INTERNATIONAL STANDARD

ISO 11094

First edition
1991-11-01

Acoustics — Test code for the measurement of airborne noise emitted by power lawn mowers, lawn tractors, lawn and garden tractors, professional mowers, and lawn and garden tractors with mowing attachments

Acoustique — Code d'essai pour le mesurage du bruit aérien émis par les tondeuses à gazon à moteur, les tracteurs de pelouse, les tracteurs de jardin et de pelouse, les tondeuses à usage professionnel, et les tracteurs de jardin et de pelouse avec équipements de tonte adaptables

Reference number
ISO 11094:1991(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 11094 was prepared jointly by Technical Committees ISO/TC 43, *Acoustics*, Sub-Committee SC 1, *Noise* and ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Sub-Committee SC 13, *Powered lawn and garden equipment*.

Annex A of this International Standard is for information only.

International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland
Printed in Switzerland

Introduction

This International Standard describes a method for measuring the airborne noise emitted by powered grass-cutting machines essentially in accordance with ISO 4872. The method specifies the determination of the acoustical characteristics of a machine in terms of the A-weighted sound power level. The values obtained are the fundamental quantities for characterizing the sound output of the machine under test. The A-weighted sound power level of the machine is calculated from measured values of the A-weighted sound pressure level at several microphone positions located on a hypothetical hemispherical surface which envelops the machine. It has, however, been considered appropriate to specify fewer microphone positions than those in ISO 4872.

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Acoustics — Test code for the measurement of airborne noise emitted by power lawn mowers, lawn tractors, lawn and garden tractors, professional mowers, and lawn and garden tractors with mowing attachments

1 Scope

This International Standard specifies methods for measuring the A-weighted sound pressure levels at prescribed microphone positions in the proximity of the machine under test while the machine is stationary or in motion. From these values the A-weighted sound power level of the machine may be calculated.

It defines acoustical requirements for measurements in an essentially free field over a partially reflecting plane, covered with a specified official absorbing material or natural grass (see 4.1). The operating and mounting conditions of the machine under test are described in detail.

NOTE 1 For noise control purposes, for example in the development of quieter machines, other methods employing frequency analysis are usually applied.

This International Standard applies to the following types of mower designed for private or professional (commercial) use in recreational, decorative and domestic areas:

— powered lawn mowers: walk-behind mowers, self-propelled mowers and riding mowers with, for example, rotary- and reel-mowing systems, and with reference to the power source such as mains-powered electric mowers, battery-powered electric mowers and internal combustion engine-powered mowers;

— lawn and garden tractors or other multi-purpose gardening machines with attachments for mowing, with mowing systems as for powered lawn mowers being powered by electric batteries and/or internal combustion engines;

— professional (commercial) mowers and turf-care equipment.

It does not apply to the following:

— towed machines with mowing systems which are not powered by the machine but powered by a gearing mechanism from the wheels of the machine;

— agricultural and forestry machines for grass-cutting or grass-harvesting.

This International Standard does not describe the following:

— measurement of sound pressure levels at the operator's position (i.e. at the ears of the operator);

— determination of the directivity characteristics of the emitted noise and of the content of impulsive noise since these quantities are irrelevant;

— determination of frequency characteristics, for example, for noise control purposes in the development of quieter machines, where frequency analysis in octave bands or one-third octave bands is usually applied.

NOTES

2 A-weighted sound power levels determined in accordance with this International Standard tend to result in repeatability standard deviations of approximately 1 dB, provided that the noise spectrum does not contain pronounced discrete frequencies. If it does, the magnitude of the repeatability standard deviations may be larger than 1 dB. The repeatability standard deviation of 1 dB reflects the cumulative effects of all causes of measurement uncertainty, excluding variations in the noise emission from machine to machine in mass or quantity production and from test site to test site.

3 For different test sites, the reproducibility standard deviation may be 2 dB. Artificial test site surfaces will

probably give the smallest reproducibility standard deviations.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 354:1985, *Acoustics — Measurement of sound absorption in a reverberation room.*

ISO 4046:1978, *Paper, board, pulp and related terms — Vocabulary.*

ISO 4872:1978, *Acoustics — Measurement of airborne noise emitted by construction equipment intended for outdoor use — Method for determining compliance with noise limits.*

ISO 5395:1990, *Power lawn-mowers, lawn tractors, lawn and garden tractors, professional mowers, and lawn and garden tractors with mowing attachments — Definitions, safety requirements and test procedures.*

IEC 651:1979, *Sound level meters.*

IEC 804:1985, *Integrating-averaging sound level meters.*

IEC 942:1988, *Sound calibrators.*

3 Definitions

For the purposes of this International Standard, the definitions given in ISO 5395 and the following definitions apply. For the convenience of users, some definitions from ISO 5395 are repeated.

3.1 sound pressure level, L_p: Ten times the logarithm to the base 10 of the ratio of the square of the sound pressure to the square of the reference sound pressure. It is expressed in decibels. The reference sound pressure is 20 µPa $(2 \times 10^{-5}$ Pa). The symbol for the A-weighted sound pressure level is L_{pA}.

3.2 A-weighted surface sound pressure level, $\overline{L_{pA}}$: Mean sound pressure level weighted over the measurement surface. (See clause 8.) It is expressed in decibels.

3.3 sound power level, L_W: Ten times the logarithm to the base 10 of the ratio of a given sound power to the reference sound power. It is expressed in decibels. The reference sound power is 1 pW$(10^{-12}$ W). The symbol for the A-weighted sound power level is L_{WA}.

3.4 measurement surface: A hypothetical surface of area S which envelops the machine under test and on which the microphone positions are located.

3.5 background noise: At the microphone positions on the measurement surface, the A-weighted sound pressure levels of any noise which is not generated by the machine under test.

3.6 maximum operating engine [motor] speed: Highest engine/motor speed obtainable when adjusted in accordance with mower manufacturer's specifications and/or instructions with the cutting means engaged, taking into account all tolerances.

[ISO 5395:1990, 1.3.23]

3.7 grass catcher: Part or combination of parts which provides a means for collecting grass clippings or debris.

[ISO 5395:1990, 1.3.17]

3.8 cutting width: Width of cut measured across the cutting means at right-angles to the direction of travel and calculated from the dimensions of the cutting means or the diameter(s) of the blade tip circle(s).

[ISO 5395:1990, 1.3.9]

3.9 directional designation: Those designations, such as front, forward, rear, right, right-hand, left-hand, which refer to the direction of travel or orientation of the vehicle, mower or parts thereof when the operator is in the normal operating position.

3.10 machine: Term used for any kind of grass-cutting machinery, e.g. lawn mower tractor with attachments for mowing.

4 Acoustic environment

4.1 Criteria for adequacy of the test environment

4.1.1 General

The test environment shall be a flat open space (a slope, if any, not exceeding 5/100), visibly free of sound-reflecting objects (building, trees, poles, sign boards, etc.) within a circular area with a radius equal to approximately three times the radius of the hemispherical measurement surface used. Two alternatives for the surface of the test environment are given in 4.1.2 and 4.1.3.

For measurements indoors, the sound field inside the measurement room shall be similar to that of an acoustical free field and the values obtained shall be the same as those obtained when measurements are undertaken outdoors in the open air using an artificial surface.

4.1.2 Artificial surface

The artificial surface shall have absorption coefficients as given in table 1, measured in accordance with ISO 354.

Table 1 — Absorption coefficients

Frequency Hz	Absorption coefficient	Tolerance
125	0,1	± 0,1
250	0,3	± 0,1
500	0,5	± 0,1
1 000	0,7	± 0,1
2 000	0,8	± 0,1
4 000	0,9	± 0,1

The absorptive material shall be placed on a hard, reflecting surface and have a size of at least 3,6 m × 3,6 m placed at the centre of the test environment. The construction of the supporting structure shall be such that the requirements for the acoustical properties are also met with the absorptive material in place. The structure shall support the mower to avoid compression of the absorbing material.

NOTE 4 See annex A for an example of a material and construction which can be expected to fulfil these requirements.

4.1.3 Natural grass

The test environment shall be covered, at least for the horizontal projection of the measurement surface used, with high-quality natural grass, cut before the measurements are taken to a height of cut in accordance with 6.1. The surface shall be clean of grass clippings and debris and shall be visibly free of moisture, frost or snow.

4.2 Criterion for background noise

At the microphone positions, the A-weighted sound pressure level due to any background noise shall be at least 6 dB, and preferably more than 10 dB, below the A-weighted sound pressure level when the machine under test is operating (see 7.3).

4.3 Climatic conditions

At the open test site, the wind speed shall be less than 8 m/s, and preferably not greater than 5 m/s. For wind speeds in excess of 1 m/s, the microphone(s) shall be equipped with a suitable wind-screening attachment and appropriate corrections for the effects of its use shall be applied in accordance with the manufacturer's instructions.

The air temperature of the test environment shall not be below 5 °C

5 Instrumentation

5.1 Instrumentation for measuring acoustical data

The instrumentation shall be designed to permit the determination of A-weighted sound pressure levels averaged over time on an energy basis. Tolerances of the measuring chain shall not exceed the tolerances specified in the relevant clauses of IEC 651 for instruments of Type 1. If used, integrating-averaging sound level meters shall be in accordance with IEC 804 for instruments of Type 1.

To minimize the influence of the observer on the measurements, the microphone(s) should preferably be connected by cables to the measuring instruments. The observer shall not stand between any microphone and the machine whose sound power is being determined, nor in close proximity to any microphone.

To ensure compliance with the requirements of IEC 651, the measuring instrumentation shall be calibrated at intervals of not more than 2 years in a suitable laboratory with a sound calibrator fulfilling at least the requirements for a Class 1 calibrator in accordance with IEC 942.

At least before and after each series of measurements, an acoustical calibrator with an accuracy of ± 0,3 dB shall be applied to the microphone(s) to verify the calibration of the entire measuring system, including microphone cable(s), if used, at one or more frequencies. One calibration frequency should be in the nominal range from 250 Hz to 1 000 Hz. The calibrator shall be checked annually to verify that its output is within the specification.

NOTES

5 An example of an appropriate instrument for these measurements is a Type 1 sound level meter that meets the requirements of IEC 651 for measurements of steady noise.

6 Another example of an appropriate instrumentation system is an integrator which performs an analog or digital integration of the squared signal over a specified time interval.

5.2 Instrumentation for measuring the climatic conditions

The wind speed shall be determined with instruments having an accuracy of ± 10 % at the limiting wind speed.

The temperature shall be determined with instruments having an accuracy of ± 1 °C.

The air pressure shall be determined with instruments having an accuracy of ± 1 kPa.

5.3 Instrumentation for measuring the operating conditions of machines

The rotational speed of engines, motors, cutting means, etc. shall be measured with speed indicators having an accuracy of ± 1 % for the range of measured values.

The voltage at the socket (plug) of the cable of mains-powered machines, and the voltage at the terminals of battery-powered machines shall be measured with a voltmeter having an accuracy of ± 1 % for the range of measured values.

6 Operation and location of machines under test

6.1 Selection of attachments and adjustment of mowing systems

The machine shall be assembled and completed for mowing as specified by the manufacturer. If a grass catcher is provided or available for the machine from the manufacturer, it shall be fitted and empty.

For cylinder (reel) mowers, the rotating cutting cylinder(s) and/or the stationary cutting edge(s) shall be adjusted using one of the following two procedures, which shall be mentioned in the test report, such that

— either a sheet of Kraft paper, as defined in ISO 4046, with a grammage (substance) of 80 g/m^2 is cut at least along 50 % of the width of cut, or

— the gap between moving and stationary blades at standstill does not exceed 0,15 mm over the whole width of cut when checked with calibrated strip gauges.

Blades of knives of cylinder (reel) mowers shall be lubricated with SAE 20/50 grade oil.

If the maximum height of cut of the machine is greater than 30 mm, the height of cut shall be adjusted to the lowest position provided, but not lower than 30 mm (the height of grass of the test environment, see 4.1). If the maximum height of cut of the machine is less than 30 mm, the height of cut shall be adjusted to the highest position provided. The height of cut shall be adjusted with the machine resting on a hard, flat surface.

NOTE 7 For cylinder (reel) mowers, care should be taken to avoid overheating the blades by operating continuously (without cutting grass) and therefore appropriate interruptions for cooling and lubrication should be introduced.

6.2 Preconditioning the machine

Prior to noise measurements, the machine under test shall have completed a running-in period of at least 2 h. During this running-in period the blades or knives of cylinder (reel) mowers shall be adjusted so that they do not come into contact with each other.

Immediately before the first series of noise measurements, the complete machine shall be operated for a period of approximately 10 min for stabilizing. For cylinder (reel) mowers with a cutting width exceeding 0,6 m, the cutting means may be declutched during this period to avoid damage to the blades.

Noise measurements shall be started immediately following this stabilizing period.

6.3 Operation of engines

The fuel or fuel/oil mixture, and the oil quantity and quality shall be as specified by the manufacturer.

The fuel tank shall be not more than one-half full at the beginning of the measurements.

6.4 Operation of electric motors supplied from mains

Machines with mains-operated motor(s), designed for a.c. only, or for a.c. and d.c., shall be supplied with a.c. power at rated voltage ± 2 % and at frequency of 50 Hz or 60 Hz, according to the usual frequency of the country in which the machine is to be used or, if designed for d.c. only, shall be supplied with d.c. power at rated voltage ± 2 %, except for commutator motors which shall be supplied with rated voltage ± 1 %. The maximum frequency tolerance shall be ± 1 %.

Machines designed for a voltage range shall be supplied with the highest voltage of the range with the same tolerance as above.

The supply voltage under load shall be measured at the plug cap of a non-detachable cable, or at the appliance inlet if a detachable cable is provided, but in no case at the entrance of extension cables.

6.5 Operation of electric motors supplied from batteries

Noise measurements shall be started with fully charged batteries as specified by the manufacturer, but shall not be continued when the battery voltage under load drops to lower than 0,9 times the battery voltage under load at the beginning of the measurements for lead-acid batteries, or to lower than 0,8 times for other batteries.

The battery voltage shall be measured at the battery terminals.

6.6 Operation and location of machines when stationary

Non-self-propelled machines, and self-propelled or ride-on machines provided with means for disengaging or separating ground-drive wheels during the mowing operation, shall be operated for noise measurements with the machine stationary, the ground-drive disengaged and no operator present, at the maximum operating engine/motor speed and the maximum operating speed of the cutting means (see 3.6).

Stationary machines shall be measured by placing them on the test surface in such a way that the projection of the geometrical centre of their main parts (excluding handle, grass catcher, etc.) coincides with the origin of the coordinate system of the microphone positions. If an artificial surface in accordance with 4.1.2 is used, it shall be placed so that its geometrical centre also coincides with the origin of the coordinate system of the microphone positions. The longitudinal axis of the machine shall be on the x-axis.

6.7 Operation and location of machines when travelling

Self-propelled or ride-on machines without means for disengaging or separating the ground-drive wheels during the mowing operation shall be operated for noise measurements with the machine travelling and an operator or in the normal position, at the maximum operating engine/motor speed and the maximum operating speed of the cutting means (see 3.6). If the machine is provided with a variable gear for the speed of travel independent of the speed of the cutting means, a setting for the lowest speed of travel shall be selected. If, however, the speed of travel depends on the speed of the cutting means, a setting shall be selected that corresponds with the maximum operating speed of the cutting means.

During travel, the projection of the geometrical centre of the main part of the machine shall coincide with the x-axis of the coordinate system of the microphone positions. The direction of travel pointing from $+x$ through the origin of the coordinate system towards $-x$.

7 Measurement of A-weighted sound pressure levels

7.1 Measurement surface and microphone positions

The measurement surface shall be a hypothetical hemisphere of area $S = 2\pi r^2$ enveloping the machine under test and terminating on the test surface.

The radius r of the hemisphere depends on the width of cut of the machine under test, and shall be

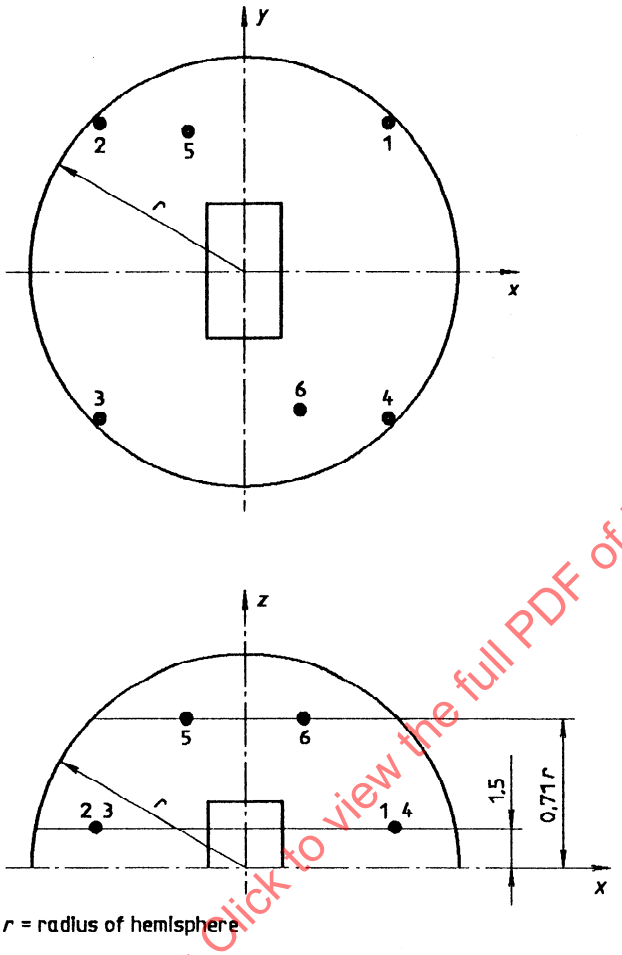
a) $r = 4$ m for machines with a width of cut up to 1,2 m;

b) $r = 10$ m for machines with a width of cut exceeding 1,2 m.

NOTE 8 This criterion is in accordance with the requirements of ISO 4872. Experience shows, however, that measurements with a 4 m hemisphere may give satisfactory results for mowers with a width of cut up to 2 m.

There shall be six microphone positions located on the hemisphere, having the coordinates listed in table 2 and illustrated in figure 1.

Dimensions in metres



r = radius of hemisphere

Figure 1 — Microphone positions on the hemisphere (see table 2)

Table 2 — Coordinates of microphone positions

Position No.	$\frac{x}{r}$	$\frac{y}{r}$	z
1	+ 0,7	+ 0,7	1,5 m
2	− 0,7	+ 0,7	1,5 m
3	− 0,7	− 0,7	1,5 m
4	+ 0,7	− 0,7	1,5 m
5	− 0,27	+ 0,65	0,71r
6	+ 0,27	− 0,65	0,71r

7.2 Measurement of sound pressure levels

The measurements shall be carried out with the frequency-weighting characteristic A. If an integrating-averaging sound level meter is used, the result obtained is the required energy average of the sound pressure level. If a sound level meter is used, the time-weighting characteristic S shall be applied. If other instrumentation is used, the time weighting shall be equivalent.

For stationary machines, the measurement time interval (period of observation) shall be at least 15 s.

For travelling machines, the measurement time interval shall be equal to the time it takes for the machine to pass at constant speed the distance of 2 m between the coordinates $x = +1$ m and $x = -1$ m.

If a sound level meter is used for the measurements and the fluctuations of the indicating pointer are within a range of 5 dB, the noise is considered to be steady for the purposes of this International Standard and the level is taken as the average of the maximum and minimum levels during the measurement time interval. If the fluctuations are greater, three to five readings shall be taken at equal intervals during the measurement time interval and the energy average of the sound pressure level at each microphone position shall be calculated from the readings using equation (1) (see 8.1).

Three series of sound pressure level measurements shall be carried out, resulting in three surface sound pressure levels calculated in accordance with 8.1. The arithmetic mean of these three values is considered to be the correct surface sound pressure level for determining the sound power level of the machine in accordance with 8.2.

If the maximum sound power level is desired, the sound pressure levels L_{pA} shall be measured at least three times. If the sound power levels obtained from these measurements differ by more than 1 dB, further measurements shall be taken until two power levels are obtained which do not differ by more than 1 dB; the higher of these shall be the sound level of the machine.

NOTE 9 If, for measurements on a travelling machine, a sound level meter is used, in most cases the sound pressure level of interest will be equal to the reading taken at the instant when the machine passes the centre of the measurement surface.

7.3 Corrections for background noise

The A-weighted sound pressure levels recorded at each of the microphone positions shall be corrected for the influence of background noise according to table 3.

Table 3 — Corrections for background noise

Values in decibels

Difference between sound pressure level measured with sound source operating and background sound pressure level alone	Correction to be subtracted from sound pressure level measured with sound source operating to obtain pressure level due to sound source alone
< 6	Measurements invalid
6	1,0
7	1,0
8	1,0
9	0,5
10	0,5
> 10	0

8 Calculation of surface sound pressure level and power level

8.1 Calculation of A-weighted surface sound pressure level, $\overline{L_{pA}}$

The A-weighted surface sound pressure level $\overline{L_{pA}}$ shall be calculated from the measured values of the A-weighted sound pressure level L_{pAi} (after corrections have been applied; see 7.3 and note 10), by using the following equation:

$$\overline{L_{pA}} = 10 \lg \left[\frac{1}{N} \sum_{i=1}^{N} 10^{0,1 L_{pAi}} \right] \text{ dB} \qquad \ldots (1)$$

where

$\overline{L_{pA}}$ is the energy-averaged A-weighted surface sound pressure level, in decibels (reference: 20 μPa);

L_{pAi} is the A-weighted sound pressure level resulting from the i^{th} microphone position, corrected if necessary for background noise and other influences, in decibels (reference: 20 μPa);

N is the total number of measurements; in general, N is equal to the number of microphone positions.

NOTE 10 Equation (1) may be used generally for determining the energy-average of measured sound pressure levels, for example in the case of fluctuating noise (see 7.2).

Corrections for the effects of temperature, humidity, altitude of the test environment and microphone wind-screening attachments shall be made, if necessary, to the measured values of the A-weighted sound pressure levels according to the instructions of the manufacturer of the acoustical instrumentation.

8.2 Calculation of A-weighted sound power level, L_{WA}

The A-weighted sound power level of the machine, L_{WA}, in decibels (reference: 1 pW), shall be calculated from the following equation:

$$L_{WA} = \overline{L_{pA}} + 10 \lg \frac{S}{S_0} \text{ dB} \quad \ldots (2)$$

where

$\overline{L_{pA}}$ is the energy-averaged A-weighted surface sound pressure level, in decibels (reference: 20 µPa);

S is the area of the measurement surface ($S = 2\pi r^2$), in square metres (reference: $S_0 = 1\ m^2$).

For hemispheres with the specified values for r, the values for S and for 10 lg(S/S_0) are given in table 4.

Table 4 — Numerical values for sound power level calculations

r	S	$10 \lg \frac{S}{S_0}$
m	m^2	dB
4	100	20
10	628	28

9 Information to be recorded

The information given in 9.1 to 9.8, when applicable, shall be compiled and recorded for measurements that are made in accordance with the requirements of this International Standard.

9.1 General data

a) Name and address of the laboratory where measurements have been carried out.

b) File number and date(s) of measurements.

c) Name and address of the company or organization which ordered measurements.

9.2 Description of the machine under test

a) Category of equipment as specified in clause 1.

b) Mowing system as specified in clause 1.

c) Manufacturer or dealer, and trade-mark.

d) Model or type dimension, and serial number.

e) Accessories and attachments for mowing.

f) Grass-catching device.

g) Power source of the machine as specified in clause 1.

h) Number of blades or cutting cylinders.

i) Type of blades, diameter in millimetres, designed for grass-catching or not, separate fan or blower for transport of grass clippings or not.

j) Total cutting width, in millimetres or metres.

9.3 Supply, fuel and lubrication for operation

a) Electric supply: d.c., a.c., rated voltage, rated frequency, battery voltage and capacity; voltage and frequency with tolerances during measurements.

b) Fuel: gasoline, diesel, fuel/oil mixture, fuel tank capacity, in litres.

c) Oil: quality and quantity, in litres.

d) Supply for hydraulic motors.

9.4 Preconditioning of the machine

a) Running-in period before testing, in hours.

b) Stabilizing period before each series of measurements, in minutes.

9.5 Operating conditions of the machine

a) Adjusted cutting height, in millimetres.

b) Setting of speed control(s).

c) Procedure of adjustment of blades and knives of cylinder (reel) mowers.

d) Speed of engine or motor, in revolutions per minute.