

Scientific and practical analysis of the issue of separating DI and Stop Lamps (SL) (SLR 73 08/Rev.1, SLR 75 11, SLR 75 12)

Road safety in relation to DI and SL in real road conditions is the result of internal consistency of the regulations, the accuracy of the choice of assessment criteria and the methodological correctness of the type-approval tests.

HUMAN FACTORS AND VISUAL PERCEPTION CONTEXT

Drivers rely on function recognition:

- This light means “braking”;
- This light means “turning”.

- At the beginning of the UNECE regulations system, there were consistent mental models of intuitive recognition that had been developed over decades: **round/rectangular shape of lamps**, uniform appearance, **clear spatial division of functions**.
- As a result of technological advances, irregular lamp shapes have been introduced based on a very simplified model of type approval requirements (intensity only). In recent years, these shapes have become extremely irregular and inconsistent with the original standard.
- They require cognitive interpretation, increasing reaction time, especially under high workload (e.g. urban intersections, overtaking on highways), adverse weather or night-time glare conditions. Non-uniform luminance produces visual saliency imbalance (bright segments dominate perception). In addition is observed masking of adjacent signals with similar colour or proximity. This is particularly critical when amber DI are spatially or visually intertwined with red SL.
- This kind of lamps are not possible to be properly assessed by the existing regulatory concept of “apparent surface” defined only by manufacturer drawings. Therefore, excessive and uncontrolled freedom in the geometry of lamps is a real threat to the correct recognition of functions.

Human brightness perception follows a **logarithmic (Weber–Fechner / Stevens) relationship**. Therefore, a **proposed 25–30% increase** in intensity may result in **only a marginal** perceived difference. Under photopic-to-mesopic transition (dusk/night), this difference may be imperceptible. Therefore at least 3:1 luminance contrast increase of DI in relation to nearby SL should be used when different lighting functions are not efficiently separated spatially - are merged in one lamp. It should be like SL to Position lamp relationship when in one lamp. Otherwise, the light of each function should be efficiently separated spatially. The light emitting surface of DI and SL and separation between them have to be bigger than visual acuity.

Therefore, **visual acuity** (visual resolution) is the key factor in determining the **size** and **distance** between lamps. Of course, provided that the actual **luminance** is sufficient to distinguish them from the surroundings. The ophthalmological norm of **visual acuity** for a driver is **two minutes of arc** (6 cm per 100 m).

FUNDAMENTAL ISSUE: "APPARENT SURFACE" IS NOT PERCEPTUALLY WELL-DEFINED

The proposals (SLR 73 08/Rev.1, SLR 75 11, SLR 75 12) relies heavily on apparent surface in the direction of the reference axis as a compensating factor for reduced intensity contrast.

Currently the apparent surface is defined only by **manufacturer drawings**, and **cannot be measured** or reconstructed physically **during approval** because of lack of appropriate "surface" requirements and test procedure.

However, **UN Regulations do not define apparent surface perceptually/ photometrically**, only geometrically.

Present definition of apparent surface:

- Ignores **luminance distribution**;
- Ignores **edge contrast**;

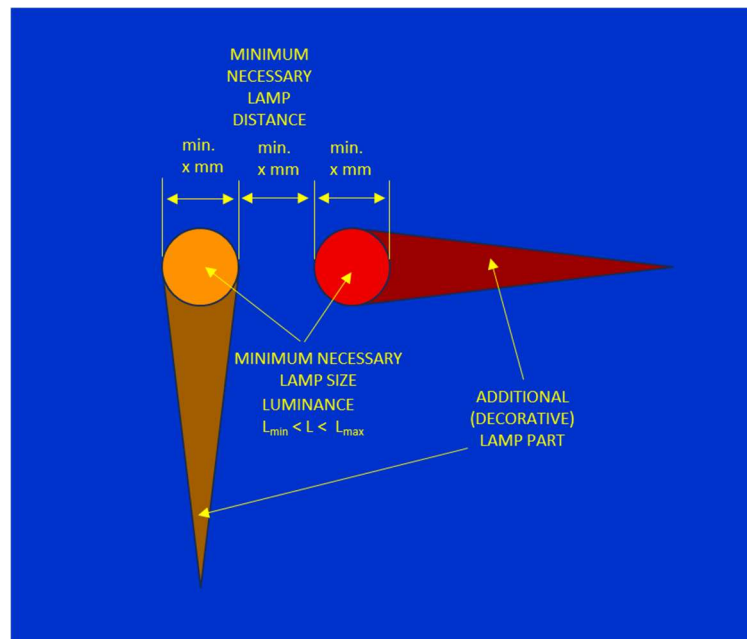
From a human-vision standpoint, area alone is a weak predictor of salience unless luminance and contrast are controlled. Therefore, any numeric threshold (e.g. $\geq 30 \text{ cm}^2$) is at best a **proxy**, not a perceptually grounded value.

CONCLUSION:

Apparent surface **defined only on paper** is not equivalent to perceptual apparent surface which highly depend on **luminance, contrast, geometric** (angular) relations and **background illumination** (luminance). Type approval authorities **cannot objectively verify** what portion of the lamp is perceptually dominant or whether brightness gradients distort the effective signal shape.

Without objective, photometric-perceptual validation of apparent surface and brightness distribution, real-road recognition of DI and SL will be compromised, especially in complex traffic environments.

EXPLANATION ON SCIENTIFIC BASIS OF THE MINIMUM LUMINANCE, MINIMUM DISTANCE AND, MINIMUM SIZES OF LAMPS



Typical following distance in city conditions is of 30 - 40 m. But in motorway conditions it increases to **at least 75 m** for most typical driving situations (2 sec. reaction time for 135 km/h). However, for safe motorway observation 200 m is treated as the proper value (e.g. hazard warning lights, emergency brake lights, other unpredictable events).

Therefore, the lamp size and separation distance in millimeters should be precisely justified by the angular resolution of the sight (visual acuity) related to the observation distance. **For 75 m** observation distance and **two minutes of arc (2')** this gives a minimum lamp size and a distance between lamps (x on drawing above) **of 4 cm** under condition that luminance of whole minimum necessary lamp surface (L) is higher than required minimum.

For smaller distances of actual light-emitting surfaces, the contrast between DI and SL should be at least 3 to 1.

FINAL CONCLUSIONS:

- First, the light-emitting surface and the requirements for its objective inspection must be correctly defined.
- Next, specific minimum dimensions, distances, and luminance values must be defined based on the above model.