
Standard Specification for Equipment for Measuring Macrotexture of Pavements at Highway Speeds

AASHTO Designation: MP 48-23¹

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Technical Subcommittee: 5a, Pavement Measurement



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1. SCOPE

- 1.1. The macrotexture of a pavement surface influences the friction between the tire and the road, noise at the tire-pavement interface, rolling resistance of vehicles, and tire wear. The objective of this specification is to define the required attributes of equipment that can measure pavement macrotexture at highway speeds. This system may be added to a host vehicle as a single function device or as a component of a multifunctional system that collects data relating to a variety of other properties including ride quality and cracking. The equipment may be used to collect network level data or project level data. The equipment shall be supplied with software that can compute macrotexture indices, particularly the mean profile depth (MPD), from the measured data.
- 1.2. It is not the intent of this specification to relieve the supplier from the responsibility to provide an appropriate product for the intended function, nor is it intended to specify all the design details. The objective is to provide a sufficiently detailed specification in order to define the function of the equipment clearly. It is intended to have enough detail that the data collected from different equipment in each class of equipment (i.e., single-spot lasers, line lasers, and 3D equipment) will be identical.

2. REFERENCED STANDARDS

- 2.1. *AASHTO Standards:*
- PP 115, Certification of High-Speed Macrotexture Measurement Equipment
 - PP 116, Operating Equipment for Measuring Macrotexture at Highway Speeds
- 2.2. *ASTM Standard:*
- E1845, Standard Practice for Calculating Pavement Macrotexture Mean Profile Depth
- 2.3. *ISO Standard:*
- ISO 13473-1:2019, Characterization of Pavement Texture by Use of Surface Profiles, Part 1: Determination of Mean Profile Depth
- 2.4. *Other Documents:*
- Katicha, S. W., Mogrovejo, D. E., Flintsch, G. W., and De Leon Izeppi. Adaptive Spike Removal Method for High-Speed Pavement Macrotexture Measurements by Controlling the False Discovery Rate. *Transportation Research Record 2525*, Transportation Research Board, Washington, DC, 2015.

- < PIARC. Road Dictionary. PIARC - World Road Association, Cedex, France, 2016. Available at <https://www.piarc.org/en/activities/Road-Dictionary-Terminology-Road-Transport>
- < Sayers, M. W. and Karamihas, S. M. ERD File format for storage and analysis of road profiles, University of Michigan Transportation Research Institute, UMTRI-97-51, October 1997. Available at <https://deepblue.lib.umich.edu/bitstream/handle/2027.42/106533/102995.pdf?sequence=1&isAllowed=y>

3. TERMINOLOGY

3.1. Definitions:

- 3.1.1. *3D system*—a laser system that collects elevation data along the full width of a travel lane. Such transverse profiles are obtained at regular intervals as the host vehicle moves along the road.
- 3.1.2. *index*—within the context of this standard, a suitably chosen index that quantifies the macrotexture of the pavement surface.
- 3.1.3. *mean profile depth (MPD)*—an index used to quantify the macrotexture of a pavement surface that is computed by averaging the mean segment depth (MSD) values over a specified distance. The procedure for computing the MPD is described in ASTM E1845.
- 3.1.4. *mean segment depth (MSD)*—an index used to quantify the macrotexture of a pavement surface over a distance of 100 mm (4 in.). The procedure for computing the MSD from macrotexture data is described in ASTM E1845. The MSD can be computed over a 100 mm (4 in.) distance for data collected along the travel direction, perpendicular to the travel direction, or at any orientation to the travel direction.
- 3.1.5. *line laser*—a line laser obtains a series of data points along a line, with the line typically being 100 mm (4 in.) long. The line laser is mounted such that it collects data perpendicular to the travel direction, or at a defined angle from the travel direction.
- 3.1.6. *macrotexture profile*—the vertical deviations of the pavement surface taken along a line with sufficient detail to capture the macrotexture-relevant features of the pavement surface; the line can be along the direction of travel, perpendicular to the direction of travel, or at any orientation to the direction of travel.
- 3.1.7. *measurement range*—the detectable range of heights that can be accurately measured by the sensor.
- 3.1.8. *pavement macrotexture*—according to the World Road Association (Permanent International Association of Road Congress (PIARC) macrotexture is defined as surface irregularities of a road pavement with horizontal dimensions ranging between 0.5 mm and 50 mm (0.02 in. and 2 in.) and vertical dimensions between 0.2 and 10 mm (0.008 in. and 0.4 in.).
- 3.1.9. *report interval*—the longitudinal distance over which a macrotexture index is averaged and reported.
- 3.1.10. *sample interval*—the longitudinal distance between data capture points in a macrotexture profile.
- 3.1.11. *single spot laser*—a laser that projects a spot of light that typically has a diameter of 1 mm (0.04 in.) or less on to the pavement surface.

4. GENERAL EQUIPMENT REQUIREMENTS

- 4.1. *General*—The sensors that collect macrotexture profile can be classified into the following three categories:
- 4.1.1. *Single-Spot Lasers*—Single-spot laser sensors typically collect temporal data along the travel direction, and the collected data are stored in a file. As data at a fixed spatial data interval are needed for computing macrotexture indices, the temporal data are post-processed to output data at a fixed spatial data interval in order to compute macrotexture indices.
- 4.1.2. *Line Lasers*—Line lasers collect data over a typical length of 100 mm (4 in.) either perpendicular or at an angle to the direction of travel. These data are collected at a fixed data recording interval in the longitudinal direction.
- 4.1.3. *3D Systems*—Equipment with 3D systems collect data along the full lane width typically approximately perpendicular to the travel direction and obtain such full lane width transverse profiles at regular intervals.
- 4.2. *Macrotexture Profile:*
- 4.2.1. The macrotexture profile shall be measured using equipment in which two primary transducers are used. The transducers are (1) a height sensor that measures the distance between the sensor and the pavement while the vehicle is traveling and (2) a distance measuring instrument (DMI) that provides a location reference for the vehicle as it travels.
- 4.2.2. A global positioning system (GPS) receiver may be installed in the host vehicle and integrated into the system software to record GPS information during testing.
- 4.3. *Supplier*—The supplier shall provide all parts and labor necessary for the installation of the equipment. The computer system provided shall include a mounting arrangement that can be easily used by the operator sitting in the front passenger seat, or by the driver when a single person drives the vehicle and collects data.
- 4.4. *Calculating Macrotexture Indices:*
- 4.4.1. The software shall be capable of calculating an appropriate macrotexture index such as the MPD from the data stored internally in the computer or on external storage media.
- 4.4.2. The software shall be capable of computing the macrotexture index over any user-defined interval.
- 4.4.3. If data are collected along the two wheelpaths using either single-spot lasers or line lasers, the macrotexture index shall be computed along each wheelpath, and the values for each wheelpath as well as the average value shall be reported.
- 4.4.4. If a 3D system is used, the macrotexture index shall be computed for the portion of the data collected along each wheelpath, and the individual wheelpath values as well as the average shall be reported.
- 4.5. *Calibration and Verification of Calibration:*
- 4.5.1. The equipment shall have provisions to facilitate the calibration of the distance measurement instrument (DMI) in the equipment and perform a verification of the measurements obtained from the height sensor.
- 4.5.2. Any external devices required for calibration shall be included with the equipment.

- 4.6. *Restraining Electronic Components*—All electronic components inside the vehicle shall be restrained with tie-downs or other applicable methods such that these components will not move during hard breaking, accelerating, or a crash.

5. EQUIPMENT

- 5.1. *General Requirements*—The equipment shall meet the following requirements:
- 5.1.1. The equipment shall be capable of measuring macrotexture on pavements with MSD values ranging from 0.1 to 5 mm (0.004 in. and 0.2 in.).
 - 5.1.2. If macrotexture is being measured along both wheelpaths, mount the sensors on the host vehicle such that the center-to-center distance between the two sensors is between 1650 and 1800 mm (65 and 71 in.), with each sensor mounted equidistant from the center of the vehicle. Select a specific value for the distance between the sensors based on owner-agency requirements. If only a single sensor is used to collect data, collect data along the left wheelpath.
 - 5.1.3. The equipment shall be capable of measuring macrotexture on pavements at vehicle speeds ranging from 0 to 112 km/h (0 to 70 mph).
 - 5.1.4. The data collected by the equipment shall not be affected by variations in the speed of the host vehicle caused by changing speed limits, braking, acceleration, or coming to a stop.
 - 5.1.5. The computer in the equipment shall be capable of collecting and storing internally at least 80 km (50 mi) of macrotexture profile during a single data collection run.
 - 5.1.6. Equipment shall be capable of measuring macrotexture over an ambient temperature range of 0 to 44 °C (35 to 110 °F).
 - 5.1.7. Equipment shall be capable of measuring macrotexture at a humidity up to 90 percent (non-condensing).
Note 1—Local environmental conditions may require extending the suggested temperature and humidity limits.
 - 5.1.8. The collected data shall not be affected by pavement color or by color changes of the pavement.
 - 5.1.9. The collected data shall not be affected by ambient light.
 - 5.1.10. The measurement system must be mounted on the vehicle such that vehicle vibrations do not influence the obtained measurements over the operating speed range, which is 0 to 112 km/h (0 to 70 mph).
 - 5.1.11. The equipment shall be equipped with an automated triggering system that can automatically initiate and terminate data collection using a reflective mark that is placed on the pavement surface or a reflective mark placed on a cone that is placed on the side of the road. The equipment shall also have the capability to initiate and terminate data collection using a manual method.
 - 5.1.12. Power consumption of all installed equipment shall not exceed the capacity of the equipment providing operating power. Complete discharge of this system shall not impact the vehicle's regular electrical system.
 - 5.1.13. The owner–agency shall specify the computer system parameters, including memory, operating system, interfaces, removable storage, etc. The computer must be ruggedized for the mobile environment.