

**STATE OF OHIO
DEPARTMENT OF TRANSPORTATION**

**SPECIAL PROVISION 400
PAVER MOUNTED THERMAL PROFILING**

January 17, 2025

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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 Profile (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 system until 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 and graph:
 - a. Surface temperature readings across the required width and with respect to a user defined subplot length,
 - b. Paver speed, and
 - c. Paver stops (location and duration).
3. Provide the paving length and duration.
4. Retain the PMTP data and keep it available for download throughout the duration of the cloud storage requirement.

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.

Calibrate and install the PMTP system(s) 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

Parameter	Requirement
Longitudinal and Lateral Surface Temperature Readings	≤ 1 -ft (300-mm) intervals at all paving speeds Tolerance: ± 1 in (25 mm)
Surface Temperature Readings Total Measurement Width	Traffic and required auxiliary lane(s) paved in 1 pass.
Surface Temperature Readings	Range: 140 °F (60 °C) to 480 °F (250 °C) Accuracy: ± 3.6 °F (2 °C) or $\pm 2.0\%$ of the sensor reading, whichever is greater.
GNSS	Accuracy $\leq \pm 2$ inches (50 mm) in the X and Y Direction

a. Global Navigation Satellite System (GNSS) – Use a GNSS receiver with the ability to obtain positional corrections using the ODOT Real Time Network (RTN) or a Base-Rover real-time kinematic (RTK) system. Tie data to the most current version of the National Spatial Reference System (NSRS) through Ohio County Coordinate System (OCCS) Coordinates.

b. Cellular modem or Wi-Fi, for transferring data to cloud storage.

c. Onboard Documentation System – Use an onboard documentation system with a minimum of the following capabilities:

(1) Display (in real-time) a map of the surface temperature readings, total distance, paver speed and location in terms of station or GNSS coordinates.

(2) Report the surface temperature readings and GNSS status.

(3) Provide real-time statistical summaries of the surface temperature readings.

(4) Have the ability to manually export data using a removable media device and the ability to store data locally when cell coverage is unavailable to be uploaded to the cloud later.

(5) Allows the operator to define the lot currently being placed according to 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 evaluations of 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

Item No.	Description	Example Data included in Header
1	State Project Number, Highway and/or Section	IR 70
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

Item No.	Date Field Name	Data Format Examples
1	Date Stamp (YYYYMMDD)	20230701
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	45
7	Speed (feet per minute or inches per minute)	30.0
8	Surface temperature Reading/Location 1 (°F) ^[1]	290
9	Surface temperature Reading/Location 2 (°F) ^[1]	295
...	...	...
N	Surface temperature Reading/Location N (°F) ^[1]	300

^[1] Surface temperature readings/locations are typically 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 or other obstructions, used for pavement smoothness, that are located in the measurement area do not affect more than two 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.

As part of the data analysis, the Department will distinctly identify the lots for thermal profile measurements using the standardized format according to Tables 400.03-1 and 400.03-2.

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

Standardized Format	Example
ROUTE-MATL-L#-XXX-XXX-DT	(e.g., IR70-442-SC-12.5mm-L1-12L-CL-WB)

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 tapers, service interchange ramps, system ramps less than 2500 ft (760 m), shoulders, cross-overs, non-continuous turn lanes, acceleration/deceleration lanes less than 2500 ft (760 m) and intersecting streets.

Ensure that the PMTP system is not capturing measurements outside of the required lanes. 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 or store data according to the requirements of this provision or the paver becomes inoperable. This includes loss of GNSS.

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.

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

Abbreviation	Definition		
ROUTE	ROUTE DESIGNATION. Replace “ROUTE” with the route system, as designated by the following acronyms or short form, immediately followed by the route number (e.g., IR70).		
	Acronym or Short Form	Full Name or Meaning	
	IR	Interstate Route	
	US	US Route	
	SR	State Route	
	CR	County Route	
	TR	Township Route	
	MR	Municipal Route	
MATL	MATERIAL/ SURFACE TYPE. The material/surface type is designated by the following acronyms or short form:		
	Acronym or Short Form	Specification	Full Name or Meaning
	301	301	Asphalt Base
	302	302	Asphalt Base
	424A	424	Fine Graded Polymer Type A
	424B	424	Fine Graded Polymer Type B
	443-SMA	443	Stone Matrix Asphalt
	441-SC-T1	441	Type 1
	441-IC-T2	441	Type 2
	442-SC-9.5mm	442	9.5mm Surface Course
	442-SC-12.5mm	442	12.5mm Surface Course
	442-IC-9.5mm	442	9.5mm Intermediate Course
	442-IC-12.5mm	442	12.5mm Intermediate Course
	442-IC-19.0mm	442	19.0mm Intermediate Course
L#	LIFT NUMBER. The lift number is designated by the following acronym or short form and are numbered based on order of placement. Only use when there are multiple lifts of the same course.		
	Acronym or Short Form	Full Name or Meaning	
	L1	Lift 1	
	L2	Lift 2	
	L3	Lift 3	
	Ln	Lift n	

XXX-XXX	CENTERLINE OFFSET. 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 solid yellow line is treated as the Center Line. Each character of the abbreviation is defined as the following: XX X – XX X (a) (b) (c) (d) (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). CL reflects the Center Line. (b) R or L, to reflect Right (R) or Left (L) of Centerline, in the direction of increasing station numbering. (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). CL reflects the Center Line. (d) R or L, to reflect Right (R) or Left (L) of Centerline, in the direction of increasing station numbering.														
DT	DIRECTION OF TRAVEL. The direction of travel is designated by the following acronyms or short form: <table border="1" data-bbox="407 1003 883 1314"> <thead> <tr> <th>Acronym or Short Form</th><th>Full Name or Meaning</th></tr> </thead> <tbody> <tr> <td>NB</td><td>North Bound</td></tr> <tr> <td>SB</td><td>South Bound</td></tr> <tr> <td>EB</td><td>East Bound</td></tr> <tr> <td>WB</td><td>West Bound</td></tr> <tr> <td>CW</td><td>Clockwise</td></tr> <tr> <td>CCW</td><td>Counterclockwise</td></tr> </tbody> </table>	Acronym or Short Form	Full Name or Meaning	NB	North Bound	SB	South Bound	EB	East Bound	WB	West Bound	CW	Clockwise	CCW	Counterclockwise
Acronym or Short Form	Full Name or Meaning														
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SB	South Bound														
EB	East Bound														
WB	West Bound														
CW	Clockwise														
CCW	Counterclockwise														

400.04 Submittals. 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 Coverage. The Department will calculate thermal coverage for each lift as follows.

1. Thermal Profile Lot Length. Calculate the thermal profile lot length using the following formula:

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

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 sublot *i*, ft (reported to the nearest whole number).

- 2. Thermal Profile Lift Length.** Calculate the thermal profile lift length using the following formula:

$$\text{Thermal Profile Lift Length} = \sum_{i=1}^n (\text{Thermal Profile Lot Length})_i$$

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

(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).

- 3. Thermal Coverage.** Calculate thermal coverage using the following formula:

$$\text{Thermal Coverage} = \frac{\text{Thermal Lift Length}}{\text{LM} \times 5280 \text{ ft}} \times 100$$

Where:

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

Lane Miles (LM) = Total number of lane miles for the given lift requiring thermal profiling, miles (reported to the hundredth).

B. Thermal Segregation

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

- a. Surface temperature readings less than 180 °F (80 °C);
- b. Surface temperature readings under overhead structures; and
- c. Surface temperature readings within 50 ft (15 m) on either side of mainline structures.

2. Differential Range Statistic (DRS). The Department will calculate the DRS, reported to the nearest tenth degree Fahrenheit, for each subplot using the following formula:

$$DRS = T_{\max} - T_{\min}$$

Where:

$T_{\max}$ = surface temperature reading at the 98.5 percentile (°F) and

$T_{\min}$ = surface temperature reading at the 1 percentile (°F).

3. Thermal Segregation Category. The Department will categorize the temperature readings for each subplot with respect to the ranges specified in Table 400.05-1. Surface readings that do not have associated GNSS coordinates are not used in calculations to determine thermal segregation categories.

TABLE 400.05-1 DATA SUBLOT DIFFERENTIAL RANGE STATISTIC

DRS Values	Thermal Segregation Category
$DRS \leq 25.0^{\circ}\text{F}$ (13.8 °C)	Low
25.0°F (13.8 °C) < $DRS \leq 50.0^{\circ}\text{F}$ (27.7 °C)	Moderate
$DRS > 50.0^{\circ}\text{F}$ (27.7 °C)	Severe

400.06 Basis of Payment. Interruptions in the availability of Ohio RTN 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.

A. Thermal Coverage (TC). Monetary Deductions for thermal coverage will be assessed per Lift according to Table 400.6-1.

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

Thermal Coverage (Percent)	Total Monetary Deduction Per Lift
70 percent or greater	No Monetary Deduction
less than 70	Total Monetary Deduction = $(20 \times TC - \$1400) \times (LM)$ Where: TC = Thermal Coverage LM = Lane Miles

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

Item	Unit	Description
690E98400	Lump Sum	Paver Mounted Thermal Profiling