
Standard Practice for Continuous Thermal Profile of Asphalt Mixture Construction

AASHTO Designation: R 110-22¹

Adopted with Revisions: 2022

Editorially Revised: 2022

Tech Subcommittee: 5c, Quality Assurance and Environmental



**American Association of State Highway and Transportation Officials
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1. SCOPE

- 1.1. This work shall consist of continuous thermal profiling of the asphalt mat temperature immediately behind the trailing edge of the paver screed plate during placement operations.
 - 1.2. This system includes a display that allows the operator in the field to view a pavement surface temperature contour plot and automatically stores and saves the data for later review.
 - 1.3. This standard practice is intended to be applied for construction quality control.
 - 1.4. All tasks are the contractor's responsibility, unless designated otherwise within this provision.
 - 1.5. The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.
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2. REFERENCED DOCUMENTS

- 2.1. *AASHTO Standards:*
 - MP 39, File Format of Intelligent Compaction Data
 - PP 114, Data Lot Names for Intelligent Construction Technologies
 - 2.2. *Software:*
 - Veta Data Management and Analysis Software. Available from <https://www.intelligentconstruction.com/veta>.
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3. TERMINOLOGY

- 3.1. *Definitions:*
 - 3.1.1. *cloud*—a Web-based user interface.
 - 3.1.1.1. *cloud storage*—network storage (typically the Internet) where the thermal profile data are stored in virtualized pools of storage.

- 3.1.1.2. *cloud computing*—the use of computing resources (hardware and software) that are delivered as a service over a network to enable near-real-time visualization (maps) and manipulation of thermal profile data.
- 3.1.2. *coordinate system*— a system that uses one or more numbers or coordinates to uniquely determine the position of a point or other geometric element on a manifold such as Euclidean space.
- 3.1.2.1. *global navigation satellite system (GNSS)*—a satellite system that is used to pinpoint the geographic location of a user’s receiver anywhere in the world. Three GNSS systems are currently in operation: the United States’ Global Positioning System (GPS), the Russian Federation’s Global Orbiting Navigation Satellite System (GLONASS), and Europe’s Galileo. Each of the GNSS systems employs a constellation of orbiting satellites working in conjunction with a network of ground stations.
- 3.1.2.2. *global positioning system (GPS)*—a space-based satellite navigation system that provides location and time information, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.
- 3.1.3. *distance measuring instrument (DMI)*—a sensor attached to a wheel on the paver to calculate distance and velocity.
- 3.1.4. *index*—measure or standard to quantify the uniformity of a hot- or warm-mix asphalt construction operation.
- 3.1.4.1. *range*—the difference between the surface temperature readings at the 98.5 and 1 percentile.
- 3.1.4.2. *standard deviation (StDev)*—the sample standard deviation of the surface temperature readings. This value reflects the variability of surface temperature measurements within a data subplot.
- 3.1.4.3. *thermal segregation index (TSI)*—a composite index of the variability of surface temperature measurements (StDev) and the transverse variability of surface temperature measurements (presence of longitudinal thermal streaking (TSV Index)) within a data subplot.
- 3.1.4.4. *transverse semivariogram index (TSV)*—this index reflects the transverse variability in surface temperature measurements (i.e., presence of longitudinal thermal streaking).
- 3.1.5. *paver mounted thermal profile (PMTP) system*—a system used to continually monitor surface temperature readings of the mat immediately behind the trailing edge of the screed plate during placement operations.
- 3.1.5.1. *contour plot*—a graphic display of data using contour lines and/or color scales. These plots may display raw values or employ varying degrees of smoothing.
- 3.1.5.2. *surface temperature readings*—the temperatures of the mat immediately behind the trailing edge of the paver screed during placement operations.
- 3.1.5.3. *thermal coverage (TC)*—the percent of the total paving area, for the given lift, where surface temperature readings (meeting the requirements of this provision) are collected and stored.
- 3.1.5.4. *thermal profile*—the surface temperature readings and associated GNSS coordinates and time stamps measured by the PMTP system.
- 3.1.6. *traffic lane*—the portion of a traveled way for the movement of a single line of vehicles. Also called *driving or through lane*.

- 3.1.6.1. *auxiliary lane*—a portion of the roadway adjoining the traveled way for parking, speed-change, or other purposes supplementary to through traffic movement.
- 3.1.6.2. *centerline offsets*—the location of the left and right edge of the production/compaction area with respect to the centerline, facing in the direction of increasing stationing. Stationing typically increases from west to east and south to north.
- 3.1.6.3. *direction of travel*—the direction that traffic moves during non-construction conditions (e.g., north bound, southbound, eastbound, westbound).
- 3.1.6.4. *left turn lane*—auxiliary lane dedicated to making a left turn that meets one or more of the following criteria: adjoins traffic lanes on both sides, adjoins a painted median, or is paved with the same production pass as the traffic lane.
- 3.1.6.5. *roadway*—general term denoting a public way for purposes of vehicular travel, including the entire area within the right of way.
- 3.1.6.6. *traveled way*—the portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes.
- 3.1.7. *site calibration*—process of comparing GNSS measurements on known coordinates and creating a best fit (least squares adjustment) for the coordinate grid by scaling and rotating grid to fit the measurements. This allows more accurate GNSS work as a result of the site being adjusted to a local coordinate system.
- 3.1.8. *system failure*—system failure occurs when PMTP system does not collect or store data per the requirements of this provision and/or the paver instrumented with the PMTP system becomes inoperable, or some combination thereof.
- 3.1.9. *Veta*—standardized intelligent construction data management (ICDM) software that stores, maps, and analyzes geospatial data resulting from intelligent construction technology (ICT) such as intelligent compaction, thermal profiling, and spot test data (e.g., density, moisture). This software can perform standardized data processing, analysis, and reporting to provide project summary results from various ICT manufacturers. In particular, the software can provide statistics, histograms, and correlations for these measurements; document coverage area; and evaluate the uniformity of the ICT measurements as part of the project quality control operations. (Software can be downloaded from www.intelligentconstruction.com.)
- 3.1.9.1. *data filter*—allows filtering of PMTP data by speed and temperature.
- 3.1.9.2. *filter group*—contains a combination of data and operation filters for filtering the data according to specific variables and user-defined boundaries. A filter group is created per data lot.
- 3.1.9.3. *operation filter*—allows filtering of PMTP data by imported file name, sensor location, machine ID, time, cold edges, ride brackets, location boundaries, and exclusions.

4. CONSTRUCTION REQUIREMENTS

4.1. *Required Measurement Locations:*

- 4.1.1. Use PMTP method on plant mixed asphalt and stone matrix asphalt for lifts 25 mm [1 in.] or greater in thickness.

Note 1—PMTP surface temperature measurements on lifts less than 25 mm [1 in.] in thickness can be significantly affected by ambient weather conditions (e.g., wind, air temperatures), causing

erroneous segregation patterns to be recorded. Therefore, the PMTP method is not recommended for lift thicknesses less than 25 mm [1 in.].

- 4.1.2. The PMTP method is required when the net lane miles of the required traffic and auxiliary lane are greater than or equal to 3.2 lane kilometers [2 lane miles] in length. The PMTP method is also required on associated routes within the plan set, when the net lane miles of the required traffic and auxiliary lane are 3.2 lane kilometers [2 lane miles] or greater, unless waived by the engineer.

Note 2—It is not recommended to use the PMTP on smaller projects due to the following: (1) amount of time required for site calibrations; (2) staging on smaller projects often leads to significant amounts of time extended towards creation and review of Veta projects; (3) staging on smaller projects may significantly affect surface temperature measurements due to site constraints; and (4) diminishing cost benefit due to the previously listed items.

- 4.1.3. *Collect PMTP measurements on 100 percent of each lift for the following lanes:*

- 4.1.3.1. Traffic lanes, excluding traffic lane tapers and roundabouts (exclude the traffic lane between the roundabout and mainline transition prior to and after the radius point of the roundabout) and

- 4.1.3.2. *The following auxiliary lanes:*

- 4.1.3.2.1. Continuous left turn lanes,

- 4.1.3.2.2. Left turn lanes, and

- 4.1.3.2.3. Passing lanes.

- 4.1.4. PMTP measurements are not required on auxiliary lane tapers, ramps, shoulders, crossovers, right turn lanes, left turn lanes adjacent to a raised median, loops, bypass lanes, acceleration/ deceleration lanes, and intersecting streets.

Note 3—Change the required locations outlined in Section 4.1, as needed, to meet project constraints and objectives. Note that it is difficult to analyze tapered locations, roundabouts, and the excluded auxiliary lanes in Veta; therefore, it is recommended that these locations be excluded from the thermal profile requirements.

- 4.1.5. PMTP measurements are not required on areas of excavation (that are below the layer requiring the PMTP method) that are less than or equal to 230 linear meters [750 linear feet].

Note 4—Smaller equipment is often brought in for subcuts less than 230 linear meters [750 linear feet] that does not contain the PMTP system.

- 4.1.6. For PMTP systems with a low accuracy GNSS (accuracy ± 1.2 m [± 4 ft] in the X and Y directions), do not record measurements outside of the required traffic and required auxiliary lanes, as 100 percent of the recorded data is used in the thermal segregation analysis.

Note 5—Removal of extraneous data with low accuracy GNSS can be subjective, and therefore, not recommended. Consequently, it is recommended that 100 percent of the recorded measurements be used in the thermal segregation analyses. It is the contractor's responsibility to ensure that the system is collecting measurements for the appropriate required width and does not include extraneous measurements.

- 4.1.7. Turn the data collection and recording off when not collecting thermal profile measurements.

- 4.2. *Design Files (Optional):*

- 4.2.1. The engineer will create the design file containing only the following levels: lane lines, in-place centerline, station text, tick marks and labeling for exceptions.

Note 6—It is recommended that the in-place alignment be created for use in Veta for the following items: (1) trimming of surface temperature measurements collected using high accuracy GNSS (i.e., systems with an accuracy of ± 50 mm [± 2 in.]); (2) use of station and offsets for overlaying of spot test data (e.g., density measurements) over the surface temperature measurements; (3) calculation of thermal coverage to ensure no missing data.

- 4.2.2. The contractor is responsible for any necessary conversions of the electronic data provided by the engineer. The Department does not guarantee the accuracy and compatibility of electronic data after any electronic conversions are executed by the contractor.
- 4.2.3. The engineer will provide the following files:
 - 4.2.3.1. Design files (in DGN and DWG format)
 - 4.2.3.2. Alignment file(s) (in LandXML format)
- 4.2.4. Convert, as needed, the provided Department design files for use with the PMTP system and software.
- 4.2.5. The engineer is allowed five working days to update files with engineer-approved changes requested by contractor.
- 4.2.6. Load design file onto the onboard data acquisition system of PMTP systems that allow for import of these files.
- 4.3. *Rover:*
 - 4.3.1. Use a survey grade GNSS Rover Receiver during site calibration and coordinate checks when using PMTP systems with a ± 50 -mm [± 2 -in.] accuracy.
- 4.4. *Control Points:*

Note 7—Control points are required for use with PMTP Systems with a ± 50 -mm [± 2 -in.] accuracy.

 - 4.4.1. The engineer will set temporary control points, prior to the project start date for use in site calibration. Permanent control points can be used; however, the engineer will verify coordinates for these points to confirm no disturbances. Temporary and permanent control points will meet the following requirements:
 - 4.4.1.1. Two control points, at start and end of project (totaling four).
 - 4.4.1.2. Control points spaced at a maximum of every 4.8 km [3 mi] within 45 m [150 ft] of centerline. Alternate the control points on each side of alignment.
 - 4.4.1.3. Control points have a clear line of site to satellites to allow for calibration.
 - 4.4.1.4. *Five of the control points, meet the following requirements (the remaining control points may be two dimensional [2D]):*
 - 4.4.1.4.1. Three dimensional (3D),
 - 4.4.1.4.2. Accuracy of 150 mm [0.1 ft] or less in the X, Y, and Z direction,
 - 4.4.1.4.3. Equally spaced throughout project, and

- 4.4.1.4.4. One control point at start and end of project.
- 4.4.1.4.5. The remaining control points with an accuracy of 150 mm [0.1 ft] or less in the X and Y direction.
- 4.4.2. The engineer will provide a project map (indicating locations of control points) and control point coordinate information (in a *.txt or *.csv format), for both permanent and temporary control points. The engineer will include the following information in the coordinate file(s):
 - 4.4.2.1. Point Name,
 - 4.4.2.2. X coordinate (Easting),
 - 4.4.2.3. Y coordinate (Northing),
 - 4.4.2.4. Z coordinate (Elevation), and
 - 4.4.2.5. Point Code / Description.
- 4.4.3. The engineer will include available agency Geodetic Data Sheets that are relevant to the project limits.
- 4.5. *Site Analysis, Setup and Calibration:*
 - Note 8**—Site calibration is required for use with PMTP Systems with a ± 50 -mm [± 2 -in.] accuracy.
- 4.5.1. Complete site setup and calibration prior to efforts requiring the PMTP method.
- 4.5.2. Use an agency designated coordinate system and zone for site calibration by connecting to a RTK-GPS using either a local, ground-based station(s) or a VRS network.
 - Note 9**—Use coordinate system used to create the design files for instances where design files are provided to contractor.
- 4.6. *Field Stationing:*
 - 4.6.1. Field station markers, when used, will match the centerline stationing in design and alignment files.
- 4.7. *Equipment Requirements:*
 - 4.7.1. Use a PMTP system that functions independently from the paving crew during normal paving operations and is calibrated according to the manufacturer's recommendations.
 - 4.7.2. An operator is not required for continuous data collection.
 - 4.7.3. Ensure that the power consumption of all installed equipment does not exceed the capacity of the equipment providing operating power. Complete discharge of this system shall not impact the vehicle's regular electrical system.
 - 4.7.4. *The following components are required:*
 - 4.7.4.1. Temperature sensor to continuously monitor surface temperature of mat;
 - 4.7.4.2. Longitudinal and lateral surface temperature readings are collected at 305 mm [12 in.] or less intervals at all paving speeds with an X–Y accuracy of ± 25 mm [± 1 in.];