S-1   (2399) PAVEMENT SURFACE SMOOTHNESS

(2013 version) ◄DO NOT REMOVE THIS. IT NEEDS TO STAY IN FOR THE CONTRACTORS.
Always use with SP2005-111 (CONCRETE PAVING MIX SPECIFICATIONS PAVEMENT) and SP2005-140 (PLANT MIXED ASPHALT PAVEMENT).
REVISED 12/28/12
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SP2005-142.2

The following is hereby added to the MnDOT Standard Specifications:

2399.1   DESCRIPTION

This work consists of measuring the smoothness of the final concrete or bituminous surface.

A   Definitions

The Department defines "Smoothness" as the Mean Roughness Index (MRI) value per 0.1 mi [0.16 km] segment. The Department defines "Areas of Localized Roughness" (ALR) as areas greater than or equal to the limiting criteria for a continuous MRI calculation with a 25 ft [7.62 m] interval, as calculated using the FHWA's Profile Viewing and Analysis (ProVAL) software.

2399.2   MATERIAL REQUIREMENTS

A   Inertial Profiler (IP)

Provide a Department certified, calibrated, and documented IP meeting the requirements of ASTM E 950, Class 1 and procedures maintained by the MnDOT Pavement Engineering Section. Refer to the procedures maintained by the MnDOT Pavement Engineering Section or to the MnDOT Smoothness website for the required settings for individual certified profilers.

Provide an IP capable of producing a profilogram and exporting raw profile data in an unfiltered electronic Engineering Research Division (ERD) file format. Produce ERD filenames in the YYMMDD-T-N-D-L-B-E.ERD standardized format in accordance with Table 2399-1:

Table 2399-1 Standardized Naming Convention for ERD Files	
Abbreviation	**Definition**
YY	Two-digit year
MM	Month (include leading zeros)
DD	Day of month (include leading zeros)
T	Route type (I, MN, US, CSAH, etc.)
N	Route number (no leading zeros) and auxiliary ID (if applicable, for example E, W, etc.)
D	Primary route direction (I or D)
L	Lane number (1 for driving lane, increasing by one for each lane to the left)
B	Beginning station
E	End station

B   Profile Analysis Software

Use ProVAL software to conduct a profile analysis to determine Smoothness and ALR. Report IRI values in units of in per mi to one digit right of the decimal [m per km to two digits right of the decimal] in accordance with conventional rounding procedures.

C   Operator Certification

Provide an operator, trained in the operation of the particular IP in accordance with 2399.2.A, "Inertial Profiler," and knowledgeable in the use of the required profile analysis software in accordance with 2399.2.B, "Profile Analysis Software." Ensure profiler operators pass a proficiency test and possess a current certification issued by the Department. The Contractor may access a list of certified operators on the MnDOT Smoothness website. Provide documentation of operator certification to the Engineer.

D   Submittals

D.1   Before Profiling

Provide the Engineer with current, valid documentation, issued by the Department, indicating both IP and the operator certification.

D.2   Day of Profiling

Submit a printout containing the IP's settings, each segment's left and right International Roughness Index (IRI) values, and the signature of the operator to the Engineer on the same day of the profiling.

Submit electronic files in ERD format representing the raw data from each pass on the same day of the profiling.

If the Contractor fails to submit actual data to the Engineer on the day of profiling, the Department will require the Contractor to reprofile the measured segments.

D.3   Upon Completion of Pavement Placement

Within 5 calendar days after all pavement placement and before beginning corrective work, submit a paper ProVAL summary report for each lane, indicating the results of the "Smoothness Assurance" analyses. Use the ERD filenames in accordance with 2399.2.A, "Inertial Profiler" to create ProVAL summary reports.

If the summary reports indicate no ALR, submit a final spreadsheet summary in accordance with 2399.2.D.5, "After Corrective Work."

D.4   Before Corrective Work

If the summary reports indicate any ALR, submit a written corrective work plan to the Engineer in accordance with 2399.3.E, "Corrective Work." Include the beginning and ending points of locations planned for correction in the corrective work plan. Do not begin corrective work before the Engineer approves the plan.

If the Engineer elects to assess a monetary deduction for ALR in accordance with Table 2399-7 instead of requiring corrective work, submit a final spreadsheet summary in accordance with 2399.2.D.5, "After Corrective Work."

D.5   After Corrective Work

After reprofiling, submit a paper summary ProVAL report for each lane, indicating the results of updated "Smoothness Assurance" analyses to the Engineer. Submit a spreadsheet summary in tabular form, with each 0.1 mi [0.16 km] segment occupying a row to the Engineer. The Contractor may access an acceptable spreadsheet summary template in electronic form on the MnDOT Smoothness website.

2399.3   CONSTRUCTION REQUIREMENTS

Using an IP, measure the final pavement surface for MRI unless otherwise excluded in Table 2399-3.

Unless otherwise approved by the Engineer, perform all profiling in the presence of the Engineer. Schedule profiling with the Engineer. Reprofile any pavement profiled in the absence of the Engineer as directed by the Engineer at no additional cost to the Department.

The Engineer will use a 10 ft [3.05 m] straightedge to evaluate areas excluded from surface testing with the IP in accordance with Table 2399-3.

A   Pavement Surface Testing

Remove objects and foreign material from the pavement surface before performing the pavement surface evaluation. Provide traffic control required for testing and performing corrective work on the final pavement surface.

Run the IP in the direction of traffic. Measure profiles in the left and right wheel paths of each lane.

Test and evaluate each lane separately. The Engineer will determine the length in miles [kilometers] of each mainline traffic lane. Operate the IP at the optimum speed as recommended by the manufacturer.

Separate each lane into segments 0.1 mi [0.16 km] in length. Evaluate the remainder segment less than 0.1 mi [0.16 km] in each lane as an independent segment. The Engineer will prorate pay adjustments for length.

Make each pass continuously, regardless of length, and end passes before exclusions in accordance with Table 2399-3, "Areas Excluded from Smoothness and ALR Evaluation." Begin each subsequent pass 50 ft [15.24 m] before, and including, construction headers and end-of-day work joints. In concrete pavements, evaluate terminal headers tying into existing portland cement concrete pavement.

For percent improvement projects, measure Smoothness before the beginning of construction and after the completion of construction. Use the same stationing for the final profiling as the stationing used for the initial profiling to allow for a direct comparison of Smoothness when calculating the percent improvement. Measure the Smoothness Before Paving and the Smoothness After Paving values with the same IP.

The Engineer will use a 10 ft [3.05 m] straightedge to measure for surface deviations greater than ¼ in [6.35 mm] in 10 ft [3.05 m]. The Engineer will evaluate transverse joints by centering the straightedge longitudinally across the transverse joint.

B   Exclusions

Table 2399-2 indicates areas that are excluded from Smoothness evaluation, but still require measurement with an IP, and are subject to evaluation for ALR and the 10 ft [3.05 m] straightedge. Table 2399-3 indicates areas that are excluded from surface testing with the IP, but are subject to evaluation with the 10 ft [3.05 m] straightedge

Table 2399-2
Areas Excluded from Smoothness Evaluation
For All Pavements
Paving in areas with a posted vehicle speed less than or equal to 45 mph [73 km/hr]
Ramps and loops
Acceleration and deceleration lanes less than or equal to 1,000 ft [304.80 m] in length
Projects less than 1,000 ft [304.80 m] in length
Bridge decks and approach – the occurrence of bridges shall not interrupt the continuity determination
For Bituminous Pavements
Single lift overlays over concrete
For Concrete Pavements
Intersections constructed under traffic – begin and end exclusion 100 ft [30.48 m] from the intersection radius

Table 2399-3
Areas Excluded from Smoothness and ALR Evaluation
For All Pavements
Paving in areas with a posted vehicle speed less than 30 mph [48 km/hr]
Turn lanes, crossovers
10 ft [3.05 m] on either side of obstructions in lane that obstruction is located
Side streets, side connections
150 ft [45.72 m] before intersections that end at a stop sign or yield signs at a roundabout
For Bituminous Pavements
Paved shoulders
Intersections where mainline profiles are merged or blended into the cross street profile – begin and end exclusion 100 ft [30.48 m] from the intersection radius
For Concrete Pavements
Undoweled shoulders less than or equal to 10 ft [3.05 m] in width
Headers adjacent to colored concrete

C   Calculations

C.1   Smoothness

Obtain the Smoothness values in an individual lane using the ProVAL "Smoothness Assurance" analysis with the 250 mm filter.

For percent improvement projects, use the Smoothness Before Paving and Smoothness After Paving values to calculate the percent ride improvement.

C.2   Areas of Localized Roughness

Identify ALR using the ProVAL "Smoothness Assurance" analysis, calculating MRI with a continuous short interval of 25 ft [7.62 m] with the 250 mm filter.

D   Pay Adjustments

D.1   Smoothness

Evaluate Smoothness requirements using the equations and criteria in accordance with the following tables:

(1)   Table 2399-4 for bituminous pavements,
(2)   Table 2399-5 for concrete pavements, and
(3)   Table 2399-6 for percent improvement projects.

The Engineer will base pay adjustments on the segment Smoothness value (or percent improvement value, for percent improvement projects) measured at the completion of surface pavement, unless corrective work is required by the summary report results. If a segment is less than 100 ft [30.48 m] in length and Table 2399-4, Table 2399-5, or Table 2399-6 requires corrective work, the Engineer will waive the corrective work requirement for the segment and instead assess a prorated disincentive. The Department will still subject the segment to ALR analysis in accordance with Table 2399-7

For segments requiring corrective work, reprofile the entire 0.1 mi [0.16 km] segment after performing corrective work as directed by the Engineer and enter the reprofiled Smoothness values into the final spreadsheet summary.

D.1.a   Bituminous Pavements

Table 2399-4 contains pay adjustments for bituminous pavements. See Section 2360, "Plant Mixed Asphalt Pavement" of the Special Provisions for the ride equation requirement.

Table 2399-4 Smoothness Pay Adjustments and Corrective Work for Bituminous Pavements		
Equation	Smoothness in/mi [m/km]	Pay Adjustment $/0.1 mi [0.16 km]
HMA-A	< 30.0 [0.47]	400.00
	30.0 – 75.0 [0.47 – 1.18]	850.00 − 15.000 × Smoothness [850.00 − 957.450 × Smoothness]
	> 75.0 [1.18]	Corrective Work to ≤ 56.7 in/mi [0.89 m/km]
HMA-B	< 33.0 [0.52]	270.00
	33.0 – 85.0 [0.52 – 1.34]	600.00 − 10.000 × Smoothness [600.00 − 638.950 × Smoothness]
	> 85.0 [1.34]	Corrective Work to ≤ 60.0 in/mi [0.94 m/km]
HMA-C	< 36.0 [0.57]	180.00
	36.0 – 95.0 [0.57 – 1.50]	414.00 − 6.500 x Smoothness [414.00 − 410.500 x Smoothness]
	> 95.0 [1.50]	Corrective Work to ≤ 63.7 in/mi [1.01 m/km]

For bituminous projects, the Engineer will not pay any positive Total Pay Adjustments if greater than 25 percent of all mainline density lots for the project fail to meet the minimum density requirements in accordance with 2360, "Plant Mixed Asphalt Pavement."

D.1.b   Concrete Pavements

For concrete pavements, the Engineer will use equation PCC-A. For concrete pavement rehabilitation projects or concrete grinding, the Engineer will use equation PCC-B if the Contract requires pay adjustments for concrete grinding.

Equation	Smoothness in/mi [m/km]	Pay Adjustment $/0.1 mi [0.16 km]
Table 2399-5 **Smoothness Pay Adjustments and Corrective Work for Concrete Pavements**		
PCC-A	< 50.0 [0.79]	890.00
	50.0 – 90.0 [0.79 – 1.42]	2940.00 − 41.000 × Smoothness [2940.00 − 2597.800 × Smoothness]
	> 90.0 [1.42]	Corrective Work to ≤ 71.7 in/mi [1.13 m/km]
PCC-B	< 50.0 [0.79]	450.00
	50.0 – 71.2 [0.79 – 1.12]	1511.30 − 21.226 × Smoothness [1511.30 − 1344.900 × Smoothness]
	71.3 – 90.0 [1.13 – 1.42]	0.00
	> 90.0 [1.42]	Corrective Work to ≤ 71.3 in/mi [1.13 m/km]

D.1.c   Percent Improvement Projects

The Engineer will base pay adjustments on the segment percent improvement values. The Engineer will not require corrective work and will not assess a negative pay adjustment if the Smoothness Before Paving value is less than 60.0 in per mi [0.95 m per km] and the percent improvement is greater than zero. The Engineer will calculate the percent improvement in accordance with the following equation:

$$\%I = \frac{SmoothnessBeforePaving - SmoothnessAfterPaving}{SmoothnessBeforePaving} \times 100$$

Determine the Smoothness Before Paving value before patching or other repair. Determine the Smoothness After Paving value after the completion of paving and any corrective work.

Table 2399-6 Smoothness Pay Adjustments and Corrective Work for Percent Improvement Projects		
Equation	Percent Improvement (%I)	Pay Adjustment, per $/0.1 mi [$/0.1609 km] segment
PI	> 64.0	180.00
	33.0 to 64.0	$-295.00 + 7.420 \times (\%I)$
	< 33.0	Corrective work to %I of at least 39.8

For bituminous percent improvement projects, the Engineer will not pay any positive Total Pay Adjustments if greater than 25.0 percent of all mainline density lots for the project fail to meet minimum density requirements in accordance with 2360, "Plant Mixed Asphalt Pavement."

Correct segments with a percentage improvement of less than 33.0 percent at no additional cost to the Department as required by the Engineer.

D.2 **Areas of Localized Roughness**

The Engineer will evaluate ALR in accordance with Table 2399-7, "ALR Monetary Deductions and Corrective Work Requirements."

Table 2399-7 ALR Monetary Deductions and Corrective Work Requirements		
Equation	**25 ft [7.62 m] Continuous MRI, in/mi [m/km]**	**Corrective Work or Monetary Deduction, per linear 1.0 ft [0.30 m]**
HMA-A or HMA-B, and a posted vehicle speed > 45 mph [73 km/hr]	< 125.0 [1.97]	Acceptable
	≥ 125.0 [1.97] to < 175.0 [2.76]	Corrective Work or $10.00, as directed by the Engineer
	≥ 175.0 [2.76] to < 250.0 [3.94]	Corrective Work or $25.00, as directed by the Engineer
	≥ 250.0 [3.94]	Corrective Work or $100.00, as directed by the Engineer
PCC-A or PCC-B, and a posted vehicle speed > 45 mph [73 km/hr]	< 125.0 [1.97]	Acceptable
	≥ 125.0 [1.97] to < 175.0 [2.76]	Corrective Work or $10.00, as directed by the Engineer
	≥ 175.0 [2.76] to < 250.0 [3.94]	Corrective Work or $25.00, as directed by the Engineer
	≥ 250.0 [3.94]	Corrective Work as directed by Engineer
HMA-C, PI, ramps. loops, concrete intersections constructed under traffic, or any paving with a posted vehicle speed ≤ 45 mph [73 km/hr]	< 175.0 [2.76]	Acceptable
	≥ 175.0 [2.76] to < 250.0 [3.94]	$10.00
	≥ 250.0 [3.94]	$25.00

The Engineer will consider ALR acceptable if the retested segment contains no ALR. The Department will reduce payment for ALR remaining after retesting as determined by the Engineer and in accordance with Table 2399-7, "ALR Monetary Deductions and Corrective Work Requirements."

D.3   Straightedge Evaluation

The Engineer will allow variations less than or equal to ¼ in [6.35 mm] within the span of the straightedge in the longitudinal or transverse direction to remain in place without correction or penalty.

The Engineer will require corrective work on surface deviations greater than ¼ in [6.35 mm] within the span of the straightedge in any direction. For corrected variations, the Engineer will accept deviations less than or equal to ¼ in [6.35 mm] within the span of a 10 ft [3.05 m] straightedge in any direction.

E   Corrective Work

Notify the Engineer at least 24 hr before beginning corrective work. Do not begin corrective work before the Engineer approves the methods and procedures in writing.

Perform corrective work using a surface diamond grinding device consisting of multiple diamond blades, unless otherwise approved by the Engineer. Fog-seal diamond ground bituminous surfaces as required by the Engineer and at no additional cost to the Department. Repair and replace joint sealant damaged by diamond grinding on concrete pavement as directed by the Engineer and at no additional cost to the Department.

The Contractor may correct bituminous pavements by overlaying the area or replacing the area by milling and inlaying as approved by the Engineer. If milling and inlaying or overlaying, perform work in accordance with 2399, "Pavement Surface Smoothness," over the entire length of the correction. If milling and inlaying or overlaying, use a transverse saw cut to begin and end the surface correction.

Perform corrective work across the entire lane width. Maintain the pavement cross slope through corrective areas.

Perform coring to determine if diamond grinding corrective work results in thin pavements, as directed by the Engineer. Provide additional coring for thickness verification at no additional cost to the Department. The Department may reduce the payment for thin pavement sections after diamond grinding. Handle residue and excess water resulting from diamond grinding in accordance with 1717, "Air, Land, and Water Pollution."

Perform surface corrections before placing permanent pavement markings. Replace permanent pavement marking damaged or destroyed by corrective work at no additional cost to the Department.

Reprofile segments containing corrected areas with the same certified IP in accordance with 2399.2.A, "Inertial Profiler" within 5 calendar days after the completion of corrective work required by the Engineer.

F   Retesting

Perform retesting as directed by the Engineer and within 30 days of the original profiling.

If the retested Smoothness values differ from the original Smoothness values by greater than 10 percent, the Engineer will use the retested values as the basis for acceptance and pay adjustments. If the retested values differ from the original values by greater than 10 percent, the Department will not pay for the cost of retesting.

If the retested Smoothness values differ by less than or equal to 10 percent of the original Smoothness values, the Engineer will use the original values. If the Engineer verifies the accuracy of the original results, the Department will pay for retesting as directed by the Engineer, except for retesting required after corrective work, at $100.00 per lane mi [$62.14 per lane km] retested or $500.00, whichever provides the greater amount.

2399.4   METHOD OF MEASUREMENT — (BLANK)

2399.5   BASIS OF PAYMENT

The Department will include the cost of the IP, testing, and traffic control in the relevant Contract unit price for wearing course mixture for bituminous pavements, concrete pavement for concrete pavements, or for concrete grinding.