TFGP-05-03

CITA Task Force: Lighting devices and reflectors

Letter of Explanation

Status paper for GRE Task Force "Glare Prevention"

Final version, 27. November 2025

The CITA Tast force on Lighting devices and reflectors (CITA-TF-LDR) submitted a status paper for the GRE Task Force “Glare Prevention”. This document will provide a more detailed explanation of the CITA-TF-LDR's positions on specific aspects. Text passages from the status paper are highlighted in grey and italics. The additional explanations are in normal font.

CITA-TF-LDR is also facing difficulties during the process of updating CITA Recommendation no. 25 on Headlamp Alignment Testing in Vehicle Inspection (rel. February 2022), because on the one hand, there is a strong need for adaptation of the current inspection procedures used during periodic technical inspections (PTI) of the vehicles in use accordingly to the present headlight technology, followed by the improvement of the measurement precision, repeatability of the results the evaluation of the headlight cut-off position is subjected to strong influence of human factor.

But on the other hand, any improvement of the situation related to the headlight adjustment in PTI environment is very complicated nearly impossible, if the fundamental requirements related to headlights and definitions laid down on the type approval level are weak, non-consistent and are missing an important criterion.

Thereof CITA-TF-LDR identified as a starting point following problems to solve:

In type approval requirements UN-ECE-R149 the current method of finding horizontal and vertical setting of headlamp before photometric measurement is visual. This method delivers subjective and not repeatable results.

The procedure for the photometric measurement of headlamps is described in Annex 5 of UN-ECE Regulation 149 (UN-ECE-R149)[1]. During this process, the specialist mounts the headlamp directly onto the goniometer. They then manually by hands align the headlamp within the goniometer's coordinate system. According to Annex 5 of UN-ECE-R149, the headlamp must be designed so that, in right-hand traffic, it has a horizontal part towards the left and a rising elbow-shoulder part towards the right. Additionally, the elbow and shoulder part shall have a sharp edge.

Based on horizontal and shoulder lines, the specialist positions the headlamp in the H-V coordinate system of the goniometer. Figure 1 in the appendix to this letter illustrates the alignment described in the regulation. The specialist first rotates the headlamp, and thus the light pattern, so that the horizontal part of the cut-off line is 1% below the H line. The headlamp is then rotated to the left and right so that the kink point (elbow) and shoulder part of the cut-off line intersects with two constructed lines A and 0.2°D. Line A is vertical and 0.5° parallel to the right of line V. Line 0.2°D is horizontal and

[1] UN-ECE-R149 Annex 5, Page 87 f

parallel 0.2° below line H.[2] With this setting the kink point (elbow) must be within a range of +/- 0.5° to the left or right of the V line. This means an uncertainty of 1° in horizontal direction.[3]

After this manual and subjective setup step, the photometric values are measured according to Table 9 or 17 of UN-ECE-R149, depending on the headlamp. If the photometric values are within the specified range, the headlamp has passed this test. If the photometric values do not meet the requirements, it is allowed to realign the headlamp and repeat the test[4]. It means an additional uncertainty in horizontal direction of 1,25° and 0,5° in vertical direction. So, the initial setting in the vertical direction, based on the horizontal part of the cut-off line, also involves some uncertainty, depending on the specialist's visual perception. In fact, the headlamps are set up based on subjective adjustments with insufficient accuracy. This means that this test can never be repeated under the same conditions. This procedure therefore does not meet the requirements for repeatability.

The description of shape of cut-off with the horizontal and elbow-shoulder part is insufficient. There is neither a definition nor given tolerances of the shape of the horizontal and elbow-shoulder parts.

The only available definition of the shape of the cut-off line has already been explained in the text above. If the headlamp passes the type approval photometric test with subjective alignment, there is no criteria to check if the actual shape of both, horizontal and shoulder part of the cut-off, are proper and proper position of the kink point. To create a repeatable and objective procedure, a suitable definition with appropriate tolerances for the shape of the cut-off must be formulated and applied.

During the periodic technical inspection (PTI), the headlamps setting is checked by comparing the position of the kink point with the reference coordinate system. As already described, UN-ECE-R149 does not provide a sufficiently precise definition of how this kink is to be determined. It only specifies a range within which this “sharp edge” must lie. As a result, the initial aim set in the type approval can be different to found during PTI test. Therefore, road illumination and glare can differ from the conditions under which type approval was granted.

If the results of visual method are not repeatable, it is possible to use the instrumental method. The starting point for instrumental aim is however the visual one. Because of that, the final result of instrumental aim is also not repeatable.

If the photometric test based on the visual method fails, the instrumental method should be used. The problem here is that the starting point is the same manual alignment of the headlamp on the goniometer. Therefore, the photometric results are unpredictable and can differ for the same headlamp between repeated measurements and different laboratories. This is because of subjective and non-repeatable initial alignment.

In the instrumental method, three vertical lines are scanned at a specific position to find the position of the cut-off line. These positions depend on the initial aim of the headlight by visual method. This gives ambiguous results. The goal is to achieve reproducibility of the results.

To determine the alignment, three vertical lines in the elbow-shoulder part are to be evaluated in relation to the H-V coordinate system. The lines are located 1°, 2°, and 3° to the right of the V-line. A line is then to be constructed at these three intersection points, which shall intersect with line V and

[2] UN-ECE-R149, Annex 5, Figure A5-I
[3] UN-ECE-R149, Annex 5, 1.2.2.(c)
[4] UN-ECE-R149, Annex 5, 1.2.3.

the horizontal part of cut-off. The method is also illustrated in Figure 2 in the appendix to this letter. Depending on how the subjective initial alignment was performed, the three lines intersect the cut-off at different points. Consequently, despite the use of an apparently objective method, the evaluation may yield different results. When we compare the results of methods 0.2°D and three lines for a headlamp, the differences are significant in many cases. Due to this problem of initial aim, the method is not proper and repeatable and therefore cannot be used in PTI.

To achieve this, two things must be fulfilled:

- *The methods must fulfil the requirement for reproducibility*
- *The definition required to align the headlight (shape of cut-off, kink point) must be so clear that it can be determined instrumentally using a standardized method for TA and PTI.*

CITA-TF-LDR is already working on proposals to solve these challenges. These methods are briefly described:

- *High-resolution scanning in horizontal and vertical directions and evaluation of the entire cut-off line*
- *The cut-off includes a horizontal and shoulder part, which must contain clear lines delimited by tolerances*
- *A method feasible to determine the kink point on all headlamps, which is the point for alignment*

The proposed method is intended to improve the alignment process in type approval. The intention is to determine the kink point based on the cut-off using a clear method. This point is then to be referenced to the H-V coordinate system of the goniometer. To do this, it is necessary to clearly define the shape of the cut-off with suitable tolerances. A clear and unambiguous method must then be defined to determine the kink. This solves the initial aim problem.

The methods to determine the cut-off and kink point described for type approval should also be feasible in the PTI. The same methods should also be used to check the adjustment of the headlights in the installed state in the vehicle. This ensures that the PTI and the tested aiming value correspond to the measurements in the type approval, which are designed to prevent glare effectively and to guarantee minimum road illumination.

To ensure that future headlights can also be tested independently and correctly, they must be compatible with the existing systems for testing. It has to be guaranteed, that the entire low beam pattern can be projected in a headlight tester with a lens size diameter of 200mm. So, it shall allow to collect the low beam pattern, that creates the essential part of cut-off to accurately find kink point. According to the requirements, the results of the measurement cut-off at 10 m and 25 m shall give the same results.

The latest developments show a trend towards split headlight systems, where several lighting units are involved in creating the light pattern. In extreme cases, this becomes impossible to determine the initial aim using the current testing equipment, because the lighting units are too far apart. For this reason, it must be ensured that the entire beam pattern can be projected in the current headlight

testers. Another point is that type approval can take place at a distance of 25 m or 10 m. Therefore, regulations must ensure that the cut-off line is required tolerance at both distances.

The initial aim and standard passing beam (class C) should be possible to activate on the vehicle in any conditions for everybody without special tools.

Some Headlamps use automatic functions, like ADB, AFS and automatic leveling which change the initial aim conditions. During the PTI, it is essential that the correct beam pattern (class) and the state (nominal leveling) should be activated without special tools when checking the initial aim.

To reduce glare in road traffic even more effectively, it is necessary to link the initial value for alignment more closely to the mounting height. The existing range for selecting the initial headlamp aim is so wide that very different road illumination distance can be achieved. This leads to a different glare effect in road traffic, depending particular combination of actual aim and beam pattern of given vehicle. To solve this problem, the range for selecting the possible setting must be specified precisely. It is the most advantageous that the initial aim value should be prescribed strictly depending on the mounting height. A linear function that provides equivalent road illumination distance for all possible mounting heights can serve as a basis. The accuracy of the initial aim is set to an accuracy of 0.1%. Additionally, the tolerance band for automated levelling systems should be required at the highest technically possible and reasonable precision and sensible level to ensure appropriate alignment in all conditions.

The legal road illumination distance can vary according to present requirements of regulation UN-ECE-R48 in a big range. In the worst cases the road illumination distance can vary between 20 m and 200 m, depending on the mounting height and inclination. The present range of UN-ECE-R48 6.2.6.1.2. causes risk of high glare or insufficient road illumination. A strict link between initial aim and mounting height as a linear function, will cause the same road illumination distance equal for every vehicle. It also will reduce average glare. Reducing the leveling tolerances also achieves less glare and better road illumination.

CITA will also propose Provisions for PTI in the certain UN lighting regulations.

APPENDIX

Figure 1: Visual aiming of the cut-off

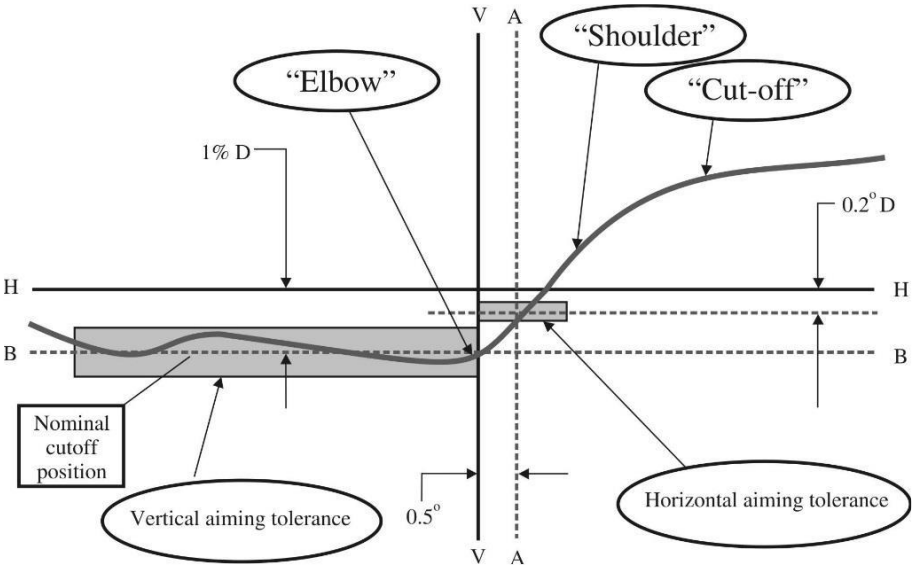
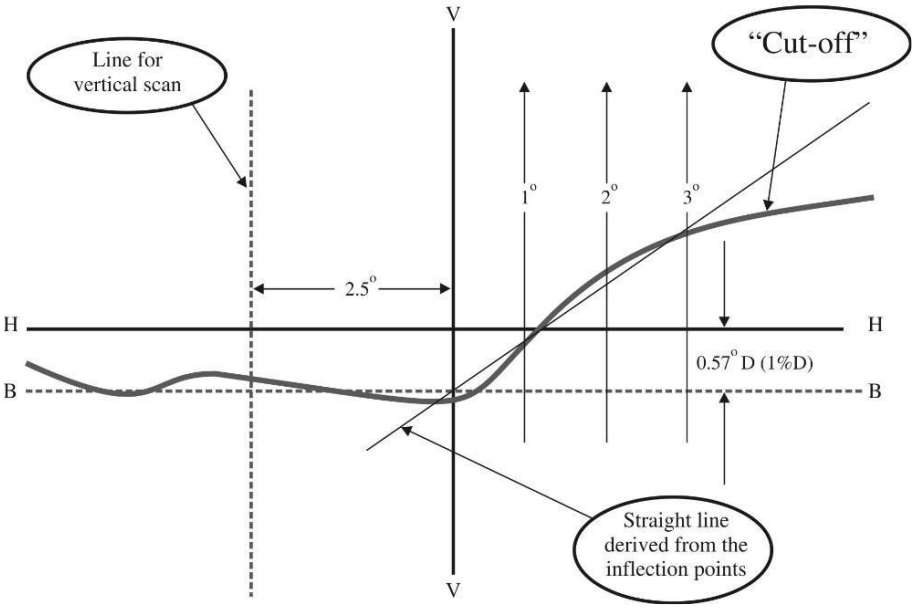


Figure 2: Instrumental vertical and horizontal adjustment - Three line scan method



Note: The scales are different for vertical and horizontal lines.