

Update of the Interior Noise Measurement Standard EN ISO 3381

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ABSTRACT

The standard for interior noise measurements in railbound vehicles EN ISO 3381 was published in 2005, together with the exterior noise measurement standard EN ISO 3095. Later, in 2013, EN ISO 3095 was revised and received various improvements: tests for acceleration and brake noise, improved description of vehicle and environmental conditions, revised tonality assessment, improved handling of acoustic track characteristics, better definition of test results and various adjustment to offer an improved association with standard situations in commercial traffic.

CEN/TC256, applied for the mandate to carry over experience from both standards to new revisions and now the drafting group, WG03, has prepared a preliminary draft of EN ISO 3381. In addition to the EN ISO 3095 improvements, there has been further development of track characteristics assessment, tonality assessment, measurement setups and data collection. The contents is reorganised along the lines of EN ISO 3095, offering separated tests for different operating conditions and offering information for the tests more detailed than only checking contractual targets. The draft is to be presented as the proposed starting point for revisions both at ISO level and CEN level, in parallel, to ensure the contribution and participation of the widest possible group of international experts.

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1. INTRODUCTION

The standard EN ISO 3381:2005 [1]⁹ describes the interior noise type test for railbound vehicles. This type test uses a set of cases for operational conditions representing commercial service on tracks with defined acoustic characteristics. Though the standard has received good acceptance, over the intervening years some reasons to develop a revised version have emerged.

- The European standards EN 15610 [2], for acoustic roughness measurement, and EN 15461 [3], for track decay rate measurement, offer improved methods to assess the acoustic track characteristics. Appropriate limits are then defined in EN ISO 3095 [4] for these conditions in order for its own assessment of the noise from different types of rolling stock to be comparable.
- EN 15892 [5], for the drivers' cab type test, has, up to now, been written as a separate document. In future, the contents of this should be included in EN ISO 3381.
- The editorial policy to split the tests into a 'toolbox' of specific tests for different operational conditions of the vehicle is already implemented in the exterior noise type test standard EN ISO 3095. It shall now also be implemented in EN ISO 3381.

⁹Although European institutions published a version dated 2011 to harmonize the standard with European legislation by adding a specific annex, this only marks the time when CEN TC 256 took on responsibility for drafting ISO 3381 under the Vienna Agreement and there was no change of content made at that time.

- The current EN ISO 3381 does not provide enough guidance for tests of conformance to specified requirements. In particular the use and choice of measurement quantities is too open.
- Vehicle conditions very often need additional details to be reported.
- The assessment of tonal noise in the current standard does not match subjective assessments properly.
- In the 2011 revision, the measurement positions did not cover all locations of interest properly and some are difficult to justify.

2. VEHICLE OPERATING CONDITIONS

The operating conditions of components have been reworked. The concept of the 2013 revision of EN ISO 3095 to provide a precise set of climate parameters has not been used, since the approach has been found since that to be specific for certain areas of climate.

For measurements under the new EN ISO 3381, all equipment that operates continuously is to be operated at normal load. For heating, ventilating and air conditioning (HVAC) systems conditioning passenger areas and working places as well as system supplying energy for this function, ‘normal load’ is defined as 50 % of the cooling power that is necessary under the maximum thermal load where the vehicle is regularly in operation. The HVAC compressor shall be set to operate continuously during the measurement.

For standstill, traction equipment is to be in a stationary thermal condition with cooling equipment working at a minimum necessary condition. The air compressor shall not operate where possible. For units with internal combustion engines, the engine shall be at idle with a load corresponding to the necessary power to operate the auxiliaries as defined above.

3. ACOUSTIC TRACK CHARACTERISTICS

In the current version of EN ISO 3381 the track quality assessment takes acoustic roughness into account but the track decay rate is not considered. For the roughness, a sample of track four times the distance of the planned microphone position to the track is assessed by the direct method that was defined in the now withdrawn 2005 revision of EN ISO 3095. It is then mandatory to assess the compliance of the complete length of track used for recording acoustic data from this sample. The track shall be proven to be in line with the roughness requirement by the assessment of data e.g. from an accelerometer mounted to an axle box.

In the new draft EN ISO 3381 the assessment of track conditions will be brought into alignment with the reference track concept that has already been implemented in the 2013 revision of EN ISO 3095. This uses EN 15610 for acoustic roughness measurement and EN 15461 for track decay rate measurement. Since the length of track that has been measured in detail may only offer short recording time on-board the train, there is a provision of a check of the longer length of track over which data may be recorded.

A ‘monitoring’ channel is dedicated to measurement of the rolling noise level (or sound-related vibration level) on board at a trailer bogie. A monitoring record is then made along the whole track over which data is recorded including the short reference

section of track at which detailed measurements of the roughness and decay rates have been made. The monitoring measurements may be carried out synchronously with the interior noise measurements or during other runs of the same unit or another unit.

The directly-measured track section is identified and analysed separately to yield the quantity $L_{direct,pAeqT}$ or $L_{direct,aAeqT}$. The measured level on the rest of the test section, denoted $L_{extend,pAeq;5s}$ or $L_{extend,aAeq;5s}$, are acquired as a series of 5 s samples. The track is then validated for train-interior noise measurements if the difference $L_{extend,pAeq;5s} - L_{direct,pAeq,T}$ or $L_{extend,aAeq;5s} - L_{direct,aAeq,T}$ is less than or equal to +1 dB.

Using this approach 5, samples of interior noise acquired on any of the 'extended test section' may be used for assembling a valid sample of measurement which shall be 20 s in total length.

In the case where there is a non-continuous valid extended test section, care must be taken to ensure that the selected samples of the interior noise measurement are representative of travel over the valid sections. Some care has therefore to be taken in the alignment of 5 s samples of measurement and monitored track. For synchronous measurements this means the time delay between the bogie where the monitoring measurements are made, and the position of the interior sensors has to be taken into account. For non-synchronous measurements the time delays not only have to take into account the position of the interior sensors on the test train and the monitoring sensors of the monitoring train, but also the locations of the position-detection sensors on the two trains as well. Clearly this also depends on accurate train speed recording.

4. MEASUREMENT POSITIONS

A new method has been introduced addressing the choice of measurement positions within the vehicle. The procedure starts by defining the areas inside the vehicle to be investigated.

The entire unit is to be divided into discrete areas and each is identified as being of a single 'type'. A list of different types of area for the particular rolling stock and the division into areas must be set out and agreed by all stakeholders in the assessment of the acoustic environment. As well as measurement teams, this may include those specifying a new unit type, the manufacturers, the buyers and eventual operators of the vehicle. It is hoped that this will lead to an improvement in the way the acoustic environment of the unit is considered through all stages of design manufacture and use.

The list is therefore flexible according to the level of detail that might be wanted. The list may contain types such as 'passenger areas', 'seating areas' (first class, standard class), standing areas (including aisles), gangway, driver's cab, train manager compartment, galley, lavatories, entrance, lobbies, restaurant, quiet, sleeping or resting areas.

Some railways may want detailed information on noise levels in many different parts of a carriage, others may be satisfied, for example, to have information relating only to 'passenger accommodation' as one area type, especially, in the latter case, for vehicles of simple design. Measurement on vehicles of more complex design with different types or classes of passenger accommodation (sleeping cars, seating areas, restaurants, *etc.*) or separate requirements for staff areas can be planned with clarity.

If defined areas within the rolling stock are understood to be similar, one area may be chosen to provide the result representative of all the areas of the same type and thus reduce the burden of measurement work.

Once the list of area types is made and the areas of the vehicle are each identified in terms of these area types, then each area that is to be assessed must be divided into equal ‘segments’ of maximum length 3 m along the unit. Measurement are then made such that each segment contains at least one measurement position. Measurement positions must not be located closer than 0,3 m to a wall, screen or door. Additional measurement positions may be defined but shall be reported separately and not as part of the characterisation of an area.

With the planning of measurements and characterisation of areas carried out in this way, the measurement work involved in practice can be quite simple, and furthermore, clearly agreed between all the stakeholders.

Figure 1 shows an example for a possible choice of areas to be tested. In terms of the interior there are four areas with the same layout. E and J are similar as are, D and I, C and H, B and G. The areas A and F have layouts that are not like any others, but E and F might be accepted to be nearly the same. A possible decision will be to measure areas A, B, C, D, E and to use the data from E for F and J also, to use data from B for G and so on. For simplicity, this example examines the similarity of areas in terms of interior layout only. It does not take any account of differences in the position of the areas with respect to sound sources such as traction equipment, aerodynamic noise *etc.* In practice, those factors would also need to be taken into consideration.

Figure 2 shows an example where a broader approach to the definition of areas to be characterised might be agreed by the stakeholders to be appropriate. In this metro vehicle, the entire car is identified as a single area. The two cars shown, however, must be regarded as different types because one is a motored and the other is a trailer.

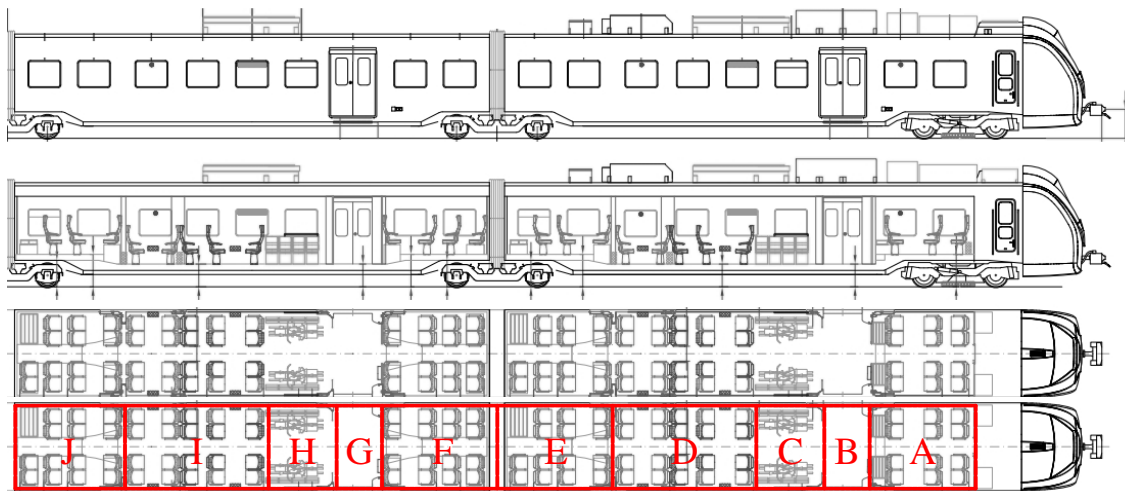


Figure 1: Example of definition of detailed areas to be tested.

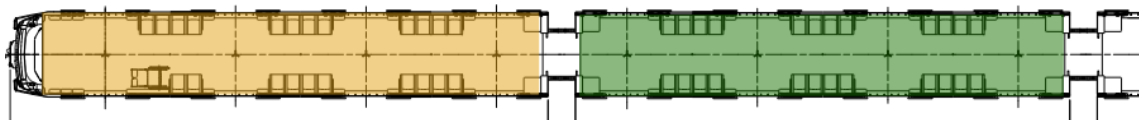


Figure 2: Example of definition of broad areas to be tested; motor and trailer cars of a metro unit.

5. DRIVER'S CAB

The test of interior noise during warning operation as set out in EN 15892 [5] has now been merged into the new draft of EN ISO 3381. In consequence EN 15892 is to be withdrawn when the new version of EN ISO 3381 is published. There are no major changes in EN ISO 3381 to the provisions of EN 15892.

The inclusion of EN 15892 does however introduce some operational details to a test.

- In the case of adjustable seats the centre of the adjusting range shall be used.
- For locomotives the load to be hauled has been set to not less than two-thirds of the maximum permissible value.
- For vehicles with tread brakes, the wheel surfaces shall be ensured to be in worn condition by executing two braking events from 80 km/h to standstill before the measurements are carried out.

6. TONALITY ASSESSMENT

Within the current revision tonality of the EN ISO 3381 is handled in a flexible way. Whenever a noise is suspected to have a tonal character a one-third octave band spectrum is to be produced. No further requirements than to present this spectrum are made. The 2005 revision of EN ISO 3095 used approximately the same approach, augmented by a decision rule. It has been found that this decision rule was too tight and, in practice, sometimes produced tonality indications, where no tones were audible. Of course, this implies that the tonality assessment in EN ISO 3095: 2013 should also be improved in a future revision.

Tests on railway noises showed the ISO 1996-2 [7] Annex C to offer the best method. This method is based on narrow band analysis and offers algorithms to calculate an indicator value for the strength of tonality. An additional penalty value can also be obtained, but this is not requested for the application according to EN ISO 3095.

In practice it was found, that the results are valuable, but the analysis consumes more time than appropriate. Too often the assessment procedure is carried out though there is no indication for the appearance of tonality. It is helpful, therefore, based on the experience with the exterior noise measurement, that a simple criterion should be provided in order to decide if a full tonality analysis is needed. As an objective criterion the one-third octave band method presented in ISO 1996-2 Annex D is used to find recordings where tonality may appear. In terms of type testing, the result of this test must be reported, together with the difference between the A-weighted level of the tonal one-third octave band and the A-weighted overall level $L_p A_{eq}$. Only in cases where this difference is less than 6 dB does the total one-third octave band affect the A-weighted overall level of the noise and it becomes worthwhile to analyse the severity of the tone further.

A method based on a narrow band spectral analysis is recommended for those that may need it. The ISO 1996-2 annex C or DIN 45681:2005 [8] are preferred for this. Though the ISO 1996-2 is the preferable reference in terms of standardisation rules, the DIN 45681 was referenced additionally, as this national standard offers improved guidance for the user. This guidance is a good basis for the proper application of the calculation procedure described in the standards.

7. TEST RESULTS

The current standard gives advice on analysing measurement data to obtain results for specific measurement quantities, but there is no advice how to obtain a test result from the analysed measurement quantities.

8. MEASUREMENT UNCERTAINTY

These days, it is required that any ISO standard addressing a test method should give advice on the measurement uncertainty. The new draft therefore includes an annex offering guidance to estimate uncertainty based on the GUM. This guidance replaces the current general statement stating that the methods provide results of ‘engineering grade’ based on the terms defined in ISO 12001 to justify a precision of ± 2 dB.

9. TOPICS NOT INCLUDED

Several subjects have been discussed as to whether they should be included, but have been ruled out.

- Noise levels in drivers’ cabs due to warning detonators or acoustic signals from train staff. Detonators are used by few railways nowadays.
- Assessment of room acoustics parameters, e.g. reverberation time. These parameters are interesting as input data for vehicle design, but they do not have direct relevance to noise performance assessment. It is decided therefore that measurement of these parameters need not be in the scope of the standard.
- TSI specific tests:
 - Audibility of signals in drivers cab,
 - Speech intelligibility.
 - Door operation signals in entrance areas. Door operation signal measurements are handled in the draft of a new separate and specific standard EN 17285 [6].
- Investigation of the contributions from separate sources (components) have been set aside from the scope of the standard. Rather EN ISO 3381 is dedicated to vehicle type testing.
- Interior noise while running on curved track sections. Knowledge about this topic is deemed not to be a stage appropriate for inclusion in the standard. A validated procedure could be produced at an appropriate future time.
- Long-term measurements, i.e. testing how the acoustic environment in the train may change with its age, have not been included as they are not in the centre of the scope.

10. CONCLUSIONS

The draft version for the next revision already offers several improvements to solve typical difficulties in the application of the 2005 revision of EN 3381. Working from the draft that has already been prepared by the EN group offers a approach to produce a document ready for the enquiry process in a short time.

There are two new key aspects of the proposal. The first is the method by which the acoustic environment should be defined in terms of defining specified areas of the train. This approach encourages the collaboration and agreement of all the stakeholders in the specification, design, manufacture and operation of the train well in advance of the acoustic measurements being made.

The second key aspect of the proposal is the way in which measurements records can be taken in 5 second blocks on validated sections of track of good acoustic quality. Not only should this improve the consistency of the track conditions on which measurements are made, but it should give testing greater flexibility in practice. Along with this measure the required total of sample record length has been reduced.

References

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