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Awareness of the proximity of Vulnerable Road Users:
UN Regulation No. 46 (Devices for indirect vision)

Proposal for a new Supplement to the 04 series of amendments to UN Regulation No. 46 (Devices for indirect vision)

Submitted by the expert from Italy*

The text reproduced below was prepared by the expert from Italy to adapt the provisions of UN Regulation No. 46 to allow the usage of free form mirrors as an alternative to spherical mirrors. It is based on informal documents GRSG-117-16 and GRSG-117-17 that were presented at the 117th session of the Working Party on General Safety Provisions (GRSG) (see report ECE/TRANS/WP.29/GRSG/96, para. 32). The modifications to the current text of UN Regulation No. 46 are marked in bold characters for new and strikethrough for deleted characters.

* In accordance with the programme of work of the Inland Transport Committee for 2020 as outlined in proposed programme budget for 2020 (A/74/6 (part V sect. 20) para 20.37), the World Forum will develop, harmonize and update UN Regulations in order to enhance the performance of vehicles. The present document is submitted in conformity with that mandate.

I. Proposal

Paragraphs 2.1.1.7. to 2.1.1.9., amend to read:

"2.1.1.7. "Spherical surface" means a **convex** surface, which has ~~a constant and equal radius in all directions~~**, in both horizontal and vertical direction, measured radii of curvature compliant with the provisions given in paragraphs 6.1.2.2.2 and 6.1.2.2.4.**

2.1.1.8. "Aspherical surface" means a **convex** surface, which ~~has only in one plane a constant radius~~ **may have variable radii of curvature both in the horizontal and vertical direction.**

2.1.1.9. "Aspherical mirror" means a mirror composed of a spherical and an aspherical part**, defined in 2.1.1.7 and 2.1.1.8 respectively,** in which the transition of the reflecting surface from the spherical to the aspherical part has to be marked. **As an example,** the curvature of the main axis of the mirrors ~~is~~ **may be** defined in the x/y coordinate system defined by the radius of the spherical primary calotte with:

$$y = R - \sqrt{(R^2 - x^2)} + k(x-a)^3$$

Where:

R: nominal radius in the spherical part

k: constant for the change of curvature

a: constant for the spherical size of the spherical primary calotte"

Paragraph 6.1.2.2.1., amend to read:

"6.1.2.2.1. The reflecting surface of a mirror shall be either flat or ~~spherically~~ convex. Exterior mirrors may be equipped with an additional aspherical part provided that the main mirror fulfils the requirements of the indirect field of vision."

II. Justification

1. The purpose of the proposal is to offer an update of quality in optical vision by adopting innovative surface designs and manufacturing processes. The intention is to let the current spherical product continue to be offered on the market and at the same time to allow for the new generation of optical reflecting mirrors being offered to the market in order to improve the quality of the reflected images and optimize the mirror size for a given field of vision.

2. Historically, the need to extend the field of vision for safety purposes suggested to adopt the spherical surface as it was the easiest surface to design and to produce. As an example, for the main rear-view mirrors, the radius was reduced step by step till the actual limit of 1200 mm as a good compromise among different requirements: field of view, mirror size, reflected objects dimensions and image distortion.

UN Regulation No. 46, in its actual form, is responding to the need of geometrical verification of the mirror surface indicating specific requirements related to the surface geometry – that has to be spherically convex with a mean radius within specified limits for each Class – as a result of measurements taken at given positions on the convex surface in order to ensure a minimum size of reflected objects at a given distance.

Vehicles should ideally be equipped with perfectly spherical mirrors. In reality, because of the production process, all of the mirrors have been provided with surfaces in which each point is randomly deviated with respect to the position on the ideal sphere.

Furthermore, the main optical properties which define the quality of the reflected objects – i.e. distortion and aspect ratio – are not defined in the Regulation and are left to the quality assurance protocols negotiated between OEMs and mirror suppliers.

3. In the last ten years many studies have been done on the optical behaviour of non-spherical surfaces, all of them showing that the usage of non-spherical surfaces allows

to get improvements of the optical performances. Moreover, it is a matter of fact that the optical axis of a spherical mirror installed on a car is rotated and decentred with respect to the axis of the driver’s eyes; this condition leads to images squeezed in the horizontal direction. The adoption of a free form surface can compensate the asymmetrical position of the mirrors, reflecting images with the right proportions.

A free form surface cannot be described by an equation because each point has been defined through a mathematical procedure that allows to achieve specific optical design targets. Taking into account the production tolerances, real spherical mirrors installed on the cars, even those better produced, actually have random free form surfaces because the deviation of each point inside the limit established by the Regulation, even if small, is due only to the random result of the production.

On the other hand, design software and manufacturing processes of moulds – CNC multi axes and optical polishing – have created the concrete conditions to reproduce complex surfaces with very affordable precision, quality and reproducibility. Current manufacturing processes of mirrors can be used to reliably produce free form surfaces.

Complying with the actual geometrical verification procedure in the field of view area, as defined in the Regulation, and utilizing the allowed tolerance (0.15 r) as a potential freedom allowance to design free form surfaces will bring the opportunity to optimize the optical performances of the mirror through the appropriate optical software tools. The Average Radius as defined in the Regulation will still be complied with by the free form mirror over that reflecting surface.

In addition, significant improvements can be achieved by the application of the free form surface concept on the aspherical area of the mirror, when that additional surface is designed to extend the viewing area to enlarge the perception of an incoming vehicle from both side rear view mirrors. While still keeping the mean radius in that area in line with the requirements of the Regulation, the free form surface will reduce both the change in aspect ratio and the magnification gap between the field of view area and the extended area, and as a result will provide the driver with a more comfortable vision through the full mirror.

4. The proposed changes to the Regulation will allow vehicle manufacturers to get all of the benefits related to free form surfaces which, according to the way they have been designed, can be one or more of the following:

- Reduction of the optical distortion (this target is valuable especially for the aspherical surface of an aspherical mirror, because the simple function given in par. 2.1.1.9. actually results in a poor quality of the reflected image);
- Blind spot reduction;
- Mirror overall size reduction, while keeping the same field of view, to improve the aerodynamic efficiency of the vehicle and achieve either a reduction of fuel consumption or an increase of the range (in the case of BEVs);
- A clear and more relaxed vision by the driver through the full mirror, thus resulting in a better ergonomics/safety, when an aspherical mirror is replaced with a wide angle free form mirror (the binocular vision through the transition between spherical and aspherical surfaces can be significantly improved by a proper design of the free form surface ensuring a smooth change in curvature between the two parts of the mirror).