
Standard Method of Test for Measurement of Tire/Pavement Noise Using the On-Board Sound Intensity (OBSI) Method

AASHTO Designation: T 360-16 (2020)¹

Technical Subcommittee: 5a, Pavement Measurement

Release: Group 1 (April)



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1. SCOPE

- 1.1. This test method describes the procedures for measuring tire/pavement noise using the on-board sound intensity (OBSI) method and the procedures for verification of the measurement system. The test method provides an objective measure of the acoustic power per unit area at points near the tire/pavement interface.
- 1.2. The OBSI measurement method described herein permits tire/pavement noise to be measured in isolation of other noise sources allowing the noise performance of pavements to be compared.
- 1.3. *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. REFERENCED DOCUMENTS

- 2.1. *AASHTO Standards:*
 - [T 389](#), Determining the Influence of Road Surfaces on Vehicle Noise Using the Statistical Isolated Pass-By (SIP) Method
 - [T 390](#), Determining the Influence of Road Surfaces on Traffic Noise Using the Continuous-Flow Traffic Time-Integrated Method (CTIM)
- 2.2. *ASTM Standards:*
 - [D2240](#), Standard Test Method for Rubber Property—Durometer Hardness
 - [F2493](#), Standard Specification for P225/60R16 97S Radial Standard Reference Test Tire
- 2.3. *ANSI Standards:*
 - S1.1, Acoustical Terminology
 - S1.9, Instruments for the Measurement of Sound Intensity
 - S1.11, Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters
 - S1.40, American National Standard Specifications and Verification Procedures for Sound Calibrators
 - S1.42, American National Standard Design Response of Weighting Networks for Acoustical Measurements

- 2.4. *International Electrotechnical Commission (IEC) Standard:*
- IEC 61260, Electroacoustics—Octave-Band and Fractional-Octave-Band Filters
- 2.5. *Other Document:*
- Donovan, P. R. and D. M. Lodico, *Measuring Tire-Pavement Noise at the Source*, NCHRP Report, Project 1-44(1), National Cooperative Highway Research Program, Transportation Research Board, Washington, 2011. Available at [http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp01-44\(01\)_FR.pdf](http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp01-44(01)_FR.pdf).

3. TERMINOLOGY

- 3.1. *arithmetic averaging of levels*—averaging levels by summing the levels and dividing by the number of samples in the average. Use the following equation to arithmetically average a set of N levels, L_i :
- $$L_{A-avg} = \frac{1}{N} \sum_{i=1}^N L_i$$
- 3.2. *coherence*—a measure of the linear dependency of two signals with a value of 0 being no dependency, and a value of 1 being perfect linear dependence. Mathematically, it is the magnitude of the cross-spectrum between two signals squared divided by the product of the auto spectrum of both signals.
- 3.3. *energy averaging of levels*—averaging levels by first transforming the levels to energy quantities, averaging the energy quantities, and then converting back to a level. Use the following equation to energy average a set of N levels, L_i :
- $$L_{E-avg} = 10 \times \text{Log}_{10} \left(\frac{1}{N} \sum_{i=1}^N \left(10^{(L_i/10)} \right) \right)$$
- 3.4. *measurement period*—the time it takes the test vehicle to traverse the distance of the test section.
- 3.5. *on-board sound intensity (OBSI) method*—a measurement procedure to evaluate the tire/pavement noise component resulting from the interaction of an [ASTM F2493](#) Standard Reference Test Tire (SRTT) on a pavement surface. Sound intensity is measured at positions located on a moving vehicle near the tire/pavement interface.
- 3.6. *overall on-board sound intensity (OBSI) level*—the tire/pavement sound intensity level corresponding to the energy sum of the A-weighted sound intensity within the one-third octave bands ranging from 400 to 5000 Hz.
- $$\text{Overall Sound Intensity Level} = 10 \times \text{Log}_{10} \left(\sum_{i=400}^{5000} \left(10^{(L_i/10)} \right) \right)$$
- where:
- L_i = the A-weighted intensity level in the one-third octave band with center frequency i .
- 3.7. *powertrain noise*—the noise from the vehicle engine, exhaust system, air intake, fans, transmission, differential, and axles.
- 3.8. *pressure-intensity index (PI index)*—defined by the arithmetic average of the sound pressure levels (SPL) of both microphones on the probe minus the sound intensity level (IL), as given by the following equation: $PI = SPL_{avg} - IL$. The PI index for each one-third octave band is calculated using the sound pressure levels and intensity level corresponding to that one-third octave band.

Note 1—Since it represents a difference in level, the units for the PI index shall be reported in dB rather than dBA.

- 3.9. *reference temperature*—an ambient air temperature of 68°F (20°C).
- 3.10. *sound intensity*—average rate of sound energy transmitted in a specified direction at a point through a unit area normal to this direction at the point. Units are watt per square meter (W/m²). As such, it is a vector quantity with magnitude and direction. The direction can be associated with the direction of sound propagation or the direction of the orientation of a probe for measuring sound intensity. (Reference ANSI S1.1, Acoustical Terminology.)
- 3.11. *sound intensity level (IL)*—ten times the logarithm to the base 10 of the ratio of the intensity of a given sound in a stated direction to the reference sound intensity of 1 pW/m² (1×10^{-12} W/m²). Units are decibels. (Reference ANSI S1.1, Acoustical Terminology.)
- 3.12. *sound pressure level (SPL)*—ten times the logarithm to the base 10 of the ratio of the time-mean-square pressure of a sound, in a stated frequency band, to the square of the reference sound pressure of 20 µPa (20×10^{-6} Pa). Units are decibels. (Reference ANSI S1.1, Acoustical Terminology.)
- 3.13. *standard reference test tire (SRTT)*—16-in. (P225/60R16) standard tire as defined in [ASTM F2493](#).
- 3.14. *system*—for this standard, refers to the entire system used to measure the sound intensity using the on-board method by means of equipment including matched microphone pairs, preamplifiers, cables, sound analyzers (computational system), probe holders, and associated items mounted on the test vehicle or test trailer.
- 3.15. *test run*—a single measurement over a test section.
- 3.16. *test section*—a 440 ± 10 ft (134 ± 3 m) length of pavement over which a sound intensity measurement is made.
- 3.17. *tire/pavement noise*—the sound generated as a tire traverses a specific length of pavement.
- 3.18. *vehicle noise*—the total noise from a vehicle, including a combination of noise generated by tire/road interaction (tire/pavement noise), air turbulence, and the powertrain.

4. SUMMARY OF TEST METHOD

- 4.1. The test method describes the measurement of sound intensity in close proximity to the tire/pavement interface.
- 4.2. Results are reported as overall A-weighted sound intensity levels, and as A-weighted one-third octave band levels.
- 4.3. General system requirement, equipment, and installation requirements that are used for these measurements are described in Annex A, Sections A2, A3, and A4.

5. SIGNIFICANCE AND USE

- 5.1. This test method provides an objective means for the on-board measurement of sound intensity of noise generated at the tire/pavement interface at defined points near the tire.

- 5.2. Using this method, measurements can be made to compare different pavements.
- 5.3. Complementing this test method are wayside methods including [TP 98](#) for the determination of noise from isolated vehicle pass-by events, and [TP 99](#) for the determination of continuous-flow traffic noise.

6. PROCEDURE

- 6.1. *Selection of Test Section:*
- 6.1.1. *Pavement Surface*—The test section shall have the same nominal material and surfacing for its length and width of the path to be tested. The test section shall be dry and free of debris to the extent practical.
- 6.1.2. *Geometry and Grade*—The test section should be a tangent (straight) section of the roadway. Horizontal curves should be avoided when possible, as should steep downgrades due to the potential for brake usage. Roadway geometry and approximate grade should be noted.
- 6.1.3. *Wheel Path*—Testing should be conducted with the test tire positioned in the normally trafficked wheel path. If testing is conducted outside of this path (for example, center of lane measurements), the location of the selected path shall be documented and reported.
- 6.1.4. *Reflective Surfaces*—There should be no acoustically reflective surfaces within 20 in. (0.5 m) of the center of the wheel path along the length of the test section. If measurements must be made with an object(s) nearby, the location and nature of the object(s) should be documented.
- 6.2. *Measurement Locations*—Measurements shall be made alongside both the leading edge and trailing edge of the SRTT contact patch on the side of the vehicle opposite of the driver (see Annex A4 and Figure A4.1). Figure A4.1 includes the specified locations for the microphone probes during measurement.
- 6.3. *Test Vehicle Operating Conditions:*
- 6.3.1. *Standard Test Speed*—60 mph (97 km/h) shall be used unless conditions do not permit, or the test purpose requires a different speed. If a speed other than the standard test speed of 60 mph (97 km/h) is used, the speed shall be clearly designated in the reporting of all sound intensity levels. Alternative standard test speeds shall be the highest achievable speed from one of the following: 45, 35, and 25 mph (72, 56, and 40 km/h, respectively). The length of the test section shall be that defined in Section 3.16, regardless of test speed. Corrections to sound levels as a function of test speed shall not be applied beyond the tolerance of the test speed. Data shall not be valid if brakes are applied during the measurement period.
- 6.3.2. *Test Speed Variation*—During the test, the vehicle shall travel with constant speed [± 1 mph (± 1.6 km/h)] over the test section in an appropriate gear setting.
Note 2—Use of cruise control is allowed to assist in maintaining constant vehicle speed.
- 6.3.3. *Tire Inflation*—Cold tires shall be inflated to 30 ± 2 psi (207 ± 14 kPa).
- 6.3.4. *Tire Inspection*—Remove small stones from the tread grooves prior to test runs. The test tire shall not have uneven or excess tread wear and/or damage relative to the appearance of a new SRTT. Refer to Annex A, Section A2.2, for additional test tire requirements.

- 6.4. *Verification*—At the beginning of the measurements, and following all warm-up procedures specified by the manufacturer, the sound level measurement system shall be verified using an acoustic calibrator or piston phone.
- 6.4.1. At a minimum, initial verification (acoustical calibration) shall be conducted no more than 1 h before and final verification no more than 1 h after the test period. Additional verification shall be conducted during the course of the measurements so that the maximum period between verification checks does not exceed 4 h.
- 6.4.2. The measurement system shall be adjusted for accuracy according to the manufacturer's instructions. The results of all measurement system accuracy checks shall be recorded in the test report. If the results of any two subsequent verification checks during the measurement period differ by more than 0.5 dB, the testing between those checks shall be considered invalid.
- 6.4.3. The sound calibration device shall meet Class 1 requirements of ANSI S1.40. (Note that some calibrators require correction for environmental conditions. The manufacturer's specifications should be consulted.) The microphones and calibrator shall be calibrated in accordance with the manufacturer's specifications and ANSI S1.9 and S1.40, respectively.
- 6.5. *Measurement Period Start*—The measurement period should begin when the test tire is within 10 ft (3 m) of the beginning of the test section. The tolerance allowed at the beginning of the test section shall not include a nominally different pavement. For the entire duration of the measurement period, the test tire shall be on pavement of the same nominal type. If needed, optical sensors and roadside reflective markers can provide capability to start the measurement within the recommended distance tolerance.
- 6.6. *Averaging Time*—The measurement defining a test section shall be an energy average over the measurement period. For the standard test speed of 60 mph (97 km/h) and the test section of 440 ± 10 ft (134 ± 3 m) length, this corresponds to an averaging time of 5.0 ± 0.1 s. Slower test speeds will result in longer averaging times.
- Note 3**—The alternate standard test speeds have the following corresponding averaging times:
- 45 mph (72 km/h): 6.7 ± 0.2 s
 - 35 mph (56 km/h): 8.6 ± 0.2 s
 - 25 mph (40 km/h): 12.0 ± 0.3 s
- 6.7. *Prevention of System Overloads*—The measurements shall not include overloaded signals. To minimize the risk of overload to the recording system, the signals should be A-weighted prior to digitization.
- 6.8. *Valid Test Run*—The measurement over a test section must meet the following conditions to be considered a valid test run:
- 6.8.1. The PI index shall be in conformance with the minimum and maximum levels in Table 1. Any test run in which these criteria are not satisfied shall be considered invalid and not used in any averages of the test runs.