Test Procedure for

OPERATING INERTIAL PROFILERS AND EVALUATING PAVEMENT PROFILES

TxDOT Designation: Tex-1001-S

Effective Date: August 1, 2018

1. SCOPE

1.1 This test method:

- covers use of an inertial profiler for ride quality measurements using Surface Test Type B for quality control (QC) and quality assurance (QA) testing,
- describes the inertial profiler apparatus as well as major and minor repairs and adjustments,
- covers calibration verification procedures,
- outlines the procedures for collecting inertial profile data on paving projects,
- prescribes the required test data description and data format and gives examples,
- provides and references the methodology used to detect areas of localized roughness, and
- details the certification of inertial profilers and inertial profiler operators.

1.2 Perform this test method as a QA test for use with the appropriate smoothness specification for paving operations. This method is recommended when using inertial profilers for QC testing.

1.3 Use the inertial profile data files obtained by following this test method as input to the RIDE QUALITY software program. The RIDE QUALITY software will perform ride summary calculations on the input data and report the bonus and penalties. The RIDE QUALITY software will also detect the location and magnitude of any areas of localized roughness contained in the paving project for acceptance tests.

1.4 The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

2. APPARATUS

2.1 *Housing vehicle,* capable of traveling at minimum speeds of 12 mph while collecting pavement profile data.

2.2 *Distance measuring subsystem,* verified accurate to within 1 ft. per 528 ft. of actual distance traveled on verification tests of horizontal calibration described in Section 4.

2.3 *Inertial referencing subsystem,* capable of measuring the movement of the housing vehicle as it traverses the pavement under test.

2.4 *Non-contact height measurement subsystem,* capable of measuring the height from the mounted sensor face to the surface of the pavement under test.

2.5 *Inertial profiler*:

- must include hardware and software capable of producing and storing inertial profiles by combining the data from the inertial referencing subsystem, the distance subsystem, and the height measurement subsystem;
- must have the capability of measuring and storing profile elevations at 3 in. intervals or less (capable of outputting these elevations in the format described in Section 6);
- must have the capability of summarizing (computing) the profile elevation data into summary roughness statistics over a section length equal to 0.1 mi. (summary roughness statistic is the International Roughness Index [IRI] for each longitudinal path profiled);
- should have design to allow field calibration and verification of calibration for the distance measurement (horizontal) subsystem and the height measurement (vertical) subsystem described in Section 8; and
- must be certified for use in Texas (described in Section 8).

Note 1—For consistent pavement profile determination, maintain air pressure on the wheels of the housing vehicle according to the manufacturer's specification. The housing vehicle and all system components must be in good repair and proven to be within the manufacturer's specifications. The operator of the inertial profiler must have all tools and components necessary to adjust and operate the inertial profiler according to the manufacturer's instructions.

3. REPAIR AND ADJUSTMENT OF INERTIAL PROFILERS

3.1 Major component repairs or replacement that would require recertification of the inertial profiler include, but are not limited to, the following:

- the accelerometer and its associated hardware,
- the non-contact height sensor and its associated hardware,
- the distance measuring instrument, or
- any printed circuit board necessary for the collection of raw sensor data or the processing of the inertial profiles and IRI.

3.2 The operator of the inertial profiler may make minor adjustments to the equipment without having to complete the recertification process as long as the adjustments allow the equipment to fulfill the procedure in Section 4. Minor adjustments to the system include, but are not limited to, the following:

- inspecting, resoldering, or replacing connectors;
- cleaning components, normal adjustments to voltage levels as required by the manufacturer; and
- setting software parameters and scale factors as required by the manufacturer.

4. VERIFYING CALIBRATION

4.1 The following verification procedures are required for QA testing and are recommended when using an inertial profiler as a QC instrument on a daily basis.

4.2 *Standards:*

4.2.1 *Horizontal:*

4.2.1.1 The horizontal or longitudinal calibration standard will be a straight roadway test section at least 528 ft. in length.

4.2.1.2 Using a steel measurement tape or electronic measuring device, measure the ground distance precisely to within 0.1%.

4.2.2 *Vertical:*

4.2.2.1 The vertical measurement standards will be flat plates of known thicknesses.

4.2.2.2 Mark the plates with the known thicknesses.

4.2.2.3 As a minimum, test a base plate and a 1-in. measurement plate.

4.2.2.4 Measure plate thickness accurate to within 0.001 in.

4.3 *Procedures:*

4.3.1 *Frequency of Verifying Calibration:*

4.3.1.1 Perform the horizontal and vertical verification of calibration of the inertial profiler before use on each paving project according to the manufacturer's recommendations.

4.3.1.2 Check the tire air pressure on the wheels of the housing vehicle and maintain according to the manufacturer's recommendations.

4.3.1.3 Maintain a log and keep it with the inertial profiler to provide a verification of calibration history.

4.3.2 *Horizontal Verification of Calibration:*

4.3.2.1 Perform the horizontal (longitudinal) verification of calibration by navigating the inertial profiler over a measured test section at least 528 ft. in length.

4.3.2.2 The inertial profiler's distance measuring subsystem must measure the length of the test section to within 0.2% of its actual length.

4.3.2.3 As necessary, adjust the inertial profiler's distance measurement subsystem according to the manufacturer's guidelines.

4.3.2.4 Failure to meet the specified tolerance will require recalibration by the contractor and reverification as described under Section 4.

4.3.3 *Vertical Verification of Calibration:*

4.3.3.1 Perform the vertical verification of calibration on a flat and level area using the flat plate of known thickness. Perform the test indoors when windy conditions exist.

4.3.3.2 Place the base plate under the inertial profiler's non-contact height sensor. The inertial profiler's height measurement subsystem takes a height measurement. Use this measurement as the reference height for subsequent measurements.

4.3.3.3 Place a 1-in. plate on top of the reference plate below the non-contact sensor. The inertial profiler's height measurement subsystem measures this displacement to within 0.01 in. of the 1-in. plate's thickness.

4.3.3.4 Remove the 1-in. plate and verify that the inertial profiler's height measurement system returns to the original reference plate's displacement to within 0.01 in. Failure to meet the specified tolerance will require recalibration. If the recalibration requires major repair, as noted under Section 3, then recertify the profiler at the Pavement Profiler Evaluation Facility located at the Riverside Campus of Texas A&M University. Section 8 describes the certification procedure. Reverify, if minor repairs are required, as indicated under Section 3.

4.3.4 *Quality Control:*

4.3.4.1 When using a profilograph for quality control purposes, convert the zero inch blanking band average PI (in inches/mile), per 0.1-mi. section, into estimated average IRI (in inches/mile) using the following equation:

$$IRI = \frac{4.445 \times PI}{1 + (0.02073 \times PI)}$$

5. PROCEDURE

5.1 Locate and mark all "leave-out" sections as directed by the Engineer. Do not evaluate "leave-out" sections for the payment of bonuses or penalties. "Leave-out" sections will

include any additional pavement length as prescribed in the smoothness specification including the first and last 100 ft. of the paving project.

5.2 Before measuring, clean the roadway path of all debris and other loose material.

5.3 Operate the inertial profiler at a constant speed of 12 mph or greater when measuring the pavement profile. Failure to maintain this minimum speed will cause the inertial referencing subsystem to "droop"; hence, the pavement profile elevations will not be usable. Re-measure any pavement segment where the average operational speed per 0.1 mi. is less than 12 mph.

5.4 A pre-section length of roadway is required to "settle" the inertial profiler's filters. This pre-section should be at least 200 ft. in length and located immediately before the section of pavement under test. Depending on the type of filter used with the inertial profiler, a lead-out may also be required immediately after the section of pavement under test to correct for phase shifts introduced by filtering. The lead-out length should conform to the operating requirement set by the profiler manufacturer. Typically, this length varies from 200 to 300 ft. Set the long wavelength cutoff to 200 ft. for profile measurements.

5.4.1 Take the inertial profile measurements on two longitudinal lines spaced 69 in. apart, corresponding to the wheel paths of each pavement travel lane.

5.4.2 The profile location will normally lie 3 ft. from and parallel to the approximate location of the pavement lane edge.

5.4.3 If the inertial profiler is capable of measuring profiles from two longitudinal wheel paths during a single pass, then the wheel path spacing will be 69 in.

5.5 Collect measurements in the direction of traffic. Set up the profiler to trigger data recording automatically at the starting location of the pavement section to be tested. Optionally, set up the profiler to stop data recording automatically at the end of this section. When using an inertial profiler that collects a single wheel path per pass, take care to ensure that the measurements from each wheel path in a travel lane start and stop at the same longitudinal locations.

5.6 Mark "leave-out" sections.

5.6.1 Place event markers in the elevation data that correspond to the location of each "leave-out" section during the measurement process.

5.6.2 Refer to Section 6.1.4 of this test method for proper location of event markers in the data file.

5.7 *Data Collection*:

5.7.1 Perform QA data collection at the end of the paving operation or staged as prescribed by the Engineer.

5.7.2 Collect pavement profiles on a project in a single data file per travel lane when both wheel paths are measured during a single pass and event markers are used to mark "leave-outs", or;

5.7.3 Collect pavement profiles on a project in two data files per travel lane when a single wheel path is measured during a single pass and event markers are used to mark "leave-outs", or;

5.7.4 Collect pavement profiles on a project in multiple data files per travel lane when "leave-outs" are specifically excluded from the test measurements made with the inertial profiler.

5.8 Submit to the Engineer a table that identifies the lanes, wheel paths, and distance locations tested for each file created during the QA testing. Present the profile elevation data to the Engineer in an electronic format (via email or USB drive), as described in Section 6 of this test method.

Note 2—The Engineer will use the RIDE QUALITY program to calculate the IRI values and associated pay factors.

5.9 The Engineer will:

- compute a summary roughness statistic for each 0.1 mi. pavement segment. (This roughness statistic is the IRI.)
- calculate and record the IRI from each longitudinal line profiled for a pavement travel lane. (The payment schedule will be based on the average IRI calculated from both wheel paths in a travel lane.)
- calculate and record the locations of areas of localized roughness.

5.10 Calculate the pay adjustment for segment lengths less than 0.1 mi. and greater than 50 ft. as illustrated below:

$$Pay\ Adjustment = \$460 \times \left(\frac{0.075}{0.10} \right) = \$345$$

Where:

0.075 mi. = the length of the short section in this example

37 in./mi. = measured IRI in this example, and

$460 = the pay for a full 0.1 mi. section with an IRI = 37 in./mi.

6. TEST DATA DESCRIPTION AND FORMAT

6.1 *Standard Test Data:*

6.1.1 Report test data in mils and in an ASCII file. This will permit the Department to directly input profile data, collected with any inertial profiler, into its data reduction program for QA testing. Each record should be separated by a carriage return and line feed (CRLF). A comma should separate each header and data entry in a record. Section 6.2 illustrates the

required format of the data file. The following information provides a description of the required format, referred to as the TxDOT .PRO format.

6.1.1.1 *First Record*—consists of the following items, each separated only by a comma, with no blanks or spaces between items in the record:

- The first item is the identifier for the record. Write this item as HEAD3 in the data file as illustrated in Section 6.2.
- Date of profile measurement in mmddyyyy format, where mm is the numeric designation for the month, dd is the day, and yyyy is the year—zero fill the first digit for the months of January to September (01 to 09). Likewise, zero fill the first digit for days 01 to 09 of a given month.
- District where profile measurements were made in ## format—note that ## is the two-digit numeric designation for the given district. Zero fill the first digit for districts 01 to 09.
- County number in ### format—Zero fill the leading digits as necessary.
- Highway name in $$####$ format where "$" represents a character descriptor following PMIS convention—the first two characters designate the highway system, e.g., interstate, US highway, state highway, farm-to-market. Always fill in these characters, which may be any of the letters from A to Z, using upper case. Allow no blanks or spaces in the highway system designation. Zero fill leading digits as necessary in the highway name. The last character is a suffix. It is usually blank or N, S, E, or W (north, south, east, or west); for park roads, it can be blank or A–Z; for business routes it can be A–Z (except I and O).
- Beginning reference marker of the measurement in ####$±##.### format—zero fill the leading entries in the first four digits of the beginning reference marker as necessary. Likewise, zero fill the first digit following the + or – sign as necessary. The character following the first four digits is a suffix. It may be any of the letters A to Z, written in upper case, or a blank (space). Following the suffix is a + or – sign, indicating the relative direction of the offset, in miles, from the beginning reference marker. The offset is specified by the number following the + or – sign. As necessary, zero fill the trailing entries to the right of the decimal point in the offset, e.g., 0412 +05.300, not 0412 +05.3. Reference marker numbers range from 0010 to 0999. (The fourth digit is provided to accommodate future expansion of the highway system.)
- Lane tested in $# format following PMIS convention (see PMIS Lane Designations)—The first character designates the roadbed and may be any of the letters K, R, L, A, and X, written in upper case. It cannot be a blank or space. Fill in the digit following the first character that may take on a value from 0 to 9.
- Additional Notes—The Engineer can run a “List of Sections to be Rated” report in PMIS to obtain the correct highway and reference marker designations to be used for testing. The resulting profile data, once converted to PMIS format, can be stored in PMIS using Rating Cycle = ‘C’ (for Contractor).

6.1.1.2 *Second Record*—consists of the following variables, each separated only by a comma, with no blanks or spaces between variables:

- The first variable is the identifier for the record. Write this as CMET3 in the data file as illustrated in Section 6.2.
- Model designation of the lightweight profiler used for testing—this variable or item in the record may consist of 1 to 20 characters. Allowed entries are the letters A to Z, numbers 0 to 9, +, - , #, $, &, colon, dash, period, asterisk, tilde, underscore, forward slash, left parenthesis or bracket, and right parenthesis or bracket. Enter letters in upper or lower case. Do not allow blanks.
- The third, fourth, fifth, and sixth items in the record must show the profiler certification level (described in Section 8), profiler operator name, profiler serial number, and the long wavelength cutoff (ft.) for the high-pass filter used to determine the profile elevations recorded in the PRO file. Each of these items may consist of 1 to 20 characters. Allowed entries are the same as those identified for the model designation described above.
- The seventh item in the record is the certification code for the given profiler. The profiler certification code is the vehicle identification number (VIN) attached to the vehicle of the inertial profiling system. Allowed entries are the same as those identified for the model designation described above.
- The last item in the record is the certification date in mmddyyyy format. Zero fill the first digit for the months of January to September (01–09). Likewise, zero fill the first digit for days 01–09 of a given month.

6.1.1.3 *Third Record*—consists of the following variables, each separated only by a comma, with no blanks or spaces between variables:

- Manufacturer of the lightweight profiler—this variable or item in the record may consist of 1–20 characters. Allowed entries are the same as those identified for the model designation specified in the second record of the data file.
- The unit of elevation used to report profile—under the current Department practice, unit is entered as mil (0.001 in.), as shown in Section 6. Enter all three letters in lower case.
- The wheel path measured—designated as L for left, R for right, or LR for dual wheel path profilers, with no blanks or spaces separating the L and R in the LR designation. Note, L and R are relative to the direction of traffic on the lane surveyed. For dual wheel path profilers, report the relative elevations in left–right order. As a result, for dual wheel path profilers, always designate the wheel paths as LR.
- The reporting interval (distance between successive relative elevation measurements) in inches or meters—the maximum reporting interval is 2 in. (0.0508 m).
- The unit of the reporting interval item—either i = inch or m = meter. Write the unit in lower case.

6.1.1.4 *Fourth Record*— consists of the initial GPS readings corresponding to the starting location of the pavement section under test. GPS readings should conform to the WGS-84

standard and include the following variables, each separated only by a comma, with no blanks or spaces between variables:

- Latitude (Lat)—measured in decimal degrees to the sixth place.
- Longitude (Lon)—measured in decimal degrees to the sixth place with no implicit (-) on longitude output.
- Altitude (Alt)—elevation or height above sea level to the nearest foot.
- Heading (Hdg)—bearing information in degrees.
- Speed (Spd)—speed information in miles per hour (mph).

6.1.1.5 *Fifth Record*—reserve fifth record for text comments. The record can hold up to 80 characters.

6.1.2 The first five records of the ASCII data file are header cards. Following the fifth header record, report the relative measurements at each longitudinal location. For profilers that measure only one wheel path in a given run, each data record will have the relative elevation measured at the given location along the test wheel path followed by the comment code. In addition to this information, there will be data records with GPS readings corresponding to different locations along the test wheel path. The distance interval between GPS readings will depend on the sampling rate of the GPS receiver and the profiler test speed. As a minimum, collect GPS readings at a rate of 1 Hz. The GPS readings will follow the comment code and will include the latitude, longitude, altitude, heading and speed as described in Section 6.1.1.4. A comma will separate each variable in the data record. Make profile measurements in the direction of traffic. There will be as many records following the fifth header card as collected elevation measurements in the longitudinal locations.

6.1.3 For profilers capable of measuring two wheel paths in a travel lane at the same time with one pass, each data record will have the relative elevation measured using the sensors on the left side of the profiler, the relative elevation measured using the sensors on the right side, and the comment code. In addition, there will be data records with GPS readings as described in Section 6.1.2. A comma will separate each variable in the data record. Make profile measurements in the direction of traffic. For dual path profilers, set the spacing between wheel path sensors at 69 in. to be consistent with Department practice.

6.1.4 Comment codes will be a single numeric character from 0 to 9. There will be a comma separating this code from the last reported elevation at a given measurement location. Include elevation data with a code of zero in the determination of IRIs and pay adjustments. Exclude elevation data with non-zero comment code. Write the non-zero comment codes to the data file through the entire length of each “leave out” area. Likewise, write the zero comment codes through the entire length of each segment included in the pay adjustment calculations based on Surface Test Type B. Section 6.2 includes a sample data file.

6.2 *Example Profile Data File:*

Note 3—Line numbers to the left are only for description purposes and are not part of each record.

1. HEAD3,08242016,17,021,SH0047S,0413 +00.200,R1
2. CMET3,Profiler_Model,HMA,John Doe,1001,200.0,123456ABCDEF,07112015
3. Manufacturer,mil,LR,2.0,i
4. 23.785523,-98.232200,858,220,50
5. PRO file for project with GPS coordinates collected during the test
6. 412,303,0
7. 424,327,0
8. 411,342,0
9. 413,348,0
10. 396,349,0
11. 391,345,9
12. 395,343,9
13. 411,369,9
14. 422,376,9
15. 422,366,9
16. 398,379,9
17. 410,390,9
18. 407,361,9
19. 393,357,0
20. 398,365,0
21. 385,393,0
22. 394,399,0
23. 392,373,0
24. 405,366,0
25. 404,371,0
26. 417,371,0
27. 395,344,0
28. 366,332,0
29. 357,303,0
30. 328,272,0

31. 338,100,0,23.785533,-98.232209,857,222,50
32. 422,366,0
33. 398,379,0
34. 410,390,0
35. 407,361,0
36. 393,357,0
37. 398,365,0
38. 385,393,0
39. 394,399,0
40. 392,373,0
41. 405,366,0

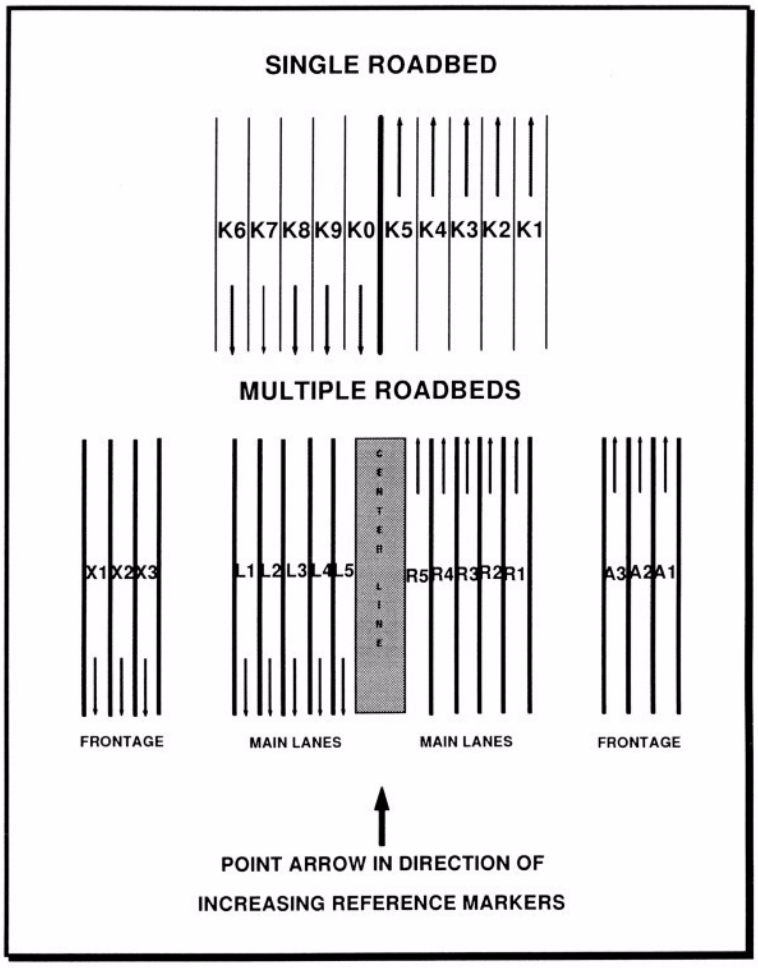

Figure 1—PMIS Lane Designations

7. DETECTING LOCALIZED ROUGHNESS

7.1 Using the RIDE QUALITY program, identify areas of localized roughness with the same measured profiles required for QA tests. The program will identify the defect locations and provide the defect magnitudes in the manner described in Section 7.2, except that the program will analyze and output the results by wheel path.

7.2 To determine the pay adjustments due to localized roughness, the RIDE QUALITY program will:

- average each elevation point from the two longitudinal profiles from a travel lane to produce a single averaged wheel path profile,
- apply a 25 ft. moving average filter to the single average wheel path profile,
- determine the difference between the averaged wheel path and the 25 ft. moving average filtered profiles for every profile point, and
- identify deviations greater than 0.150 in. as detected areas of localized roughness. (Positive deviations are "bumps," and negative deviations are "dips.")

7.3 The procedure implemented is a modification of the methodology described in the following reference: *Application of Profile Data to Detect Localized Roughness* by Emmanuel Fernando and Carl Bertrand, Transportation Research Record 1813, Transportation Research Board, Washington, D.C., 2002, pages 55–61.

8. INERTIAL PROFILER CERTIFICATION

8.1 This section provides minimum certification requirements for inertial profilers used for quality assurance testing of surface smoothness on Department paving projects where the profile-based smoothness specification is enforced. The Texas A&M Transportation Institute (TTI) administers the inertial profiler certification for the Department.

8.2 The certification procedure covers test equipment that measures longitudinal surface profile based on an inertial reference system mounted on an inertial transport vehicle such as that shown in Figure 2. The intent of minimum requirements stipulated herein is to address the need for accurate, precise, uniform, and comparable profile measurements during construction.

Figure 2—Illustration of a Lightweight Inertial Profiler Developed by the Department

8.3 *Minimum Requirements:*

8.3.1 *Operating Parameters:*

8.3.1.1 The inertial profiler must be capable of providing relative elevation measurements that meet the following requirements:

- Reporting Interval—the interval at which relative profile elevations are reported must be less than or equal to 2 in.
- Long Wavelength Cutoff —the algorithm for filtering the profile data must use a long wavelength cutoff of 200 ft. to be consistent with current Department practice.

8.3.1.2 The profiler must also be able to calculate and report the IRI (in./mi.) from the corresponding measured profile and permit the operator to:

- automatically trigger the start of data collection at the designated location;
- provide the measured profiles in electronic text files following the format prescribed by the Department in Section 6;
- evaluate profiler accuracy and repeatability as described in this document; and
- verify the height and distance measurements as described herein.

8.3.2 *Equipment Certification:*

8.3.2.1 On an annual basis, the inertial profiler must undergo certification tests to establish that it complies with the minimum requirements for accuracy and repeatability set forth in this test method. A profiler must also undergo certification testing after undergoing major component repairs or replacements as identified in this test method.

8.3.2.2 To monitor compliance with this requirement, an item will be included in the contract documents for a given project attesting that the contractor knows and understands the requirements for profiler certification as stipulated in this test method and that each profiler used on the project is current in its certification. Equipment certification involves

using the inertial profiler to collect profile data on test sections designated by the Department for this purpose. Before equipment certification, the owner of the profiler should verify the horizontal and vertical calibration of his or her equipment following the procedures given under Sections 4.3.2 and 4.3.3. Conduct this verification at the owner's facility to permit making necessary recalibrations before the scheduled date of certification testing.

8.3.2.3 *Profile Tests:*

- *Test Sections*—Certify profilers on test sections representative of the pavements on which the profiler will be used for ride quality assurance testing. Profiler certification is tied to the certification level the profiler successfully passed, as shown in Table 1. Each section will be 0.1 mi. in length. Make 10 repeat runs of the inertial profiler on the designated wheel path of each test section in the prescribed direction of measurement. To evaluate the profiles from the test equipment, measure the profile of the test wheel path on each section using static level methods.

Table 1—Inertial Profiler Certification Levels*

Profiler Certification Level	Hot-Mix Asphalt (HMA)			Portland Cement Concrete (PCC) Pavement		
	Dense-graded		Open-graded	Transversely-tined		Longitudinally-tined
	Smooth	Medium smooth		Smooth	Medium smooth	
HMA	X	X	X			
PCC2				X	X	
PCC1				X	X	X
HMA/PCC2	X	X	X	X	X	
HMA/PCC1	X	X	X	X	X	X

Note: The owner of the profiler will select the inertial profiler certification level for testing.

- *Test Data*—Refer to Section 6 for descriptions and formats of the .PRO files to be submitted from certification tests.

8.3.2.4 During the certification tests, the same wheel paths are profiled in the designated direction for all runs on a given test section. Operators of single-path inertial profilers will run each wheel path separately and provide test data by wheel path on each test section. To facilitate the analysis of the data, name the files from the tests described herein according to the following convention:

- Reserve the first 4 characters of the file name for identifying the profiler tested, provided by the testing agency, on or before the day of testing.
- The fifth character is an underscore,"_".
- The sixth, seventh, and eighth characters will be HMA for runs made on a hot-mix asphalt section, or PCC for runs made on a portland cement concrete section.

- The ninth character is the section ID for the given pavement type (HMA or PCC). The testing agency must provide the section ID, which will range from A to Z.
- The 10th and 11th characters will designate the run number (01–10).
- The 12th character will designate the wheel path tested. For dual path profilers, use the letter B to indicate profiling both wheel paths in the same run.; for single-path profilers, use L or R to indicate profiling the left or right wheel path, respectively, in the given run.

8.3.2.5 Use the extension .PRO for the data files generated from testing.

8.3.2.6 The testing agency will analyze test data submitted by the equipment operator to establish the repeatability and accuracy of the test profiles.

- *Profile Repeatability*—to evaluate profile repeatability, compute the variance of the 10 repeat measurements at each reporting interval for each wheel path surveyed. Determine the average variance, and take the square root of this statistic. To pass the profile repeatability test, the square root of the average variance must not exceed 35 mils on each wheel path.
- *Profile Accuracy*—the testing agency will establish the benchmark or reference profiles on the test section using static methods such as the rod and level, Dipstick, Walking Profiler, SurPRO, and/or other suitable devices that provide unfiltered profiles. Reference elevations will be collected at 2-inch intervals or less.
  - The testing agency will use devices that measure and integrate differential elevations, such as the Dipstick, Walking Profiler, and the SurPRO, to establish the benchmark profiles; however, the testing agency will check the measurements from these devices with the rod and level at distances along the test wheel path that are multiples of the reporting interval for the specific device used.
  - Collect rod and level measurements such that the sight distance between the level and the rod is no more than 100 ft. at each setup station. Collect reference profile measurements on the designated wheel path of each test section as well as on the section lead-in and lead-out. The lead-in distance will be at least 300 ft. The lead-out distance will conform to the profiler manufacturer's operating requirement.
  - Filter the reference profiles using the same filter type implemented with the profiler tested. For this purpose, the owner or manufacturer of the profiler will provide a Windows-compatible computer program to accomplish this filtering. The testing agency will use this program to filter the reference profiles for evaluating the accuracy of the measurements from the profiler. This program must be set up to permit use of a 200-ft. long wavelength cutoff and to read the reference profile from an ASCII or text file in the TxDOT .PRO format. Additionally, the program must output the filtered reference profile in an ASCII or text file in the TxDOT .PRO format. The testing agency will keep the executable copy of the filter program.

- Synchronize the test profiles as necessary so that the interval between reported elevations is the same as the interval between points in the filtered reference profiles. To evaluate accuracy, determine the average profile from the ten repeat runs on a given wheel path by computing the mean of the relative elevations from the ten repeat runs on a point-by-point basis, i.e., at each reporting interval. In the same manner, determine the average of the filtered reference profiles on the test wheel path. Use at least three repeat measurements for the determination of the average filtered reference profile. Calculate differences between the average test profile and the average filtered reference profile , point-by-point. Compute the average of these differences (μ_1) and the average of the absolute differences (μ_2) to establish the accuracy of the inertial profiler. To pass the accuracy test, the average of the point-to-point differences, μ_1, must be within ±15 mils, and the average of the absolute differences, μ_2, must not be greater than 50 mils for each wheel path tested.

8.3.2.7 The testing agency will determine the repeatability of the IRIs in the following manner:

- Compute ten IRI values using the profiles from the 10 repeat runs made on a given wheel path.
- For each test wheel path, compute the standard deviation of the IRIs.
- To pass IRI repeatability, the IRI standard deviation must not exceed 2.5 in./mi. on each wheel path tested.

8.3.2.8 The average of the IRIs is also determined for each wheel path. To evaluate the accuracy of the IRIs from the test data, compare the average IRI against the corresponding average determined from the unfiltered reference profiles. The absolute difference between the average IRIs from the profiler and the reference must not exceed 6.0 in./mi. for each wheel path tested.

9. TEST RESULTS

9.1 The testing agency will report the certification results by pavement type tested (HMA/PCC). The report will include the following information:

- identification of the profiler tested to include the model, profiling system serial number, and the vehicle identification number;
- operator of the profiler;
- names of the individuals from the testing agency who conducted the test;
- date of test;
- section and wheel paths tested;
- filter type, name of the filter program, and the applicable program version number used to evaluate the profiler accuracy;
- type of lasers installed on the inertial profiler;
- overall determination from the test: Pass or Fail; and
- individual test results determined from the profile data, which will include:

- the profile repeatability statistic;
- statistics, μ_1 and μ_2, for evaluating the accuracy of the profiles with respect to the reference;
- standard deviation of the IRIs computed from the profiles; and
- the difference between the average of the IRIs determined from the profiler test data on a given wheel path, and the average of the IRIs determined from the unfiltered reference profiles on the same wheel path.

9.2 The testing agency will determine the appropriate certification level based on the profiler's test results. For the profiler to be certified at the certification level the owner selected prior to testing, the profiler must pass on all test sections within that level; however, a profiler that fails on any one section may still be certified under a lower level if it passes on the test sections assigned to that lower level. Table 2 identifies the applicable cases. The testing agency will provide a decal showing the profiler certification level and expiration date (month and year) of the certification.

Table 2—Determination of Profiler Certification Level

Selected Profiler Certification Level	Profiler Performance on Test Sections	Assigned Profiler Certification Level
HMA	Fails one or more of the HMA test sections	No certification
PCC2	Fails one or more of the transversely-tined test sections	No certification
PCC1	Fails the longitudinally-tined section but passes all transversely-tined sections	Profiler certifies under PCC2
PCC1	Fails one or all transversely-tined sections	No certification
HMA/PCC2	Fails one or more of the HMA sections but passes all transversely-tined sections	Profiler certifies under PCC2
HMA/PCC2	Fails one or all transversely-tined sections but passes all HMA sections	Profiler certifies under HMA
HMA/PCC2	Fails one or more of the HMA sections and fails one or all transversely-tined sections	No certification
HMA/PCC1	Fails the longitudinally-tined section but passes all HMA and transversely-tined sections	Profiler certifies under HMA/PCC2
HMA/PCC1	Fails one or more of the HMA sections but passes all PCC sections	Profiler certifies under PCC1
HMA/PCC1	Fails one or more of the HMA sections and the longitudinally-tined section but passes all transversely-tined sections	Profiler certifies under PCC2
HMA/PCC1	Fails one or all transversely-tined sections but passes all HMA sections	Profiler certifies under HMA
HMA/PCC1	Fails one or more of the HMA sections and fails one or all transversely-tined sections	No certification

10. OPERATOR CERTIFICATION

10.1 Operators of inertial profilers used for QA testing of pavement ride quality must pass a proficiency test and be certified to operate an inertial profiler in Texas. The Texas A&M Transportation Institute administers the test for the Department. The test for inertial profiler certification will include the following:

- current specifications and/or special provisions for ride quality for pavement surfaces,
- Tex-1001-S, and
- verification of profiler calibration and collection of profile data.

10.2 Applicants for operator certification must pass both written and practical examinations.

10.3 The written examination will cover the following items.

10.3.1 *Ride Specifications.* Required documentation for equipment and operators:

- applicable areas profiled under Item 585 and Item 247 (flexible base ride specification) and
- quality assurance testing under Item 585 and Item 247.

10.3.2 *Tex-1001-S:*

- inertial profiler components,
- verification of profiler calibration,
- profile measurements with inertial profilers,
- profile data format, and
- inertial profiler certification.

10.4 The practical examination will cover the following areas:

- verification of profiler calibration and
- profile measurements.

10.5 To qualify as a certified inertial profiler operator in Texas, the applicant must:

- pass the written examination with a score of 70% or higher;
- pass the practical examination for verification of profiler calibration, demonstrated on the profiler operated by the applicant; and
- pass the practical examination for profile measurements, demonstrated on the profiler operated by the applicant.

10.6 The applicant will demonstrate that he or she can perform the horizontal and vertical calibrations described under Section 4. Additionally, the applicant will perform profile measurements along a given route established by the testing agency. The route will be at least 2,500 ft. long, with designated 0.1-mi. test sections and “leave-out” segment(s). The

applicant will profile the designated wheel paths of the test route in the specified direction following the procedures given in this test method. He or she will provide the test data in electronic files following the requirements stipulated in Section 6. For the practical examination, the applicant's performance is evaluated as passing or failing. The applicant must pass both areas of the practical examination and obtain a score of 70% or higher in the written examination to qualify as a certified inertial profiler operator in Texas.

10.7 Upon passing the proficiency test, the testing agency will give the successful applicant an identification card, which will verify the certification to operate an inertial profiler for QA testing on Department paving projects. The card will identify the specific types or brands of inertial profilers for which the operator certification is valid. This card will also specify the issue date and the expiration date of the certification. The Department has the authority to revoke the card before the expiration date because of misuse.

10.8 Upon expiration, recertification of the operator will require successful completion of another proficiency test as described in this Section for inertial operator certification.

11. ARCHIVED VERSIONS

11.1 Archived versions are available.