

**STATE OF OHIO  
DEPARTMENT OF TRANSPORTATION**

**SPECIAL PROVISION 400  
PAVER MOUNTED THERMAL PROFILING**

**March 30, 2022**

**400.01 Description**

**400.02 Equipment**

**400.03 Thermal Profile Data Collection**

**400.04 Thermal Profile Analysis Software**

**400.05 Calculations Submittals**

**400.06 Basis of Payment**

**400.01 Description.** This work consists of obtaining thermal profiles to identify the presence of any thermal segregation of an un-compacted mat of hot mix asphalt. This method includes procedures for determining thermal profile using a paver-mounted thermal imaging system.

**400.02 Equipment.** Provide a Paver Mounted Thermal Profiler (PMTP) system as follows:

A. PMTP System Supplier. Use a thermal equipment supplier that can provide a qualified representative for on-site technical assistance during the initial setup, pre-construction verification, and data management and processing, as needed, during the Project to maintain equipment within specifications and requirements.

B. PMTP System Software. Provide the Engineer with access to the cloud storage and cloud computing before the start of paving requiring the PMTP method until ninety (90) days after final acceptance of all work.

Use PMTP software, and cloud computing and storage, capable of collecting, mapping, retaining, and analyzing the mat temperature readings during placement and exporting thermal profile data meeting the requirements of this provision and supporting the following features:

- (1) Filtering by surface temperature reading location (items 8 through N of Table 400.02-3).
- (2) Display through a map/graph:
  - (2.1) Surface temperature readings across the required width and with respect to a user defined subplot length,
  - (2.2) Paver speed and
  - (2.3) Paver stops (location and duration).
- (3) Provide the paving length and duration.

C. PMTP System

1. System Requirements. Use a PMTP system that functions independently from the paving crew during normal paving operations but requires an operator to initiate the start of data collection. After initializing the equipment, no operator attendance is required for continuous data collection.

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.

Provide the Engineer with PMTP System(s) calibrated and installed according to Manufacturer's recommendations.

Ensure the PMTP System meets the requirements of Table 400.02-1 and is instrumented with the following:

**TABLE 400.02-1 PMTP SYSTEM REQUIREMENTS**

<b>Parameter</b>	<b>Requirement</b>
Longitudinal and Lateral Surface Temperature Readings	≤ 1-ft (300-mm) intervals <b>at all paving speeds</b> Tolerance: ± 1 in (25 mm)
Surface Temperature Readings Total Measurement Width	Traffic / Required Auxiliary lane(s) paved in one (1) pass.
Surface Temperature Readings	Range: 32°F (0°C) to 480°F (250°C)  Accuracy: ± 3.6°F (2°C) or ± 2.0% of the sensor reading, whichever is greater.
GNSS	Accuracy ≤ ± 4 feet (1.2 m) in the X and Y Direction

- (1) Modem, or Wi-Fi, for transferring data to cloud storage.
- (2) Onboard Documentation System – Use an onboard documentation system with a minimum of the following capabilities:
  - (2.1) Display (in real-time) a map of the surface temperature readings, total distance, paver speed and location in terms of station and/or GNSS coordinates.
  - (2.2) Report the surface temperature readings and GNSS status.
  - (2.3) Provide real-time statistical summaries of the surface temperature readings.
  - (2.4) Have the ability to manually export data using a removable media device.
  - (2.5) Allows the operator to define the lot currently being placed per Tables 400.03-1 and 400.03-2.

2. Thermal Profiling Data. Provide thermal profiling data in a file format compatible with Veta. Veta accepts the following file formats: .log, .paveproj, .csv, or .tds. Ensure the PMTP date/time stamp is reflective of the local time zone for both mapped and exported data. Encrypt the data logged in the results files to prevent tampering or manipulation.

Veta is a software that stores, maps and analyzes geospatial data resulting from PMTP. This software can perform standardized data processing, analysis, and reporting to provide project summary results from various PMTP manufacturers. In particular, the software can provide statistics, histograms, correlations for these measurements, document coverage area and evaluates the uniformity of the PMTP measurements.

Include the information in Table 400.02-2 in the header of each data file or section. Include the fields in Table 400.02-3 with each data point.

**TABLE 400.02-2 REQUIRED INFORMATION IN DATA HEADERS**

<b>Item No.</b>	<b>Description</b>	<b>Example Data included in Header</b>
1	State Project Number, Highway and/or Section	Highway 77
2	Machine Trade Name	ABC Company
3	Machine ID	1234AC78
4	Lateral Spacing between surface temperature measurements (in)	12
5	Longitudinal Spacing between surface temperature measurements (inch)	12
6	Vertical Distance between the temperature sensor(s) and asphalt pavement mat (inch)	120
7	Reporting resolution for independent surface temperature data – in the paver moving direction (inch)	13
8	Number of lateral surface temperature measurements/sensors	12
9	Number of surface temperature measurement data blocks	5000

**TABLE 400.02-3 REQUIRED FIELDS FOR EACH DATA BLOCK**

<b>Item No.</b>	<b>Date Field Name</b>	<b>Data Format Examples</b>
1	Date Stamp (YYYYMMDD)	20080701
2	Time Stamp (HHMMSS.S -military format)	090504.0 (9 hr 5 min. 4.0 s.)
3	Longitude (decimal degrees, with at least 6 significant digits)	94.859204
4	Latitude (decimal degrees, with at least 6 significant digits)	45.227773
5	Distance (feet)	1
6	Direction heading (degree angle, clockwise from the north); or calculated value, in Veta, using values from the other data blocks, ft/min	45
7	Speed (feet per minute or inches per minute)	30.0
8	Surface temperature Reading/Location 1 (°F)*	290
9	Surface temperature Reading/Location 2 (°F)*	295
...	...	...
N	Surface temperature Reading/Location N (°F)*	300

\* Surface temperature readings/locations are numbered from 1 to N, left to right, in the direction of paving.

3. PMTP System Setup on Paver(s). Instrument all pavers that are paving the traffic and required auxiliary lanes with the PMTP System. The PMTP system is not required on secondary pavers. Secondary pavers are those pavers that are not used for paving of traffic lanes, but are used for paving of shoulders, ramps, intersecting streets, etc.

Ensure the installed PMTP System takes measurements within 10 ft (3 m) of the trailing edge of the screed plate. Ensure that brackets and/or other obstructions, used for pavement smoothness, that are located in the measurement area do not affect more than two (2) surface temperature readings recorded in the lateral direction (items number 8 through N in Table 400.02-3).

Verify that the surface temperature readings and the GNSS are working within the requirements of this specification prior to the first day of paving and when requested by the Engineer.

**400.03 Thermal Profile Data Collection.**

A. Lot Establishment. A lot is defined as all asphalt paving for a given day, lift, material type and centerline offsets.

Distinctly identify the lots for thermal profile measurements using the standardized format per Tables 400.03-1 and 400.03-2. Ensure that the lot designations are digitally stored with the associated thermal profile measurements.

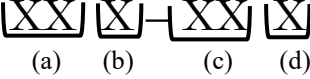
The GNSS coordinates contain the date component of the lot designation, and therefore, it is not included in the standardized naming convention.

**TABLE 400.03-1 STANDARDIZED NAMING CONVENTION FOR THERMAL PROFILE LOTS**

<b>Standardized Format</b>	<b>Example</b>
ROUTE-MATL-L#-XXX-XXX-DT	(e.g., IR70-442-IC-19.0mm-L2-12L-CL-WB)

**TABLE 400.03-2 STANDARDIZED ABBREVIATIONS FOR THERMAL PROFILE LOTS**

Abbreviation	Definition																																							
ROUTE	<p><b>ROUTE DESIGNATION.</b> Replace “ROUTE” with the route system, as designated by the following acronyms or short form, immediately followed by the route number (e.g., IR70).</p> <table border="1" data-bbox="407 352 946 615"> <thead> <tr> <th data-bbox="407 352 597 422">Acronym or Short Form</th> <th data-bbox="597 352 946 422">Full Name or Meaning</th> </tr> </thead> <tbody> <tr> <td data-bbox="407 422 597 457"><b>IR</b></td> <td data-bbox="597 422 946 457">Interstate Route</td> </tr> <tr> <td data-bbox="407 457 597 493"><b>US</b></td> <td data-bbox="597 457 946 493">US Route</td> </tr> <tr> <td data-bbox="407 493 597 529"><b>SR</b></td> <td data-bbox="597 493 946 529">State Route</td> </tr> <tr> <td data-bbox="407 529 597 564"><b>CR</b></td> <td data-bbox="597 529 946 564">County Route</td> </tr> <tr> <td data-bbox="407 564 597 600"><b>TR</b></td> <td data-bbox="597 564 946 600">Township Route</td> </tr> <tr> <td data-bbox="407 600 597 636"><b>MR</b></td> <td data-bbox="597 600 946 636">Municipal Route</td> </tr> </tbody> </table>	Acronym or Short Form	Full Name or Meaning	<b>IR</b>	Interstate Route	<b>US</b>	US Route	<b>SR</b>	State Route	<b>CR</b>	County Route	<b>TR</b>	Township Route	<b>MR</b>	Municipal Route																									
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MATL	<p><b>MATERIAL/ SURFACE TYPE.</b> The material/surface type is designated by the following acronyms or short form:</p> <table border="1" data-bbox="407 737 1398 1157"> <thead> <tr> <th data-bbox="407 737 764 772">Acronym or Short Form</th> <th data-bbox="764 737 992 772">Specification</th> <th data-bbox="992 737 1398 772">Full Name or Meaning</th> </tr> </thead> <tbody> <tr> <td data-bbox="407 772 764 808"><b>301</b></td> <td data-bbox="764 772 992 808">301</td> <td data-bbox="992 772 1398 808">Asphalt Base</td> </tr> <tr> <td data-bbox="407 808 764 844"><b>302</b></td> <td data-bbox="764 808 992 844">302</td> <td data-bbox="992 808 1398 844">Asphalt Base</td> </tr> <tr> <td data-bbox="407 844 764 879"><b>424A</b></td> <td data-bbox="764 844 992 879">424</td> <td data-bbox="992 844 1398 879">Fine Graded Polymer Type A</td> </tr> <tr> <td data-bbox="407 879 764 915"><b>424B</b></td> <td data-bbox="764 879 992 915">424</td> <td data-bbox="992 879 1398 915">Fine Graded Polymer Type B</td> </tr> <tr> <td data-bbox="407 915 764 951"><b>443-SMA</b></td> <td data-bbox="764 915 992 951">443</td> <td data-bbox="992 915 1398 951">Stone Matrix Asphalt</td> </tr> <tr> <td data-bbox="407 951 764 987"><b>441-SC-T1</b></td> <td data-bbox="764 951 992 987">441</td> <td data-bbox="992 951 1398 987">Type 1</td> </tr> <tr> <td data-bbox="407 987 764 1022"><b>441-IC-T2</b></td> <td data-bbox="764 987 992 1022">441</td> <td data-bbox="992 987 1398 1022">Type 2</td> </tr> <tr> <td data-bbox="407 1022 764 1058"><b>442-SC-9.5mm</b></td> <td data-bbox="764 1022 992 1058">442</td> <td data-bbox="992 1022 1398 1058">9.5mm Surface Course</td> </tr> <tr> <td data-bbox="407 1058 764 1094"><b>442-SC-12.5mm</b></td> <td data-bbox="764 1058 992 1094">442</td> <td data-bbox="992 1058 1398 1094">12.5mm Surface Course</td> </tr> <tr> <td data-bbox="407 1094 764 1129"><b>442-IC-9.5mm</b></td> <td data-bbox="764 1094 992 1129">442</td> <td data-bbox="992 1094 1398 1129">9.5mm Intermediate Course</td> </tr> <tr> <td data-bbox="407 1129 764 1157"><b>442-IC-12.5mm</b></td> <td data-bbox="764 1129 992 1157">442</td> <td data-bbox="992 1129 1398 1157">12.5mm Intermediate Course</td> </tr> <tr> <td data-bbox="407 1157 764 1184"><b>442-IC-19.0mm</b></td> <td data-bbox="764 1157 992 1184">442</td> <td data-bbox="992 1157 1398 1184">19.0mm Intermediate Course</td> </tr> </tbody> </table>	Acronym or Short Form	Specification	Full Name or Meaning	<b>301</b>	301	Asphalt Base	<b>302</b>	302	Asphalt Base	<b>424A</b>	424	Fine Graded Polymer Type A	<b>424B</b>	424	Fine Graded Polymer Type B	<b>443-SMA</b>	443	Stone Matrix Asphalt	<b>441-SC-T1</b>	441	Type 1	<b>441-IC-T2</b>	441	Type 2	<b>442-SC-9.5mm</b>	442	9.5mm Surface Course	<b>442-SC-12.5mm</b>	442	12.5mm Surface Course	<b>442-IC-9.5mm</b>	442	9.5mm Intermediate Course	<b>442-IC-12.5mm</b>	442	12.5mm Intermediate Course	<b>442-IC-19.0mm</b>	442	19.0mm Intermediate Course
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XXX-XXX	<p><b>CENTERLINE OFFSET.</b> The location of the left and right edge of the production area with respect to the centerline, facing in the direction of increasing stationing. Stationing typically increases from West to East and South to North. On divided sections, the inside edge of pavement is treated as the Center Line. Each character of the abbreviation is defined as the following:</p> <p style="text-align: center;">  </p> <p>(a) The offset distance (in feet rounded to the whole number) from the centerline to the left edge of the production area (e.g., CL, 12, 24). <b>CL</b> reflects the <b>Center Line</b>.</p> <p>(b) R or L, to reflect Right (R) or Left (L) of Centerline, in the direction of increasing station numbering.</p> <p>(c) The offset distance (in feet rounded to the whole number) from the centerline to the right edge of the production area (e.g., CL, 12, 24). <b>CL</b> reflects the <b>Center Line</b>.</p> <p>(d) R or L, to reflect Right (R) or Left (L) of Centerline, in the direction of increasing station numbering.</p>										
DT	<p><b>DIRECTION OF TRAVEL.</b> The direction of travel is designated by the following acronyms or short form:</p> <table border="1" data-bbox="407 919 873 1121"> <thead> <tr> <th>Acronym or Short Form</th> <th>Full Name or Meaning</th> </tr> </thead> <tbody> <tr> <td><b>NB</b></td> <td>North Bound</td> </tr> <tr> <td><b>SB</b></td> <td>South Bound</td> </tr> <tr> <td><b>EB</b></td> <td>East Bound</td> </tr> <tr> <td><b>WB</b></td> <td>West Bound</td> </tr> </tbody> </table>	Acronym or Short Form	Full Name or Meaning	<b>NB</b>	North Bound	<b>SB</b>	South Bound	<b>EB</b>	East Bound	<b>WB</b>	West Bound
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B. Sublot Establishment Using Veta. Once established, the Engineer will divide the lot into 150 linear ft (45 linear m) sublots. Partial sublots will be prorated by length.

C. Thermal Profile Measurements. Collect thermal profiles on **100 percent of each lift** of trafficked lanes:

Thermal profiles are not required on auxiliary lane tapers, ramps less than 1500ft, shoulders, cross-overs, non-continuous turn lanes, acceleration/deceleration lanes less than 1500ft and intersecting streets.

Ensure that the PMTP system is not capturing measurements outside of the traffic and required auxiliary lanes, as 100 percent of the recorded data is used in the thermal segregation analysis. Turn the data collection and recording off when not collecting thermal profile measurements.

D. PMTP System Failure. System Failure occurs when the PMTP system does not collect and/or store data per the requirements of this provision and/or the paver becomes inoperable.

Immediately notify the Engineer when PMTP system failure occurs and immediately after resolution of the issues. Additionally, provide the Engineer with a written notification of the dates of PMTP system failure, along with a brief description detailing the PMTP system failure and the paving areas affected by this failure. Do not proceed with placement the next working day without a functioning PMTP system.

**400.04 Submittals.** Thermal Profiling Data Submittal. Store the thermal profiling data internally until transfer of data. Transfer the thermal profiling data directly from the PMTP to Cloud Storage within 15-minute intervals, or at least once per day when there is limited cellular coverage. Notify the Engineer when cellular coverage is limited or not available. Transfer the thermal profiling data directly to the Engineer at the end of daily paving when cellular coverage is not available.

## 400.05 Calculations by ODOT

### A. Thermal Segregation

1. Surface Temperature Readings. The Department will evaluate thermal segregation using 100 percent of the recorded data for each subplot. The following surface temperature readings will be excluded from each subplot:

- (1) Surface temperature readings less than 180°F (80°C); and
- (2) Surface temperature readings within 2 ft (0.5 m) prior to and 8 ft (2.5 m) after paver stops that are greater than 1 minute in length.

B. Thermal Coverage. The Department will calculate thermal coverage for each lift per Equation 400.05-3.

#### 1. Thermal Profile Lot Length

$$\text{Equation 400.05-1: Thermal Profile Lot Length} = \sum_{i=1}^n \text{Sublot Length}_i$$

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 subplot  $i$ , ft (reported to the nearest whole number).

#### 2. Thermal Profile Lift Length

$$\text{Equation 400.05-2: Thermal Profile Lift Length} = \sum_{i=1}^n (\text{Thermal Profile Lot Length})_i$$

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

$(\text{Thermal Profile Lot Length})_i$  = 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, ft (reported to the nearest whole number). (See Equation 400.05-1)

#### 3. Thermal Coverage

$$\text{Equation 400.05-3: Thermal Coverage} = \left( \frac{\text{Thermal Profile Lift Length}}{LM \times 5280} \right) \times 100$$

Where:

*Thermal Coverage* = % (reported to the nearest whole number);

*Thermal Profile Lift Length* = see Equation 400.05-2, 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).

**400.06 Basis of Payment.** Interruptions in the availability of VRS Network and/or satellite signals to operate this system will not result in any reduction to the daily thermal coverage or adjustment to the “Basis of Payment” for any construction items or to Contract time.

Monetary Deductions for thermal coverage will be assessed per Lift per Table 400.6-1.

**Table 400.6-1 Monetary Deduction for Thermal Coverage (TC)**

<b>Thermal Coverage (Percent)</b>	<b>Total Monetary Deduction Per Lift</b>
70 percent or greater	No Monetary Deduction
less than 70	Total Monetary Deduction = $(20 \times TC - \$1400) \times (LM)$  where: TC = Thermal Coverage, see Equation 400.05-3 and LM = Lane Miles, see Equation 400.05-3.

The Department will pay for accepted work at the contract prices as follows:

<b>Item</b>	<b>Unit</b>	<b>Description</b>
690E98400	Lump Sum	Paver Mounted Thermal Profiling