ODOT Provisional TM 773

Provisional Method of Test for

CONTINUOUS THERMAL PROFILE OF ASPHALT MIXTURE CONSTRUCTION

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(s) 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 All tasks are the contractor's responsibility, unless designated otherwise within this Test Method and/or the Contract Special Provisions.

2. REFERENCED DOCUMENTS

2.1 AASHTO PP 80-14

2.2 ODOT Provisional TM 774(9-17)

3. TERMINOLOGY

3.1 Cloud—a Web-based user interface.

3.2 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.

3.3 Cloud Storage—network storage (typically the Internet) where the thermal profile data are stored in virtualized pools of storage.

3.4 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.

3.5 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.

3.6 Daily Thermal Coverage (DTC)—the percent of thermal coverage (TC) for the given lot.

3.7 Distance Measuring Instrument (DMI)—a sensor attached to a wheel on the paver to calculate distance and velocity.

3.8 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.

3.9 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.

3.10 Index—measure or standard to quantify the uniformity of a hot- or warm-mix asphalt construction

3.11 Range—the difference between the surface temperature readings at the 98.5 Percentile (**Tmax**) and 1 Percentile (**Tmin**).

3.12 Sample Interval—the longitudinal distance between data thermal profiles.

3.13 Summary Indices—the combination of real-time indices plus the distribution of placement temperatures and the location and duration of paver stops exceeding 1 min.

3.14 Surface Temperature Readings—the temperatures of the mat immediately behind the paver screed during placement operations.

3.15 Thermal Coverage (TC)—the percent of the total paving area, for the given lift, where surface temperature readings (meeting the requirements of this special provision) are collected and stored.

3.16 Thermal Profile—the surface temperature readings and associated GNSS coordinates and time stamps.

3.17 Thermal Profile Area - The total area where the thermal profile measurements are generated on a given lift.

3.18 Thermal Profiling System—the combination of the equipment and host vehicle used to measure the thermal profile.

Note 1—The paving machine will typically serve as the host vehicle.

3.19 Tmax – The 98.5(°F) high temperature in each 150 ft. thermal sublot when analyzed through Veta, or other Engineer approved analysis software.

3.20 Tmin – The low surface temperature reading at the 1 percentile (°F) in each thermal sublot when analyzed through Veta, or other Engineer approved analysis software.

3.21 Veta— a standardized intelligent construction data management (ICDM) software that stores, maps and analyzes geospatial data resulting from 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 quickly in the field from various intelligent compaction and thermal profiling manufacturers. In particular, the software can provide statistics, histograms, correlations for these measurements, document coverage area and evaluate the uniformity of compaction and surface temperature measurements as part of the Project quality control operations. Software can be downloaded from www.intelligentcompaction.com)

4. THERMAL IMAGING SYSTEM

4.1 Thermal Imaging System requirements. Equip each paver with a paver mounted Thermal Imaging System capable of the following:

4.1.1 Uses infrared sensors measuring from 32°F – 475°F with an accuracy of ± 3°F or ± 1.5% of reading, whichever is greater.

4.1.2 Profiles entire paving width, excluding pavement edges, with longitudinal and lateral measurements in less than 1.0 foot intervals at all paving speeds.

4.1.3 Measures distance using a Distance Measuring Instrument (DMI) and equipped with a Global Navigation Satellite System (GNSS) with a horizontal accuracy of 4 feet.

4.1.4 Collects; displays real time, color-coded maps of the thermal profile; saves; and analyzes temperature readings while in operation, using the latest software available.

4.1.5 Produces output files of pavement temperatures for each day's placement and daily summary in an approved test report that identifies locations of thermal segregation with a recording of the temperature at such locations.

4.1.6 Provides software capable of developing and analyzing Thermal Profiles for the entire project.

4.1.7 Provides an operating system with at least one USB port to save test results to a portable USB memory device.

4.1.8 Paver mounted color display.

4.1.9 Calibrate each temperature sensor to a known standard on an annual basis. Provide documentation from the system manufacturer that this has been done no later than the Prepaving Conference.

4.1.10 Provide account access to no less than 3 ODOT users the real-time monitoring, cloud storage and cloud computing (e.g. user IDs, passwords) at the pre-pave meeting. Continue access to the cloud storage and cloud computing until ninety (90) days after Final Second Notification.

4.1.11 Produces data files compatible with data analysis software, Veta Version 4.3 or later.

4.2 GNSS System –See ODOT Provisional TM 774-17 for GNSS System requirements, with the following exception: the RTK receiver and RTK solution are not required for the Thermal Profiling System.

5. PLACING ACP WITH THE THERMAL IMAGING SYSTEM- Measure the thermal profile of the un-compacted mat of ACP that identifies the presence of thermal segregation.

5.1 Determine the thermal profile using the Thermal Imaging System.

5.2 Operate the Thermal Imaging System in accordance with the manufacturer's recommendations.

5.3 Verify the calibration for each temperature sensor prior to collecting temperature measurements per manufacturer's recommendations and within the tolerances stated in above.

5.4 Thermal profiles in miscellaneous paving areas that are subject to handwork such as intersections, driveways, crossovers, turnouts, gores, tapers, and other similar areas are exempt.

5.6 Verify the temperature sensor(s), DMI and GNSS are working within the requirements of this Provisional TM, when requested by the Engineer.

5.7 Record thermal profiles in 150 foot segments, Record the beginning and ending station numbers of all thermal profiles.

5.8 Obtain all temperature measurements in units of degrees Fahrenheit.

5.9 Obtain all temperature measurements while the paver is moving.

5.10 Configure the system to record pavement temperatures at increments of no more than 1.0 foot of forward movement.

5.11 When performing a thermal profile, if the paver stops for more than 60 seconds, exclude the area 2 feet behind the screed and 8 feet in front of the screed (in the direction of travel) from the thermal profile.

5.12 Exclude surface temperature readings less than 180°F (80°C).

5.13 Prepare and submit the Thermal Imaging System (TIS) Daily Report (Form 734-5126) on a daily basis no later than two hours before the start of each succeeding shift.

6. THERMAL PROFILE ANALYSIS – Using VETA version 4.3, or newer, analyze the thermal profiles and produce reporting according to the following:

6.1 Thermal Segregation Category

6.1.1 Evaluate data in sublots 150 feet in length. A Lot will be the total length of travel lane paving, for each lift, each shift.

6.1.2 Evaluate thermal segregation using 100 percent of the recorded data for each sublot.

6.1.3 Determine a new **Tmax** and **Tmin** for every thermal profile measured. Obtain the **Tmax** by analyzing the temperature readings recorded throughout the entire 150 ft. length and recording the surface temperature reading at the 98.5 percentile (°F), while the **Tmin** will be the surface temperature reading at the 1 percentile (°F). Calculate the Range for each

thermal sublot. The **Range** will be the difference between the **Tmax** and **Tmin** in each sublot.

6.1.4 Thermal Segregation Category - Categorize the surface temperature readings for each sublot with respect to the ranges specified in the following Table. Provide the total number and locations (i.e. sublot #, station range and GPS coordinates of beginning and ending of sublot) of Low, Moderate and Severe sublots in the report generated by the analysis software.

Table 773-1
Sublot Temperature Differential

Range (Tmax – Tmin)	**Thermal Segregation Category**
Range ≤ 25.0°F	Low
25.1°F < Range ≤ 50.0°F	Moderate
50.1 °F < Range	Severe

6.2 Thermal Coverage

6.2.1 Calculate the Thermal Profile Lift Length according to the following:

$$Thermal\ Profile\ Lot\ Length = \sum_{i=1}^{n} Sublot\ Length_i$$

Where:

- *Thermal Profile Lot Length* = the total linear length of the surface temperature readings used for the thermal segregation analysis for the given lot, ft (reported to the nearest whole number).
- *n* = the total number of sublots; and
- *Sublot Length* = the linear length of sublot *i*, ft (reported to the nearest whole number).

6.2.2 Calculate the Thermal Profile Lift Length according to the following

$$Thermal\ Profile\ Lift\ Length = \sum_{i=1}^{n} Thermal\ Profile\ Lot\ Length_i$$

Where:

- *Thermal Profile Lift Length* = the total linear length of the surface temperature readings used for the thermal segregation analysis for the entire lift, ft (reported to the nearest whole number).
- *n* = the total number of lots for the entire *lift*; and
- $Thermal\ Profile\ Lot\ Length_i$ = the total *linear* length of the surface temperature readings used for the thermal segregation analysis for the given lot *i* and lift as calculated by Veta, or other approved analysis software, ft (reported to the nearest whole number).

6.2.3 Calculate the Thermal Coverage according to the following equation:

$$Thermal\ Coverage = \left(\frac{Thermal\ Coverage\ Lift\ Length}{LM\ X\ 5280}\right) X\ 100$$

Where:

- *Thermal Coverage* = % (reported to the nearest whole number);
- *Thermal Profile Lift Length (ft)* = reported to the nearest whole number); and
- *Lane Miles (LM)* = Total number of lane miles for the given lift requiring thermal profiling, miles (reported to the hundredth).

6.3 Paver Stops

6.3.1 Record in Table form the location and duration of all paver stops in excess of 1 minute