørn Brekke, project coordinator and report editor
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In addition, the following persons have contributed directly to the work of the project group, including the studies and experimental investigations which have been performed:

- Harald Lund-Jessen,
  LTL, Denmark
- Olli Halonen,
  Finnish Organization for Standardization, Finland
- Tapani Timonen,
  Technical Research Centre of Finland
- Sven-Olof Lundkvist,
  VTI, Sweden
- Bjørn Eide-Olsen
  EFI, Norway

The coordinating group has examined and accepted the report, and has at an earlier stage forwarded the proposals of the project group of technical requirements for pedestrian retroreflectors, to the road and traffic authorities of all the four countries.

initiated studies in order to determine what requirements should be put on retroreflectors when the aim is to ensure sufficient traffic safety value over a reasonable life time.

A safety distance of 140 m was adopted as the basis of technical requirements. This led to a corresponding minimum retroreflection requirement of about 300 mcd/lux for safe detection by car drivers on vehicle illuminated roads.

The optical and physical properties of retroreflectors have been reviewed. It turns out that the moulded prismatic (cube-corner) retroreflector is the most efficient type for dangling tags, while the glass bead retroreflector has properties that makes it advantageous for permanent mounting on garments (retroreflective fabric).

Comprehensive investigations of retroreflector qualities have been performed. New (unused) materials have been measured, and the processes of wear and tear during use have been studied, both by simulated strain in the laboratory and by actual use over time. These results show that polystyrene tags have a life time not much longer than one winter season (5 months), while the life time of retroreflective fabrics depends greatly upon the garment treatment, especially washing. Most high-quality materials of today will loose almost half of their initial retroreflection after 10 washings. Also, the washing deterioration may be partly compensated by applying larger retroreflector areas on the particular garment.

The main conclusion of the present work is a set of specifications for each main type of retroreflectors: Tags and retroreflective fabrics. The specifications state the functional requirements and describe relevant laboratory tests designed to ensure

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VISIBILITY AND SAFETY OF PEDESTRIANS IN NIGHT TRAFFIC

by Kåre Rumar.

It is generally accepted that night driving is two - three times more hazardous than daylight driving per driven km. However, since most of the traffic is carried out during daylight hours the absolute accident figures are generally higher for daylight illumination. But some accident types - such as pedestrians being hit by cars are in many countries even in absolute figures more frequent in night driving than in daylight. These types of accidents are normally very severe since the speed of the car is high and since the pedestrian is completely unprotected.

Not only does accident statistics show very bad figures for night driving but basic research concerning vision under low levels of illumination also indicates that night driving is a situation for which man is not constructed and in which man's visual system proves inefficient.

The visual system is developed to function in good lighting conditions and has its highest performance characteristics at normal daylight conditions. In night driving conditions on the other hand, the visual situation is radically worsened. The illumination levels under which night traffic is carried out are in the lower region of photopic vision where the receptor sensitivity is considerably decreased. But it is important to stress that although it is called night traffic the illumination levels are so high that it is not scoptic vision that is used in night traffic. We normally refer to the night traffic illumination levels as photopic or mesopic.

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According to the Nordic Association for Road Technique (NVF 1976) the shortest safe visibility distance at a normal rural road speed of 90 kmph is 140 m.

The various efforts to aid the visual system presented and tested so far (optical filters, glare shield glasses, special adaptation lamps, drugs, etc.) have been unsuccessful in improving vision in real night driving situations. On the other hand every effort should be taken to correct visual deficiencies of the eye - e.g. myopia, astigmatism.

The possibilities to improve visual performance by training are very limited. The contrast thresholds are of a physiological-optical nature rather than psychological. On the other hand it is quite possible to train drivers what to look for, where to look for it and when to look for it. Together with having drivers experience how bad their visibility level really is such a training would probably have favourable effects on the accident situation. The comparatively good night driving statistics for professional drivers gives some hope for the effect of training.

In order to make the traffic conditions during night driving correspond to daylight driving two different principles of light sources have been introduced - road and vehicle lighting. Road lighting is solved in principle but is a very expensive method in sparsely populated areas - such as the Nordic countries. In vehicle lighting the problem is the meeting phase - both the initial part on high beam and the final part on low beam. In this phase visibility distances to dark objects (pedestrians) on the road are normally around 50 metres and very seldom above 100 metres (Johansson et al 1963, Johansson & Rumar 1968, Rumar 1974, Helmers & Rumar 1975, Helmers & Yttenborn 1980). The only possibility to increase visibility

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relate the CIL-values to visibility distances to pedestrians in low beam - low beam situations (the most difficult situation) is given in Figure 1. This curve is based on the unpublished measurements obtained by Berggrund & Rumar (1975). As can be seen from this curve a visibility distance of 140 metres roughly requires a CIL-value of 300 mcd/lux.

Pedestrians could be wearing retroreflective material in the form of special auxiliary retroreflectors such as dangling tags or as retroreflectors fixed to the normal clothing. The dangling tag has been shown to have a higher attention value when it is rotating (blinking) as compared to the fixed retroreflector (Berggrund & Rumar 1975). But the fixed retroreflectors improve the driver probability to identify the pedestrian as being a pedestrian (pattern recognition) and not something else. The identification of objects is an important but overlooked function. The more common retroreflectors become along our roads, the more important becomes a special way to identify pedestrian retroreflection pattern. Furthermore, the standard flat hanging tag always runs the risk of not showing any of its retroreflective surfaces. Therefore in a longer perspective the fixed retroreflective materials seem more promising. They do not demand anything from the wearer, they are always there and they always function - that is under two conditions:

- that they are so placed that they are effective in all horizontal directions,
- that they can endure normal wear and washing.

The large effect of pedestrian retroreflectorization is obtained on roads without stationary illumination. But tests (Berggrund & Rumar 1975) have shown that especially in wet conditions the effect is also substantial within street lighted areas - provided the

Scandinavian report (Morkertrafik Night Traffic Rapport Nr. 5 1982).
[Linkoping, Sweden : National Swedith Road & Traffic Research Institute]
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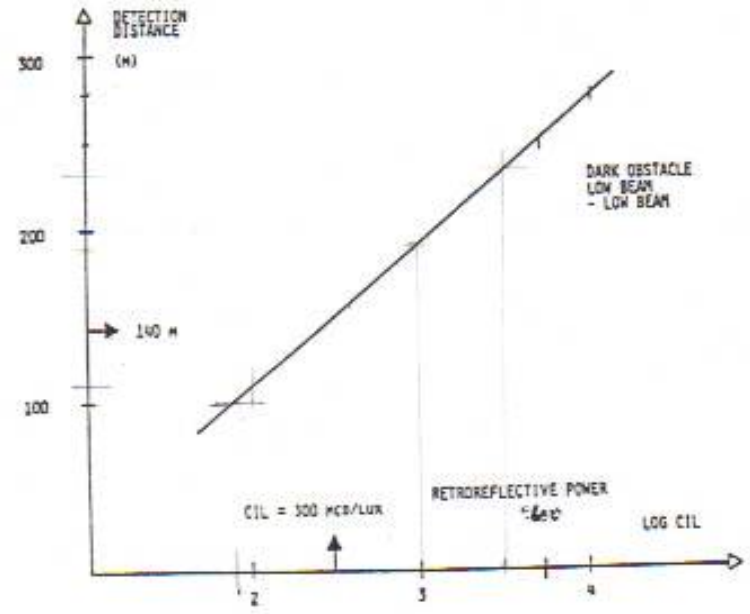

Figure 1. The relation between retroreflection and detection distance to a dark obstacle equipped with retroreflective material in a low beam - low beam situation.