MICHIGAN
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
PAVEMENT RIDE QUALITY (MEAN ROUGHNESS INDEX ACCEPTANCE CRITERIA)

CFS:PDS 1 of 11 APPR:KPK:CRB:04-08-25
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a. Description. This work consists of furnishing a pavement surface with acceptable ride quality for all pavements covered by this special provision. Furnish, operate, and maintain a profiler, in proper calibration, to measure ride quality for QC purposes. Prepare and submit a Ride Quality Plan and, if required, a corrective action plan, to the Engineer for approval. Complete all corrective action as required by this special provision.

Ensure that the pavement on which ride quality measurements are taken, including acceptance runs conducted by the Engineer, is clean prior to ride quality measurements.

The following subsections of the Standard Specifications for Construction apply only to areas excluded from pavement ride quality in Class II, III and IV sections:

Subsection 501.03.H (10-foot straightedge on HMA pavements)

Subsection 602.03.I (10-foot straightedge on concrete pavements)

b. Terminology.

Bridge Ride Quality Limits. That area between the two end reference lines or between the outermost limits of any structure expansion joint devices, whichever is longer. Within Class I sections ride quality requirements will apply unless specifically noted otherwise. Within Class II, Class III and Class IV sections, bridge ride quality limits will be considered predetermined excluded areas.

Certified Operator. Operators of profilers used for acceptance testing who pass a proficiency test and are certified by the Department.

Class I Ride Quality. Sections where no project specific excluded areas are allowed, a threshold MRI criteria must be met, and incentives will apply.

Class II Ride Quality with Incentive. Sections having a design speed of 50 mph or greater where a threshold Mean Roughness Index (MRI) criteria must be met and incentives will apply.

Class II Ride Quality. Sections where threshold MRI criteria must be met, but incentives do not apply.

Class III Ride Quality. Sections where the preconstruction MRI must be maintained or improved by a specified percentage. Penalties may apply in lieu of corrective action.

Class IV Ride Quality. Sections where acceptance is based on a 10-foot straightedge criteria. Incentives and penalties do not apply.

Contractor Quality Control Run. Informational run(s) made by the Contractor to determine ride quality acceptability, need for corrective action, or need for a process change. Also includes runs made after corrective action to determine if corrective action has been sufficient.

Correction Areas. Areas of the pavement that exceed any of the correction limits for ride quality as defined in Table 1 or Table 2 as applicable.

Course. A layer of a particular bituminous mixture, paved in one or more lifts.

Equipment Validation Section. Equipment Validation Sections are established throughout the state with a minimum of one in each MDOT Region. The Engineer determines a reference MRI value for each validation site based on the mean of 10 runs taken with Department owned or provided equipment. The standard deviation of the 10 runs is also calculated.

International Roughness Index (IRI). A statistic used to determine the amount of roughness in a measured longitudinal profile. The IRI is computed from a single longitudinal profile using a quarter-car simulation as described in the paper "On the Calculation of International Roughness Index from Longitudinal Road Profile" (Sayers 1995). The IRI is reported as described in *ASTM E1926*.

Mean Roughness Index (MRI). A number calculated by averaging the IRI values from the left and right wheel path profiles.

Predetermined Excluded Areas. Areas of pavement within the project where this Pavement Ride Quality special provision does not apply. Straightedge requirements of subsection 501.03.H or 602.03.I of the Standard Specifications for Construction will apply. Predetermined excluded areas include:

- Ramps other than freeway-to-freeway ramps
- All ramp tapers
- Shoulders
- Railroad crossings
- Designated QC/QA loose material sampling areas on the wearing course of HMA pavement projects within Class II, Class III and Class IV sections only collected per MTM 324. This will not include areas where informational samples are taken by the Contractor for other purposes.

Profile. The elevation of a pavement along a line parallel to the centerline of the pavement. Also defined as a two-dimensional plot of the elevation of a pavement, taken in a longitudinal direction, and drawn to scale. Profiles are measured separately along each wheel path of a lane.

Profiler. In general, a device that measures the relative elevation of a pavement surface at discrete intervals and creates a profile. In particular, a device that meets the requirements for a General Motors type rapid travel profiler, as stated in *MTM 726 - Michigan Test Method for Determining Ride Quality Using an Inertial Profiling System*

Project Specific Excluded Areas. Pavement areas identified in the approved ride quality plan where this Special Provision for Pavement Ride Quality does not apply. Straightedge requirements will apply. No project specific excluded areas will be considered within Class I Ride Quality sections of the project.

Ride Point of Beginning. Ride Point of Beginning will be 20 feet after the start of the new pavement surface.

Ride Point of Ending. Ride Point of Ending will be 20 feet before the end of the new pavement surface.

Ride Quality Equipment Certification. A process managed by the Department to assure that ride quality measuring equipment are capable of measuring ride quality to the standards established in *MTM 730 - Michigan Test Method for Certification of Profilometers.*

Ride Quality Measurement Area. The traveled way, collector distributor roadways, freeway to freeway ramps, and other areas as shown on the plans.

Section. A portion of a project which has a single class of ride quality assigned to it. Section beginning and section ending points will be defined in the Special Provision for Ride Quality Limits contained in the contract.

Segment. For ride quality reporting purposes, each lane of each section will be subdivided into segments. A full segment is 0.1 miles long while a partial segment is less than 0.1 miles long.

Wheel Path. Longitudinal locations 3 feet from each edge of a lane.

c. Ride Quality Plan. Submit a written Ride Quality Plan to the Engineer for approval a minimum of 14 calendar days prior to the start of paving operations. The Engineer will submit the Plan to the Pavement Evaluation Group at Construction Field Services for concurrent review and to coordinate ride quality acceptance testing. Do not begin paving operations before approval of the Ride Quality Plan by the Engineer. The Engineer will notify the Contractor in writing of approval, or any objections to the Plan, within 14 calendar days of receipt of the Plan.

Include the following minimum details in the Ride Quality Plan:

1. Equipment used to measure ride quality on the project for quality control.

2. Proposed project specific excluded areas (see Section d of this special provision). Use the form “Proposed Ride Quality Excluded Areas” (MDOT Form 1978).

3. Method(s) to correct surface irregularities.

4. Correction layout method.

5. Anticipated ride quality measurement schedule for acceptance testing, including how project staging will affect Department access to the completed pavement.

6. Predetermined excluded areas that apply to this project.

d. Project Specific Excluded Areas. Propose for exclusion, from Class II, III and IV ride

quality sections, circumstances or physical features that will substantially hinder the ability to achieve ride quality. Identify these proposed areas in the Ride Quality Plan. The Engineer has the right to accept or reject each proposed project specific excluded area. Project Specific Excluded Areas may include, but are not limited to, the following for freeway and non-freeway projects:

1. Freeway Pavements. Areas where the constructed pavement must match grades of an existing feature (e.g. curb and gutter or an existing lane that will not be overlaid).

2. Non-Freeway Pavements.

A. Areas where the constructed pavement must match grades of an existing feature (e.g. curb and gutter, or an existing lane that will not be overlaid).

B. Major at-grade intersections with part width or staged construction (where traffic flow is maintained during construction) may be considered for exclusion if listed as such in the ride quality plan. The excluded area will extend between the approach and departure spring points of the intersection.

C. In general, areas surrounding existing utility and drainage structures may be designated as excluded areas.

D. In general, pavement gapped areas may be designated as excluded areas.

E. Roundabouts.

3. Bridge Decks (as defined by the Bridge Ride Quality Limits). For bridge decks included in Class I sections, no exclusions will be considered.

Project specific excluded areas will not be considered for Class I Ride Quality sections.

e. Contractor Quality Control Runs. Test in accordance with *MTM 726*. If the equipment used to measure ride quality excludes a given distance at the beginning and end of each run, account for this when marking the actual starting and stopping locations.

For any HMA project with 2 or more lifts, take QC runs on both the leveling and top courses. Furnish results of the QC runs to the Engineer as requested.

f. Corrective Action Requirements. Take initial corrective action to address all surface irregularities (bumps or dips) on any leveling course that exceed 0.5 inches in 25 feet.

Take corrective action to address all surface irregularities (bumps or dips) as defined in Table 1 or Table 2 prior to the ride quality acceptance runs on the final riding surface.

Use QC measurements to locate surface irregularities. Examine the profilograph measurements to identify surface irregularities and field check the locations to verify that correction is justified. Alternate bump finding methods which utilize software may be considered. All QC measurements are at Contractor's expense.

Submit a corrective action plan to the Engineer for approval. The Engineer must approve of the Contractor's corrective method prior to the Contractor starting corrective work. Any corrective

action must meet the specifications for ride quality over the entire length of the segment. Replace, at no cost to the Department, any permanent pavement markings that are damaged or destroyed during surface correction activities. All proposed corrective action is at the Contractor's expense.

Use a profiler or an Engineer approved method to locate and mark all surface irregularities requiring correction. Correct all segments containing areas exceeding the corrective limits shown in Table 1 or Table 2.

Corrective action for Class I, II, III and IV sections must consist of the following methods:

1. For Concrete Pavement and Diamond Grinding Work Types. Diamond grind in accordance with subsections 603.03.A.4 and 603.03.C of the Standard Specifications for Construction. Do not impair surface drainage or create any areas that allow water to pond.

2. For All Other Work Types. Use one or a combination of the following methods:

A. Diamond grind the HMA surface in accordance with the requirements as stated in subsections 603.03.A.4 and 603.03.C of the Standard Specifications for Construction. Do not impair surface drainage or create any areas that allow water to pond.

B. Fine Tooth Milling. Furnish equipment that consistently mills the HMA surface in one or more passes to the required grade or cross section with the required uniform textured surface. Do not impair surface drainage or create any areas that allow water to pond. Use equipment that will not cause damage to the underlying surface of the pavement. To remove residue and excess water, furnish vacuum equipment that extracts the milled material and excess water from the pavement and prevents dust from escaping into the air.

Furnish machines equipped with the following:

(1) Automatically controlled and activated cutting drums,

(2) Grade reference and transverse slope control capabilities,

(3) Cutting drums with teeth spacing at a maximum 5/16 inch, and

(4) Built-in automatic grade averaging control.

Mill HMA pavement in the longitudinal direction beginning and ending at lines perpendicular to the pavement centerline. Ensure the milled surface has a mean texture depth of at least 0.03 inches and a maximum 0.06 inches, in accordance with *ASTM E965*.

Construct a uniform transverse slope with no depressions or misalignment greater than 1/8 inch when checked with a 10-foot straightedge. Provide for cross slope drainage.

C. Remove and replace a minimum of 1.5 inches of HMA pavement surface one full lane width wide by the length required (a minimum of 100 feet).

D. Profile milling can be used for corrective action on leveling and base courses only.

For Class III pavements (all segment speeds) that exceed the correction limits indicated in Table

1 or Table 2, the Engineer may assess penalties in accordance with Table 3 in lieu of corrective action.

Do not, under any circumstance, subject the pavement to an artificial heat source.

g. Documentation of Ride Limits. As part of the corrective action plan, furnish a list of approved excluded areas on the form "Proposed Ride Quality Excluded Areas" (MDOT form 1978) for each lane. Include the locations of any noted surface irregularities on new surfaces that the Engineer evaluated and agreed did not require correction.

h. Ride Quality Acceptance. The Engineer will take measurements for ride quality acceptance. Ride quality acceptance testing will be completed within 7 days of notification provided the following conditions are met: the entire length of the pavement (or an entire phase of a phased project) can be accessed and measured, the pavement is clean and clear of all obstructions for the entire length of a proposed run, and the Contractor has kept the Engineer informed of changes to the anticipated ride quality measurement schedule. It is the Engineer's responsibility to coordinate ride quality measurement with the appropriate MDOT personnel. The Engineer will determine pavement acceptance based on the selected method of measurement for the final MRI for each lane for the entire project length minus excluded areas. Each tenth-mile segment of pavement falling outside the acceptable range for ride quality will be removed and replaced or corrected at the Contractor's expense.

1. Unit of Measurement. Ride quality measurements will be calculated and reported by the Engineer as MRI. Calculations will be in accordance with *MTM 726*.

2. Project Layout. Acceptance runs will be laid out in one tenth-mile segments in the direction of travel starting at the section beginning point and ending at the section ending point. Distance measurement will be continuous through excluded areas. Segments that include an excluded area will be reported as partial segments. Project phasing will not affect project layout.

3. Measurement Means. One of the following methods will be selected by the Engineer at the time of approval of the Ride QC Plan. Method B can only apply if agreed to by the Contractor:

A. The Engineer will furnish and operate a certified profiler. Should discrepancies exist between the Department's acceptance measurement and the Contractor's QC measurements, the Contractor may request that the segments of the project with discrepancies be tested for acceptance using method B.

B. The Engineer will furnish a Certified Operator to operate the Contractor's certified profiler. The Contractor may require that their employee drive the vehicle the profiler is mounted on, but the Engineer must be in total control of the profile measurement and analysis.

4. Equipment Validation. For each day that acceptance measurements are taken, the Engineer will verify that the profiler passes all daily checks as outlined in *MTM 726*. In addition, for each day that acceptance measurements are taken using Contractor furnished equipment, the Engineer will use one of the following three methods to validate the profiler operation:

A. Measure a nearby Equipment Validation Section. One run will be made with the Contractor's profiler and the data of profilograph plot must visually match valid plots previously obtained by Department owned or furnished equipment. In addition, the MRI value obtained by the Contractor's profiler must be within two standard deviations of the Department's previously determined reference value, using the Department's previously determined standard deviation.

B. When acceptance measurements are taken on consecutive days, re-measure a one tenth-mile long portion of the previous day's acceptance runs. Method A or C must have been used to validate equipment operation on the first day of acceptance testing. One run will be made and the graphical representation of the profile (for example, a profilograph plot) must visually match the valid plot previously obtained. In addition, the MRI value obtained must be within 5.7 percent of the previous day's value.

C. Measure a one tenth-mile long portion of the project with both Contractor- and Engineer-furnished equipment. One run will be made with each piece of equipment and the graphical representation of the profile (for example, a profilograph plot) must visually match. In addition, the MRI value obtained by the Contractor's equipment must be within 10 percent of the value obtained by the Engineer's equipment.

The Engineer may require equipment re-certification if measurements cannot be validated or the equipment repeatedly fails daily checks.

5. Calculation Method. The Engineer will calculate and report an MRI value for each tenth-mile segment and for the entire length of each lane in each section. Reported values will be rounded to the nearest whole number following the rounding method of *ASTM E29*.

Segments less than a tenth of a mile in length will be reported as partial segments and the MRI calculation will account for the shorter length by using weighted averaging.

Ride quality on Class III sections will be measured by the Engineer before and after construction. The "before" measurement will be completed in the same construction season as the paving. The "after" measurement will be completed within 10 days after completion of each stage of paving. Before and after MRI values (for the entire lane length and for each tenth-mile segment) will be compared to calculate the percentage improvement in ride quality. Percent improvement values will be rounded to the nearest whole percent following the rounding method of *ASTM E29*.

Acceptance test results will be made available to the Contractor within 7 calendar days of the run.

6. Ride Quality Requirements. Required ride quality values are given in the attached tables for each Class of Ride Quality. Each lane of each section must meet the criteria listed for both the entire length of the lane, and for each tenth-mile segment.

i. Measurement Appeal Process. Appeal only applies if the method in subsection h.3.A is used for acceptance measurement. If the Engineer's acceptance measurements indicate corrective action is required and the Contractor's QC measurements show no corrective action is required, the Contractor may request that the disputed segments be rerun. The Engineer and the Contractor will recertify the profilers and rerun the disputed segments.

j. Measurement and Payment. All costs associated with QC ride quality measurements are included in other items of work and will not be paid for separately.

All corrections within the limits of ride quality will be done at the Contractor's expense. In addition, all corrections required to bring excluded areas into compliance with the straightedge requirements of subsections 501.03.H or 602.03.I of the Standard Specifications for Construction, will be done at the Contractors expense.

Table 1: Ride Quality Requirements (MRI) for Design Speeds Greater than 50 mph

Class	Work Type	For Total Length of Lane		For Each Tenth-Mile Segment	Surface Irregularities Subject to Correction (a)
		Acceptable Range (MRI)	Correction Limit (MRI)	Correction Limit (MRI)	
I	HMA Pavement (Excluding Bridge Decks)	0-70	> 70	> 75	> 0.3 inch in 25 feet
I	Concrete Pavement (Excluding Bridge Decks)	0-70	> 70	> 75	> 0.3 inch in 25 feet
I	Bridge Decks (b)	0-130	> 130	N/A	> 1/8 inch in 10 feet
II	HMA or Composite Pavement (2 or more lifts)	0-75	> 75	> 85	> 0.3 inch in 25 feet
II	Concrete Pavement	0-75	> 75	> 85	> 0.3 inch in 25 feet
III	Single Course HMA Overlay (with milling)	≥ 25% Improvement (c)	< 25% Improvement (c)	>Initial MRI (c)	N/A
III	Single Course HMA Overlay (without milling)	≥ 20% Improvement if initial MRI is > 165	< 20% Improvement if initial MRI is > 165	> Initial MRI (c)	N/A
		< 105 if the initial MRI is ≤ 165.	> 105 if the initial MRI is ≤ 165.	> Initial MRI (c)	N/A
III	Diamond Grinding	≥ 40% Improvement (d)	< 40% Improvement (d)	< 30% Improvement (d)	> 0.3 inch in 25 feet
IV	HMA Pavement	N/A	N/A	N/A	(e)
IV	Concrete Pavement	N/A	N/A	N/A	(f)

a. See Section f of this special provision.
b. Includes all new bridge decks, and all shallow and deep concrete overlays within Class I sections.
c. Requirement waived if final MRI ≤ 85.
d. Requirement waived if final MRI ≤ 75.
e. See subsection 501.03.H of the Standard Specifications for Construction.
f. See subsection 602.03.I of the Standard Specifications for Construction.

Table 2: Ride Quality Requirements (MRI) for Design Speeds 30 to 50 mph

Class	Work Type	For Total Length of Lane		For Each Tenth-Mile Segment	Surface Irregularities Subject to Correction (a)
		Acceptable Range (MRI)	Correction Limit (MRI)	Correction Limit (MRI)	
II	HMA or Composite Pavement (2 or more lifts)	0-100	> 100	> 125	> 0.5 inch in 25 feet
II	Concrete Pavement	0-100	> 100	> 125	> 0.5 inch in 25 feet
III	Single Course HMA Overlay (with milling)	≥ 25% Improvement (b)	< 25% Improvement (b)	> Initial MRI (b)	N/A
III	Single Course HMA Overlay (without milling)	≥ 20% Improvement if initial MRI is > 165	< 20% Improvement if initial MRI is > 165	> Initial MRI (b)	N/A
		< 105 if the initial MRI is ≤ 165	> 105 if the initial MRI is ≤ 165	> Initial MRI (b)	N/A
III	Diamond Grinding	≥ 40% Improvement (b)	< 40% Improvement (b)	< 30% Improvement (b)	> 0.3 inch in 25 feet
IV	HMA Pavement	N/A	N/A	N/A	(c)
IV	Concrete Pavement	N/A	N/A	N/A	(d)

a. See section f of this special provision.
b. Requirement waived if final MRI ≤ 100.
c. See subsection 501.03.H of the Standard Specifications for Construction.
d. See subsection 602.03.I of the Standard Specifications for Construction.

Table 3: Optional Penalties for Class III Pavements in Lieu of Corrective Action Based on Final MRI

Class	Work Type	Acceptable Range (MRI) from Table 1 or Table 2, as applicable	Actual Range of Improvement in MRI for total length of lane		
III	Single Course HMA Overlay (with milling)	≥ 25% Improvement (a)	20-24% Improvement	15-19% Improvement	< 15% Improvement
III	Single Course HMA Overlay (without milling)	≥ 20% Improvement if initial MRI is > 165	15-19% Improvement	10-14% Improvement	< 10% Improvement
III	Single Course HMA Overlay (without milling)	< 105 if initial MRI is ≤ 165	≥ 105 and < 115	≥ 115 and < 135	≥ 135
III	Diamond Grinding (b)	≥ 40% Improvement	35-39% Improvement	25-34% Improvement	< 25% Improvement
		Penalty Amount (c)	**$200.00/segment of traffic lane**	**$400.00/segment of traffic lane**	**$600.00/segment of traffic lane**

a. Requirement waived if final MRI ≤ 85 for design speeds above 50 mph or if final MRI ≤ 100 for design speeds 30 to 50 mph.
b. For diamond grinding all surface irregularities per Table 1 or 2 must be addressed in each segment.
c. Penalties will be determined based on the average MRI value for each segment of each lane. The penalties will be assessed for segment of the lane. Calculate lane lengths to the nearest tenth of a mile.