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Sweepers - Part 3: Efficiency of particulate matter collection - Testing and Evaluation

Kehrmaschinen - Teil 3: Aufnahmefähigkeit von Feinstaub - Prüfung und Bewertung

Balayeuses - Partie 3: Efficacité de la collecte des matières particulaires - Essai et évaluation

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Foreword

This document (EN 15429-3:2015) has been prepared by Technical Committee CEN/TC 337 “Road operation equipment and products”, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2015, and conflicting national standards shall be withdrawn at the latest by September 2015.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document (EN 15429-3:2015) is part of a series of documents made up of the following parts:

— EN 15429-1, *Sweepers — Part 1: Classification and Terminology*;

— EN 15429-2, *Sweepers — Part 1: Performance requirements and test methods*;

— EN 15429-3, *Sweepers — Part 3: Efficiency of particulate matter collection — Testing and Evaluation*;

— EN 15429-4, *Sweepers — Part 4: Symbols for operator controls and other displays*.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

Road sweepers are designed to clean transportation surfaces of varying textures. These surfaces exist in many forms, including roadways, sidewalks, and parking lots throughout urban and rural areas. Different size fractions of debris, dirt, and fine dust that originate from various sources accumulate on these surfaces. Fine road dust components, including particulate matter classified as PM_{10} and $PM_{2,5}$, are of particular interest due to the respiratory health hazards that have been associated with these fine particulates.

The European air quality directive requires municipalities throughout Europe to monitor airborne particulate levels, and initiate action plans when prescribed limits are exceeded. Since transportation surfaces are significant accumulators of fine particulate, regular sweeping of these surfaces has been identified as a method that can potentially reduce particulate matter pollution.

Different road sweeper technologies and configurations are available for various sweeping applications. However, the ability of the different technologies and configurations to remove and capture particulate matter from the road surface, and minimize the level of airborne particulates resulting from sweeping, has not been thoroughly evaluated for adequate technical information on this issue to be available. As a result, municipalities may have difficulty selecting a sweeper best suited to a particular sweeping application when making purchasing decisions.

The test method for determining PM_{10} and $PM_{2,5}$ efficiency of road sweepers has been developed to provide an objective and quantitative procedure for assessing the ability of a road sweeper to remove fine particulate from typical paved asphalt surfaces and to reduce the amount of airborne fine particulate generated as a result of the sweeping process.

1 Scope

This European Standard establishes a method to assess the PM_{10} and $PM_{2,5}$ efficiency of road sweepers. PM_{10} and $PM_{2,5}$ efficiency includes a sweeper's ability to:

— Remove and capture PM_{10} and $PM_{2,5}$ particulate matter, and coarse size fractions, from typical urban road surfaces;

— Minimize the amount of airborne and entrained PM_{10} and $PM_{2,5}$ particulate matter resulting from the sweeping process.

The sweeper's ability to remove and capture particulate matter and coarse size fractions is assessed using procedures and equipment to determine the amount of a test material (consisting of particulate matter and coarser size fractions) the sweeper is able to remove from a test surface during a controlled test run. This test measurement is used to calculate the removal efficiency for the sweeper.

The sweeper's ability to minimize the amount of airborne and entrained particulate matter is also assessed using procedures and equipment to determine the airborne concentrations of PM_{10} and $PM_{2,5}$ resulting from the sweeping of a test material (consisting of particulate matter and coarser size fractions) during a controlled test run. The test measurements are used to calculate PM_{10} and $PM_{2,5}$ emission ratings for the sweeper.

This test allows the use of dust suppression water. Sweepers configured as flushing machines, or equipped with front-mounted spray bars which are not part of a dust suppression water system are not within the scope of this test.

The road sweeper's performance results are reported in a quantitative numerical format that will allow comparative assessments of similarly classified sweepers. This test does not specify pass/fail criteria for the PM_{10} and $PM_{2,5}$ efficiency measurements specified in the test procedure.

This test is applicable to truck mounted, self-propelled, towed and attached sweeping equipment as defined in EN 15429-1:2007, Clause 2.

This test is a model/type test, requiring the sweeper being tested to be representative of all factory production of that particular sweeper model.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 12341, *Ambient air — Standard gravimetric measurement method for the determination of the PM10 or PM2,5 mass concentration of suspended particulate matter*

EN 15429-1:2007, *Sweepers — Part 1: Classification and Terminology*

EN 60335-2-69, *Household and similar electrical appliances — Safety — Part 2-69: Particular requirements for wet and dry vacuums, including power brush, for industrial and commercial use (IEC 60335-2-69)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 15429-1 and the following apply.

3.1
PM_{10}
particulate matter which passes through a size-selective inlet as defined in the reference method for the sampling and measurement of PM_{10}, EN 12341, with a 50 % efficiency cut-off at 10 µm aerodynamic diameter

3.2
$PM_{2,5}$
particulate matter which passes through a size-selective inlet as defined in the reference method for the sampling and measurement of $PM_{2,5}$, EN 12341 with a 50 % efficiency cut-off at 2,5 µm aerodynamic diameter

3.3
dust suppression water
water of high-pressure mist sprayed to knock down the fine airborne dust, as dust gets heavy when in contact with the fine water mist

3.4
dust suppression water system
spraying system for dust suppression water consisting e.g. in a pump, a spray bar and nozzles

3.5
front-mounted spray bar
tube with an arrangement of nozzles, holes or slashes as part of a dust suppression water system or flushing system

3.6
flushing system
system for cleaning road surfaces with flushing water

4 Test method features

A test facility (see Figure A.1) is utilized for performing the sweeper test to create a controlled test environment that provides some isolation from the variable effects and influences of the ambient environment. This controlled test environment results in testing conditions that are consistent and repeatable, which translates into more credible test results.

The controlled test environment is created within the test facility using two end wall assemblies to enclose a centrally located, 20 m long sweeper test area. All measurements used to establish test sweeper performance results are performed within the confines of the sweeper test area.

The test facility configuration and sweeper test methodology capture and evaluate performance of the test sweeper while it is in a steady-state operating mode under controlled and consistent test conditions. As the test sweeper travels through the test facility in full operational mode, a representative sampling of test sweeper performance is taken as it sweeps a test material that simulates road dirt within the controlled conditions of the sweeper test area.

A known amount of test material is applied to the test surface to determine the removal efficiency of the test sweeper. The amount of applied test material, although much greater than typical street loading conditions, promotes confidence and repeatability in the test measurements performed.

A sweeper test consists of four valid, individual test runs performed over a period of one or more consecutive days. If weather conditions disrupt testing on an individual day, or prevent testing over consecutive days, the next test run can be postponed and performed when weather and/or test course conditions permit testing to resume. Postponement due to adverse weather conditions will not void the sweeper test.

Of the four individual test runs performed, only the three most consistent test runs yielding the lowest PM emission ratings and highest removal efficiency results will be used to establish the final sweeper test performance results. The results from these three test runs will be averaged to determine the final sweeper test performance results for both removal efficiency and PM emission rating.

A test sweeper can be tested under various operational settings, as it is logical to assume that a change in operational settings will have a positive or negative influence on the test sweeper's emission rating and/or removal efficiency performance. It is also reasonable to assume that a sweeper manufacturer will have identified the operational settings required for optimum sweeper performance in the specified test conditions. Once the optimum operational settings are established, the settings shall remain unchanged throughout the series of four individual test runs that comprise a sweeper test. If an operational setting change is required to improve sweeper performance, a new series of four test runs shall be performed. The operational settings shall be fully documented for each series of test runs.

Dust suppression water can be used to achieve optimum emission rating and removal efficiency results. Since the amount of dust suppression water applied will affect both, emission rating and removal efficiency results, the dust suppression water application rate selected for a series of test runs shall be measured and reported with the results of a sweeper test.

Vacuuming of the test surface in the sweeper test area is performed to determine the amount of test material not captured by the test sweeper during the test run. The use of high efficiency filter and fine dust filter bag equipped vacuums is an effective method for thoroughly capturing the remaining test material, especially the particulate matter component of the test material. This allows for an accurate determination of the test sweeper's removal efficiency.

Aerosol dust monitors centrally located in the sweeper test area and sampling at a height representative of an average adult's nose height, record PM_{10} and $PM_{2,5}$ concentration levels. The concentration levels are recorded prior to the test sweeper entering the sweeper test area, as the test sweeper sweeps through the sweeper test area and after the test sweeper has exited the sweeper test area. The concentration data is used to determine the PM_{10} and $PM_{2,5}$ emission ratings for the test sweeper.

The intent of the test procedure is to provide quantitative numerical performance results, and not impose pass/fail criteria for the PM_{10} and $PM_{2,5}$ efficiency measurements that the test sweeper shall satisfy. The test sweeper's performance results will be reported in a format that allows comparative assessments of similarly classified sweepers tested under the conditions and procedures specified in this test method.

5 Technical requirements

5.1 Test facility

The test facility shall be configured to minimize, to the greatest degree possible, any external disturbances resulting from ambient wind and precipitation conditions. This is critical for creating and maintaining a controlled and consistent test environment in the test facility.

The test facility shall either exist, or be assembled, on a surface that meets the requirements of the test surface specified in 5.3.

The test facility shall accommodate a test course that has minimum dimensions of 40 m long and 7,5 m wide.

The test facility shall have an overall cross-sectional area of 300 m^2, with an allowable variance of ± 10 %.

The test facility shall include a sweeper test area that is 20 m in length and centrally located along the overall length of the test facility. The sweeper test area should be created with two end walls spaced 20 m apart. The end walls shall be configured with door openings and functioning doors. The end walls and doors shall be configured to minimize, to the greatest degree possible, air movement and disturbances inside the sweeper test area resulting from ambient wind conditions acting on the exterior envelope of the test facility.

The door openings in the sweeper test area end walls shall be large enough to allow passage of the largest sweeper that may be tested in a particular test facility.

The end wall doors shall be overhead, top-down closing or horizontal sliding or folding doors. Side-hinge swing-out doors are a not allowed door configuration. The doors shall have the necessary stiffness and perimeter sealing to prevent flexing and leakage due to ambient wind acting against the door. The operation of these doors is likely to influence the environment within the test facility by creating air disturbances during opening and closing.

The end wall doors shall be configured with manual or automatic opening/closing mechanisms. The mechanisms shall permit the doors to open and close as rapidly as possible to ensure minimal disturbance of sweeper test area environments. Rapid opening and closing will ensure the door opened for test sweeper entry into the sweeper test area is completely closed before opening of the opposite door to allow exit of the test sweeper from the sweeper test area.

The test facility may be permanent or temporary. The test facility shall be waterproof and shall have a smooth inner surface/coating to minimize retention of particulate matter.

A steel framed, tarpaulin covered portable shelter structure would be acceptable for use as a temporary test facility.

If a portable shelter structure is assembled to serve as a temporary test facility, the structure should be assembled, if the locations allows, such that the length of the structure is perpendicular to the prevailing wind direction of the region. This will assist in reducing potential ambient wind disturbances that could affect the test.

Refer to the schematic drawing in Annex A for an example of a test facility set-up.

5.2 Test course

Within the dimensions of the test facility, the test course will consist of a 20 m long sweeper test area inside the sweeper test area, and sweep-in/sweep-out areas extending a minimum of 10 m to the outside of each sweeper test area end wall.

The test course shall have one 10 m long curb located along either side of the sweeper test area. The length of the curb shall be centrally located within the length of the sweeper test area.

It is recommended a test course centerline, a curb line and a test material application area outline be marked on the test surface to serve as guides for test sweeper alignment during the test run and test material application.

Refer to the schematic drawings in Annex A and Annex B for test course details.

5.3 Test surface

The test surface shall be a level asphalt surface that is a typical representation of paved urban roads.

The test surface shall have minimal surface roughness resulting from eroded loss of asphalt cement and/or exposure of coarse aggregates.

The test surface shall not have depressions, cracks and/or potholes that would prevent the surface applied test material from potentially being swept by the test sweeper.

5.4 Kerb

A representative kerb structure, measuring 150 mm to 200 mm high, a minimum 50 mm wide, and 10 m long, shall be installed in the sweeper test area. The sweeping side of the kerb shall be a vertical surface.

The kerb shall be centrally located along the length of the sweeper test area. An optional second kerb can also be installed on the opposite side of the sweeper test area to facilitate test runs from either end of the test facility, if test sweeper configuration and/or ambient wind conditions dictates so.

The kerb will serve as a test course obstacle. Test material shall be applied directly adjacent to the kerb such that the test sweeper channel or main broom shall sweep against the kerb to effectively sweep the test material from along the kerb.

Once positioned in the sweeper test area, the kerb structure shall be sealed along its bottom edge to form a continuous surface between the test surface and the kerb. This will eliminate any voids that could accumulate test material and prevent it from being swept during the test run.

The kerb structure shall be constructed of material suited to the application.

The kerb structure shall be secured to the test surface or configured in a manner that ensures it does not move out of position during a test run.

5.5 Test material

A standard test material shall be used for all test runs and shall consist of, by weight:

— 15 % gravel/grit; particle size ranging from 2 mm to 8 mm;

— 65 % washed sand; particles size less than 2 mm;

— 20 % particulate matter (PM) material.

The PM material shall be fine grind calcium carbonate. Fine grind calcium carbonate has a constant particle size distribution and other material properties that make it an acceptable fine road dust simulant for the purpose of this test procedure.

The calcium carbonate product sourced for use shall have a mean particle diameter of 3 microns and a minimum 80 % of its product mass shall have an aerodynamic diameter less than 10 microns.

Technical product information for all test material components shall be referenced for verifying that the material properties meet these specified requirements.

All test material shall be sourced in a dry condition and stored in a dry indoor location.

5.6 Test material application

Given the particle size range of the individual test material components, the PM material and washed sand shall be combined to form a mixture for application on the test surface. Sealed containers and a tumble-type mixer shall be used to ensure thorough mixing of the PM material and washed sand test material components without any material loss.

The gravel/grit component of the test material shall be applied to the test surface as an individual test material component. The gravel/grit component of the test material shall be applied first, prior to the application of the PM material/washed sand mixture.

A commercial grade, manually operated fertilizer drop spreader shall be used to uniformly distribute the PM material/washed sand mixture on the test surface. The necessary spreader settings and any required spreader modifications shall be determined prior to the sweeper test to ensure uniform PM material/washed sand mixture application over the test material application area.

The drop spreader settings required to uniformly apply the PM material/washed sand mixture will not accommodate uniform distribution of the coarse gravel/grit. Therefore, the gravel/grit component shall be