METHOD OF TEST FOR CALIBRATING, CORRELATING, AND CONDUCTING SURFACE SMOOTHNESS MEASUREMENTS USING AN INERTIAL PROFILER

1. SCOPE

1.1 This procedure covers the method which is used for approving laser inertial profilers and for conducting surface smoothness measurements on ministry contracts with these devices.

2. RELEVANT DOCUMENTS

2.1 AASHTO R 56 Standard Practice for Certification of Inertial Profiling Systems

2.2 AASHTO R 57 Standard Practice for Operating Inertial Profiling Systems

2.3 ASTM E950 Standard Test Method for Measuring the Longitudinal Profile of Traveled Surfaces with an Accelerometer Established Inertial Profiling Reference

2.4 MTO's Field Guide for the Acceptance of Hot Mix and Bridge Deck Waterproofing

2.5 ProVAL 3.4 User's Guide

3. DEFINITIONS

3.1 The CORRELATION SITE consists of one or more locations established by the ministry to conduct inertial profiler correlations.

3.2 A DATA FILTER FACTOR is an input parameter which is used to electronically modify the surface trace.

3.3 DMI (Distance Measuring Device) is a device for measuring the longitudinal distance along a profile when using an inertial profiler.

3.4 INERTIAL PROFILER means a vehicle which is equipped with dual lasers and accelerometers and provides vertical elevation as a function of longitudinal distance along a prescribed path.

3.5 INTERNATIONAL ROUGHNESS INDEX (IRI) is 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 sublot length. It is expressed in units of m/km.

3.6 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.

3.7 MEAN ROUGHNESS INDEX (MRI) means the number calculated by averaging the IRI values from the two wheel path profiles.

3.8 QUARTER CAR FILTER calculates the suspension deflection of a simulated mechanical system with a response similar to one corner of a passenger car travelling at 80 km/hr.

3.9 REDUCTION LENGTH is an input parameter equal to the sublot length.

3.8 SMOOTHNESS MEASURING DEVICE (SMD) is an inertial profiler used for measuring the surface smoothness of a pavement section.

3.10 A SUBLOT is a continuous traffic lane of pavement; excluding the shoulder, which has been measured by an inertial profiler for purposes of repairs and price adjustments and normally having a length of 100 m, measured horizontally, for highway survey purposes.

3.11 WHEELPATH 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. APPARATUS

4.1 LASER INERTIAL PROFILERS

The certification and operation of the inertial profiler shall conform to AASHTO R 56-10, R 57-10 with the modifications as described in this procedure.

4.1.1 Hardware

All inertial profilers shall conform to the minimum requirements of an ASTM Class 1 Profilometer Standard/Specification (ASTM Standards, Vol. 04.03 Designation: E 950-09) and AASHTO R 57-10, and shall also meet all the requirements specified in Appendix 1.

4.1.2 Software

The on-board computer shall be programmed to meet all the requirements specified in Appendix 1.

Note 1:

As the measurements are being taken, the following additional Metadata Tags and Descriptions shall also be *automatically* generated and stored in the ®ProVAL ppf data files:

- Profiler trade name and model number
- Date and time data was collected and average vehicle speed associated with the data (km/hr)
- Original filename before Import, data history, date and time file last modified
- Run number (multiple runs-same location on the same day)
- GPS latitude and longitude co-ordinates of point where measurements begin and end

In addition the following “Metadata Tags and Descriptions” shall be inputted:

- Vehicle identification (i.e. licence plate number) and profiler operator name
- Roadway designation (i.e. highway number), lane identification, direction of travel
- Station number of beginning and end points; milepost of beginning and ending points
- Pavement surface type (i.e. mix type) and whether measurements are for QC, QA, or Referee

- Ambient temperature and climatic conditions
- Profile offset, profile start index (for use in lead-in), profile stop index (for use in lead-out)
- First and last sublots measured

4.2 CALIBRATION BLOCKS: Four rigid blocks or plates (i.e. 6.35 mm, 12.7 mm, 25.4 mm, and 50.8 mm in height), are required for checking the vertical calibration of each sensor. The height (or thickness) of the calibration blocks (or plates) shall be clearly engraved on at least one of its sides.

4.3 SMOOTH RIGID BASE PLATE: A steel or aluminium plate, approximately 0.3 x 0.3 m square and 6.35 mm for use with the calibration blocks.

5. PROCEDURES

5.1 CALIBRATION AND CORRELATION OF INERTIAL PROFILERS

5.1.1 Visual Check

Prior to making any measurements, the profiler operator should check the inertial profiler to ensure that all mechanical parts and the associated electronics appear to be in suitable condition and that all appropriate accessories and peripherals are included with the device. For inertial profilers, the glass in the sensors should be checked for cleanliness and any signs of damage.

5.1.2 Checking Pressure of Pneumatic Tires

The pressure of all four pneumatic tires must be checked in their cold state. The pressure of each tire shall be adjusted to the manufacturer's recommended pressure.

5.1.3 Checking Height Sensor Calibration (i.e. Block Test)

5.1.3.1 The calibration of the height sensor shall be performed in accordance with the manufacturer's recommended procedures and the results tabulated and recorded in a calibration log. In the absence of the manufacturer's procedures, the sensor calibration shall be checked in accordance with steps 5.1.3.2 to 5.1.3.10.

5.1.3.2 A smooth base plate is positioned under one of the height sensors of the profiler and ten separate height measurements shall be taken.

5.1.3.3 Position a 6.35 mm calibration block on top of the base plate and underneath the height sensor and take ten more height measurements.

5.1.3.4 Remove the 6.35 mm calibration block and position a 12.7 mm calibration block on top of the smooth base plate underneath the height sensor and take ten more height measurements.

5.1.3.5 Remove the 12.7 mm calibration block and position a 25.4 mm calibration block on top of the base plate underneath the height sensor and take ten more height measurements.

5.1.3.6 Remove the 25.4 mm calibration block and position a 50.8 mm calibration block on top of the base plate underneath the height sensor and take ten more height measure-ments.

5.1.3.7 The difference between each measurement taken on the top of the calibration block and the average of the ten measurements that were taken on the top of the smooth base plate is then calculated to determine the thickness of the calibration block.

5.1.3.8 The calculation given above is repeated for each of the ten separate measurements and for each calibration block. The average of the absolute value of the differences between the calculated thickness and the known average calibration block thickness must be less than or equal to 0.25 mm for each calibration block, in accordance with the equation given below:

For each Block i, where i = 1 to 4, $$\left| \frac{\sum_{j=1}^{10} \left| Bij - \frac{\sum_{k=1}^{10} Pk}{10} \right|}{10} - TBi \right| \leq 0.25$$

Where: Bi_j is the j th sensor measurement taken on the top of Block i,
P_k is the k th sensor measurement taken on the top of the base plate, and,
TBi is the average of 3 caliper measurements of the Block i's height.

5.1.3.9 The smooth base plate must then be placed under the second height sensor and steps 5.1.3.2 to 5.1.3.8 repeated with all four calibration blocks.

5.1.3.10 All of the measurements must be tabulated and recorded in a calibration log.

5.1.4 The "Bounce" Test

5.1.4.1 The operator must push down and pull up, in an eccentric manner, on the vehicle near the right front wheel of the inertial profiler for a period of thirty seconds while the IRI is being recorded.

5.1.4.2 A flat profile trace must be produced during the testing and the maximum IRI recorded must be no more than 0.157 m/km.

5.1.4.3 The operator must repeat steps 5.1.4.1 and 5.1.4.2 near the left front wheel then near the left rear wheel and finally near the right rear wheel for a period of thirty seconds each.

5.1.5 Checking the DMI

5.1.5.1 The operator must place a reflector at the beginning and end of a line established by the ministry for checking the longitudinal accuracy of the DMI. The established line shall have a minimum length of 200 m. The operator then must drive the inertial profiler beside the established line for its entire length at the manufacturer's minimum recommended speed.

5.1.5.2 Step 5.1.5.1 is repeated two more times.

5.1.5.3 The average of the three absolute differences between the DMI reading and the known distance traversed must be less than or equal to 0.10%, in accordance with the following equation:

$$\frac{\sum_{i=1}^{3} \left| DMI_i - Dist \right|}{3 \times Dist} \times 100 \leq 0.10\%$$

Where: DMI_i is the i th DMI distance reading, and

$Dist$ is the actual distance travelled (measured by steel tape).

5.1.5.4 If the DMI does not meet this requirement, the operator must then recalibrate the DMI and repeat steps 5.1.5.1 to 5.1.5.3.

5.1.6 Conducting Correlation Runs

In order to be approved for use on MTO construction contracts, an inertial profiler will be required to participate in an annual inertial profiler correlation program, established by the ministry.

5.1.6.1 Reference Pavement Section

A Reference Pavement Section (RPS), at least 400 m long, consisting of two parallel Reference Profiles (RP's) 1.76 m apart, will be established by the ministry at each inertial profiler correlation site using a reference profiling device.

5.1.6.2 The inertial profiler must run the Reference Pavement Section five times at 70 km/h, in accordance with the requirements given in Section 5.2 using at least a 100 m lead-in and lead-out.

5.1.6.3 The operator of the inertial profiler must determine the average IRI for each of the two parallel RP's and the locations and values of all localized roughness, in accordance with Section 7.3.

5.1.6.4 The operator of the inertial profiler must then give the individual IRI's and the average IRI's for each wheelpath and all localized roughness locations and values on forms similar to those in Figures 1a and 1b, as well as all unfiltered data files, to the ministry representative.

5.2 SURFACE SMOOTHNESS MEASUREMENTS ON MINISTRY CONTRACTS

5.2.1 General

The height sensors, the DMI, and the tire pressures of all pneumatic tires must always be within acceptable tolerances and checked using the methods described in Section 5.1. Stationary reflectors must be established and an *autostart* function used at the beginning of every profile run.

All individual profile runs must be less than or equal to 2.0 km in length. However, an inertial profiler will be allowed to increase the length of its runs, if it can be demonstrated to the satisfaction of the Contract Administrator that the longitudinal stations can be consistently maintained within 1 m of the actual stations that are marked out in the field.

6. CORRELATION CALCULATIONS AND ANALYSES FOR INERTIAL PROFILER ACCEPTANCE

6.1 PROFILER CERTIFICATION USING ®ProVAL 3.4

A ministry representative will determine the acceptance of each inertial profiler at each Reference Profiler Section (RPS) using Reference Profiles (RP's) based on the following criteria:

6.1.1 "Unit System" will be changed to *"Metric"*, "Distance Units" to *"Kilometers",* and "Elevation Units" to *"Millimeters"*.

6.1.2 ProVAL's *"Profiler Certification"* option will be used with *1.524 m* for the "Maximum Offset", *92%* for the "Repeatability Passing Score", *90%* for the "Accuracy Passing Score", and *IRI* as the "Filter Type". The checkbox beside "250 mm Filter" will be selected.

7. REPORTING OF RESULTS

7.1 UNFILTERED DATA FILES

The *unfiltered* data files obtained from each profile run taken by an inertial profiler shall be saved and submitted in a format that is readable by ®ProVAL 3.4 software.

7.2 CORRELATION SITE

7.2.1 The calculated IRI's and their associated statistics for the five runs of each wheelpath, within each 100 m section that were measured by the inertial profiler, shall be filled out on separate forms, such as those shown in Figures 1a and 1b, for each Reference Pavement Section.

7.2.2 The operator of the inertial profiler shall then present all forms along with the applicable unfiltered data files to the ministry representative on site.

7.3 MINISTRY CONTRACTS

7.3.1 ProVAL File Management

The ProVAL files obtained from each profile run shall be named using the following convention:

Characters 1 through 4:	Year portion of the contract number;
Next Character:	Write "-";
Character 6 through 9:	Last four digits in the contract number;
Next Character:	underscore "_";
Next 6 to 10 Characters:	Mix type using the naming convention in the ERS spreadsheet
Next Character:	Write underscore "_" -
Next 1 to 3 Characters:	Number* of the first sublot
Next 2 Characters:	Write "TO"
Next 1 to 3 Characters:	Number* of the last sublot
Next 2 to 3 Characters:	Write "QA" for Quality Assurance Measurements or "RF" for Referee Measurements
Next Character:	Write "I" for initial Measurements, "S" for subsequent measurements
Next Character:	"R"
Last Character before extension:	Run number

Notes: * Include the first and last sublots numerically, even if several intervening ones are not included in the measurements

Example #1
Contract number 2005-3036 on Highway 19, Superpave 12.5, Sublots 1 to 20, QA Initial Measurements, Run 2:

File Name: 2005-3036_SUP125_001TO020QAIR2.ppf

Example #2
Contract number 2005-4010 on Highway 401, Superpave 12.5 FC2, Sublots 54 to 70, Referee, Run 1:

File Name: 2005-4010_SUP125FC2_054TO070RFSR1.ppf

7.3.2 Determining IRI Using ProVAL 3.4

The following method shall be used for determining the IRI for both the left and right wheel paths in each 100 m sublot.

7.3.2.1 Open up the xxxxxxxxxxxxxxxx_xxxTOxxxxxRx.ppf file representing any particular profile run. Select "*SI Units*" from the "Options" menu and "*km/mm*" from the "Units" drop down menu.

7.3.2.2 Select the *"Ride Quality"* option under "Analysis" menu and then *"Fixed Interval"* as "Analysis Type" and *"IRI"* as "Ride Quality Index". Select both wheel paths. Make sure that the check-box beside "250 mm Filter" is selected. Set the "Threshold" to "*1.25 m/km*".

7.3.2.3 Set the "Segment Length" to "*100 m"* or where a single sublot is not 100 m long, set it to the proper length and run the analysis for that one sublot. Left click on the *"*Analyze*"* button.

7.3.2.4 Select the report menu, specify the destination, and save the IRI values in excel format.

7.3.2.5 The calculated IRI values (in m/km) for both the Left and Right wheel paths for each sublot can then be copied from the Excel worksheet to another Excel spreadsheet such as the ministry's Excel template for calculating payment factors.

7.3.2.6 Repeat above steps until the IRI values have been calculated for all of the runs that are made for all of the sublots that have been measured by the inertial profiler.

7.3.3 Determining Locations of Localized Roughness Using ProVAL 3.4

The following method shall be used for determining the locations of "Localized Roughness" for both the left and right wheel paths in each 100 m sublot.

7.3.3.1 Open up the selected file. Select "*SI Units*" from the "Options" menu and "*km/mm*" from the "Units" drop down menu.

7.3.3.2 Go to the "Analysis" menu and select the *"Smoothness Assurance"* option. Choose "*MRI*" as a "Ride Quality Index" and select the profiler run that is to be analyzed. Apply 250 mm filter.

7.3.3.3 Against "Short Continuous" Analysis, change the "Segment Length" and "Threshold" to "*7.62 m"* and "2.4 *m/km",* respectively, then left click on the *"Analyze"* button. In the "Navigate" drop down menu select "*Short Continuous*" and the graph will be visible.

7.3.3.4 Save the list of locations and respective MRI in Excel format.

7.3.3.5 Repeat the above steps for every remaining profile run.

7.3.4 Surface Smoothness Reporting Files in Excel Format

7.3.4.1 The IRI for each wheelpath within each sublot shall be entered into an Excel template form, similar to the one shown in Figure 2.

7.3.4.2 Areas of special conditions, such as superelevations or curves, any additional information such as joints or major intersections, and any areas that are being measured but will be exempt from surface smoothness-related price reductions/repairs must also be clearly marked on all summary sheets.

7.3.4.3 The locations of all incidents of localized roughness and their respective MRI values that exceed the threshold limit of 2.4 m/km shall also be listed on a separate sheet, similar to the one shown in Figure 3.

7.3.4.4 Excel File Naming Convention

The Excel data files created for each mix type shall be named using the following convention:

Characters 1 through 4:	Year portion of the contract number;
Next Character:	Write "-";
Characters 6 through 9:	Last four digits in the contract number;
Next Character:	Write underscore "_";
Next 6 to 9 Characters:	Mix type using the naming convention in the ERS spreadsheet
Next character:	Underscore "_" -
Next 3 Digits:	Number* of the first sublot
Next 2 Characters:	Write "TO"
Next 3 Digits:	Number* of the last sublot
Next 2 Characters:	Write "QA" or "RF" (when QA and Referee results are included)**
Next Character before xls extension:	"I" for Initial Measurements, "S" for files that contain subsequent Measurements (e.g. after a repair) or "F" for Final Summary***

Note: * Include the first and last sublots numerically, even if several intervening ones are not included in the measurements
** Use "RF" whenever any referee results are included
*** Use "F" only when the measurements for all of the sublots have been finalized for payment.

Example #1
Contract number 2005-3036, Superpave 12.5 FC2, Sublots 1 to 87, Initial measurements taken by QA inertial profiler when 50% of the surface course has been completed.

File Name: 2005-3036_SUP125FC2_1TO87QAI.xls

Example #2
Contract number 2005-4010, Superpave 12.5 FC2, Sublots 1 to 225, Final summary including all Referee Measurements:

File Name: 2005-4010_SUP125FC2_1TO225RFF.xls

7.3 GPS DATA FILES

Submit GPS data files corresponding to all your measurement runs along with your results.

8. CRITERIA FOR GAINING AND MAINTAINING SMD ACCEPTANCE

8.1 YEARLY CORRELATION ACCEPTANCE

8.1.1 In order for an inertial profiler to be acceptable for ministry work, minimum "Repeatability" of 0.92 and minimum "Accuracy" of 0.90 are required for each of the left and right wheelpaths.

8.1.2 The operator of the inertial profiler will also be required to correctly measure all Reference Profile Section(s) as well as calculate the individual IRI's and the locations and values of all localized roughness, using the ProVAL 3.4 software to the satisfaction of the ministry representative.

8.2 MAINTAINING ACCEPTANCE THROUGHOUT THE YEAR

The operator of the inertial profiler must carry out regular inspections of all equipment including pneumatic tires, electronics, etc. to ensure that it is in suitable condition at all times.

8.2.1 Each profiler must be equipped with all necessary peripherals in good working condition and all accessories such as suitable calibration blocks, a tire pressure gauge, air pump, reflectors, tape measures, chalk, paints, wooden stakes.

8.2.2 All pneumatic tires must be maintained at the manufacturer's recommended tire pressure.

8.2.3 The height calibration of the sensor(s) must be within acceptable limits at all times.

8.2.4 The inertial profiler's DMI must measure within acceptable limits at all times (i.e. 0.15%).

8.2.5 Any changes to the equipment and/or software from those that were demonstrated at the Correlation Site, during the initial yearly approval, must be discussed with either the ministry's Bituminous Section prior to taking further measurements on any contract.

Figure 1a –Sheet 1 for Correlation of Inertial Profilers

Correlation of Inertial Profiler (IRI) at ____ km/hr

Site:_____ Date:_____

Name of Company:_____ Operator:_____

Manufacturer:_____ Serial #:_____

Left Sensor IRI (m/km)

Stations	Run #1	Run #2	Run #3	Run #4	Run #5	Average	Std. Dev.	Coefficient of Variation (%) = Std. Dev. / Average X 100
Average								

Average Coefficient of Variation = _____ %

Company's Average IRI = _____ m/km

Right Sensor IRI (m/km)

Stations	Run #1	Run #2	Run #3	Run #4	Run #5	Average	Std. Dev.	Coefficient of Variation (%) = Std. Dev. / Average X 100

Average								

Average Coefficient of Variation **= _____ %**

Company's Average IRI **= _____ m/km**

Figure 1b –Sheet 2 for Correlation of Inertial Profilers

Correlation of Inertial Profiler (Localized Roughness) at _____ km/hr

Site:_____ Date:_____

Name of Company:_____ Operator:_____

Manufacturer:_____ Serial #:_____

Run #1		Run #2		Run #3		Run #4		Run #5		Combined	
Start Location Stop Location	MRI (m/km)	Start Location Stop Location	MRI (m/km)	Start Location Stop Location	MRI (m/km)	Start Location Stop Location	MRI (m/km)	Start Location Stop Location	MRI (m/km)	Start Location Stop Location	MRI (m/km)

*** Location means station as well as GPS coordinates**

Figure 2 – Summary Sheet for IRI Sublot Measurements by Inertial Profiler

Ontario

Ministry of Transportation

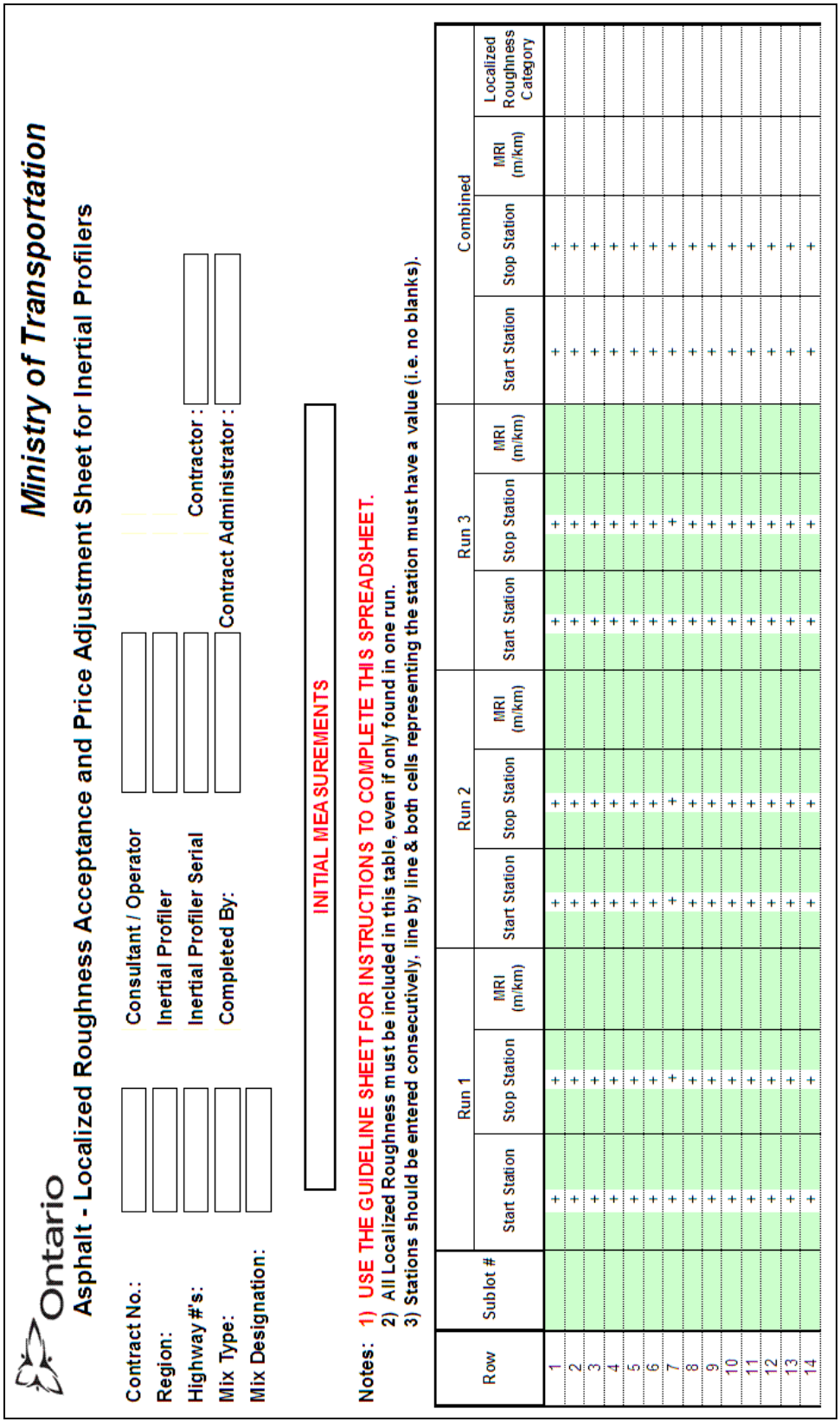
Hot Mix Asphalt - IRI Smoothness Acceptance and Price Adjustment Sheet for Inertial Profilers

Contract No.:		Consultant / Operator		INITIAL MEASUREMENTS	
Region:		Inertial Profiler Manufacturer:		Number of Sublots:	
Highway Number:		Inertial Profiler Serial No.:		Contractor:	
Mix Type:		Completed By:		Contract Administrator :	

Note: *Special areas like superelevations and curves should be designated as "S" or "C", respectively. If the sublot has been repaired, put an "R" in this space.

Location / Length					Special Areas*	Surface Smoothness Measurements - IRI (m/km)													Payment Factor
							Run #1			Run #2			Run #3			Averages			
Sublot #	Start	to	End	Length (m)		Date (mm/dd/yyyy)	Left	Right	Avg.	Left	Right	Avg.	Left	Right	Avg	Left	Right	Avg. (nearest 0.005)	
	+	to	+																
	+	to	+																
	+	to	+																
	+	to	+																
	+	to	+																
	+	to	+																
	+	to	+																
	+	to	+																
	+	to	+																
	+	to	+																
	+	to	+																
	+	to	+																
	+	to	+																
	+	to	+																
	+	to	+																
	+	to	+																
	+	to	+																
	+	to	+																
	+	to	+																
	+	to	+																
	+	to	+																

Figure 3 – Summary Sheet for Localized Roughness Measurements by Inertial Profiler



Ontario

Ministry of Transportation

Asphalt - Localized Roughness Acceptance and Price Adjustment Sheet for Inertial Profilers

Contract No.: Consultant / Operator
Region: Inertial Profiler
Highway #'s: Inertial Profiler Serial Contractor :
Mix Type: Completed By: Contract Administrator :
Mix Designation:

INITIAL MEASUREMENTS

Notes: 1) USE THE GUIDELINE SHEET FOR INSTRUCTIONS TO COMPLETE THIS SPREADSHEET.
2) All Localized Roughness must be included in this table, even if only found in one run.
3) Stations should be entered consecutively, line by line & both cells representing the station must have a value (i.e. no blanks).

Row	Sublot #	Run 1			Run 2			Run 3			Combined			
		Start Station	Stop Station	MRI (m/km)	Start Station	Stop Station	MRI (m/km)	Start Station	Stop Station	MRI (m/km)	Start Station	Stop Station	MRI (m/km)	Localized Roughness Category
1		+	+		+	+		+	+		+	+		
2		+	+		+	+		+	+		+	+		
3		+	+		+	+		+	+		+	+		
4		+	+		+	+		+	+		+	+		
5		+	+		+	+		+	+		+	+		
6		+	+		+	+		+	+		+	+		
7		+	+		+	+		+	+		+	+		
8		+	+		+	+		+	+		+	+		
9		+	+		+	+		+	+		+	+		
10		+	+		+	+		+	+		+	+		
11		+	+		+	+		+	+		+	+		
12		+	+		+	+		+	+		+	+		
13		+	+		+	+		+	+		+	+		
14		+	+		+	+		+	+		+	+		

APPENDIX 1

REQUIREMENTS FOR INERTIAL PROFILERS

General

Item	Requirement
Laser Footprint	≥ 70 mm width
Sampling Rate	≥ 3 kHz
Sampling Interval	≤ 25.4 mm
Laser Resolution	≤ 0.05 mm
Error warning	Audible warning and automatically records message in data file when one of the sensors ceases functioning or is out of range or recording erroneous data.
Laser Sensors	Dual laser sensors with accelerometers
Sensor Spacing	1.76 m
Accelerometer Range	± 2 to ± 3 g (assuming that the 1 g bias due to gravity is taken care of)
Overall Accuracy of Accelerometer	≤ .010 g (including all relevant factors such as bias and scale factor, thermal sensitivities, non-linearity, non-repeatability, resolution, threshold, and noise).
Input	Accepts any input information that is required by an agency's specification and incorporates it directly into the data file.
	Automatically marks the data file to detect tampering.
Output	Produces raw data files without any further filtering of the data after it has been collected from the sensors. The data files should be readable by ProVAL 3.4.
Auto Start/Stop	Automatically detects roadside markers and incorporates an event marker
Calibration/Correlation	Must meet and maintain MTO's calibration and correlation requirements.

Computer System

Item	Requirement
Overall Specification	Is compatible with the data collection requirements within the vehicle speed range recommended by the manufacturer for measurement.
Software	Reads in metric units and capable of calculating IRI to the nearest 0.01 m/km or better
	Is loaded with the version of the software for the inertial profiler that is used during the agency's annual calibration.

Item	Requirement
	Automatically marks the data file whenever a file has been tampered with
	Is loaded with the version of ProVAL specified in the agency's specification.
Data Storage and Transfer	Is equipped with a CD burner to leave a copy of the raw data files on site.

DISTANCE MEASUREMENT DEVICE

Item	Requirement
Longitudinal Distance Accuracy	$\leq$ 0.1% up to the maximum speed specified by the inertial profiler's manufacturer.
Interface	Connects directly to the profile measurement device and inputs data directly into the file.

GPS DEVICE

Item	Requirement
Accuracy	Is accurate to within ± 1 m.
Minimum Update Rate	5 records per seconds (5 Hz)
Interface	Connects directly to the profile measurement device and inputs the start and end points, as well as any event markers directly into the file.

CARRIER

Item	Requirement
Transverse Offset	Maintains an offset ± 150 mm using an aid such as a projected laser dot, video camera, or other suitable device.
Mounting of Inertial Measurement Devices	The devices must be housed in a dedicated vehicle that meets all of the manufacturer's requirements.
Speed of travel	At least 60 km/hr and no more than the speed at which any of the other limits specified in this or any of the other tables given above are exceeded.
Safety	Is equipped with an operating flashing strobe type light and a warning device (flashing arrow or equivalent).