

ASPHALTIC CONCRETE SURFACE SMOOTHNESS - Asphaltic Concrete Payment Adjustment for Surface Smoothness Based on Quality Assurance Measurements Taken by an Inertial Profiler

Special Provision No. 103F31

June 2017

1.0 SCOPE

This Special Provision covers all surface smoothness requirements for hot mix asphalt construction.

2.0 REFERENCES

Ontario Provincial Standard Specifications, Construction

OPSS 313 Hot Mix Asphalt – End Result

Ontario Ministry of Transportation Publications

LS-100 Rounding-Off of Test Data and Other Numbers

LS-296 Method of Test for Calibrating, Correlating and Conducting Surface Smoothness Measurements Using an Inertial Profiler

American Association of State Highway and Transportation Officials (AASHTO)

M 328 Standard Specification for Inertial Profiler

R 56 Standard Practice for Certification of Inertial Profiling Systems

R 57 Standard Practice for Operating Inertial Profiling Systems

ASTM International

E 950 Standard Test Method for Measuring the Longitudinal Profile of Traveled Surfaces with an Accelerometer Established Inertial Profiling Reference

3.0 DEFINITIONS

For the purpose of this Special Provision, the definitions in OPSS 313 and the following definitions apply:

Category B Pavement Treatment means the application of one lift of HMA after:

- a) Milling; or
- b) Cold in-place recycling; or
- c) Full depth reclamation.

Existing Surface means the original pavement surface prior to construction under the Contract.

Expanded Asphalt Mix (EAM) means “Full Depth Reclamation with Expanded Asphalt Stabilization” which is a mixture of reclaimed existing asphalt pavement, granular base, corrective aggregate if required, and expanded asphalt.

Final Measurements means the set of three measurements used for acceptance purposes.

Inertial Profiler means a device used for surface smoothness measurements conforming to requirements of a Class 1 Profilometer according to ASTM E 950 and meeting the additional requirements stated in LS-296.

Initial Measurements means the first set of three measurements taken by an inertial profiler on a given pavement section.

International Roughness Index (IRI) means a specific mathematical transform of a true profile in which a low pass filter (usually consisting of a moving average with a 250 mm base length) followed by a “Quarter Car Filter” are applied to the true profile then the absolute values of the vertical vibration of the “Quarter Car Filter” are accumulated and divided by the subplot length. It’s expressed in units of m/km.

Localized Roughness is calculated using smoothness assurance module of ProVAL based on MRI Ride Quality Index and Short Continuous Analysis with 7.62 m baselength. Incident of Localized Roughness is a location where localized roughness has been identified at stations that are within ± 2 m of one another in at least two of the three runs that were measured by the applicable inertial profilers. Its station and average MRI shall respectively be considered to be the average station and the average MRI for the individual localized roughness locations that were identified in the 2 or 3 applicable runs.

Mean Roughness Index (MRI) means the number calculated by averaging the IRI values from the two wheel path profiles.

Profiler Operator means any person who has been adequately trained by the manufacturer of an inertial profiler to operate the inertial profiler and to use ProVAL software and has received a certificate of training.

Quarter Car Filter calculates the suspension deflection of a simulated mechanical system with a response similar to one corner (a quarter) of a passenger car travelling at 80 km/hr.

Sublot means a continuous traffic lane of pavement; excluding the shoulder, which has been measured by inertial profiler for purposes of repairs/payment adjustments and normally having a length of 100 m.

Subsequent Measurements means any measurements by an inertial profiler taken after the initial measurements.

Unfiltered Data File means a data file representing the profile of a pavement surface taken by the inertial profiler before any user-controlled filtering is applied.

Wheel path means 0.9 m on each side of the centreline of the actual trafficked lane. The trafficked lane does not include adjacent paved areas such as paved shoulders or tapers.

4.0 DESIGN AND SUBMISSION REQUIREMENTS - Not Used

5.0 MATERIALS - Not Used

6.0 EQUIPMENT

6.01 Inertial Profiler

The Owner shall measure smoothness using an inertial profiler.

7.0 CONSTRUCTION - Not Used

8.0 QUALITY ASSURANCE

8.01 Surface Smoothness

8.01.01 Lot Size

A lot for surface smoothness shall consist of the total pavement quantity in a given surface course Contract item that was measured by the QA inertial profiler. Each lot shall generally be divided into 100 metre single lane sublots. Lot acceptance for surface smoothness shall be based on measurements of IRI and incident(s) of localized roughness.

8.01.02 Surface Smoothness Measurement

The Owner shall measure all through lane pavement surfaces using an approved inertial profiler, with the following exceptions:

- a) Where the posted speed is 60 km/hour or less.
- b) Where a single lift is placed on an existing surface.
- c) Within 10 m of the end of a placement where the paving Contractor is not responsible for the adjoining surface.
- d) Bridge decks and within 10 m of bridge deck expansion joints.
- e) Detours and other temporary pavement that shall be removed or overlaid under this Contract.
- f) The first adjacent lane consisting of one or more lifts of hot mix asphalt where the Contractor must match to an existing surface that is not being resurfaced under this Contract.
- g) Within 10 m of any access holes, water valves, or similar structures which are located within the lane or within 1.5 m of the outside edge of the lane.
- h) Lanes less than 400 m in length.
- i) Curves with a centerline radius of less than 300 m and pavement within the superelevation transition, i.e. slope changes, of such curves.
- j) 100 m either side of a stop bar at signalized intersections.
- k) 100 m either side of a stop bar at stop controlled intersections for the lanes being measured for smoothness.
- l) The following additional stations, roadways, major commercial entrances, and major intersections:

[* Designer Fill-in - See Notes to Designer]

8.01.02.01 Sublots to be Measured

The Contract Administrator shall provide a draft sketch to the Contractor at the pre-paving meeting showing the proposed details for the numbering and stations of each subplot to be measured. During preparation of the

sublot sketch, when the last sublot is less than 50 m in length, it shall be added to the previous sublot in the lane. The sketch shall be finalized by the Contract Administrator before the beginning of surface course paving. Prior to beginning the construction of the surface course, the Contractor may propose changes to the sketch or any areas for consideration by the Contract Administrator.

8.01.02.02 Inertial Profiler Acceptance Testing

The Contractor shall notify the Contract Administrator, in writing, when the surface course is ready for QA inertial profiler acceptance testing. The Owner shall perform QA inertial profiler acceptance testing only when, regardless of the number of surface course tender items involved, the surface course has been completed to one of the following milestones:

- a) 50% completed; or
- b) Once within a given calendar year; or
- c) Surface course completed.

Prior to testing, the sublot number and the station at the beginning of each sublot shall be clearly marked out by the Contractor in a manner that remains visible to the QA profiler operator until the final measurements are completed and accepted.

Within 10 Business Days of receiving the Contractor's written notification that QA testing can begin and, the Contract Administrator is fully satisfied that the locations of the sublots that are to be measured have been properly marked out, surface smoothness acceptance testing with the inertial profiler shall begin. When weather conditions as determined by the manufacturer of the inertial profiler will not provide reliable results, the testing shall be suspended and not resume until reliable results can be obtained.

When reflectors are used for QA or referee measurements, the Contractor shall obtain the reflectors from the profiler operator and place them on the left/right shoulder or the highway median at the beginning and end of each profile run as required by the profiler operator. After smoothness measurements are completed each day, the Contractor shall remove the reflectors and return them to the profiler operator.

When Global Position System-Distance Measuring Instrument (GPS-DMI) technology is used for QA or referee measurements, the profiler operator shall collect static GPS coordinates while stopped on the shoulder. Traffic protection for the collection of static GPS coordinates shall be provided by the Contractor.

An inertial profiler shall be required to do three runs of any particular pavement section. However, when the profiler operator deems that the results for one or more sublots within a particular run are invalid, due to technical difficulties or other reasons, then the profiler operator, after consultation with the Contract Administrator, shall be allowed to repeat that run and the data file for the repeated run shall be used to calculate the IRI for all of the sublots and all of the localized roughness that are identified within that run.

The profiler operator shall run all of the applicable unfiltered data files through the ProVAL Version 3.40 or 3.50, according to the procedures specified in LS-296. After the measurements by the QA inertial profiler are analyzed, all areas to be repaired due to rejectable sublots and/or incidents of localized roughness shall be marked on the pavement surface by the Contractor at the direction of the Contract Administrator and prior to the Contractor doing any corrective work.

The Contract Administrator shall provide the following information to the Contractor within 7 Business Days after the surface smoothness measurements have been completed to any of the milestones listed above:

- a) All of the unfiltered data files from the final measurements that are generated by the inertial profiler in ppf or erd format for each profile run;
- b) A summary of the longitudinal reference lines and offsets that were used for each profile run;
- c) A summary of all “lead-in” distances that the inertial profiler required, prior to the start of the first subplot being measured in every profile run;
- d) Summaries of all IRI measurements and the locations and values of all localized roughness in both wheel paths for each run of each subplot, as determined by the ProVAL software in accordance with LS-296, in Microsoft Excel spreadsheet file(s).

The information shall be provided to the Contractor on CD’s or DVD’s for use by IBM compatible personal computers or by email.

8.01.03 Referee Testing

For each measurement results taken by the QA inertial profiler at any milestone identified in Inertial Profiler Measurements clause , the Contractor may make a single written request for “Referee testing” no more than 5 Business Days after the Contractor has received all of the summary sheets and the QA profiler’s applicable files. Each request shall state the sublots that are to be re-measured. The referee inertial profiler shall be chosen from a list of certified profilers maintained by the Ministry.

All sublots that are requested for referee testing shall be re-measured three times using a “referee inertial profiler”, within 15 Business Days of the Contract Administrator receiving the Contractor’s written request for referee testing.

When weather conditions as determined by the manufacturer of the inertial profiler will not provide reliable results, the testing shall be suspended and not resume until reliable results can be obtained. The disposition of all of the re-measured sublots and all incident(s) of localized roughness that are located within those sublots shall be based on the Referee measurements and the results shall be binding on both the Contractor and the Owner.

8.01.04 Damage to Existing Pavement Surface after Preparation or Damage to Surface Course Prior to Smoothness Measurements

The Contractor shall provide written documentation to the Contract Administrator within 1 Business Day of becoming aware of the damage to areas of:

- a) existing pavement surfaces underlying a subplot, which have been milled and/or padded; or
- b) surface course within a subplot;

when such damage was due to circumstances beyond the Contractor’s control and occurred prior to measurement for surface smoothness.

The Contractor shall not cover the affected area with hot mix asphalt until a decision is made by the Contract Administrator. The Contract Administrator shall evaluate the Contractor’s submission and may exclude all or part of the affected area from the final calculation for the payment factor.

8.01.05 Repairs and Redecisioning

8.01.05.01 General

Smoothness-related or surface tolerance-related repairs are not allowed prior to initial smoothness measurements.

Any incident of localized roughness shall either be repaired or receive a payment adjustment according to the requirements given in Table 2.

For any subplot with an IRI which is greater than 1.25 m/km, the subplot is rejected and the Contractor shall repair at least a portion of the subplot.

All repairs and redecisioning of all sublots which are constructed in a given construction season shall be completed within 30 Days of the Contractor receiving written notice from the Contract Administrator that the last set of measurements had indicated repairs for those sublots. However, if such repairs cannot be made, due to rapid changes in weather or other issues that are no fault of the Contractor, then, at the discretion of the Contract Administrator, the Contractor may be requested to delay those repairs until the beginning of the next construction season, at no additional cost to the Owner.

The Contractor shall inform the Contract Administrator, in writing, when the repaired sublots are ready for QA inertial profiler acceptance re-testing. The Contractor shall be responsible for the cost of QA inertial profiler acceptance re-testing.

8.01.05.02 Repairs

8.01.05.02.01 General

At least 5 Business Days prior to beginning any surface smoothness-related or tolerance-related repairs, the Contractor shall submit a written proposal to the Contract Administrator with the subplot and repair locations including the appropriate stations, length of each repair area, distance between the ends of the repair areas on the same lane that are within 100 m of each other, and the method(s) of repair that the Contractor intends to use for each repair area. The Contractor shall not start repairs unless the Contract Administrator has given written permission. If permission is denied, then the Contract Administrator shall provide the Contractor with the reason(s) in writing.

Surface smoothness-related or tolerance-related repairs shall consist of one or more of the following corrective measures:

- a) Diamond grinding;
- b) A hot mix asphalt overlay, where permitted;
- c) Remove and replace; and/or
- d) Other methods of repair, if approved by the Contract Administrator, in consultation with the Ministry.

8.01.05.02.02 Diamond Grinding

Diamond grinding shall not be allowed in any area of the surface course where that area:

- a) Consists of a single lift of hot mix asphalt placed on a granular surface, Expanded Asphalt Mix (EAM) base or on pulverized grade; or
- b) Will be reduced by more than 5 mm below the general profile of the surrounding pavement surface after the repair.

A subplot shall be limited to no more than three separate diamond ground repair areas. If additional repair areas are identified within a subplot, then other methods of repair shall be used, subject to approval by the Contract Administrator.

The slurry produced from diamond grinding shall be removed from the site by the Contractor and managed as specified elsewhere in the Contract Documents.

8.01.05.02.03 Hot Mix Asphalt Overlay / Remove and Replace

Overlays on traffic lanes beneath structures may be allowed, if clearances between the pavement surface and the underside of the structure after overlay meet the established minimum requirements. Overlays on traffic lanes adjacent to curb-and-gutter or on bridge decks shall not be permitted.

A paver shall be used wherever corrective measures include overlay / remove and replace. Hot mix asphalt used in such repairs shall meet all of the requirements specified for the item in the Contract. The minimum width of every repair by “remove and replace” or a “hot mix asphalt overlay” shall be the width of the lane being repaired.

8.01.05.03 Redecisioning

When repairs are made to all or part(s) of any smoothness subplot, then the entire subplot shall be re-tested by the QA inertial profiler at the Contractor’s cost. Re-testing by QA inertial profiler shall include at least 15 m on either side of the repaired area. If this requirement extends the testing onto an adjacent subplot, then the adjacent subplot shall also be re-tested. After such repairs to the subplot, subsequent measurements shall be used in the final calculations for the payment adjustment to the lot.

After a subplot is repaired/overlaid, then the subsequent measurements of the subplot shall have no incident(s) of localized roughness and its IRI shall be less than or equal to 1.25 m/km.

9.0 MEASUREMENT FOR PAYMENT - Not Used

10.0 BASIS OF PAYMENT

10.01 Payment Adjustment for Surface Smoothness

10.01.01 Hot Mix Asphalt Quantity Calculation

Where the unit of measure is by square metres; the quantity of HMA for use in the calculations (Q_{mix}) shall be the theoretical area of surface course in the lot using the length of pavement on which the inertial profiler measurements were made and the design widths of the finished lane; excluding any paved shoulder.

When the unit of measure is tonnes, Q_{mix} shall be determined using the theoretical tonnage. The theoretical tonnage shall be calculated by the Contract Administrator as follows and rounded to one decimal according to LS-100:

$$Q_{mix} = [0.975 \times BRD_{mix} \times (T_D/1000) \times A_{mix}] \quad \text{(Formula 1)}$$

Where:

BRD_{mix} = the lot average bulk relative density in t/m^3 , calculated from values obtained in the testing of bulk samples obtained during production of the first complete lot of at least 3 sublots of HMA placed in the work. The values shall be the same as those used in calculating the final payment factor for air voids for the lot.

T_D = the design thickness, in millimetres, of surface course.

A_{mix} = theoretical area of surface course in the lot using the length of pavement on which the inertial profiler measurements were made and design widths of the finished lane; excluding any paved shoulder, in square metres.

10.01.02 Payment Adjustment Calculation

A subplot's payment factor for smoothness shall be based on the initial measurements using a QA inertial profiler, unless that subplot has been repaired or the initial quality assurance IRI has been substituted as a result of referee testing. Where a subplot has been repaired, the subsequent measurements taken after the repair shall be used in the calculation for the payment adjustment to that subplot. Subsequent measurements of IRI shall not be used to increase a payment factor, unless the subplot has been repaired. No subplot that has been repaired for any reason shall receive a payment factor greater than 1.0.

For any subplot with an initial average IRI measurement for the three runs that is greater than 1.000 m/km but less than or equal to 1.250 m/km, the Contractor may either accept the inclusion of its payment factor in the calculation for the lot or the Contractor may choose to repair at least a portion of the subplot.

The payment factors for sublots shall be determined by the Contract Administrator according to Table 1A or Table 1B, as applicable. Table 1B shall be used only for sublots consisting of Category B pavement treatment.

The subplot payment factor shall be rounded to three decimal places, according to LS-100. The payment factor for smoothness (PFS) for the entire lot shall be the lesser of the following:

- a) The average of the individual payment factors for all measured sublots of surface course within the lot, rounded to three decimal places, according to LS-100, or;
- b) 1.050.

If the average payment factor for the lot is equal to 1.000, the payment adjustment shall be zero.

If the average payment factor for the lot is greater than 1.000, the payment adjustment shall be:

$$(PFS - 1.000) \times \text{Price} \times Q_{mix} \quad \text{(Formula 2)}$$

If the average payment factor for the lot is less than 1.000, the payment adjustment shall be:

$$(1.000 - \text{PFS}) \times \text{Price} \times Q_{\text{mix}} \quad (\text{Formula 3})$$

Where:

Price = means the Contract price of the hot mix asphalt surface course tender item.

TABLE 1A
Sublot Payment Factor Based on IRI for all Pavement Treatments Except Category B

Average IRI of both wheel paths from a set of 3 measurements taken by an Inertial Profiler in each sublot (m/km)	Sublot Payment Factor
≤ 0.500	1.200 (subject to Note 1 below)
> 0.500 to 0.600	2.2 - (2.0 x IRI) (subject to Note 1 below).
> 0.600 to 1.000	1.000
> 1.000 to 1.250	1.40 - (0.4 x IRI) (subject to Note 2 below)
> 1.250	REJECTED (Requires repairs – subject to Note 2 below)
Notes:	
<ol style="list-style-type: none"> The payment factor shall not exceed 1.000 for subsequent IRI measurements which are taken after repairs regardless of the reason for the repairs. Sublots with IRI's between 1.000 and 1.350 m/km and located in areas of hot-in-place recycling being used as a surface course shall receive a payment factor of 1.00. Sublots with IRI's greater than 1.350 m/km and located in areas of hot-in-place recycling being used as a surface course shall be repaired. 	

TABLE 1B
Sublot Payment Factor Based on IRI for Category B Pavement Treatments

Average IRI of both wheel paths from a set of 3 measurements taken by an Inertial Profiler in each sublot (m/km)	Sublot Payment Factor
≤ 0.500	1.200 (subject to Note 1 below)
> 0.500 to 0.600	2.2 - (2.0 x IRI) (subject to Note 1 below).
> 0.600 to 1.250	1.000
> 1.250	REJECTED (Requires repairs)
Notes:	
<ol style="list-style-type: none"> The payment factor shall not exceed 1.000 for subsequent IRI measurements which are taken after repairs regardless of the reason for the repairs. 	

10.01.03 Incident(s) of Localized Roughness:

The Contractor shall either be given payment adjustments or be required to repair all incidents of localized roughness according to Table 2. However, where two or more incidents of localized roughness are found to be within 3 m of one another and they are left unrepaired, then the localized roughness at those locations shall be respectively treated as a single incident of localized roughness and the MRI of that single incident of localized roughness shall be considered to be the average MRI for all of the individual incidents of localized roughness within that 3 m for assessment of payment adjustment.

The payment adjustment for any subplot which includes any unrepaired incidents of localized roughness shall be unaffected by any payment adjustment given for such incidents of localized roughness.

**TABLE 2
Payment Adjustments / Repairs for Localized Roughness**

Incidents of Localized Roughness (Average MRI determined from three sets of measurements taken by an Inertial Profiler, run through ProVAL Version 3.40 or 3.50, m/km)	Payment Adjustment
2.400 to 3.499	The Contractor shall receive a payment reduction (subject to Notes 1 and 2) of \$2,500 for each incident of localized roughness located in multi-lane freeways, and \$2,000 for each incident of localized roughness located in all other highway types. Repairs shall be allowed for any incident of localized roughness in this amplitude range subject to Note 1.
≥ 3.500	All incidents of localized roughness shall be repaired in this range (subject to Note 1).
<p>Notes:</p> <ol style="list-style-type: none">1. Subject to the restrictions on repairs stated in Repairs clause, the Contractor may repair an incident of localized roughness with an average MRI greater than 2.400 m/km. If the repair removes that incident of localized roughness, then the payment adjustment for that incident of localized roughness shall be waived.2. Payment adjustment shall be waived for any incident of localized roughness located within transition zones. Transition zone is the section of a through lane adjacent to the taper of an added or terminated new lane and includes an additional 10 m either side of the start and end of the taper.	

10.01.04 Repair Costs

All repairs shall be made entirely at the Contractor’s expense. Where overlays are allowed, any other associated costs such as additional granular materials for shoulders, shall also be borne by the Contractor.

10.01.05 Costs for QA Re-Testing and Referee Testing

The Contractor shall be responsible for the cost of QA inertial profiler acceptance re-testing.

If the Contractor requests Referee testing and the average IRI for the sublots tested by the referee profiler in that request is larger or less than 10% smaller than the average IRI determined from the measurements taken by the QA inertial profiler for the same sublots, then the cost of the referee testing shall be borne by the Contractor. Otherwise, the Owner shall be responsible for the costs of referee testing.

10.01.06**Tolerance/Smoothness Measurements and Associated Traffic Control**

No additional payment shall be made to the Contractor for the cost of tolerance measurements that are required by the Contract Administrator.

No additional payment shall be made to the Contractor for the cost of traffic protection provided to the profiler for daily placement and removal of the reflectors or for collection of static GPS coordinates as specified in Inertial Profiler Acceptance Testing clause unless placement or removal of the reflectors or collection of static GPS coordinates requires the closure of a traffic lane, in which case, the cost of such traffic control shall be administered as a Change in the Work.