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BSI Standards Publication

Sweepers

Part 2: Performance requirements and test methods

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee B/513, Construction equipment and plant and site safety.

A list of organizations represented on this committee can be obtained on request to its secretary.

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This European Standard was approved by CEN on 27 October 2012.

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Foreword

This document (EN 15429-2:2012) has been prepared by Technical Committee CEN/TC 337 “Winter maintenance and road service area maintenance equipment”, 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of an identical text or by endorsement, at the latest by June 2013, and conflicting national standards shall be withdrawn at the latest by June 2013.

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.

Generally, all surface cleaning machines – sweepers, are designed to clean paved surfaces of varying textures associated with areas exposed to vehicular traffic, pedestrians and those within industrial complexes.

Most of these sweepers are equipped with sweep gear to scarify debris with a pick-up system that collects and conveys the spoil into a hopper. This hopper can be discharged at dumping grounds, unloading stations, into containers or at refuse transfer stations.

Sweeping applications are mainly related to the physical size and dimensions of the sweeper. Sweepers of larger dimensions are designed to operate mainly on streets, highways, motorways, large parking areas and within industrial complexes.

Sweepers of smaller dimensions are designed for the cleaning of inner town streets, pedestrian zones, pavements, bicycle lanes, car parking facilities market places and within industrial plants etc. Manœuvrability is one of the main features of this category of sweeper.

Depending on the dimensions, sweeping attachment equipment (e.g. equipment temporally mounted on multi-purpose carrier vehicles or other machines) may be used in similar applications as above.

Additional equipment for specialised cleaning applications; that may be attached to a sweeper is not covered by this standard.

This document (EN 15429-2:2012) 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 2: Performance requirements and test methods*;

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

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

According to the CEN/CENELEC Internal Regulations, the national standards organisations 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.

1 Scope

This European Standard applies to surface cleaning machines for outdoor applications in public areas, roads, airports and industrial complexes. Cleaning machines for winter maintenance and/or indoor applications are not included within the scope of this European Standard. Surface cleaning machines in terms of this standard, are self-propelled, truck mounted, attached sweeping equipment or pedestrian controlled.

This European Standard deals with the performance and functional characteristics and the test methods applied to the sweeping equipment when used as intended and under the conditions foreseen by the manufacturer.

This European Standard does not include carrier vehicles (e.g. trucks). These are covered in national or EU Directives for vehicles.

This European Standard does not apply to road surface cleaning equipment that would be front mounted on tractors according to EN 13524, or other vehicles.

This European Standard does not apply to machines or components that are specifically designed for cleaning tramlines and rail tracks.

This European Standard does not cover noise emission or any overload protection as these are covered by regulatory requirements.

Industrial sweepers, within the scope of EN 60335-2-72 are excluded from this standard.

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 12281, *Printing and business paper — Requirements for copy paper for dry toner imaging processes*

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

ISO 612:1978, *Road Vehicles — Dimensions of motor vehicles and towed vehicles — Terms and definitions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 15429-1, ISO 612 and the following apply.

3.1
performance
numerical value or meeting a criterion resulting from a defined test method or as a theoretical value from a calculation

Note 1 to entry: Additionally, performance may be stated as a value resulting from a calculation with no associated test conducted, in which case, the declaration shall be disclosed as a theoretical value.

3.2
functional characteristics
describes the operational requirements of a system or a mechanism

3.3
test method
discloses a procedure to achieve the performance criteria

3.4
calculation
equation and method of calculation to determine a performance numerical value

3.5
theoretical value
value derived from drawings and/or from calculation

Note 1 to entry: The value shall declare the absolute performance criteria, the criterion used in the calculation would be those given as advertised in the manufacturer's published data. As this value is purely theoretical, it may be unlikely to be achieved in use.

3.6
maximum sweeping speed
a speed expressed in m/s and/or km/h declared by the manufacturer related to a foreseen sweeping application and/or test

3.7
work mode
condition when the sweeper is conducting cleaning/sweeping activities when used as intended and under the conditions foreseen by the manufacturer

3.8
travel mode
condition when the sweeper is moving between work sites and being driven in a similar way to that of a typical automotive road vehicle

3.9
prime mover
primary power source be it; an internal combustion engine (diesel/petrol/gas), electric motor or hybrid drive system providing the principal power sources for work and travel mode functions.

Note 1 to entry: Some sweepers may employ separate prime movers for propulsion and for driving the sweeping mechanisms.

3.10
truck/carrier vehicle
base vehicle on to which the sweeper equipment is mounted, the sweeper equipment may be in some cases powered by the truck/carrier vehicle prime mover via power-take-off facilities or similar

4 Performance requirements and test methods

4.1 Theoretical sweeping capability

A theoretical value, expressed in m^2/h, derived from a calculation of the product of the maximum sweeping width and the manufacturer's declared maximum sweeping speed.

4.2 Sweep ability

4.2.1 Performance

Sweep ability is the maximum sweeping speed expressed in m/sec and/or km/h. The value is derived from a test method described in 4.2.2.

4.2.2 Test method

Sweep ability shall be derived from a sweeping test, where a test material; composing a dry mixture by weight of 65 % washed sand (< 2 mm), 15 % gravel/grit (2 mm to 8 mm) and 20 % calcium carbonate, shall be spread at a rate of 700 g/m^2 on to a dry smooth paved test surface in a zone extending at least 25 m long and by 60% of the sweeper's maximum sweeping width wide (this sweeping width would be the same value as used for the calculation in 4.1). The maximum sweeping speed would be the speed where the sweeper collects at least 90 % of the test material, the performance assessment may be judged visually.

4.3 Air flow capability

4.3.1 Performance

Sweepers that use pneumatic means to collect and transport swept debris to the collection hopper require sufficient air velocity within the duct communicating with the pick-up device and hopper for satisfactory conveyance. Air movement is usually performed by an exhausting means, e.g. by a fan extracting air from the hopper. The air velocity within the duct and its cross sectional area has a direct correlation with the volume of air movement. Air velocity within the duct shall be expressed as m/sec. Volume of air movement within the duct shall be expressed as m^3/sec, calculated as the product of the average velocity and the duct's cross section expressed in m^2.

Air temperature, atmospheric pressure and the depression within the duct all affect the air density and flow characteristic, hence, any declared values shall be expressed in standard conditions of 20 °C and at 101,3 kPa atmospheric pressure.

The effects of changes in relative humidity also affect air density, but as the effect is minimal, variance affects can be disregarded. Performance shall be advertised at 50% relative humidity with the proviso that tests are conducted in dry weather conditions. If adverse weather conditions are expected then tests shall be aborted.

The following information shall accompany the air flow capability declaration:

- sweeper - model/type;
- declaration expressed in m^3/sec at 20 °C and at 101,3 kPa atmospheric pressure;
- settings and running speeds.

4.3.2 Test method

The average air velocity within the duct may be measured using suitable means. Prior to any test, the machine shall be inspected to ensure that it is in good working order, clean and that any filters and/or communicating ductwork are free of restrictions and or blockages. During tests, the machine shall be set up according to the manufactures recommended settings. In addition, a record of these settings and running speeds shall accompany the performance results.

Annex A describes a technique to measure duct velocity using the Pitot tube method.

4.4 Conveyor or elevator capability

4.4.1 Performance

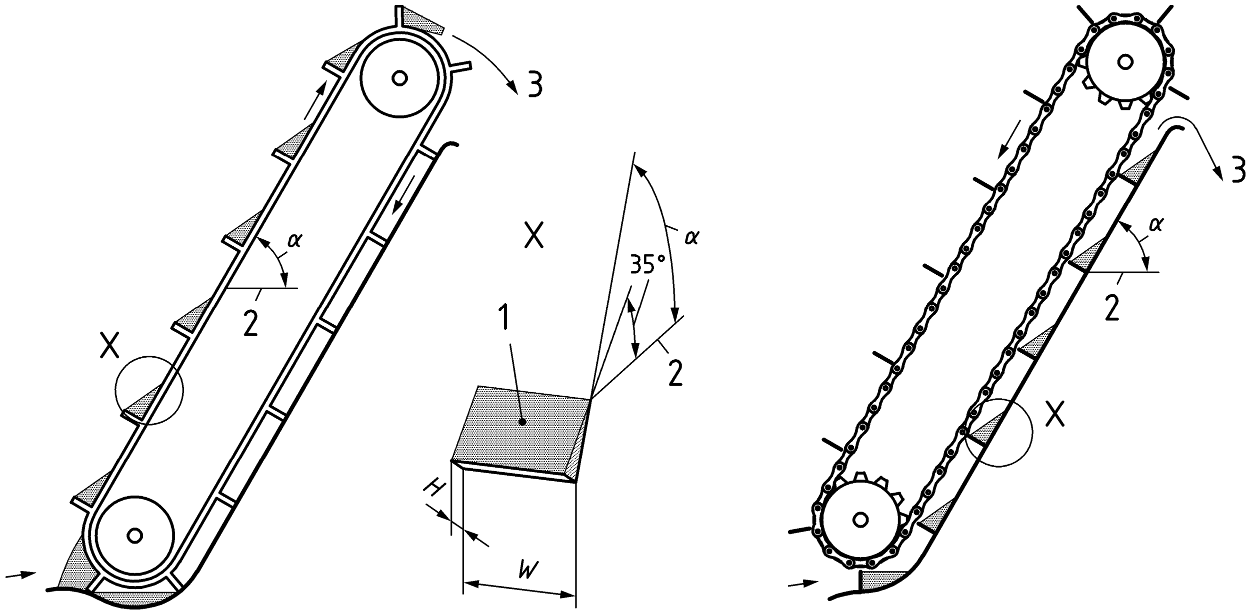
Machines that employ a mechanical means to transfer swept debris to the collection hopper may use a conveyor or elevator system (see figure 1). These systems may be of typical designs arranged vertically or inclined using a number of elevating catchments, e.g. flights/ribs on a conveyor belt, flights dragging up an inclined ramp or other similar mechanisms. In each case, the catchment (C) has a calculated volume in its transfer position, gauged when loaded with dry sand having an angle of repose of 35°. The conveyor system will have an operating speed where the catchment discharge (C_d) rate and its volume can be equated to a maximum loading capability – V_{MLC}, expressed in m^3/min. Performance is assessed by calculation.

The following information shall accompany the conveyor or elevator capability declaration:

- sweeper - model/type;

— capability declaration expressed in m^3/min;

— catchment dimensions and running speed/discharge rate per min.



a) Belt conveyor **b) Flight elevator**

Key

H catchment height
W catchment width
1 catchment (volume)
2 horizontal plane
3 discharge
35° angle of repose (dry sand)
α elevator inclination

Figure 1 — Conveyor/elevator load catchment volume

4.4.2 Calculation

Maximum loading capability V_{MLC} is determined by calculation and disclosed as a theoretical value, thus:

$$V_{MLC} = \frac{H^2 \times W \times C_d}{\tan(\alpha - 35°) \times 2} \quad (1)$$

where

V_{MLC} is the maximum loading capability in (m^3/min);

C_d is the number of catchments discharging per minute (1/min);

H is the catchment height in metres;

W is the catchment width in metres.

4.5 Fuel consumption

4.5.1 Performance

Sweepers may be powered by a single prime mover – known as single-engine machines, providing power for propulsion and for driving the sweeping/collection mechanisms during work mode. Alternatively, separate prime movers may be used solely for propulsion and solely for driving the sweeping/collection mechanisms, typically in the case of truck mounted sweepers – these are known as twin-engine machines. The former single-engine variety is typical of self propelled sweepers though there are also varieties of truck mounted sweeper that are single-engine machines where the sweeping mechanisms are driven via power-take-off systems that are engaged in work mode.

In the case of attached sweeping equipment, the sweeping/collection mechanisms may have their own prime mover or be driven by power-take-off facilities from the carrier vehicle. Fuel consumption declaration in these cases shall be according to the closest similarity to either of the other two other classification type of sweeper.

An example test report of the fuel consumption is given in Annex B.

Table 1 shows prime mover configuration according to machine type.

Table 1 — Classification of sweeper – according to EN 15429-1

Sub-Type	Machine Type	Prime Mover Configuration Single (S) Engine Twin (T) Engine
Large	Truck mounted sweeper	Mainly T / Some S
Small	Truck mounted sweeper	Mainly T / Some S
Maxi-Compact-Sweeper	Self propelled sweeper	S
Compact-Sweeper	Self propelled sweeper	S
Midi-Compact-Sweeper	Self propelled sweeper	S
Mini-Compact-Sweeper	Self propelled sweeper	S
with hopper	Attached sweeping equipment	Mainly S / Some T

Fuel consumption(s) shall be declared in litres per hour (l/h) rounded to the first decimal point and derived from the quantity of fuel used from an average of three test cycles as defined in Figure 2.

In the case of truck mounted sweepers and attached sweeping equipment of the twin-engine variety, the fuel usage of each internal combustion engine shall be declared separately. The fuel used by the non-propulsion internal combustion engines would only be recorded during the sub-test 2) with the quantity used representing the hourly consumption. The following information shall accompany the fuel consumption declaration:

- Sweeper - model/type (and truck/carrier vehicle details if applicable);
- maximum travel speed (km/h) and work speed (km/h);
- details of sweeping-gear, swept width, number and details of brushes in use;
- power setting(s) specifically declared by manufacturer in their operator's manuals;
- total fuel consumption expressed in litres per hour (l/h).

Annex B shows a test report template recording the required information for a fuel consumption declaration.

4.5.2 Test method

The test shall be conducted under the following conditions and method shown in Figure 2:

— Prior to the test, the sweeper shall be prepared in a ‘ready for work’ condition and laden to at least 75% of its maximum permitted mass - inc. fuel, water, driver and with the hopper partially loaded with suitable material. All internal combustion engines and associated driven equipment shall be at their normal operating temperatures prior to test.

— During the work mode sub-test 2) all sweeping/collection mechanisms shall be in their working positions and work at their specific power ratings stated by the manufacturer in their operator's manual. No sweeping performance requirement is required.

— The test shall be conducted on a flat, paved, clean test track with any gradients less than 2 %.

— Maximum speeds of sub-test 1) and maximum work speed of sub-test 2) shall be constant within a tolerance of ± 10 % and recorded in the test report (see Annex B).

— Acceleration activity shall be conducted as quickly as possible.

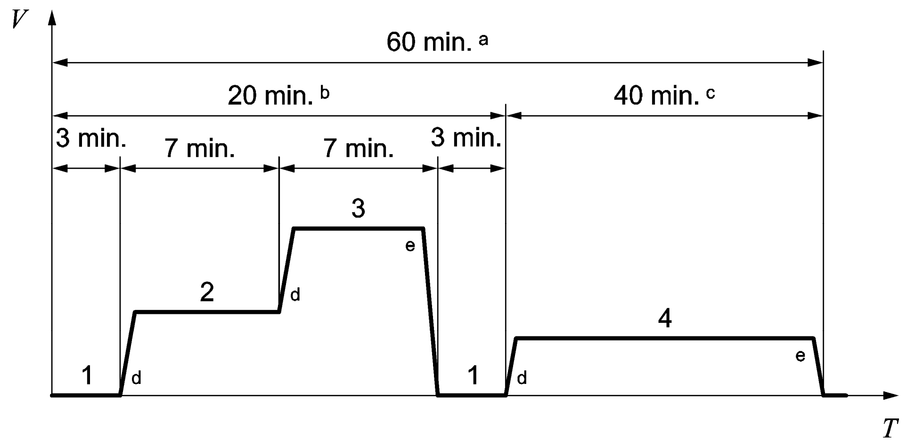
— Braking activity shall be conducted rapidly and in a safe manner.

— Fuel used by each prime mover shall be measured with a ± 3 % accuracy for example using flow meters or graduated containers. Measurements before and after test shall be conducted on a level surface.

NOTE Fuel density, calorific values and temperature can effect fuel consumption and may lead to variation in results

— Weather conditions shall be within an ambient temperature range 10 °C to 25 °C.

— In the case of the prime movers driving solely the sweeping/collection mechanisms, fuel usage measurement is only recorded during the work mode sub-test 2).



Key

1 propulsion prime mover at idle speed
2 maximum travel speed, not exceeding 16 km/h
3 maximum travel speed, not exceeding 40 km/h
4 50% maximum work speed, not exceeding 6 km/h
V speed (km/h)
T time (min)
a simulation – typical operational conditions (test run 60 minutes duration)
b travel mode sub-test 1 (20 minutes duration)
c work mode sub-test 2 (40 minutes duration)
d accelerate
e brake

Figure 2 — Fuel consumption test cycle

4.6 Grade-ability

4.6.1 Performance

The maximum grade-ability shall be expressed as % Grade, where the maximum grade is the lesser of the following conditions; ability to start and maintain a climbing speed > 2 km/h, ability to stop, bring to rest and hold the machine, unless endorsed with details of specific operational modes, e.g. forward, reverse, service brake, park brake etc.

All conditions are where the mass of the machine is at its permitted maximum.

The following information shall accompany the grade-ability declaration:

a) sweeper - model/type and maximum permitted mass;

b) grade-ability expressed as % grade as the lesser of:

  1) the ability to start in a forward and reverse direction;

  2) the ability to stop, bring to rest from a moving condition;

c) and hold the machine in a forward and reverse direction.

4.6.2 Test method

Calculation and/or applicable practical tests may be used to determine the % grade performance.

Annex C discloses an example using a towed braked vehicle together with calculations.

4.7 Kerb climbing and clearance capability

4.7.1 Performance

The tractive effort of the sweeper's propulsion system and the approach angle when mounting a kerb or step affects its ability to mount it and generally, the more acute the angle of approach the greater the difficulty. Performance shall be expressed as the maximum step height (mm) the sweeper can mount when approaching from a static position, at alternate angles of 30° and 60°. The mass of the machine may affect the achievement and performance shall be declared at the maximum permitted mass.

Physical constraints where a structural element of the sweeper may impact a kerb shall be declared as the limiting factor in defining maximum kerb/step height. Impact with flexible elements, for example brush tines and flexible curtains etc. shall be excluded.

The following information shall accompany the kerb climbing and clearance capability (see figure 3) declaration:

— sweeper - model/type and maximum permitted mass;

— wheel/tyre size;

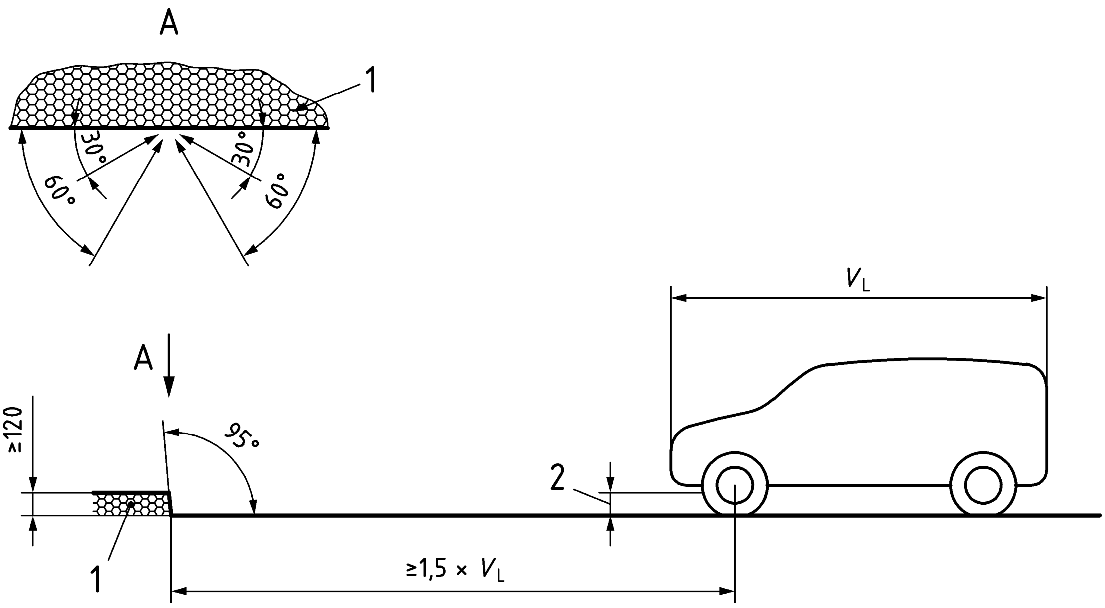
— any structural element limitation;

— kerb height expressed in mm as the lesser of:

  — approaching the kerb at the alternate angle of 30°;

  — approaching the kerb at the alternate angle of 60°.

Dimensions in millimetres



Key
1 roadside kerbing
2 kerb clearance
A plan view on arrow showing approach angles
V_L vehicle length

Figure 3 — Kerb climbing ability

4.7.2 Test method

The sweeper under test shall approach the kerb from a static position and from a distance of at least 1.5 times the machine's length away from kerb and at angles of 30° and 60° to the kerb with the steering set in the straight-ahead position. The test is complete once all wheels have mounted the kerb without impact with any structural element, save impact with brush tines or flexible curtains.

The test kerb shall have initial start height of 120 mm and ideally be of artificial construction where it can be increased in height specifically for the test. If the initial test kerb height of 120 mm is impractical then it may be reduced to allow a test to be conducted.

The sweeper shall be laden to its permitted maximum mass and equipped with tyres in a new condition and pressurized according to the sweeper manufacturer's recommendation.

For sweepers with fluid power transmission systems, the drive and prime mover controls may be moderated to adjust the approach speed and climbing ability while each wheel climbs the kerb. All-wheel drive systems when fitted may be employed.

For sweepers with mechanical transmissions, the transmission shall be set in its lowest drive gear and the engagement mechanism and prime mover control may be moderated to adjust the approach speed and climbing ability while each wheel climbs the kerb. Differential locks and all-wheel drive systems when fitted may be employed.

4.8 Ramp, approach and departure angles

These are as defined in ISO 612:1978, definition numbers; 6.9, 6.10 and 6.11 respectively. Angles shall be defined with all sweeping gear in their stowed positions.

All conditions are where the mass of the machine is at its permitted maximum.

Physical constraints where a structural element of the sweeper may impact a paved surface, shall be declared as the limiting factor. Impact with flexible elements, for example brush tines and flexible curtains etc. shall be excluded.

The following information shall accompany the ramp, approach and departure angle declarations:

- sweeper - model/type and maximum permitted mass;
- wheel/tyre size;
- any structural element limitation;
- ramp, approach and departure angles expressed diagrammatically using illustrations similar to those found in ISO 612:1978.

4.9 Ground (footprint) pressure

4.9.1 Performance

Ground (footprint) pressure; is defined as the contact pressure exerted by the sweeper in a static condition on a smooth paved surface. This pressure is derived as the product of the loaded force of a particular wheel divided by the area of its tyre footprint or contact witness on the paved surface. The tyre demonstrating the greatest ground pressure shall be deemed as the maximum ground (footprint) pressure exerted by the sweeper. Tyres shall be in a new condition and pressurized according to the sweeper manufacturer's recommendations with the sweeper loaded to it permitted maximum mass. Maximum ground (footprint) pressure shall be defined in Pascal (Pa) or (N/m²) units.

The following information shall accompany the maximum ground (footprint) pressure declaration:

— sweeper - model/type and maximum permitted mass;

— wheel/tyre sizes according to axles and inflated pressures;

— maximum ground (footprint) pressure expressed as the wheel/tyre demonstrating the greatest pressure found from the test method.

4.9.2 Test method

In cases where differing tyre sizes or multiple wheels/tyres (e.g. twin wheels on truck mounted sweepers) are fitted on particular axles, the test shall be repeated for each case to determine the footprint with the greatest ground pressure. Where multiple wheels/tyres are fitted in one location the combined area of the tyre footprints shall be used to determine the ground pressure. The sweeper shall be laden to its permitted maximum mass and equipped with tyres in a new condition and pressurized according to the sweeper manufacturer's recommendation. Where the same size wheels/tyres are solely fitted on each axle of the sweeper, the test may be applied to the wheel/tyre with the greatest load.

To determine the contact witness (footprint, see also figure 4) of the tyre the following procedure may be adopted, a smooth test surface able to support the mass of the sweeper is a requirement:

— load sweeper to its maximum permitted mass;

— raise wheel/tyre under test clear of the test surface with a jacking means;

— place under the tyre an 'inking' means to impress the tyre's tread pattern with a marking medium;

— lower wheel/tyre gently on to the 'inking' means to mark the tyres tread pattern;

— raise wheel/tyre and remove 'inking' means;

— place under the wheel/tyre a paper sheet typically of 80 g/m^2 according to EN 12281;

— lower wheel/tyre to 'ink-blot', the tyres contact witness (footprint) onto the paper sheet;

— remove paper sheet with contact witness and record detail of the test on the sheet;

— evaluate the loaded force in Newton (N) impacted by the wheel/tyre with suitable weighing means and record data on the test sheet;

— the area occupied by the tyre tread voids is ignored;

— repeat the test for other wheels/tyres as required.

4.9.3 Calculation

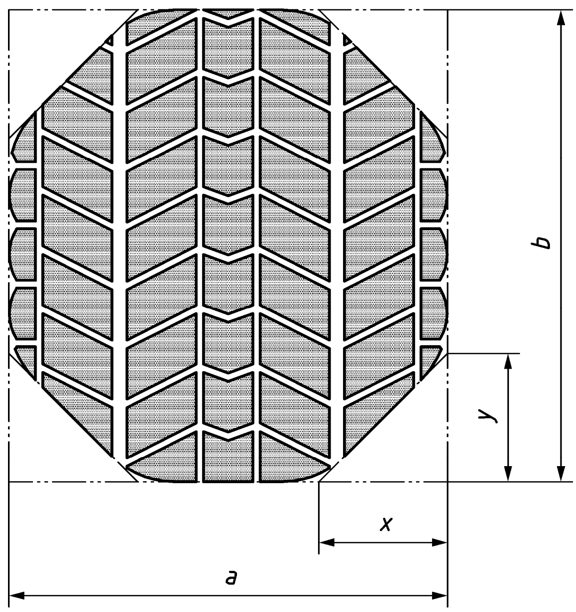


Figure 4 — Footprint - contact area evaluation

1) Contact witness area = total rectangular surface - 4 x triangular surfaces

$$C_a\left(\text{mm}^2\right) = (a \times b) - [2(x \times y)] \text{ in mm}^2 \quad (2)$$

2) Ground (footprint) pressure = loaded force impacted by the wheel/tyre (N) divided by C_a

$$G_p\left(\text{kPa}\right) = \frac{\text{loaded force (N)}}{C_a} \text{ in Pascal (Pa) or (N/m}^2\text{)} \quad (3)$$

5 Functional characteristics

5.1 Water system

a) The function of water pumps and systems shall not be impaired when there are risks of impurities in the water.

b) It shall be possible to fully drain the water system to reduce the risk of freezing in cold weather.

5.2 Sweeping gear

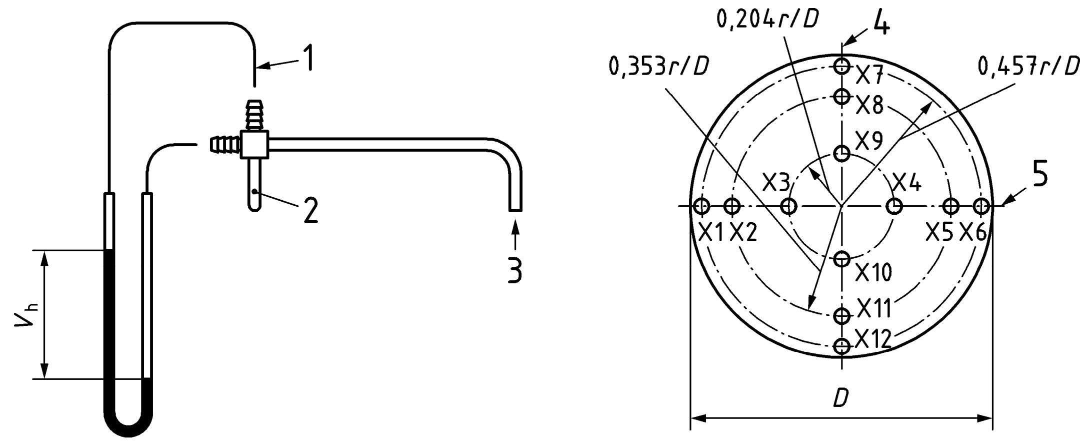
The sweeping gear when active in working positions shall deflect on impact with solid obstacles.

Annex A
(informative)

Air velocity and volume measurement using the Pilot tube method

Where duct velocities are likely to exceed 3m/sec, the Pitot tube method (see figure A.1) is a traditional method of measurement. Full explanation of the equipment, its general use and application within the duct are disclosed in the ASTM Standard D3154-00(2006).

The following elaborates the test locations for the Pitot tube when used in a circular duct and the calculation steps to determine the duct air velocity (m/sec) together with corrections necessary to equate to standard climatic conditions of 20 °C and 101,3 kPa. Multiplying the standard corrected average velocity by the duct's cross section area (m^2) defines the air volume flow (m^3/sec), A suggested test log is also shown, see table A.1.



Key

V_h velocity head
1 static pressure
2 direction pointer
3 air flow
4 second pass
5 first pass
D duct diameter
X pitot tube test locations

Figure A.1 — Pitot tube and test locations in a circular duct

1) To ascertain the average velocity head V_h (mm H_2O) from the pitot tube test readings (X_n), each reading is squared and the summation of all, then divided by the number of test readings (NTR), the square root of this calculation equates to the average velocity head (mm H_2O).

$$V_h = \sqrt{\frac{\left(\sum X_n^{\ 2}\right)}{\text{NTR}}} \qquad \text{(A.1)}$$

2) Equation (2) is applied to derive the standard temperature correction factor T_s (20 °C). The ambient temperature T (°C) shall be the temperature recorded during the test.

$$T_s = \frac{(\text{T} + 273)}{273} \qquad \text{(A.2)}$$

3) Equation (3) is applied to derive the standard barometric pressure p_b (101,3 kPa), correction factor. The ambient pressure p (kPa) shall be the pressure recorded during the test.

$$p_b = \frac{101,3}{p} \tag{A.3}$$

4) The conveying air within the duct will be under a depression, so again affecting its density. Equation (4) is applied to derive a standard density correction factor D_C.

$$D_C = \frac{10\,363}{(10\,363 + \text{static depression (mm } H_2\text{O) in test duct})} \tag{A.4}$$

5) Equation (5) is applied using the values derived from equations (1), (2), (3) and (4) to determine the average duct velocity V_a (m/sec). Variance in relative humidity has little effect in the result and can be ignored.

$$V_a = 4,032 \times \sqrt{(1) + (2) + (3) + (4)} \tag{A.5}$$

Air volume (m^3/s) at the standard conditions is derived by multiplying the value found from equation (5) by the cross section (m^2) of the duct where the Pitot tube test readings were taken.

Table A.1 — Test log

<table>
<tr><td>Sweeper Data</td><td colspan="3"></td></tr>
<tr><td colspan="3">Ambient temperature T (°C)</td><td></td></tr>
<tr><td colspan="3">Ambient barometric pressure p (kPa)</td><td></td></tr>
<tr><td colspan="3">Fan speed (r/min)</td><td></td></tr>
<tr><td rowspan="14">Uncorrected Pilot Tube Test Readings (mm H_2O)</td><td rowspan="6">First Pass</td><td>X1</td><td></td></tr>
<tr><td>X2</td><td></td></tr>
<tr><td>X3</td><td></td></tr>
<tr><td>X4</td><td></td></tr>
<tr><td>X5</td><td></td></tr>
<tr><td>X6</td><td></td></tr>
<tr><td rowspan="6">Second Pass</td><td>X7</td><td></td></tr>
<tr><td>X8</td><td></td></tr>
<tr><td>X9</td><td></td></tr>
<tr><td>X10</td><td></td></tr>
<tr><td>X11</td><td></td></tr>
<tr><td>X12</td><td></td></tr>
<tr><td colspan="2">Average velocity head V_h (mm H_2O)</td><td></td></tr>
<tr><td colspan="2">Static pressure (mm H_2O) in test duct</td><td></td></tr>
<tr><td rowspan="2">Corrected Values
(20 °C/101,3 kPa)</td><td colspan="2">Average duct velocity V_a (m/s)</td><td></td></tr>
<tr><td colspan="2">Test duct air volume (m^3/s)</td><td></td></tr>
</table>

Annex B
(informative)

Test Report - Fuel consumption

Fuel Consumption to EN 15429-2 **Test Report**	**Reference N°** …………… Date ……………………………

Machine Details:

Make: ………...

Model Designation: ………………………………………………………………………………………………………

Serial No: ……

Engine Type: ……………………………………………………………………………………………………...

Auxiliary Engine Type (if fitted): ………………………………………………………………………………….

Fuel Type: ………………………………………………………………………………………………………...

Sweeper classification (EN 15429-1): …………………………………………………………………………

Special Features: ………………………………………………………………………………………………...

Test Results:

Aspect	Fuel Used (litre)	Travel Mode Distance (km)	Work Mode Distance (km)
Test Run 1			
Test Run 2			
Test Run 3			
Total (Run 1 + Run 2 + Run 3)			
Average (Total / 3)			

NOTE; Test run conditions/method according to EN15429-2, each run of 1hr duration

Remarks, Operating and Equipment Functional Conditions:

Power setting(s) as specifically declared by the manufacturer in the their operator's manual:

………...

Engine speed (1/min) …………… Auxiliary engine speed (1/min) ……………. Suction fan speed (1/min) …………….

Max travel speed (km/h) ……………………………….….Max work speed (km/h) ………….…………………………

Description of active brush/broom configuration, types/size, speed, sweeping path width, etc:

………...

Fuel measurement method (e.g.: flow meter, graduated containers):……………………………………………...…

Wheel/Tyre sizes, pressures etc.: ………………………………………………………………………………...

………...

Other active equipment: Heating/air-conditioning ………………………….. Work-lamp/s ………………………………

Beacon/s ……………………………. Other…………………………………………………………………………...

Road surface type (e.g. asphalt, concrete, dry, wet, etc: ………………………………………………………………...

………....

Climatic Conditions (within an ambient temperature range 10 °C to 25 °C):

…………………………………………………………………………………………………..……

Test Organisation/Engineer: ………………………………………………………………..................	**Declared Fuel Consumption (l/h)** ………………………………………

Annex C
(informative)

Example - Grade-ability test and calculation

C.1 Introduction

The sweeper under test is coupled to, and set up to tow a brake vehicle with a force sensor located in the towing linkage with additional means to measure the speed of vehicle combination. Tests shall be carried out on a flat, dry and level paved surface.

The towing force F and speed v sensor signals will be recorded ideally by a data acquisition system showing the towing force and speed simultaneously.

The brake vehicle may be any wheeled vehicle with a tractive and braking capability, where the tractive effort is greater than the braking effort of the test sweeper and the braking effort greater than the tractive effort of the test sweeper.

C.2 Test Procedure – Tractive Effort – Ability to start on and climb a gradient

C.2.1 General

1) With the towing linkage attached to the rear of rear of the test sweeper, the sweeper is then held and arrested in a static position by the brake vehicle;

2) the test sweeper is then made pull away in a forward direction with maximum tractive effort but retrained by the brake vehicle;

3) the brake of the brake vehicle is then gradually released to allow the test sweeper to start to move forward but still under restraint by the braking effort of the brake vehicle so that maximum tractive effort from the test vehicle is required achieve a maximum speed v of 2,0 m/s (7,2 km/h);

4) the brake of the brake vehicle is then applied to bring the test sweeper to a stop still under maximum tractive effort;

5) the test sweeper's towing effort is then neutralized;

6) the test is then repeated a further two more times (3 test runs in total);

7) the stages 1 to 6 are then repeated in the reverse mode – by coupling the tow linkage to the front of the test sweeper and driving it backwards.

Remarks:

a) the sweeper shall be loaded to its maximum permitted mass to prevent potential wheel spin;

b) the test cycle should be of short duration to minimum risks of overheating the brakes and systems.

The recordings of the two parameters; force F and speed v will show the towing force behaviour during the test. The value of F in Newtons (N) shall be the maximum peak towing force occurring during the test stages 2), 3) and 4).

C.2.2 Test result and calculation

The average value F, from the three test runs for the forward and reverse tests shall be used in the calculation to determine the sweeper's capability to start on and climb a gradient in either condition.

$$F = \frac{1}{n}\sum_{i=1}^{n} F_i \quad n = 3 \tag{C.1}$$

The maximum inclination angle α can be calculated by taking the arcsine of the average force in Newtons F divided by the maximum permitted mass in kg GPM times "g" (where: g = 9,807).

$$\alpha = \arcsin\left\{\frac{F}{GPM \times g}\right\} \tag{C.2}$$

C.3 Test Procedure – Braking Effort - Ability to slow, stop and hold on a gradient

C.3.1 General

To determine the test sweeper's braking ability, the functions of the test sweeper and brake vehicle are be reversed where the test procedure is modified as follows:

1) With the tow linkage coupled to the front of the test sweeper, the brake machine is held and arrested in a static position by the test sweeper;

2) the brake vehicle is then made pull away in a forward direction but retrained by the test sweeper applying its maximum braking effort – tests may be done for both service and parking brakes;

3) the tractive effort of the brake vehicle is then gradually increased to overcome the braking effort of the test sweeper without skidding so that it starts to gain speed v to a maximum of 2,0 m/s (7,2 km/h);

4) the brake vehicle's towing effort is then neutralized;

5) the test is then repeated a further two more times (3 test runs in total);

6) the stages 1 to 6 are then repeated in the reverse mode – by coupling the tow linkage to the rear of the test sweeper and towing it in backwards.

Remarks:

a) The sweeper shall be loaded to its maximum permitted mass to prevent potential wheel skid;

b) the test cycle should be of short duration to minimum risks of overheating the brakes and systems.

The recordings of the two parameters; force F and speed v will show the braking force behaviour during the test. The value of F in Newtons (N) shall be the peak reactive braking force resulting during the test stages 2) and 3).

C.3.2 Test Result and Calculation

The same equation and calculation as used for the tractive effort is applicable.

The product of a complete series of grade-ability tests should realize six values for; starting on and climbing a gradient, in both forward (1) and reverse (2) directions, stopping and holding on gradient in both forward (3) and reverse (4) directions, ability of the park brake to hold on a gradient in both forward (5) and reverse (6) directions.

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The following references are made to these documents which only serve for information and have merely served as reference in the preparation of this standard.

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