

MICHIGAN
DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION
FOR
PAVEMENT RIDE QUALITY

C&T:TEH

1 of 9

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FHWA:APPR:09-19-06

a. Description. Provide a pavement that meets specified requirements for ride quality. Furnish and operate a profiler or profilograph to measure ride quality for quality control purposes. Maintain the profiler or profilograph in calibration and good working order. Prepare and submit a Ride Quality Plan and, if required, a corrective action plan to the Engineer for acceptance. Complete all corrective action as required by this special provision.

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

This special provision deletes the following subsection of the Standard Specifications for Construction:

Subsection 502.03.A.4, paragraph 4 (grade and slope control on HMA pavers)

The following subsections of the Standard Specifications for Construction will apply only to areas excluded from pavement ride quality:

Subsection 502.03.H (10 foot straightedge on HMA pavements)

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

b. Terminology.

Certified Operator - Operators of profilers or profilographs used for acceptance testing will pass a proficiency test and be certified by the Department.

Coefficient of Variation - The standard deviation of a series of measurements divided by the mean of those measurements multiplied by 100. Expressed as a percentage.

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

Correction Area - An area of the pavement which exceeds any of the correction limits for ride quality as defined in Table 1.

Predetermined Excluded Areas - Pavement within the project where this Pavement Ride Quality special provision does not apply. Straightedge requirements of subsection 502.03.H or 602.03.I of the Standard Specifications for Construction will apply as applicable. Predetermined excluded areas include:

- Ramps other than freeway-to-freeway ramps,
- All ramp tapers
- Shoulders
- Railroad crossings
- Bridges - The predetermined excluded area is that area between the two end reference lines or between the outermost limits of any structure expansion joint devices.
- Designated loose material sampling areas on the wearing course of HMA projects.

Project Specific Excluded Areas - Pavement areas identified in the accepted ride quality plan where this Pavement Ride Quality special provision does not apply. Straightedge requirements will apply.

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.

Profile Index (PI) - An index used to quantify the ride quality of a pavement. PI is based on the mechanical response of a California type profilograph to a pavement profile. PI is manually or mathematically determined in accordance with MTM 727 - *Michigan Test Method for Manual Analysis of California Type Profilograms*.

Profiler - In general, it is a device that measures the elevation of a pavement 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 a GM Type Rapid Travel Profilometer*.

Profilograph - In general, a device that mechanically measures the elevation of a pavement using a contact sensor and creates a profile. In particular, a device that meets the requirements for a California type profilograph, as stated in MTM 725 - *Michigan Test Method for Determining Ride Quality Using a California Type Profilograph*.

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.

Equipment Validation Section - A 0.1 mile-long section of dense-graded HMA roadway with a RQI of less than 65. Equipment Validation Sections will be established throughout the state with a minimum of one in each MDOT Region. The Engineer will determine a

reference RQI and/or PI value for a Contractor's recently certified profiler or profilograph based on the mean of 10 runs. The standard deviation of the 10 runs will also be calculated. To be acceptable for further use, the coefficient of variation for the reference index value must be 2.5% or less.

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 729 - *Michigan Test Method for Certification of California Type Profilographs* or, MTM 730 - *Michigan Test Method for Certification of Profilometers*.

Ride Quality Index (RQI) - An index used to quantify the ride quality of a pavement. RQI is derived from a correlation between the user's perception of the ride of a pavement and the physical characteristics of its profile. A perfectly smooth road has an RQI of zero while an extremely rough road has an RQI approaching 100. RQI is mathematically determined in accordance with MTM 726 - *Michigan Test Method for Determining Ride Quality Using a GM Type Rapid Travel Profilometer*.

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

Wheel Path - The longitudinal locations three 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 and Technology for concurrent review and to coordinate ride quality acceptance testing. Do not begin paving operations before acceptance 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 7 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. Selected method of measurement (RQI or PI) for acceptance
3. Proposed project specific excluded areas (see section (d) of this special provision)
4. Method(s) to correct surface irregularities
5. Correction layout method
6. Anticipated ride quality measurement schedule for acceptance testing, including how project staging will affect Department access to the completed pavement
7. Predetermined excluded areas that apply to this project

d. Project Specific Excluded Areas. Propose for exclusion from ride quality areas, circumstances or physical features that will substantially hinder the ability to achieve ride quality.

Identify these proposed areas in the Ride Quality Plan submitted to the Engineer for approval prior to paving. 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

- 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)

2. Non-Freeway

- 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 utility and drainage structures may be designated as excluded areas.
- D. In general, pavement gapped areas may be designated as excluded areas.

e. Contractor Quality Control Runs. Test in accordance with MTM 725 (for profilographs) or MTM 726 (for profilers). 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.

f. Corrective Action Requirements. Take corrective action to address all surface irregularities (bumps or dips) prior to the ride quality acceptance runs. If corrective action is required after ride quality acceptance measurements have been completed, corrected segments shall be measured at the Contractor's expense. Use quality control measurements to locate surface irregularities. Examine the California profilograph type plot with the Engineer to identify surface irregularities following the guidance in MTM 727 and field check the locations to verify that correction is justified. Submit a corrective action plan to the Engineer for approval.

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

Corrective action must consist of the following methods, in any combination depending on the irregularities to be corrected.

1. Concrete or HMA pavement - 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. HMA Pavement - Remove and replace a minimum of 1.5 inches of HMA one full lane width wide by the length required (a minimum of 100 feet). If necessary, diamond grind the surface after replacement.

g. Documentation of Ride Limits. Provide a list of approved excluded areas on the attached format for each lane. Include the locations of noted surface irregularities that the Engineer 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 seven 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 weighted average for both wheel path values within 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 Ride Quality Index (RQI) or a zero vertical height blanking band Profile Index (PI_0). Calculations will be in accordance with MTM 726 (RQI) and MTM 727 (PI_0). The method of measurement used will be the one selected by the Contractor in the approved Ride Quality Plan.
2. **Project Layout** - Acceptance runs will be laid out in one tenth-mile segments in the direction of travel starting at the ride point of beginning and ending at the ride point of ending. 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. **Method of Measurement** - One of the following methods will be selected by the Engineer at the time of approval of the Ride Quality Control Plan. Method B can only apply if agreed to by the Contractor:
 - A. The Engineer will provide and operate a certified profiler. Should discrepancies exist between the Department's acceptance measurement and the Contractor's quality control measurements, the Contractor may request that the segments of the project with discrepancies be tested for acceptance using method B.
 - B. The Engineer will provide a Certified Operator to operate the Contractor's certified profiler or profilograph. 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 or profilograph passes all daily checks as outlined in MTM 726 or MTM 727. In addition, for each day that acceptance measurements are taken using Contractor provided equipment, the Engineer will use one of the following three methods to validate the profiler or profilograph operation:
 - A. Measure a nearby Equipment Validation Section. One run will be made and the shape of California-type profilograph plot must visually match valid plots previously obtained. In addition, the index value obtained (RQI or PI) must be within two standard deviations of the previously determined reference value, using the previously determined standard deviation.
 - B. When acceptance measurements are taken on consecutive days, re-measure a 0.1 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 shape of California-type profilograph plot must visually match the valid plot previously obtained. In addition, the index value obtained (RQI or PI) must be within 5.7 percent of the previous day's value.
 - C. Measure a 0.1 mile long portion of the project with both Contractor and Engineer-supplied equipment. One run will be made with each piece of equipment and the shape of California-type profilograph plots must visually match. In addition, the index value obtained (RQI or PI) by the Contractor's equipment must be within 10 percent of the value obtained by the Engineers equipment.

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

5. **Calculation Method** - The Engineer will calculate and report an RQI or PI_0 value for each tenth-mile segment and for the entire length of each lane. Reported values will be the average of the left and right wheel path values. Reported values will be rounded to the nearest whole number following ASTM E 29.

Segments less than a tenth of a mile in length will be reported as partial segments and the RQI or PI_0 calculation will account for the shorter length by using weighted averaging.

Ride quality on two-course HMA overlay projects and diamond grinding projects will be measured by the Engineer, in RQI only, before and after construction. Before and after 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 E 29.

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 Table 1. Each project 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 method h.3.A is used for acceptance measurement. If the Engineer’s acceptance measurements indicate corrective action is required and the Contractor’s quality control measurements show no corrective action is required, the Contractor may request that the disputed segments be rerun and accepted based on method h.3.B. Any costs for maintaining traffic for appeal reruns will be borne by the party whose ride data is shown to be incorrect.

j. Measurement and Payment. All costs associated with quality control 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. Corrections to areas outside the limits of ride quality or within excluded areas will be done under the direction of the Engineer and paid for at the contract unit price for the following contract item (pay item):

Contract Item (Pay Item)	Pay Unit
Bump Grinding	Square Yard

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

	For Total Length of Lane				For Each Tenth-Mile Segment		Surface Irregularities Subject to Correction (c)
	Acceptable Range (RQI)	Correction Limit (RQI)	Acceptable Range (PI ₀)	Correction Limit (PI ₀)	Correction Limit (RQI)	Correction Limit (PI ₀)	
HMA - Surface (3 or more total lifts) (a)	0-40	>40	0-30 inch/mile	>30 inch/mile	>40	> 3 inch	>0.3 inch in 25 feet
HMA-Surface (2 lifts total) (a)	≥40% Improvement (b)	<40% Improvement (b)	N/A	N/A	<30% Improvement (b)	N/A	>0.3 inch in 25 feet
New Concrete Pavement	0-40	>40	0-30 inch/mile	>30 inch/mile	>40	>3 inch	>0.3 inch in 25 feet
Diamond Grinding	≥40% Improvement (b)	<40% Improvement (b)	N/A	N/A	<30% Improvement (b)	N/A	>0.3 inch in 25 feet
a. Any layer of new HMA material placed; any crush and shape operation; or any in-place recycling operation is considered a lift. Milling operations or wedging is not considered a lift. b. Requirement waived if final RQI<40. c. Based on California Type Profilograph Plot. N/A = Not applicable							

Table 2: Ride Quality Requirements for Design Speeds 30 - 50 mph

	For Total Length of Lane				For Each Tenth-Mile Segment		Surface Irregularities Subject to Correction (c)
	Acceptable Range (RQI)	Correction Limit (RQI)	Acceptable Range (PI ₀)	Correction Limit (PI ₀)	Correction Limit (RQI)	Correction Limit (PI ₀)	
HMA - Surface (3 or more total lifts) (a)	0-60	>60	0-55 inch/mile	>55 inch/mile	>60	> 5.5 inch	>0.5 inch in 25 feet
New Concrete Pavement	0-60	>60	0-55 inch/mile	>55 inch/mile	>60	>5.5 inch	>0.5 inch in 25 feet
a. Any layer of new HMA material placed; any crush and shape operation; or any in-place recycling operation is considered a lift. Milling operations or wedging is not considered a lift. c. Based on California Type Profilograph Plot.							

Control Section: _____ Job Number: _____ Route: _____ Lane: _____

Submit one form for each lane with ride quality.

Proposed Excluded Feature (eg intersection, bridge)	Location Description (eg 0.3 miles south of River Road)	Station		Distance from Ride P.O.B. (feet)	Mileage from Ride P.O.B. (miles)	Exclusion Approved by MDOT?		Distance Correction for Station Equations
		start	end			yes	no	
Ride POB (1)		start		0	0.00			
		start				yes	no	
		end						
		start				yes	no	
		end						
		start				yes	no	
		end						
		start				yes	no	
		end						
		start				yes	no	
		end						
		start				yes	no	
		end						
		start				yes	no	
		end						
Ride POE (2)		end						

Notes:

- (1) Ride Point of Beginning (POB) will be 20 feet after the start of new pavement surface, unless otherwise agreed upon.
- (2) Ride Point of Ending (POE) will be 20 feet before the end of the new pavement surface, unless otherwise agreed upon.
- (3) Distance and Mileage from Ride POB must be adjusted for any station equations within the job.

Contractor Signature and Date: _____

MDOT Approval and Date: _____