
Standard Method of Test for

**Determining the Influence of Road
Surfaces on Traffic Noise Using
the Continuous-Flow Traffic
Time-Integrated Method (CTIM)**

AASHTO Designation: T 390-20¹

Technical Subcommittee: 5a, Pavement Measurement

Release: Group 1 (April)



**American Association of State Highway and Transportation Officials
555 12th Street NW, Suite 1000
Washington, DC 20004**

Determining the Influence of Road Surfaces on Traffic Noise Using the Continuous-Flow Traffic Time-Integrated Method (CTIM)

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1. SCOPE

- 1.1. The Continuous-Flow Traffic Time-Integrated Method (CTIM) describes the procedures for measuring the influence of road surfaces on highway traffic noise at a specific site. It provides a quantitative measure of the sound pressure level at locations adjacent to a roadway. Measurements capture the sound from existing traffic for all vehicles on all roadway lanes. Measurements also include propagation effects over the roadway pavement and adjacent terrain to the nearby measurement location.
- 1.2. CTIM is to be applied on roadways where measuring single-vehicle pass-by events would be difficult due to continuously flowing, relatively dense traffic (sound levels from single vehicles cannot be properly captured due to contamination from sound from other vehicles).
- 1.3. This standard is intended for use by acoustic professionals. Competency with acoustical measurement, modeling, and analysis techniques is assumed.
- 1.4. *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 360](#), Measurement of Tire/Pavement Noise Using the On-Board Sound Intensity (OBSI) Method
 - [TP 98](#), Determining the Influence of Road Surfaces on Vehicle Noise Using the Statistical Isolated Pass-By (SIP) Method
- 2.2. *ASTM Standard:*
 - [F2493](#), Standard Specification for P225/60R16 97S Radial Standard Reference Test Tire
- 2.3. *FHWA Reports:*
 - FHWA-PD-96-008, Development of National Reference Energy Mean Emission Levels for the FHWA Traffic Noise Model (FHWA TNM[®]), Version 1.0

- FHWA-PD-96-009, FHWA Traffic Noise Model (FHWA TNM[®]): User's Guide, TNM[®] Version 2.5 Addendum, April 2004
- FHWA-PD-96-010, FHWA Traffic Noise Model (FHWA TNM[®]), Version 1.0: Technical Manual, 2004, update sheets available from FHWA
- FHWA-PD-96-046, *Measurement of Highway-Related Noise*, Section 4: Existing-Noise Measurements in the Vicinity of Highways

2.4. *IEC Standards:*

- IEC 60942: 2003, Electroacoustics—Sound Calibrators
- IEC 61260: 1995, Electroacoustics—Octave-Band and Fractional-Octave-Band Filters
- IEC 61672-1: 2002, Electroacoustics—Sound Level Meters—Part 1: Specifications

2.5. *ANSI Standards:*

- S1.42: 2001 (R2006), American National Standard Design Response of Weighting Networks for Acoustical Measurements
- S12.8: 1998 (R2008), American National Standard Methods for Determination of Insertion Loss of Outdoor Noise Barriers

3. TERMINOLOGY

3.1. *Definitions:*

- 3.1.1. *analysis time block*—the shortest length time block for which all sound level, traffic, and meteorological data are analyzed. The analysis time block length shall range from 5 to 15 min. The length of the analysis time block should be long enough to minimize variation in sound levels from one analysis time block to the next, but short enough to facilitate the elimination of periods of time where the measurements were contaminated by nonhighway source noise. (For example, if measuring 15-min analysis time blocks, it would be undesirable to eliminate the entire 15 min because 5 min of the time period had noise contamination from jets flying overhead; in this case, shorter time blocks would minimize the amount of data lost to contamination.)
- 3.1.2. *control block*—the calculated energy average, L_{eq} , of all modeled analysis time blocks over the first measurement period that meets the data quality criteria specified in this standard. This control block is used for normalization of the remaining analysis data blocks for all data sets.
- 3.1.3. *data set*—the acoustical, traffic, and meteorological data collected over a measurement period during one site visit.
- 3.1.4. *measurement period*—a period of time selected to capture enough data to properly represent the site. A minimum of three reporting time blocks or data points are required; additional data are desirable.
- 3.1.5. *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 measurements are taken at defined locations near the tire/pavement interface.
- 3.1.6. *powertrain noise*—the noise generated from the powertrain, including the vehicle engine, exhaust system, air intake, fans, transmission, differential, and axles.
- 3.1.7. *reporting time block*—a time block comprised of 15-min L_{eq} sound levels for which sound level, traffic, and meteorological data shall be reported. The reporting time block shall be comprised of one or more analysis time blocks.

- 3.1.8. *sampling period*—the period of time over which data are collected during data acquisition. The sampling period must be shorter than or equal to the analysis time block.
- 3.1.9. *Statistical Isolated Pass-By (SIP) method*—a test method for measuring the influence of road surfaces on highway traffic noise. The SIP method captures the sound pressure level from isolated vehicles in existing traffic and allows for the comparison of vehicle noise on roadways of varying surfaces and across studies by comparing measured sound levels to a reference noise curve.
- 3.1.10. *tire/pavement noise*—the sound generated by the interaction of the tire with the pavement surface as it traverses the pavement.
- 3.1.11. *traffic noise*—the overall noise emitted by multiple vehicles running over the road being evaluated.
- 3.1.12. *vehicle categories*—a vehicle category consists of vehicles that have certain common features easy to identify in the traffic stream, such as the number of axles and the size. The common features are assumed to correspond to similarities in sound emission when driven under the same operating conditions. The following vehicle categories are considered to be sufficient to describe the noise characteristics of road surfaces and are used in this part of the CTIM method:

Table 1—Vehicle Categories

Vehicle Category	Number of Axles, Number of Tires, Gross Vehicle Weight (examples)
Automobiles	2 axles, 4 tires, and generally <9,900 lb (4,500 kg) (designated primarily for transportation of 9 or fewer passengers or for transportation of cargo—cars, pickup trucks, and sports utility vehicles)
Medium Trucks	2 axles, more than 4 tires, and generally >9,900 lb (4,500 kg) and <26,400 lb (12,000 kg)
Heavy Trucks	3 or more axles and generally >26,400 lb (12,000 kg)
Buses	2 or 3 axles (designated for transportation of 9 or more passengers)
Motorcycles	2 or 3 tires (with an open-air driver and/or passenger compartment)

Notes:

- The definitions for these vehicle categories are intended for U.S. applications, including the FHWA Traffic Noise Model (FHWA-PD-96-009, FHWA-PD-96-010) and its vehicle noise emission database (FHWA-PD-96-008). The vehicle category definitions can be found in those references as well as the FHWA highway noise measurement manual (FHWA-PD-96-046).
- Only vehicles that clearly fall within any of the types described in this Section shall be measured. Where there is any doubt in classifying a vehicle, the measurement for that vehicle shall be discarded from the study.

- 3.1.13. *vehicle noise*—the total noise from a vehicle, including a combination of noise generated by the tire/road interaction (tire/pavement noise), air turbulence, and the powertrain.

4. SUMMARY OF TEST METHOD

- 4.1. A-weighted, time-integrated sound pressure levels, traffic volumes, speeds, and vehicle categories, and meteorological data are measured continuously on the side of a roadway for a period of time that captures enough data to properly represent the site.
- 4.2. The acoustical, traffic, and meteorological data measurements are repeated at the same site at a later time to determine either: (1) the difference in sound levels before and after the application of a new surface on the highway; or (2) the difference in sound levels as the pavement on a highway ages. For comparison purposes, traffic and site conditions between data sets should be similar; for example, measuring at the same time of day, weekday or weekend, and the same time of year all help to minimize variation.
- 4.3. To allow for comparisons between data sets, the measured sound levels are normalized for differences due to variations in traffic using the FHWA Traffic Noise Model (TNM) (FHWA-PD-96-009 and FHWA-PD-96-010), or another model. Traffic data are input into the

model to predict the sound levels for the same period of time that the acoustical data were captured and to determine any sound level adjustments necessary to remove traffic variation influences.

Note 1—This procedure does not currently allow for site-to-site comparison.

- 4.4. The method is detailed below, and additional CTIM considerations are available in a memorandum to FHWA dated April 20, 2017, “Additional Considerations for AASHTO Standard Methods of Test [TP 98](#) (SIP) and [TP 99](#) (CTIM).” The memorandum is available at: http://downloads.transportation.org/TP98-TP99/SIP_CTIM_Considerations_Memo.pdf

5. SIGNIFICANCE AND USE

- 5.1. This CTIM method provides a measure of the influence of road surfaces on traffic noise at a specific site adjacent to a roadway and allows for the comparison of different pavement conditions at a specific site, either due to changes over time or through the application of a new pavement surface.
- 5.2. CTIM measurements capture the sound from existing traffic for all vehicles on all roadway lanes and include propagation effects over the roadway pavement and adjacent terrain to the nearby measurement location. Although it may be possible to compare results across studies through the use of noise modeling to reduce site and traffic differences, the procedure for such comparisons is not included in this standard at this time.
- 5.3. The CTIM procedure reports broadband A-weighted, time-integrated sound pressure levels. While it is possible to measure one-third octave band levels in conjunction with the broadband levels, methods to analyze the one-third octave band data are not included in this procedure.
- 5.4. CTIM should be applied on roadways with continuously flowing and sufficiently dense traffic that sound levels from single vehicles cannot easily be captured due to sound contamination from other vehicles. In situations where lower traffic volumes allow for the measurement of single vehicle pass-by events without contamination from other vehicles, [TP 98](#), Determining the Influence of Road Surfaces on Vehicle Noise Using the Statistical Isolated Pass-By (SIP) Method, or other similar method should be applied. The appropriate measurement technique should be selected based on site and traffic conditions.
- 5.5. The CTIM test method may be used in conjunction with the on-board sound intensity (OBSI) method described in [T 360](#) that measures the tire/pavement component of vehicle noise exclusively.

6. APPARATUS

- 6.1. *Sound Level Instrumentation*—The sound level meter (or equivalent measuring system) shall meet the requirements of a Class 1 instrument according to IEC 61672-1.
- Note 2**—It is recommended to use a pressure response/random incidence microphone at grazing incidence (i.e., vertical orientation); see Figure 1.

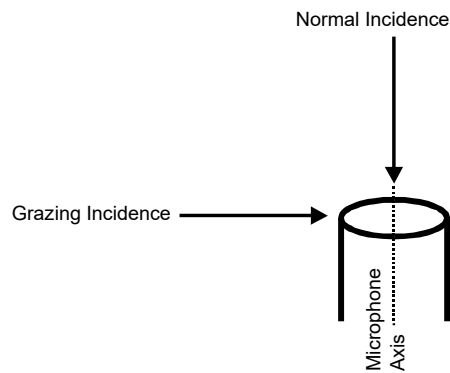


Figure 1—Illustration of Directions for Microphone Orientation

- 6.2. *Windscreens*—A windscreen that does not detectably influence the measured sound levels shall be used.
- 6.3. *Frequency Analysis Instrumentation*—Frequency analysis of the measured sound using one-third octave-band resolution is recommended, but not mandatory. The frequency range of 50 to 10 000 Hz (center frequencies of one-third octave bands) shall be covered. The one-third octave-band filters shall conform to IEC 61260.
- 6.4. *Calibration Instrumentation*—The acoustic calibration device used shall meet the requirements of a Class 1 instrument according to IEC 60942. (Note that some calibrators require correction for environmental conditions. The manufacturer's specifications should be consulted.)
- 6.5. *Vehicle Speed Measurement Instrumentation*—The average vehicle speed for each lane of travel shall be determined. A list of measuring devices/methods is found in *Measurement of Highway-Related Noise* (FHWA-PD-96-046) and includes radar gun, stopwatch, light sensors, and pneumatic tubes. Care must be taken to avoid interfering with the sound level measurements, including actions that could influence driver behavior and/or generating any intrusive noise caused by a measurement device. The vehicle speed measuring instrument(s) shall have an accuracy of ± 1 mph (± 1.6 km/h) for the range of speeds of interest.
- 6.6. *Temperature Measurement Instrumentation*—The air temperature measuring instrument(s) shall have an accuracy of $\pm 2^\circ\text{F}$ ($\pm 1.2^\circ\text{C}$). Meters using an infrared technique shall not be used to measure air temperature.
- 6.7. *Traffic Counting Instrumentation*—Traffic volumes shall be collected. Traffic-counting instrumentation or methods shall not interfere with noise measurements.
- 6.8. *Wind Measurement Instrumentation*—The wind speed measuring instrument(s) shall have an accuracy of ± 2 mph (± 0.9 m/s). The wind direction measuring instrument(s) shall have an accuracy of ± 10 degrees.

7. SELECTION OF TEST SITES

- 7.1. *The following considerations apply for site selection:*
 - 7.1.1. Each road test section shall extend for a distance of at least four times the distance from the center of the near travel lane to the microphone location in both the up- and down-stream directions from the microphone location. For example, for a microphone located at a distance of 50 ft (15.2 m)

from the center of the near travel lane, the road test section must extend 200 ft (61 m) in each direction.

- 7.1.2. The road shall be essentially level and straight. Horizontal curves should be avoided when possible. Roadway geometry and approximate grade shall be noted.
- 7.1.3. A test section shall have the same nominal material and surfacing for its length. The road surface should be homogeneous over the entire test section and the test section should be representative of the road under study. The condition of the road should be documented with pictures of the typical surface included when possible.
- For example, if the pavement is generally free of distress, the test section should be selected to exclude any portion of pavement that exhibits surface cracking, bleeding, or excessive stone loss. If, however, pavement distress is prevalent, then the test section should include these same distresses.
- 7.1.4. It is recommended that the On-Board Sound Intensity (OBSI) Method (AASHTO T 360) be applied to help determine potential CTIM locations to represent a roadway section; the best locations would be those with OBSI levels most prevalent in the roadway section of interest. OBSI testing may reveal variations in pavements that appear homogeneous from visual inspection.
- Note 3**—It is recommended to use a pressure response/random incidence microphone at grazing incidence (i.e., vertical). The noise characteristics of some road surfaces change quickly after opening for traffic. Changes in noise characteristics of newly constructed surfaces (aged less than 2 to 6 months) may not represent aging effects over the lifespan of the pavement.
- 7.1.5. The road surface shall be free of extraneous material, such as gravel or road debris to the extent practical.
- 7.1.6. The site shall consist of an open space free of large sound reflecting surfaces that could affect the CTIM measurements, such as parked vehicles, signboards, buildings, hillsides, safety barriers (or any other type of barrier), and guardrails. The line-of-sight from the microphone(s) to the roadway shall not be obscured within an arc of 120 degrees.
- 7.1.7. The ground surface between the roadway and the microphone(s) should consist of relatively flat and acoustically hard terrain (e.g., pavement, hard ground). The ground surface and any foliage located between the roadway and the microphone(s) shall be documented, and foliage should be consistent from one data set to the next.
- 7.1.8. The site shall be located away from intersections, lane merges, or any other features that would cause traffic to accelerate or decelerate, so that measured vehicles are operating under cruise conditions.
- 7.1.9. The site should be located away from known intrusive noise sources that could influence the noise measurements, such as airports, construction sites, rail yards, or other heavily traveled roadways.
- 7.2. *Additional considerations for site selection:*
- 7.2.1. The availability of a nearby overpass (or side-of-the-road alternative) can be useful for traffic counting purposes.
- 7.2.2. For long-term pavement studies, it is beneficial to select a site that is expected to have minimal physical or operational changes that could bias the results. (Refer to Appendix X1.)
- 7.2.3. It may be possible to use the paired measurement technique by collecting data simultaneously at two or more contiguous sites, which could reduce uncertainty when comparing multiple sites due