

HOW TO USE MIRRORS

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ABSTRACT

Blind spots of trucks are a very often discussed problem. The usual way to reduce blind spots is to use a mirror. The new mirror regulation 2003/97/EC is improving the visible areas around a truck. The new trucks in Europe are equipped with mirrors which have to fulfil the new mirror regulation. This is the current technical situation. But how do the driver use these mirrors? What do they know about the new mirror systems? Do the driver know how to adjust the mirrors to provide the best view?

This paper will provide an overview about the mirror-related knowledge of German truck drivers and, subject to the type of mirror system mounted, how they are adjusted and used.

That is followed by the presentation of a solution to an old problem: so far there is no system which shows the driver of a truck whether his mirrors are adjusted in the right way or not. An idea coming from the Netherlands was to use markings painted on the ground to help the truck drivers to adjust their mirrors. This idea was improved by Daimler, MAN and DEKRA and is now offered e.g. to fleet operators to help their drivers.

Furthermore the remaining part is about how drivers use there mirrors on the road in different traffic situations.

INTRODUCTION

A driver has to take care of the traffic situation around the vehicle. This also includes the necessity to be able to see all relevant details. It is natural that a human is not able to see everything without turning around. This turning is necessary to get the required information. Is there another road user or an object? Do the other road user or the object lead to a possible conflict with the own vehicle? Only in case of visibility and noticeability the driver is able to act in a way to avoid a collision.

The simple driving manoeuvre of changing a lane is made by a passenger car driver by looking in the rear view mirror and turning his head to the side for a direct view. A truck driver on the contrary has with the same movement of the eyes and a large number of mirrors mounted to the cab still a large area he can not overlooked – the so called blind spot.

BASICS

Passenger cars do also have blind spots. They are primarily caused by the A-, B- and C-Pillars. The problem is limited to a 2-dimensional level and thus far smaller than that of trucks: A truck includes related to blind spots a third dimension. This is caused by the height difference between the eyes of the truck driver and the eyes of the other road users (e. g. pedestrians or car drivers, see Figure 1). The eyes of the truck driver are for most of the big European trucks (mass > 8.0t) roughly on a level of 2.5m, whereby the eye of a pedestrian will be on a level of 1.6m for a 50-percentile male. Besides the height of the drivers eyes there are two other main factors influencing the size of the blind spot. One is the height of the lower edge of the windscreen and the side windows. The other is the horizontal distance between the driver and the window. These three factors are influencing which points outside the truck will be visible. It is not unusual that a truck driver looking through the side window is not able to directly see a point on the ground in a distance of up to 7.5m beside the truck. For that area mirrors are required.

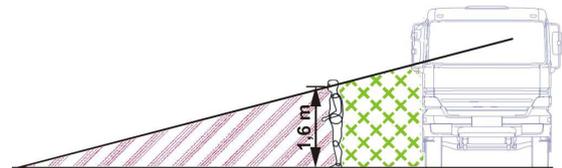


Figure 1. Visibility of a 50-percentile male from the position of the truck driver

The trucks (mass > 8.0t) which were following the former European mirror regulation (71/127/EWG [1]) were equipped with at least three mirrors on the co-driver's side and one on the driver's side. The new regulation 2003/97/EC [2] requires one additional mirror for the driver's side and one for the front. It is also allowed to use a camera monitor system instead of the front mirror. The new mirror systems have to show a larger area. Therefore a smaller radius of the mirror's convex surface is necessary. The currently allowed minimum radius is 300mm. It seems to be unbelievable, but with this radius the resolution limit of the human eyes is nearly reached. It is not possible to further reduce the radius.

The European regulation 2007/38/EG [3] requires the retrofitting of all trucks (N2+N3) first registered 2000 or later with the 300mm radius side mirror (only a few trucks are excepted).

Today we have the new mirror system at least for new trucks. What is the advantage of the new system? The truck driver is able to at least see an area of two meters in front of the truck and two meters on the co-driver's side. This is given by the requested areas of each single mirror. The problem is given by the fact that the truck drivers are not directly told how to adjust the mirrors in an optimal way. Many truck drivers are not taught about the differences between the old and the new mirror systems. Therefore they cannot use the advantages of the new mirrors. There was already a lack of knowledge for the old mirror system. Some truck drivers got their driving license when there was only one mirror on the right side. They were taught to adjust the mirror in a way that on the co-driver's side the rear axle should be visible in the mirror. This is not enough knowledge for today's mirrors.

CURRENT MIRROR USE

DEKRA initiated a study to look how the mirrors are adjusted on the road [5]. To have fast and comparable results the external point of the bottom edge of the wide angled mirror (class IV, see Figure 2) was measured. The results of the measured mirrors are separated to mirrors following the old regulation (71/127/EC) and the new regulation (2003/97/EC). The regulation 71/127/EC states that the interested point normally should be 3.0m behind the eyes of the driver and 2.5m beside the truck (co-driver's side). It was found that the wide-angled mirrors following the old regulation have a mean value which is very close to the target value (see Figure 3).

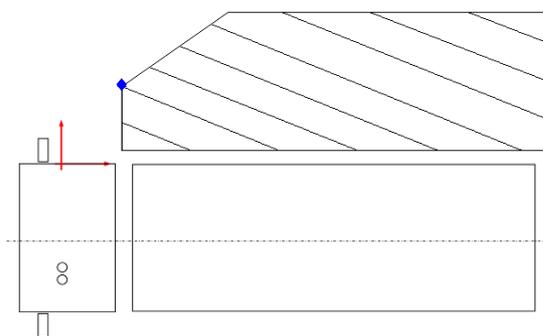


Figure 2. Explanation of measured point visible in the wide angled mirror (class IV)

The adjustment of the new wide angled mirrors do not have such a good result (see Figure 4). The target value should be 2.5m behind and 4.5m beside the truck. The mean value of the measured

mirrors is 0.9 meter further away from the driver's eyes and 0.7 meter close to the truck. Both deviation reduce the visible areas and generate an additional blind spot which is not necessary. In consequence this means that in many cases the advantages of the new mirrors could not be used, because the mirrors only show more of the side of the truck and/or trailer.

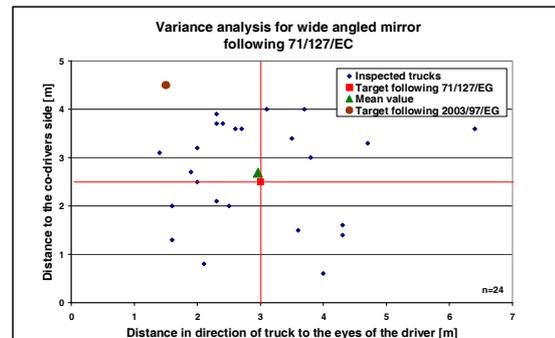


Figure 3. Variance analysis for wide angled mirrors (class IV) following the old regulation (71/127/EC) [5].

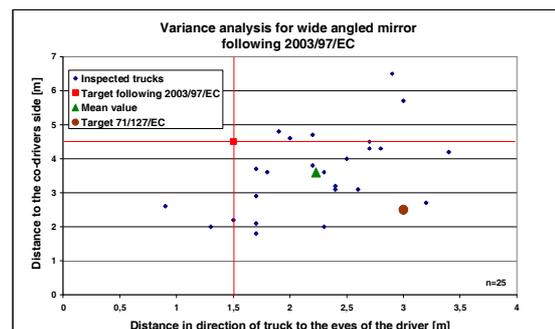


Figure 4. Variance analysis for wide angled mirrors (class IV) following the new regulation (2003/97/EC) [5].

The side mirror is one very important mirror for the blind spot problems of a truck driver. The other mirror which is often mentioned as a mirror to reduce the blind spot is the proximity mirror (class V). The origin intention of this mirror was to help the truck driver to drive as near as possible to a loading rack with a very low speed used for manoeuvring the truck. To make other road users visible is an add-on task for the proximity mirror. It is not easy for the driver to recognise another road user with this mirror while driving. The new front mirror (class VI), which was not part of the old mirror system, enables the truck driver to see an area of up to 2.0m in front of the truck.

MIRROR LIMITS

The driver has to look to the mirror to get information about possible obstacles which are not visible through the windows. When will the driver recognise those? Will it be enough to e.g. see a couple of hairs of a pedestrian? There are some problems in this context. It was already mentioned, that the proximity mirror was not given to the truck to see other road users. Figure 5 is showing what is visible from the driver's point of view for an old proximity mirror. Although the pedestrian is positioned in the area which is visible by the mirror, only left arm and left leg are shown in the mirror. Why? Only details which are inside the yellow pyramid on the picture could be shown by the mirror. The head, the main part of the body and the right leg are outside. Therefore these details can't be shown by the old class V mirror. Figure 6 shows the same situation for a new class V mirror. This mirror has a radius of 300mm instead of 400mm for the old class V mirror. Therefore this mirror is able to show the requested area given by 2003/97/EC. The pedestrian is not visible in total because of the same reason as mentioned for the old class V mirror. The bigger requested area is compressed to a surface which is nearly the same for old and new class V mirrors. Therefore every shown detail is smaller which requires a higher attention of the driver.

Not only the extent of an object shown by the mirror may be a possible problem. If the detail is shown near the border of the mirror there is a possibility to overlook this shown detail. Figure 7 and Figure 8 are showing a cyclist positioned just above a point (marked by the stone) which is visible in the mirror. The recognizability is very limited. This example shows the difference between theoretical visibility and the real view. Additional in praxis the truck is moving e.g. in a turning manoeuvre and the driver has also to be aware of the vehicle which may be just front of the truck.

The blind spot problem does not only affect vulnerable road users. Figure 9 may indicate the impression, that everything is alright. Figure 10 is showing the reality outside the same truck. This was an original accident situation. The truck driver intended to change the lane to the right without seeing the passenger car. The car was hit in the area of the rear axle while it was driving in an urban area with roughly 50km/h. Caused by this first contact with the truck the car turned to the left. The car suffered a second collision with an oncoming motorcyclist. Coming back to the adjustment of the mirrors Figure 9 is directly showing the bad adjustment of the proximity mirror. Two third of the mirror is only showing the truck's door.



Figure 5. Visibility of a pedestrian by an old class V mirror (71/127/EC)



Figure 6. Visibility of a pedestrian by a new class V mirror (2003/97/EC)



Figure 7. Positioning of a cyclist just above a point in the corner of a class IV mirror (71/127/EG)



Figure 8. Visibility of a cyclist positioned just above a point in the corner of a class IV mirror (71/127/EG)



Figure 9. Example of driver view to the co-drivers side



Figure 10. Adjusted accident scenario with a visibility problem of the truck driver

MIRROR ADJUSTMENT

The main cause of the described accident were the not correctly adjusted mirrors. But how could these mirrors be adjusted in a better way? There is an idea coming from the Netherlands to paint special markings on the road (see Figure 11). These markings may give the truck driver an orientation to adjust the mirrors. The Dutch system has a small disadvantage. It requires much space beside the truck. Daimler, DEKRA and MAN found an improvement (see Figure 12). On one hand the new system requires less space to the side (4,5m instead of 15m). It includes on the other hand also markings for trucks with an old mirror system (yellow markings). There is also a separation between the mirrors at the co-driver's side and the front mirror. This is caused by the different points of orientation. The adjustment of the front mirror is orientated to the front of the truck whereby all other mirrors are orientated to the eye-point of the driver. There could be an extreme combination of truck and driver which may result in an adjustment of the mirrors with a small mistake. This mistake may end in a blind spot and cause an accident. Therefore Daimler, DEKRA and MAN decided to separate the system in two adjustment areas.



Figure 11. System to adjust truck mirrors following the regulation 2003/97/EC developed in the Netherlands



Figure 12. System to adjust truck mirrors following the regulation 2003/97/EC and 127/71/EC developed by Daimler, DEKRA and MAN.

The Dutch and the German system are only a help for the truck driver to have a point of orientation for the adjustment of the mirrors. The driver has the possibility to change the adjustment in the personally preferred way – the right adjustment stays the driver's responsibility. There is another effect coming from this system. The system is leading to an increasing awareness of the problem. It was also used for public campaigns to show the people the blind spots of trucks. The more information other road users will get around this problem the more they could be aware of critical traffic situations.

This system is currently available in Germany at roughly 100 locations. Beside the locations of the three German developing partners there are additional supporting companies like another truck manufacturer, mineral oil companies, or truck hirer and forwarding companies. Some of these locations are also used by driving schools which teach new truck drivers. They start the driving lesson after the future driver has adjusted the mirrors of the truck.

OPEN RESEARCH

Beside the adjustment of the mirrors there is one remaining lack of knowledge. Who is able to tell the truck driver at what time in a special traffic situation it will make sense to have a look to the mirror(s). This is a result of a pilot study made in Berlin. Truck drivers were equipped with a helmet camera to follow the eyes movement (see Figure 13). The first results of the analysis of these videos were interesting. Some truck drivers had a first look to the wide angled mirror in a right turning situation when the truck had already done a movement of 45 degrees of the intended 90 degrees. With such a use of mirrors there are two possibilities. First there is no vulnerable road user (VRU) having a conflict with this truck. The second is more problematic. The VRU will be already under the truck. To have a first look to the class IV mirror in this situation is too late.

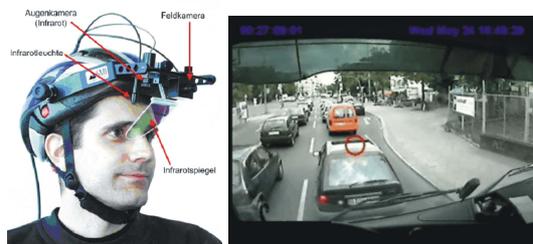


Figure 13. Example of eye tracking system used for truck drivers [4]

CONCLUSIONS

The new mirror regulation 2003/97/EC is beyond any dispute a good regulation to reduce the blind spot of trucks. But the equipment of trucks is only the first step. The second step just starts with the orientation help for adjustment of the mirrors. The use of the adjustment help has to be accompanied by a transfer of mirror knowledge to the driver. It is necessary to know for the driver what the mirrors are able to show. Where is a vulnerable road user located when it is shown by a mirror. Are there some remaining blind spots? Where are these blind spots? What is a good way for the driver to use the mirror system of the truck? Only if the driver got the complete knowledge he or she will be able to use the mirror system in a perfect way.

There is currently not enough knowledge how to use the mirrors in different traffic situations. An additional study is necessary. The results could be easily given to European truck drivers by using the directive 2003/57/EC which requires within five years 35h of educations for truck drivers. The knowledge how to handle mirrors in different traffic situations may reduce the number accidents caused from the blind spot problem in the future. This is possible independent from the equipment

(old or new mirror system). The knowledge should be transferred to all truck drivers.

The OEMs are developing also new assistance systems to reduce the blind spot problems of trucks. But the current truck fleet is neither equipped with such an assistance system nor are these systems available for all new trucks. It will take a lot more time until all trucks will have this kind of equipment.

REFERENCES

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