CATEGORY 500
PAVING

SECTION 535 — PAVEMENT SURFACE PROFILE

535.01 DESCRIPTION. This work shall consist of measuring the roughness of the final surface of hot mix asphalt (HMA) or portland cement concrete (PCC) pavements. The Contractor shall use an International Roughness Index (IRI) Inertial Profiler to collect Quality Control (QC) data. The IRI Inertial Profiler shall conform to E 950 and MSMT 563. The Administration will use an IRI Inertial Profiler to perform all Quality Assurance (QA) testing and acceptance. All traveled way surfaces shall be measured unless otherwise indicated in this Specification.

535.01.01 Existing Conditions. The following are the IRI values measured for this project in 2003:

IRI INDICATOR	REPORTED VALUES FOR BOTH WHEEL PATHS (in./mile)	REPORTED STATEWIDE ------------------ VALUES (20--) (in./mile)
Average	N/A	N/A
Maximum	N/A	N/A
Minimum	N/A	N/A
Standard Deviation	N/A	N/A

NOTE 1: IRI is an abbreviation for the International Roughness Index developed under World Bank Technical Report No. 46.
NOTE 2: IRI values were generated from pavement longitudinal profile measured in the outside travel lane in both directions of traffic.
NOTE 3: The average, maximum, minimum, and standard deviation IRI values are based on intervals of 1/10 of a mile in length.
NOTE 4: A definition of ride quality based on IRI, as defined by The Federal Highway Administration, for interstate and other principal arterial roadways is given below:

ROADWAY TYPE	IRI RANGE (in./mile)	RIDE QUALITY
Interstates	< 60	Very Good
	60 – 94	Good
	95 – 119	Fair
	120 – 170	Mediocre
	> 170	Poor
Principal Arterials and Other Routes	< 60	Very Good
	60 – 94	Good
	95 – 170	Fair
	171 – 220	Mediocre
	> 220	Poor

535.02 MATERIALS. Not applicable.

535.03 CONSTRUCTION.

535.03.01 Equipment Standardization Testing. Standardization testing shall be completed on Administration specified sites at regular intervals in conformance with MSMT 563. Additional standardization testing may be required for a device that is potentially out of conformance between regular standardization tests. Standardization shall be completed and a copy of the results shall accompany the profile report for the project. QC test data obtained with a profiler that has not completed standardization testing in conformance with MSMT 563 will not be accepted.

535.03.02 Quality Control Testing for Pavement Profile. The finished surface of all pavements shall be measured with a profiler by the Contractor in conformance with MSMT 563 and E 950. Pavement profiles shall be measured in both wheel paths simultaneously, parallel to the right edge of the lane, and in the direction of travel for each lane. The Contractor shall establish and document in the HMA field Quality Control Plan (504.03) or the PCC proposed paving plan (520.03) a regular schedule of pavement profiling to verify conformance with these Specifications. The Contractor shall notify the Engineer at least 24 hours prior to performing any QC testing. The Contractor's QC data shall be submitted to the Engineer and the Administration's Office of Materials and Technology in conformance with the following schedule:

Submittal	Percentage of Paving Completed*	Testing Time Limit*
First	10 %	Within 72 hr of completion
Interim	50 %	Within 72 hr of completion
Final	100 %	Within 72 hr of completion

* The percentage of paving completed refers to the percentage of all pavement requiring profiling that has been paved. Areas not profiled [535.03.02(a)] are not considered in the percentage computation. Completion is defined as opening to traffic for HMA pavement and curing sufficiently to support traffic for PCC pavement.

When any profile testing and data submission has not been completed within the specified times and in conformance with MSMT 563 for all sections on the project, the tested pavement will not be eligible for incentive payment as stated in 535.04.03(a).

The QC IRI shall be determined using the Contractor's Inertial Profiler and shall be reported in sections equal to 25 ft in length and one lane in width. Tested sections shorter than 25 ft due to exempt areas or the project end shall be ignored. A full 25 ft section shall be started after each exempt area. Three runs shall be made as described in MSMT 563. The coefficient of variation of the overall average IRIs shall be less than or equal to 4 percent for three runs for the data to be accepted. When the first three runs do not meet the above criteria, additional runs shall be performed until three measured runs meet the criteria. All three runs shall be submitted to the Administration; however, only the median run (based on average IRI) will be considered the Contractor's QC data and will be used for acceptance and any pay adjustments.

   (a) **Areas Not Profiled.** The following pavement areas shall not be profiled:

   (1) Shoulder areas.

   (2) Parking areas of ride sharing facilities or park and ride lots.

   (3) Pavements of ramps, side street tie-ins, acceleration lanes, or deceleration lanes less than 0.1 mile in length.

   (4) Pavements on projects with less than 0.5 lane-miles of measured roadway (after elimination of areas not to be profiled under items 1, 2, and 3 above.)

   (b) **Exempt Areas.** The following areas shall be profiled, but not reported on for pay adjustment:

   (1) Bridge decks or railroad crossings and pavement within 50 ft thereof.

(2) Pavement within 50 ft of transverse joints that separate it from existing pavement. This does not apply when a transverse joint is paved on both sides as part of one contract.

Any areas exempted by 1 or 2 above or by the Engineer shall be documented as to the location and reason for exemption in all data reports submitted to the Administration.

(c) Defects. When any section IRI is greater than IRI_e (table in 535.04), the Contractor shall suspend all paving operations until one of the following corrective actions are taken as directed and approved by the Engineer. The corrective actions shall be taken by the Contractor at no additional cost to the Administration:

(1) Remove and replace the pavement that exceeds IRI_e, or

(2) Grind the section to bring the section IRI into conformance with these Specifications, or

(3) Accept the Defect Cost (P_{defect}, in 535.04) for any defect section where corrective action is not performed.

Items 1, 2, or 3 above shall be applied to each defect section as directed by the Engineer. Any approval from the Engineer to waive items 1 or 2 shall not constitute a waiver of item 3 unless explicitly stated by the Engineer. The Contractor shall reprofile all affected pavement sections, including any additional transverse paving joints created, after any corrective work to determine if the sections are within Specification. The reprofiled data shall include the section prior to the corrected sections and the four sections after the corrected sections. The reprofiled data shall be used for final pay calculations; however, the minimum IRI value for any corrected section shall be limited to IRI_c (table in 535.04).

Data Submittal. All data shall be submitted to the Engineer and in electronic format to the Administration's Office of Materials and Technology via one of the following:

(a) E-mail: ridespec@sha.state.md.us

(b) Delivered: Office of Materials and Technology
                         2323 West Joppa Road
                         Lutherville, MD 21093
                         Attention: Independent Assurance Auditing Team Leader

535.03.03 Quality Assurance Testing for Pavement Profile (IRI). The Administration will test sections of the pavement to verify the Contractor's QC data. When the QA testing has not been performed within 14 calendar days from the date that the final, 100 percent QC data submittal is received by the Administration's Office of Materials and Technology, the QC data only will be used for any pay adjustments on the project. The QA testing will follow the same

procedures required in 535.03.02(a),(b), and (c). The initial QA test will consist of one run on all 25 ft sections. The initial QA run and the median QC run will be compared to determine acceptance of QC data. The average IRI, the number of defects, and the number of tested sections will be compared as follows:

STATISTIC	UNIT	QC DATA TOLERANCE WITH RESPECT TO QA DATA
Average IRI	in./mile	± (2 % + 2)
Number of Defects	Sections	± (10 % + 2)
Number of Tested Sections	Sections	± (1 % + 1)

When the Contractor's QC data falls within the above tolerances, the Contractor's QC data will be used for all pay adjustments. When the Contractor's QC data does not agree with the initial QA data as described above, the Administration will profile a minimum of two additional QA runs. The three QA runs (one initial and two retests) will then be evaluated to determine if the coefficient of variation of the overall average IRIs is less than or equal to 4 percent for all three runs. When the three QA runs do not meet the above criteria, additional runs will be performed until three measured QA runs meet the criteria. The median run (based on average IRI) of the three QA runs will then be recompared with the Contractor's QC data in conformance with the above table.

When the QC and QA data still do not concur for Average IRI or Number of Defects after three QA runs, both profilers shall be retested on a standardization test site to determine if either profiler no longer conforms to MSMT 563. When either profiler is out of standardization, the equipment shall be recalibrated or repaired as necessary to bring the device back into compliance with MSMT 563.   When the Contractor's profiler is not restandardized and brought into compliance with MSMT 563 within three paving days, the Contractor shall cease the paving operation or use another standardized profiler for QC data collection. Once the Contractor's profiler complies with MSMT 563, the Contractor may: retest sections for comparison with the Administration's data or accept the Administration's QA data as the basis for any pay adjustment on all sections. When the Administration's profiler is out of standardization, the Contractor's QC data for all sections will be accepted. When both profilers are found to be in noncompliance with MSMT 563, the profilers shall be repaired or recalibrated as necessary and all QC and QA testing since the previous QC/QA comparison shall be repeated.

When the QC and QA data do not concur for Number of Tested Sections, the Contractor shall evaluate the QC data and perform additional QC testing until the QC data meets the acceptance criteria for Number of Tested Sections.

535.04 MEASUREMENT AND PAYMENT. Pavement surface profile testing costs will be incidental to the HMA surface material or PCC material as specified in the Contract Documents. Payment will be full compensation for all set up, technicians, traffic control, any type of

corrective work to bring the pavement into conformance with this Specification, and for all material, labor, equipment, tools, and incidentals necessary to complete the work. The Overall IRI (535.04.01) and Defects (535.04.02) pay adjustment numbers shall be calculated first. The pay adjustment for pavement surface profile applied on the Contract shall be the Total Pay Adjustment in conformance with 535.04.03.

535.04.01 Overall IRI. The overall average IRI for the project (IRI_{AVG}) will be calculated as the average IRI value of all tested 25 ft sections on the project. The pay adjustment for Overall IRI will then be calculated based on the factors shown below. This pay adjustment applies only to the pavement within the tested sections.

Incentive. $PF = P_{max}$, when IRI_{AVG} is less then or equal to IRI_a
$PF = P_{max}$ x $(IRI_b - IRI_{AVG}) / (IRI_b - IRI_a)$, when IRI_{AVG} is greater than IRI_a
    and less than IRI_b

INCENTIVE = PF x NS x (25/5280 lane miles per section)
DISINCENTIVE = 0

Full Pay.   When IRI_{AVG} is greater than or equal to IRI_b and less than or equal to IRI_c

INCENTIVE = 0
DISINCENTIVE = 0

Disincentive. $PF = P_{min}$ x $(IRI_{AVG} - IRI_c) / (IRI_d - IRI_c)$, when IRI_{AVG} is greater than IRI_c
    and less than $IRI_{d,}$
$PF = P_{min}$, when IRI_{AVG} is greater than or equal to IRI_d

INCENTIVE = 0
DISINCENTIVE = PF x NS x (25/5280 lane miles per section)

535.04.02 Defects. The IRI for each individual section on the project will be used to calculate any cost to be applied for defects on the project. The pay adjustment for defects will be calculated based on the factors shown below. This pay adjustment applies only to the pavement within the tested sections.

NS_{defect} = Number of sections with an IRI greater than or equal to IRI_e
DEFECT COST = P_{defect} x NS_{defect}

Where:

	DESCRIPTION	VALUE	UNITS
P_{max}	Maximum Incentive for Overall IRI	+	Dollars per lane-mile
P_{min}	Maximum Disincentive for Overall IRI	+	Dollars per lane-mile
P_{defect}	Defect Cost	+	Dollars per section
PF	Pay Factor for Overall IRI	*	Dollars per lane-mile
INCENTIVE	Incentive for Overall IRI	*	Dollars
DISINCENTIVE	Disincentive for Overall IRI	*	Dollars
DEFECT COST	Cost for Defects	*	Dollars
IRI_a	IRI for Maximum Incentive	+	Inches per mile
IRI_b	Minimum IRI for Full Pay	+	Inches per mile
IRI_c	Maximum IRI for Full Pay	+	Inches per mile
IRI_d	IRI for Maximum Disincentive	+	Inches per mile
IRI_e	IRI threshold for Defects	+	Inches per mile
IRI_{AVG}	Overall average IRI for the project	*	Inches per mile
NS	Number of tested 25 foot Sections	*	Sections
NS_{defect}	Number of 25 foot Defect Sections	*	Sections

　* Value to be determined on the project.

　+ The ride specification limits for P_{max}, P_{min}, P_{defect}, IRI_a, IRI_b, IRI_c, IRI_d, and IRI_e for other roadways
　　 will be determined by the Engineer in conformance with 535.04.04.

535.04.03 Total Pay Adjustment. The Total Pay Adjustment for pavement surface profile on the Contract will be the total of any incentive or disincentive for Overall IRI minus any cost for Defects and shall be subject to conditions (a) and (b) below.

Total Pay Adjustment = INCENTIVE - DISINCENTIVE - DEFECT COST

  (a) Regardless of the measured profile of any test section, incentive payment will not be permitted for the project when the Contractor's QC data was not submitted on time in conformance with 535.03.02. All other sections of this Specification shall still apply.

Total Pay Adjustment = 0 - DISINCENTIVE - DEFECT COST

  (b) The total value of Overall IRI disincentive and Defect Cost shall not be more than the Maximum Disincentive pay adjustment for all of the profiled 25 foot sections.

If DISINCENTIVE + DEFECT COST is greater than P_{min} x NS x (25/5280 lane miles per section)
then Total Pay Adjustment = - P_{min} x NS x (25/5280 lane miles per section)

535.04.04 Pay Limit Determination. The pay limits will be determined in conformance with Appendix A.

APPENDIX A

Step 1. Determine Rating 1 Related to Overall Ride (a)   **Rating 1**_____

CONDITION		RATING
Number of HMA Lifts	1	+ 2.5
	2 or more	+ 0.0
Wedge/Level on the project?		- 1.5
Grinding on the project?		- 1.5
Poor Condition (b)?		+ 1.5
Curb/Gutter (c)?		+ 2.0
Tight Radius (d)?		+ 1.0

CONDITION	RATING
Tie-ins (e)?	+ 0.5
Night Paving?	+ 0.5
PG 76-22 in cold weather (f)?	+ 0.5
Confined Work Zone?	+ 0.5
Manholes/Inlets (g)?	+ 0.5
Crack Sealing (h) without grinding?	+ 0.5
Extensive Patching (i)?	+ 0.5

Total the Ratings for all of the Conditions that apply.

(a) Selection shall be made for the conditions when or where the majority of the surface tonnage is placed on the project.
(b) Poor condition is defined as average preconstruction existing IRI greater than 220 in./mile (refer to Office of Materials and Technology for values) or PCI < 40 (if available).
(c) Contractor is required to match preconstruction existing curb and gutter with less than 8 ft of shoulder for more than 40 percent of the center line miles on the project for undivided roadways, or for more than 40 percent of the directional miles on the project for divided roadways.
(d) Roadway horizontal curve has a center line radius less than 2000 ft for more than 30 percent of the center line miles on the project.
(e) An average of more than 10 driveways, entrances, and cross-streets per center line mile on the project for undivided roadways, or per directional mile on the project for divided roadways.
(f) HMA with a PG 76-22 binder being placed when ambient air temperatures are below 50 F.
(g) An average of more than five manholes, utility covers, and inlets per lane mile on the project.
(h) Preconstruction existing crack sealing in any part of the lane width for more than 30 percent of the lane miles on the project.
(i) More than 10 percent main line patching for single lift overlays without grinding or wedge/level.

Step 2. Select Specification Limits for Overall Ride.   **IRI$_c$**_____
                                                                 IRI$_d$_____

RATING 1	IRI$_c$	IRI$_d$
1.0 or less	70	90
1.5 to 2.5	80	100
3.0 to 4.0	90	110
4.5 to 5.5	100	120
6.0 or greater	120	120

IRI values provided in in./mile

Step 3. Compare Overall Ride Specification Limits with Existing IRI.

A. Reconsider IRI_c and IRI_d determined in Step 2, when IRI_c falls outside of the noted percentages of existing IRI. Final selection of IRI_c and IRI_d shall be limited to the five pairs of IRI_c and IRI_d listed in the table in Step 2.

CHANCES TO IMPROVE RIDE (Grinding, Wedge/Level, & No. of HMA lifts)	PERCENT OF EXISTING IRI	
	for minimum IRI_c	for maximum IRI_c
1	70 %	90 %
2	50 %	80 %
3	35 %	70 %
4 or more	25 %	60 %

B. Incentive pay limit values are $IRI_a = 40$ and $IRI_b = 60$. When existing IRI is less than IRI_b, reduce IRI_a and IRI_b in 5 IRI increments until IRI_b is less than existing IRI.

Step 4. Select Defect Threshold (IRI_e). IRI_e _____

Select IRI_e based on the predominant Functional Class of the roadway.

FUNCTIONAL CLASS	IRI_e
Interstates & Freeways/Expressways	120
Rural Other Principal Arterials	140
Urban Other Principal Arterials, Minor Arterials and Collectors	160
Locals	200

Step 5. Select the appropriate pay level.

FUNCTIONAL CLASS	MAXIMUM INCENTIVE FOR OVERALL RIDE (P_{max} in dollars per lane mile)	MAXIMUM DISINCENTIVE FOR OVERALL RIDE (P_{min} in dollars per lane mile)	DEFECT COST (P_{defect} in dollars per section)
Interstates & Freeways/Expressways	5000	5000	250
Other Principal Arterials	4500	4500	225
Minor Arterials and Collectors	4000	4000	200
Locals	3500	3500	175