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Acoustics — Measurement of noise emitted by railbound vehicles

Acoustique — Mesurage du bruit émis par les véhicules circulant sur rails

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up 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.

Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 3095 was drawn up by Technical Committee ISO/TC 43, *Acoustics*, and circulated to the Member Bodies in March 1973.

It has been approved by the Member Bodies of the following countries :

Austria	Hungary	Romania
Belgium	Ireland	South Africa, Rep. of
Brazil	Israel	Spain
Bulgaria	Mexico	Sweden
Canada	Netherlands	Switzerland
Czechoslovakia	New Zealand	Thailand
Finland	Norway	United Kingdom
France	Poland	U.S.A. *
Germany	Portugal	U.S.S.R.

* With the exception of clauses 9.1 and 9.2.

No Member Body expressed disapproval of the document.

Acoustics – Measurement of noise emitted by railbound vehicles

1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies the conditions for obtaining reproducible and comparable measurements of the noise level and the noise spectrum emitted by all kinds of vehicles operating on rails or other types of fixed track.

In the annex, specifications for exhaust or air-intake noise measurement and measurements with stationary and accelerating vehicles and for measurements at stations, on bridges or viaducts and in tunnels are given.

NOTES

1 The test procedures specified in this International Standard are engineering methods as defined in ISO 2204, *Acoustics – Guide to the measurement of airborne acoustical noise and evaluation of its effects on man*. Note, however, that frequency band analysis is only required for type tests.

2 Measurements may be made on sources emitting noise of an impulsive character with an impulsive sound level meter (see clause 5).

2 REFERENCES

IEC Publication 179, *Precision sound level meters*.

IEC Publication 225, *Octave, half-octave and third-octave band filters intended for the analysis of sound and vibrations*.

3 NATURE OF TESTS

3.1 type tests : Measurements performed to prove that the vehicle delivered by the manufacturer corresponds to noise specifications.

The conditions prescribed for each test shall be complied with as closely as possible but if unavoidable variations have to be made, these must be stated in the test report.

3.2 monitoring tests : Measurements performed in order to check that the noise of the vehicle is still within prescribed limits and that no noticeable changes have occurred since acceptance on initial delivery or after modification, as applicable, or between individual units in a consignment of vehicles.

For monitoring tests, slight deviations from the test conditions specified for type tests may be tolerated in respect of the test site, the background noise and the operating conditions.

Any variation shall be described in the test report.

4 MEASURED QUANTITIES

4.1 All readings of the sound level meter are to be taken with the dynamic characteristic "fast".

4.2 The values to be measured at all microphone positions in type and monitoring tests are A-weighted sound pressure levels L_A expressed in decibels (dB).

NOTE – If the weighting curve used is not otherwise stated, the measured values shall be expressed in dB(A).

4.3 For spectral analysis, the values to be measured are octave band or 1/3 octave band sound pressure levels in decibels (dB). Spectral analysis shall be performed in type tests.

5 MEASUREMENT EQUIPMENT

5.1 The sound level meter shall comply with IEC Publication 179.

5.2 If additional measuring equipment including, for example, a tape recorder and/or level recorder is used, its overall electro-acoustic performance shall conform to the relevant clauses of IEC Publication 179.

5.3 For the measurement of noise spectra, the filters shall correspond to IEC Publication 225.

5.4 The overall acoustic performance of the measurement equipment shall be checked according to the instructions of the manufacturer, preferably with a standard sound source (for example pistonphone), at the beginning and at the end of each series of measurements.

At time-intervals not longer than 2 years, the sound level meter shall be calibrated for compliance with IEC Publication 179.

NOTES

1 A suitable wind-shield may be used to reduce the influence of wind on the reading.

2 If an impulse sound level meter in accordance with the amendment of IEC Publication 179¹⁾ is available, it is recommended that, in addition, the values read with A-weighting and the "impulse" dynamic characteristics, symbol L_{A1} , be stated and that the values be expressed in decibels (dB), when measuring impulsive noises. The values shall be expressed in dB(A1), if the weighting curve and the "impulse" dynamic characteristics are not otherwise stated.

1) In preparation.

6 ACOUSTICAL ENVIRONMENT, METEOROLOGICAL CONDITIONS, BACKGROUND LEVEL

6.1 The test site shall be such that sufficient free sound propagation exists to within ± 1 dB between the sound source and the microphone.

This condition may be considered as fulfilled if for the reference distance of 7,5 m the surroundings of the microphone up to 50 m are free of large, sound-reflecting objects like barriers, hills, rocks, bridges or buildings.

In the vicinity of the microphone, there shall be no obstacles that could disturb the sound field. Therefore, no person shall be between the microphone and the noise source, and the observer shall be in such a position that influences on the reading of the meter are avoided.

NOTE — In practice, the suitability of a test site may be checked with a relatively small sound source generating a wide band noise. The sound level of the test sound should decrease by about 6 dB if, under normal measuring conditions, the measuring distance is doubled (for example from 5 m to 10 m). If this condition is not fulfilled, this shall be stated in the test report.

The area between the vehicle under test and the measuring microphone shall be as free as possible from sound-absorbing covering such as high grass, snow or ballast of other tracks.

6.2 At wind velocities above 10 m/s, the sound propagation may be disturbed and measurements shall not be performed, especially at large distances between vehicle and microphone. Meteorological conditions with wind velocities below 5 m/s are to be preferred.

6.3 For type tests, the A-weighted sound level due to other noise sources (for example other vehicles or industrial plant) and due to wind shall be at least 10 dB below the A-weighted sound pressure level of the noise from the vehicle.

For spectral analysis, this difference shall be at least 10 dB in the required filter bands.

In the case of monitoring measurements, A-weighted round pressure level of the background noise shall be at least 3 dB below the A-weighted sound pressure level of the reading obtained during the passage of the vehicle. The reading has then to be corrected as follows :

Increase of the indication of the A-weighted sound pressure level obtained during the passage of the vehicle	Correction to be applied to the reading of the A-weighted sound pressure level obtained during the passage of the vehicle
dB	dB
≥ 10	0
6 to 9	-1
4 to 5	-2
3	-3

7 TRACK CONDITIONS

7.1 The measurements shall be made with ballast bed (preferably dry and not frozen) and wooden or reinforced concrete sleepers.

The track of the measuring section shall be straight, level, free of rail corrugations and laid without rail joints (welded rails).

7.2 Non-conventional vehicles shall be tested on their own tracks. The bed and the entire mounting of the rails shall be described in the test report with a special attention to details in the case of non-conventional systems.

7.3 Special track conditions, for example tunnels, bridges, points, crossings, stations may cause additional noises. To investigate these influences, supplementary measurements may be necessary. The track conditions must be described in the test report.

8 OPERATING CONDITIONS FOR THE VEHICLE DURING THE TEST

The wheel threads shall be as smooth and free from wheel flats as possible.

NOTE — This condition does not apply if the control of the vehicles in service is intended. Lack of smoothness and presence of flats on wheel treads may substantially increase the noise level.

If a single coach or wagon is to be tested, appropriate steps shall be taken to ensure that only the noise produced by that vehicle is measured; for example the distance between the power unit and the test vehicle shall be such that the reading of the measuring instruments for the test vehicle is not significantly affected by the noise of the power unit.

For power units during the test, all operating conditions of the engine shall correspond to the specifications given by the manufacturer, for example, lubricating oil, timing of fuel injection pump, temperature of lubricating oil and coolant liquid.

8.1 Loading of the vehicles

The vehicles shall be unladen or unoccupied except for the driver. For power units (for example locomotives), however, their weight under normal working conditions shall be aimed at.

8.2 Doors, windows, auxiliary equipment

During measurements, doors and windows of the vehicle shall be kept closed. Auxiliary equipment of the test vehicle which can operate during the run shall be in action if its noise contributes significantly to the noise level at the microphone position. However, if the auxiliary equipment noise appears for only a short time (less than 1 min) and if it affects the noise level from other sources by less than 5 dB, it shall not be considered in the measurements.

8.3 Constant speed test

In the measuring section of the track, the vehicle under test shall be run at the following specified speeds steady to $\pm 5\%$ limits :

- 1) 80 km/h for interurban trains
- 60 km/h for urban and underground trains
- 40 km/h for tramcars

NOTES

1 If additional measurements are performed at higher speeds, the following speeds are recommended :

120, 160, 200 km/h

as far as allowed by the vehicles and the test track.

2 If freight trains are not able to run at 80 km/h, then 60 km/h shall be used.

2) The maximum speed of the vehicle under test and, for power units, at full traction.

8.4 Tests on stationary vehicles

8.4.1 Power units with electrical engines and coaches

All equipment which can be operated with the vehicle stationary, including main engines where relevant, shall be operated. The auxiliaries shall be operated at their maximum load.

8.4.2 Power units with internal combustion engines

8.4.2.1 Engine idling unloaded, fan at minimum speed, auxiliary equipment with load, compressor not operating.

8.4.2.2 Engine at maximum speed unloaded (given by the speed-governor), fan at maximum speed if possible, auxiliary equipment with rated load, compressor operating with full load.

8.4.3 Power units with turbines and other engines

These shall be tested under conditions comparable to those specified above. The operating conditions shall be described in the test report.

9 MICROPHONE POSITIONS

The microphone shall be directed perpendicular to the track.

NOTE — For additional measurements on stationary vehicles, on platforms and in tunnels, use the microphone positions specified in A.1.1, A.3.1 and A.4 of the annex.

9.1 Measurements on vehicles in motion

The reference distance between the centre of the track and the microphone is 7,5 m.

NOTE — If measurements are taken at a distance differing from 7,5 m, the measuring distance shall be stated separately in the test

report. If possible, corrections may be applied to find the value corresponding to the reference distance.

Preferred distances are 25 m, 50 m and 100 m. The measuring distance of 25 m is recommended for measurements at high speeds.

The microphone shall be placed at a height between 1,2 and 1,5 m above the upper surface of the rails. A second microphone position at a height of 3,5 m above the rails is recommended if important sound sources are present in the upper part of the vehicle under test (for example with power units).

NOTE — For measurements at large distances, the height of the microphone above the ground shall be at least 3,5 m.

If the sound pressure levels differ on both sides of the vehicle, the sound pressure levels read on the side with the higher A-weighted sound pressure levels shall be retained as measurement results.

9.2 Measurement on stationary vehicles

The microphone shall be placed on each side of the vehicle at a distance of 7,5 m from the centre of the track at a height between 1,2 and 1,5 m above the upper surface of the rails and opposite the centre of the vehicle. A second microphone position at a height of 3,5 m above the rails is recommended if important sound sources are present in the upper part of the vehicle under test.

10 TEST PROCEDURE

10.1 The maximum A-weighted sound pressure level indicated during the passage of the vehicle under test shall be read. Any peak which is obviously out of character with the general sound level being read shall be ignored (for example pressure waves caused by vehicles passing at high speed).

For measurements on stationary vessels, the mean value of the A-weighted sound pressure level shall be read.

10.2 For type tests at each microphone position and for each measuring condition, at least three measurements shall be made. The mean value of each set of readings shall be retained as the test result and shall be rounded to the nearest integral decibel.

If the spread of the results is larger than 3 dB, a new series of measurements shall be made.

For monitoring purposes, it is sufficient to perform one measurement.

10.3 The presence of easily audible pure tones or noise of distinctly impulsive character shall be stated in the test report.

11 TEST REPORT

The test report shall include a reference to this International Standard and all relevant details concerning :

11.1 The nature of the tests.

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11.2 The test site, track and meteorological conditions, for example ambient temperature, barometric pressure and wind velocity, if relevant.

11.3 The measurement equipment.

11.4 The background noise level.

11.5 The vehicle, its engine and its speed during the test.

11.6 The auxiliary equipment and its operating conditions.

11.7 The loading of the vehicles.

11.8 The microphone positions.

11.9 The A-weighted sound pressure levels L_A and, if necessary, the noise spectrum.

11.10 The presence of pure tones or noise of an impulsive character.

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ANNEX

ADDITIONAL MEASUREMENTS

A.1 ADDITIONAL MEASUREMENTS WITH STATIONARY VEHICLES**A.1.1 Microphone position**

The microphone shall be placed at a distance of 7,5 m from the centre of the track. The distance x so obtained between the microphone and the side of the vehicle shall be maintained around the contour of the vehicle in accordance with figure 1. The spacing a between the microphone positions parallel to the side walls of the vehicle shall be between 3 and 5 m in such a manner as to obtain three microphone positions for each side, if possible. For vehicle lengths exceeding 20 m, more than six microphone positions shall be used parallel to the side walls besides the six positions in front and at the rear end of the vehicle.

The microphone positions shall include positions on the transverse axes of the driver's cabin and of the driving engine.

The microphone shall be placed at a height between 1,2 and 1,5 m above the upper surface of the rails. A second microphone position at a height of 3,5 m above the rails is recommended for those positions where important sound sources are present in the upper part of the vehicle under test.

The microphone shall be directed perpendicularly to the contour of the vehicle.

If the sound levels at the intake and exhaust of the engine or the air-conditioning and cooling system are to be measured, it is recommended that the microphone be placed outside the gas stream at a distance of 1 m from the edge of the intake or exhaust opening at an angle of 30° to the direction of the gas stream (see figure 2) and as far as possible from reflecting surfaces.

A.1.2 Vehicle conditions

The vehicle conditions shall be the same as those specified in 8.4. If the throttle of the idling engine is fully actuated and an intense noise level is produced shortly before the engine is regulated, this sound pressure level shall be stated separately.

For evaluation of the noise of fans, the fan shall be operated at its minimum and maximum speeds; if possible, intermediate conditions may also be chosen.

A.2 MEASUREMENT DURING DEPARTURE

This measurement shall evaluate the noise of the vehicles during normal departure.

The microphone shall be placed at a distance of 7,5 m from the centre of the track at a height between 1,2 and 1,5 m

above the upper surface of the rails in such a way that the maximum or characteristic sound pressure level or noise spectrum is measured.

A.3 MEASUREMENT OF NOISE AT PLATFORMS AND STOPPING POINTS

This measurement shall evaluate the noise on platforms caused by the passing, arrival or departure of vehicles at platforms in stations and at stopping points.

A.3.1 Microphone position

The microphone shall be placed on the platforms at a distance of 3 m from the centre of the nearest track at a height between 1,2 and 1,5 m above the platforms in those places where there is an interest in the sound pressure level. This is generally half-way along the side and near the front and rear ends of the stationary train.

The microphone shall be directed perpendicularly to the track. Other measurements may be made at corresponding positions on neighbouring platforms.

The maximum A-weighted sound pressure level shall be retained.

For the measurements on underground stations, a drawing of the cross-section shall be given in the test report.

A.3.2 Vehicle conditions

During the tests, the vehicles shall accelerate and decelerate in the normal way. The driving conditions shall be kept as constant as possible and shall be described in the test report, for example by stating the throttle or controller notch position together with the notch range of the unit, for example : Notch 4 position, Range 1-8.

A.4 MEASUREMENT OF NOISE ON BRIDGES AND IN TUNNELS

The microphone shall be placed at a height between 1,2 and 1,5 m above the upper surface of the rails at a distance of 7,5 m from the centre of the track in the case of bridges and viaducts and, if possible, at 3 m from the centre of the track in tunnels.

For bridges, a further microphone position at 25 m (and, if suitable, at 50 m and at 100 m) from the track at 3,5 m above the ground is recommended.

The height of the microphone with respect to the surface of the rails shall be stated in the test report.

The vehicle conditions may be the same as those specified in clause 8.

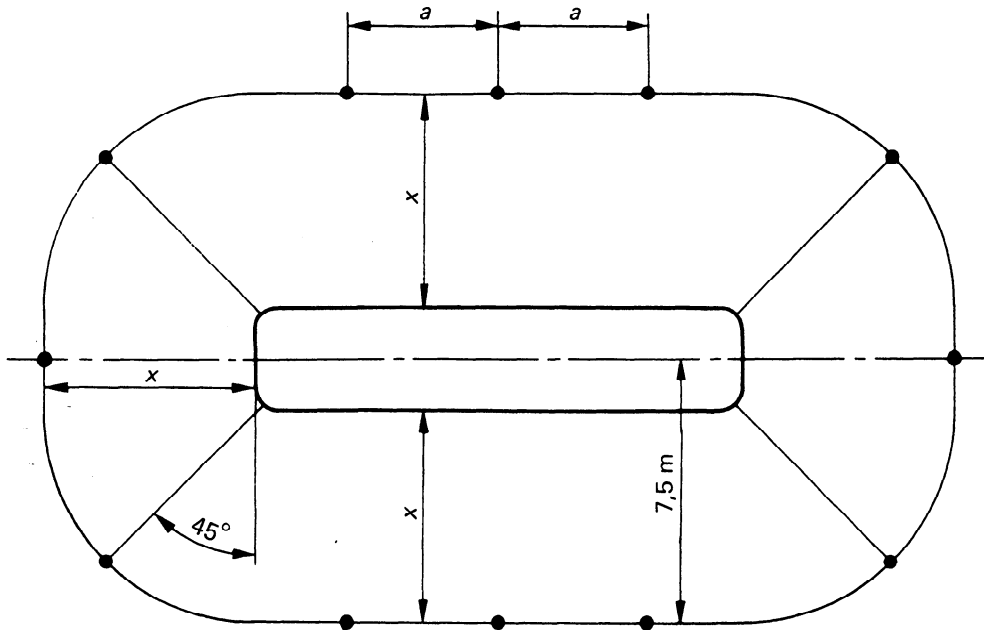


FIGURE 1 – Positions of the measuring points around stationary vehicles
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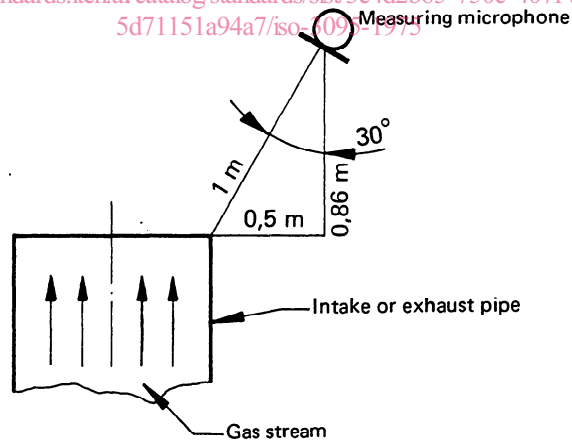


FIGURE 2 – Positioning of the measuring microphone at the intake or exhaust apertures