

S-1 (2016) QUALITY MANAGEMENT - PAVER MOUNTED THERMAL PROFILE (PMTP) METHOD

NEW WRITE-UP 01/09/17 ◀DO NOT REMOVE THIS. IT NEEDS TO STAY IN FOR THE CONTRACTORS.

SP2016-65

This write-up is to be used for the given specification and tied project when the net lane miles to be paved are greater than or equal to 4; when adequate data cellular coverage is available at least one time per day during paving; and when adequate global navigation satellite system (GNSS) coverage is available throughout the project limits. Note to Designer – The Designer and Construction personnel will decide which specifications (highlighted in the following paragraph) to include to require the PMTP method.

MnDOT 2360 (Plant Mixed Asphalt Pavement) and 2365 (Stone Matrix Asphalt – SMA) are modified with the following:

S-1.1 DESCRIPTION

This work consists of using the Paver Mounted Thermal Profile (PMTP) Method to continually monitor the surface temperature of the mat immediately behind the paver screed during placement operations.

The Advanced Materials and Technology Manual, Veta and forms are available on the MnDOT Advanced Materials and Technology (AMT) Website at: <http://www.dot.state.mn.us/materials/amt/index.html>.

A Definitions

Refer to Sections 210 “Definitions” in the MnDOT Advanced Materials and Technology Manual for definitions related to the paver mounted thermal profile method not included below.

A.1 ADVANCED MATERIALS AND TECHNOLOGY MANUAL. A Department manual that contains requirements, best practices and examples related to the use of technologies such as the paver mounted thermal profile method, intelligent compaction method and 3D production monitoring for excavation. References to the **Advanced Materials and Technology Manual** from the contract are to the edition in effect on the letting date.

A.2 AUXILIARY LANE. See MnDOT 1103 “Definitions”. This provision is required only on continuous left turn lanes and passing lanes. Exclude auxiliary lane tapers, ramps, shoulders, cross-overs, non-continuous turn lanes, loops, bypass lanes, acceleration/deceleration lanes and intersecting streets.

A.3 DAILY THERMAL COVERAGE (DTC). The percent of **thermal coverage** (TC) for the given lot.

A.4 DRIVING LANE. See **traffic lane**.

A.5 PAVER MOUNTED THERMAL PROFILE (PMTP) METHOD. This method uses a system that continually monitors the surface temperature readings of the mat immediately behind the paver screed during placement operations.

A.6 RANGE. The difference between the surface temperature readings at the 98.5 and 1 percentile.

A.7 SURFACE TEMPERATURE READINGS. The temperatures of the mat immediately behind the paver screed during placement operations.

A.8 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.

A.9 THERMAL PROFILES. The surface temperature readings and associated GNSS coordinates and time stamps.

A.10 THRU LANE. See **traffic lane**.

A.11 TRAFFIC LANE. See MnDOT 1103 “Definitions”. This provision is required on all traffic lanes with the exception of traffic lane tapers and roundabouts (including the traffic lane between the roundabout and mainline transition prior to and after the radius point of the roundabout).

A.12 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. **Veta** can be downloaded from the Advanced Materials and Technology Website.

B Acronyms and Abbreviations

Refer to Section 220 “Glossary of Acronyms and Abbreviations” in the MnDOT Advanced Materials and Technology Manual for the full name or meaning of acronyms and/or abbreviations used within this provision.

S-1.2 MATERIALS – (BLANK)

S-1.3 CONSTRUCTION REQUIREMENTS

A Equipment Requirements

A.1 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.

A.2 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 per MnDOT 1516.2.

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 2016-3 [PMTP]).
- (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.

A.3 PMTP System

A.3.a 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 Manufacturers recommendations.

Ensure the PMTP System meets the requirements of Table 2016-1 (PMTP) and is instrumented with the following:

Table 2016-1 (PMTP) 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 / 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 2016-4 (PMTP) and 2016-5 (PMTP).

A.3.b Thermal Profiling Data

Export the thermal profiling data:

- (1) as dbase ASCII or Text Format, or
- (2) directly into Veta if a file format compatible with Veta is available.

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.

Include the information in Table 2016-2 (PMTP) in the header of each data file or section. Include the fields in Table 2016-3 (PMTP) with each data point.

Table 2016-2 (PMTP) Required Information in Data Header		
Item No.	Description	Example Data included in Header
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

Table 2016-2 (PMTP) Required Information in Data Header		
Item No.	Description	Example Data included in Header
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 2016-3 (PMTP) Required Fields for Each Data Block		
Item No.	Date Field Name	Data Format Examples
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.

B Design File

The Engineer will create the background and alignment file(s) containing, at a minimum, the following layers: centerline, station text, station tick marks and labeling for exceptions.

Note – Highly accurate horizontal positioning is not required since the required accuracy for the PMTP system is less than or equal to ± 4 ft (1.2 m) (see Table 2016-1 [PMTP]). See Chapter 7 “Alignment” of the MnDOT Design Scene (<http://www.dot.state.mn.us/pre-letting/scene/index.html>) for further guidance

The Engineer will provide the following within three (3) working days of Contract approval:

- (1) 2D-DGN and 2D-KMZ for both background and alignment file(s);
- (2) County coordinate system used to generate design file(s); and
- (3) Total lane miles per lift (rounded to the nearest hundredth) for lifts on MnDOT 2360 and/or MnDOT 2365 requiring thermal profiling.

It is the Contractor’s responsibility to convert, as needed, the provided Department design files for use with the selected PMPT System and/or Software.

The Engineer is allowed five (5) working days to update files with Engineer approved changes requested by the Contractor.

C Field Stationing

Ensure that field station markers, when used, match the centerline stationing used in the background alignment design file.

D PMTP System Setup on Paver(s)

Refer to section 440 “Paver Mounted Paver Mounted Thermal Profile (PMTP) Method” of the Advanced Materials and Technology Manual for recommended system checks of the PMTP System(s) prior to paving.

Instrument all pavers that are paving the traffic and required auxiliary lanes with the PMTP System (see **S-xx.3.F**). The PMTP system is not required on the secondary paver for instances where echelon paving is used to assist with the paving of auxiliary lanes. Secondary pavers are considered as those pavers that are not used for paving of traffic lanes, but are used for paving of approaches, 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 2016-3 [PMTP]).

Verify that the surface temperature readings and the GNSS are working within the requirements of this Special Provision when requested by the Engineer.

E Definition of Lot and Sublot for Thermal Profiling

E.1 Lot Establishment

The Engineer defines a lot 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 2016-4 (PMTP) and 2016-5 (PMTP). Ensure that the lot designations are digitally stored with the associated thermal profile measurements. See section 420 “Lot Establishments” of the Advanced Materials and Technology Manual for examples of the standardized naming convention for lots.

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

Standardized Format	Definition
ROUTE-MATL-L#-XXX-XXX	Undivided Highways (e.g., TH68-HMA-L1-12L-CL)
ROUTE-MATL-L#-XXX-XXX-DT	Divided Highways (e.g., TH68-HMA-L1-12L-CL-NB)

Table 2016-5 (PMTP)
Standardized Abbreviations for Thermal Profile Lots


Abbreviation	Definition												
ROUTE	<p>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., TH12).</p> <table border="1" data-bbox="402 380 943 611"> <thead> <tr> <th>Acronym or Short Form</th> <th>Full Name or Meaning</th> </tr> </thead> <tbody> <tr> <td>CR</td> <td>County Road</td> </tr> <tr> <td>CSAH</td> <td>County State Aid Highway</td> </tr> <tr> <td>MS</td> <td>Municipal Street</td> </tr> <tr> <td>MSAS</td> <td>Municipal State Aid Street</td> </tr> <tr> <td>TH</td> <td>Trunk Highway</td> </tr> </tbody> </table>	Acronym or Short Form	Full Name or Meaning	CR	County Road	CSAH	County State Aid Highway	MS	Municipal Street	MSAS	Municipal State Aid Street	TH	Trunk Highway
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CR	County Road												
CSAH	County State Aid Highway												
MS	Municipal Street												
MSAS	Municipal State Aid Street												
TH	Trunk Highway												
MATL	<p>MATERIAL/ SURFACE TYPE. The material/surface type is designated by the following acronyms or short form:</p> <table border="1" data-bbox="402 732 1398 894"> <thead> <tr> <th>Acronym or Short Form</th> <th>Specification</th> <th>Full Name or Meaning</th> </tr> </thead> <tbody> <tr> <td>HMA</td> <td rowspan="2">2360</td> <td>Hot Mix Asphalt</td> </tr> <tr> <td>WMA</td> <td>Warm Mix Asphalt</td> </tr> <tr> <td>SMA</td> <td>2365</td> <td>Stone Matrix Asphalt</td> </tr> </tbody> </table>	Acronym or Short Form	Specification	Full Name or Meaning	HMA	2360	Hot Mix Asphalt	WMA	Warm Mix Asphalt	SMA	2365	Stone Matrix Asphalt	
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HMA	2360	Hot Mix Asphalt											
WMA		Warm Mix Asphalt											
SMA	2365	Stone Matrix Asphalt											
L#	<p>LIFT NUMBER. The lift number is designated by the following acronym or short form:</p> <table border="1" data-bbox="402 984 824 1220"> <thead> <tr> <th>Acronym or Short Form</th> <th>Full Name or Meaning</th> </tr> </thead> <tbody> <tr> <td>L1</td> <td>Lift 1</td> </tr> <tr> <td>L2</td> <td>Lift 2</td> </tr> <tr> <td>L3</td> <td>Lift 3</td> </tr> <tr> <td>...</td> <td>...</td> </tr> <tr> <td>Ln</td> <td>Lift n</td> </tr> </tbody> </table>	Acronym or Short Form	Full Name or Meaning	L1	Lift 1	L2	Lift 2	L3	Lift 3	Ln	Lift n
Acronym or Short Form	Full Name or Meaning												
L1	Lift 1												
L2	Lift 2												
L3	Lift 3												
...	...												
Ln	Lift n												
XXX-XXX	<p>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. Each character of the abbreviation is defined as the following:</p> <p 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). CL reflects the Center Line.</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). CL reflects the Center Line.</p> <p>(d) R or L, to reflect Right (R) or Left (L) of Centerline, in the direction of increasing station numbering.</p>												

Table 2016-5 (PMTP) Standardized Abbreviations for Thermal Profile Lots											
Abbreviation	Definition										
DT	<p>DIRECTION OF TRAVEL. The direction of travel is designated by the following acronyms or short form:</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th style="text-align: center;">Acronym or Short Form</th> <th style="text-align: center;">Full Name or Meaning</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">NB</td> <td style="text-align: center;">North Bound</td> </tr> <tr> <td style="text-align: center;">SB</td> <td style="text-align: center;">South Bound</td> </tr> <tr> <td style="text-align: center;">EB</td> <td style="text-align: center;">East Bound</td> </tr> <tr> <td style="text-align: center;">WB</td> <td style="text-align: center;">West Bound</td> </tr> </tbody> </table>	Acronym or Short Form	Full Name or Meaning	NB	North Bound	SB	South Bound	EB	East Bound	WB	West Bound
Acronym or Short Form	Full Name or Meaning										
NB	North Bound										
SB	South Bound										
EB	East Bound										
WB	West Bound										

E.2 Sublot Establishment Using Veta

Once established, the Engineer will divide the lot into 150 linear ft (45 linear m) sublots. Partial sublots will be treated as follows:

- (1) Lot \geq 150 linear ft (45 linear m)
 - (1.1) Sublot $<$ 75 linear ft (23 linear m) is combined with the previous sublot.
 - (1.2) Sublot \geq 75 linear ft (23 linear m) is treated as one sublot.
- (2) Lot $<$ 150 linear ft (45 linear m)
 - (2.1) Surface temperature readings from lot are treated as one sublot.

Set the sublot “start” and “end” location for the given lot in Veta to correspond with the start and end of paving, respectively. Ensure that these locations are immediately adjacent to the beginning and end of the surface temperature readings.

F Thermal Profile Measurements

Collect thermal profiles on **100 percent of each lift** for the following lanes:

- (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
- (2) the following **Auxiliary Lanes** (excluding auxiliary lane tapers):
 - (2.1) **Continuous Left Turn Lanes** and
 - (2.2) **Passing Lanes**

Thermal profiles are not required on auxiliary lane tapers, ramps, shoulders, cross-overs, non-continuous turn lanes, loops, bypass lanes, acceleration/deceleration lanes 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 (see **S-xx.3.J.1**). Turn the data collection and recording off when not collecting thermal profile measurements.

G 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.

Contact the Engineer verbally, or via e-mail, 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.

The day of PMTP system failure notification and the following two (2) working days are accepted as providing a daily thermal coverage of 100 percent, for each day of this grace period. The daily thermal coverage is considered zero during the subsequent days of PMTP system failure.

No monetary price adjustments for thermal segregation, per Table 2016-10 (PMTP), are made during PMTP system failure.

H Thermal Profile Analysis Software

Use the Veta software to plot thermal profile measurements and to determine thermal segregation and coverage. Produce *.VETAPROJ filenames in the **SPXXXX-XXX ROUTE PMTP** standardized format per Table 2016-6 (PMTP).

Table 2016-6 (PMTP) Standardized Naming Convention for *.VETAPROJ Files * 													
Abbreviation	Definition												
SPXXXX-XXX	PROJECT NUMBER. Replace the “X’s” with the project numbers (e.g., SP5509-79). Replace “SP” with “SAP”, “CP”, or other, as needed.												
ROUTE	<p>ROUTE NUMBER. Replace “ROUTE” with the route system, as designated by the following acronyms or short form, immediately followed by the route number(s) mapped in the given Veta project. (e.g., TH12, TH12-34, TH12-34-56)</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th style="text-align: center;">Acronym or Short Form</th> <th style="text-align: center;">Full Name or Meaning</th> </tr> </thead> <tbody> <tr> <td style="text-align: center;">CR</td> <td style="text-align: center;">County Road</td> </tr> <tr> <td style="text-align: center;">CSAH</td> <td style="text-align: center;">County State Aid Highway</td> </tr> <tr> <td style="text-align: center;">MS</td> <td style="text-align: center;">Municipal Street</td> </tr> <tr> <td style="text-align: center;">MSAS</td> <td style="text-align: center;">Municipal State Aid Street</td> </tr> <tr> <td style="text-align: center;">TH</td> <td style="text-align: center;">Trunk Highway</td> </tr> </tbody> </table>	Acronym or Short Form	Full Name or Meaning	CR	County Road	CSAH	County State Aid Highway	MS	Municipal Street	MSAS	Municipal State Aid Street	TH	Trunk Highway
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CR	County Road												
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PMTP	PMTP reflects the paver mounted thermal profile method, the data set contained within the Veta project file.												
*	<p>Example *.VETAPROJ filename: SP1234-56 TH78 PMTP</p> <p>Add the county name at the end of the Veta project file name for instances where projects are calibrated for more than one county (e.g., site calibrations are completed in both Carlton and Pine County – two Veta projects are created [SP1234-56 TH78 PMTP Carlton; SP1234-56 TH78 PMTP Pine]).</p>												

Create filter groups, operation filter and subplot names using the **LOT# MMDDYY LOTNAME** standardized format per Table 2016-7 (PMTP).

Table 2016-7 (PMTP) Standardized Naming convention for Veta Filter Group, Operation Filter and Sublot Names *	
Abbreviation	Definition
LOT#	LOT NUMBER. The lot number is a two-digit number increasing sequentially (01, 02, 03, ..., n). Create filter groups, operation filters and subplot names in sequential order with respect to the lot dates. Lots containing Exceptions and/or Temporary Exceptions: Include a capital letter, in alphabetical order (A, B, ...), immediately after the two-digit lot number to designate the side of the exception, or temporary exception, that the thermal profile data reflects (e.g., 01A, 01B, 02A, 02B, ...).
MM	MONTH (include leading zeros)
DD	DAY OF MONTH (include leading zeros)
YY	TWO-DIGIT YEAR
LOTNAME	STANDARDIZED LOT NAME per Table 2016-4 (PMTP)
	* Example Filter Group/Operation Filter Name (lot contains no exceptions): 01 070915 TH12-HMA-L1-CL-12R, 02 071015 TH12-HMA-L1-CL-12R, ... * Example Filter Group/Operation Filter Name (lot contains an exception): 01A 070915 TH12-HMA-L1-CL-12R, 01B 070915 TH12-HMA-L1-CL-12R, 02A 071015 TH12-HMA-L1-CL-12R, 02B 071015 TH12-HMA-L1-CL-12R, ... Temporary exceptions are areas to be paved at a later date.

I Veta Software Operator Certification

Provide a software operator that is knowledgeable in the use of Veta and has taken the hands-on class and/or an E-Learning class provided by the Engineer. Provide documentation that the software operator has completed the class to the MnDOT Advanced Materials and Technology Unit. Certification expires 3 years from the date of receiving the certification. Certifications will be invalidated (expired) prior to 3 years if significant changes are made to Veta or to the submittal requirements of Veta projects. A list of certified Veta Software Operators, along with expiration dates, is available on the MnDOT Advanced Materials and Technology (AMT) website at: <http://www.dot.state.mn.us/materials/amt/veta.html>.

J Calculations

J.1 Thermal Segregation

J.1.a Surface Temperature Readings

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

Exclude the following surface temperature readings 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.

J.1.b Range

Calculate the Range, reported to the nearest tenth degree Fahrenheit, for each subplot per Equation 2016-1 (PMTP):

$$\text{Equation 2016-1 (PMTP): Range} = T_{\max} - T_{\min}$$

Where: T_{\max} = surface temperature reading at the 98.5 percentile (°F) and
 T_{\min} = surface temperature reading at the 1 percentile (°F).

J.1.c Thermal Segregation Category

Categorize the surface temperature readings for each subplot with respect to the ranges specified in Table 2016-8 (PMTP). Record the total number of low, moderate and severe sublots for the given lot in electronic form PMTP-102.

Table 2016-8 (PMTP) Sublot Temperature Differential	
Range Equation 2016-1 (PMTP)	Thermal Segregation Category
Range $\leq 25.0^{\circ}\text{F}$	Low
$25.1^{\circ}\text{F} < \text{Range} \leq 50.0^{\circ}\text{F}$	Moderate
$50.1^{\circ}\text{F} < \text{Range}$	Severe

J.2 Thermal Coverage

Calculate thermal coverage for each lift per Equation 2016-4 (PMTP) using form PMTP-101.

J.2.a Thermal Profile Lot Length

Equation 2016-2 (PMTP): 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).

J.2.b Thermal Profile Lift Length

Equation 2016-3 (PMTP): 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 2016-2 [PMTP])

J.2.c Thermal Coverage

Equation 2016-4 (PMTP): Thermal Coverage = $\left(\frac{\text{Thermal Profile Lift Length}}{LM \times 5280} \right) \times 100$

Where:

- *Thermal Coverage* = see S-xx.1.A.8, % (reported to the nearest whole number);
- *Thermal Profile Lift Length* = see Equation 2016-3 (PMTP), 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).

J.3 Monetary Price Adjustment

J.3.a Thermal Coverage (TC)

Calculate monetary price adjustments for thermal coverage for the given lift and material type per Table 2016-9 (PMTP). Surface temperature readings that do not have associated GNSS coordinates are not used in the calculations to determine thermal coverage.

Table 2016-9 (PMTP) Monetary Price Adjustment for Thermal Coverage (TC)	
Thermal Coverage (%) (Form PMTP-101)	Total Price Adjustment Per Lift and Material Type
≥ 70	No Price Adjustment
< 70	Total Price Adjustment (Disincentive) = $(20 \times TC - \$1400) \times (LM)$ where: TC = Thermal Coverage, see S-xx.3.J.2.c and LM = Lane Miles, see S-xx.3.J.2.c.

J.3.b Thermal Segregation

Calculate monetary price adjustments for thermal segregation per Table 2016-10 (PMTP). Surface temperature readings that do not have associated GNSS coordinates are not used in the calculations to determine thermal segregation categories of sublots per Table 2016-8 (PMTP). Prorate monetary price adjustments for subplot linear length, as established in S-xx.3.E.2, that are not equal to 150 linear feet.

Record the monetary price adjustment for the given lot in electronic form PMTP-102.

Table 2016-10 (PMTP) Monetary Price Adjustment for Thermal Segregation	
Thermal Segregation Category	Adjustment per 150-ft Sublot
Low	\$20 incentive
Moderate	No pay adjustment
Severe	\$20 disincentive

K Submittals

K.1 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.

K.2 Veta Projects

Submit the first Veta project to the Engineer within three (3) days after the start of production for mixture requiring the PMTP Method. Submit an updated Veta project(s) to the Engineer at least two (2) non-consecutive days per calendar week. Ensure Veta projects include the following:

- (1) **Alignment File**
- (2) **Surface Temperature Readings**
- (3) **Filter Groups** per:
 - (3.1) lot (e.g., 01 090415 TH12-HMA-L1-12L-CL),

- (3.2) lane and per lift (e.g., TH12-HMA-L1-12L-CL) and
- (3.3) lift (e.g., TH12-HMA-L1)
- (4) **Operation Filters** per lot (e.g., 01 090415 TH12-HMA-L1-12L-CL)
- (5) **Data Filter** (Temperature \geq 180°F)
- (6) **Sublot Creation** per lot (e.g., 01 090415 TH12-HMA-L1-12L-CL)
- (7) **Override Filters per Machine ID** per:
 - (7.1) lift (e.g., TH12-HMA-L1 Machine ID) and
 - (7.2) lane and per lift (e.g., TH12-HMA-L1-12L-CL Machine ID)

Note – the override filters are needed for cases where more than one paver (paving in Echelon) is instrumented with the PMTP system.

Submit the final version of the Veta Project(s) within 14-calendar days of completion of paving efforts requiring the PMTP method.

L.4 Forms

Submit updated forms PMTP-101 and PMTP-102 with Veta projects. Submit final version of forms PMTP-101 and PMTP-102 within 14-calendar days of completion of paving efforts requiring the PMTP method.

S-1.4 METHOD OF MEASUREMENT – (BLANK)

S-1.5 BASIS OF PAYMENT

The Contract lump sum prices for the thermal profiling include all costs related to this Special Provision.

Interruptions in the availability of MnCORS 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.

The Department will pay for the thermal profiling on the basis of the following schedule:

<u>Item No.</u>	<u>Item</u>	<u>Unit</u>
2016.601	Quality Management	Lump Sum