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Road ~~Vehicles~~ vehicles — Sensors for automated driving under adverse weather conditions — Assessment of the cleaning system efficiency

Véhicules routiers — Capteurs pour la conduite automatisée dans des conditions météorologiques défavorables — Évaluation de l'efficacité du système de nettoyage

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Foreword

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This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 35, *Lighting and visibility*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at ~~www.iso.org/members.html~~www.iso.org/members.html.

Introduction

With the development ofVehicles with automated driving systems (ADS) , vehicles need more and more sensors:, such as radars, lidars, and cameras, etc. As they. These components are located outside the vehicle, which means they are exposed to weather conditions that could lead to accumulation of impuritiescan cause contamination on the sensitive surface. Alteration of surfaces. This can affect visibility could then result in a lack of appropriate information to enable, which can impair safe driving.

For Level 1 and Level 2 AD systems ADS (defined in ISO/SAE PAS 22736,), any failure ofin sensor detection is overcome by immediate recovery the driver immediately recovering control of the vehicle control by the driver.. From Level 3 and higheronwards, the driver onlyalone cannot guarantee vehicle safety, and a scenario-based safety evaluation must be performed (see ISO 34502).

Sensor technologies are technology is evolving rapidly improving their robustness. Given these circumstances, it is and becoming more robust. It is therefore difficult to determine single set of uniform criteria on how clean is enough to achieve the sensorsensors have to be for automated driving systems to perform as expected performance, and it may further vary according to the situation to be covered by each specific. This can also depend on the role of the given sensor.

Regardless of which sensor.

In this context, regardless of the sensor is used to determine thea vehicle's environment, the sensor front surface of a sensor is kept clean by a cleaning system that allows to maintain a goodmaintains visibility performance. For this purpose, the evaluation ofEvaluating the cleanliness of a sensorthe front surface of a sensor after a cleaning operation allows also to characterizedetermines the efficiency of the cleaning systems.

Road ~~Vehicles~~ vehicles — Sensors for automated driving under adverse weather conditions — Assessment of the cleaning system efficiency

1 Scope

This document proposes a standard test procedure~~, in order~~ to assess the efficiency of cleaning systems for sensors. It addresses the following conditions:

— ~~—~~dust~~ / /~~mud~~,~~

— ~~—~~frost~~ / /~~snow~~,~~

— ~~—~~mist~~ / /~~rain~~.~~

~~There is no~~ This document does not propose a preferred cleaning system ~~described as this~~. This document is intended to be technologically neutral and performance~~ -~~oriented ~~for~~. Its focus is on the cleaning system ~~and~~, not ~~for the~~on sensor detection. ~~For this reason, the~~ The assessment method ~~is~~specified in this document is therefore fully independent from ~~the~~ sensor technology and from the data generated by the sensor ~~itself during~~ when in use.

~~The scope~~ This document is entirely focussed on the cleanliness of the ~~sensor~~ front surface of the sensor.

This document does not address continuous contamination, such as continuous rain~~, as~~. This is because in these circumstances, the efficiency of the cleaning system can only be assessed from ~~the interior of~~inside the sensor ~~in those situations~~.

For ~~a~~ non-continuous contamination, this document includes intermittent cleaning, which is considered ~~as~~ a succession of ~~periodically launched~~ cleaning cycles that are launched periodically, as defined in ~~3.2.~~3.2.

~~This document~~ The test does not include specific day time/night time conditions ~~during the test as they~~. This is because these conditions have no impact on the results and the ~~mean of cleaning~~ average clean remains similar. However, ~~a better~~more efficient cleaning ~~efficiency~~ can be ~~sought for the~~ done at night.

This document does not ~~include~~cover contamination with insects due to the ~~difficulty to get a~~challenges of ensuring homogeneous application.

This document does not provide ~~any direct indicator co-related to the~~ indicators for sensor performance~~, it~~. This document is~~ limited to the evaluation ~~in terms~~ of ~~apparent visual~~ the removal of ~~the contaminant in terms of superficial coverage.~~contamination from surfaces.

This document does not include evaluation on ~~the~~ preventive ~~countermeasure~~measures taken ~~from its~~in the installation design ~~point of view.~~. The aerodynamic design affects how mud sprayed ~~out~~ from a ~~running~~moving vehicle or rain droplets can reach and build-up ~~onto~~on the sensor's frontal protection layer. Countermeasure design is ~~out of~~beyond the scope of this document.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 19403-2, *Paints and varnishes — Determination of the surface free energy of solid surfaces by measuring the contact angle*

ISO 2808, *Paints and varnishes — Determination of film thickness*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obphttps://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/https://www.electropedia.org/

3.1
cleaning system
system able to remove contamination laid down onfrom the sensor surface by using an extrinsic washing procedure, by intrinsically adopting contaminant repelling treatment, or asa combination of both

Note 1 to entry: Intrinsic cleaning refers to treatment that reduces the ability of contaminants to adhere ontoto the surface of the sensor.

3.2
cleaning cycle
set of successive operations of the *cleaning system* (3.1),(3.1), launched by oneanan impulsion initiated either manually or automatically initiated impulsion

3.3
relative wind
wind resulting from the ego motion of the vehicle in motion atin a windless environmental stateenvironment

Note 1 to entry: For practical reasons, the test may be performed within a wind tunnel with the equipment kept steady.

4 Principle of the cleaning efficiency assessment

The assessmenttest described in this document evaluates the efficiency ofhow efficiently the system in removing theremoves contamination from the frontal surface of the sensor outermost window area,of the sensor. This is done by comparing the visually observed contaminants observed visually using photographically captured picturephotographic images (Figure 1). see Figure 1).

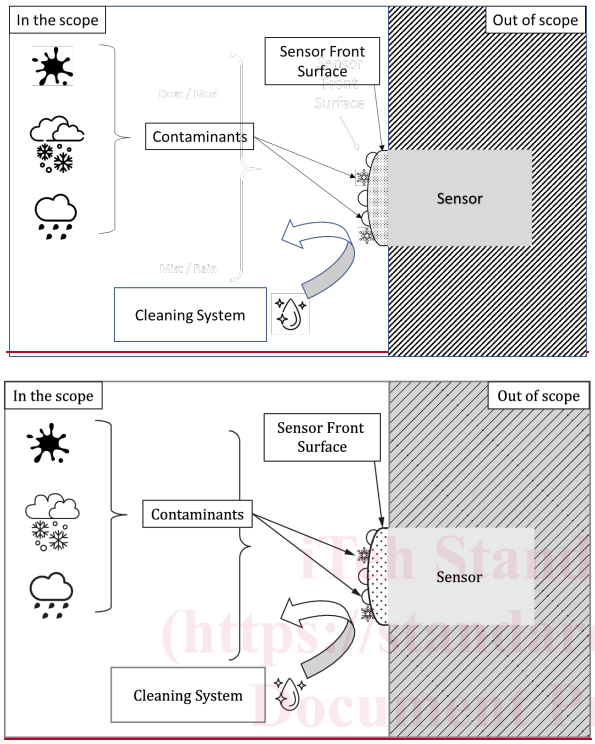

Figure 1 — Cleaning efficiency assessment principle

The surface is evaluated in three stages:

a) ~~a)~~ the initial clean stage;

b) ~~b)~~ the contaminated stage;

c) ~~c)~~ the ~~cleaned~~clean stage after the cleaning cycle.

~~Figure 2~~Figure 2 illustrates a simplified stage of the physical test and the use of photographic ~~image capturing~~images that capture the following:

— the sensor surface before the application of the contaminant (picture 1),

— ~~—~~after the application of the contaminant and the defined cure process when applicable (dry/wet) (picture 2),~~ and~~

— ~~—~~after the cleaning cycle (picture 3).

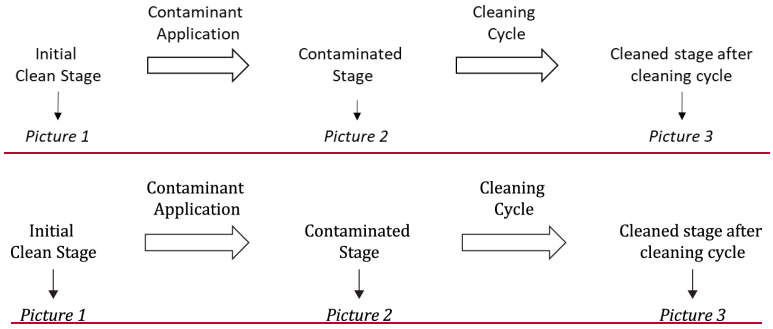

Figure 2 — Test principle

~~The quantitative~~Quantitative evaluation is performed by ~~means of~~ analysing the ~~residual contaminant~~contamination left on the ~~frontal~~front surface of ~~the~~a sensor, e.g. its opening window area ~~specified as a region~~, which is of interest ~~in terms of the spatial area.~~given its size. The contaminant is captured by photographic means~~ and subject~~. The image is then assessed to ~~spatial percentage evaluation~~gauge the proportion of the ~~captured photographic images~~contaminant.

This document does not take into account the ~~volumetric~~volume of contaminants removed~~ but rather a spatial area visual removal~~. Instead, it considers the physical area of the front surface of the ~~contaminants from the~~ sensor ~~frontal surface~~ from which contamination has been removed (see ~~6.4).~~6.4). The ~~evaluation~~ test procedure ~~takes~~determines the contaminated area by taking advantage of ~~the light diffusing characteristic of~~how small particles laid on a flat surface ~~to determine the contaminated area. The residual~~diffuse light. Residual contaminant particles on the ~~frontal~~front surface of the sensor diffuse the incoming reference light. ~~Removal of those~~Removing these contaminants will result in ~~negligible~~less diffusion of ~~the reference~~this light~~, thus enabling a visual differentiation~~. This leaves a visible difference where contamination was successfully removed by the cleaning operation.

~~The quantitative~~Quantitative cleaning efficiency is based on comparing the ~~comparison of the measured~~ areas of the cleaned and contaminated surfaces between pictures 1, 2 and 3 (~~Figure 3~~).see Figure 3).

The relative efficiency of the cleaning system is ~~characterized~~determined by the ~~portion~~size of the clean surface ~~by comparing the amount of contaminated~~ after cleaning. The surface area of the applied contamination is compared with the ~~application of contamination to the amount of~~ contaminated surface after ~~the active cleaning operation.~~