WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

GUIDE FOR USING A HIGH-SPEED INERTIAL PROFILER TO MEASURE THE LONGITUDINAL PROFILE OF PAVEMENT

1. SCOPE

1.1. This procedure establishes a process for collecting longitudinal profiles of roadways using a High-Speed Inertial Profiler (HSIP) equipped with laser height sensors. The HSIP shall be capable of collecting data at speeds between 15 mph and 65 mph. The collected data is analyzed to determine rate of smoothness or Ride Quality.

1.2. The rate of smoothness of the pavement is measured using the International Roughness Index (IRI) with units of inches per mile (in/mi).

2. PURPOSE

2.1. To establish a procedure for safe operation of a HSIP and the collection of quality pavement longitudinal profile data.

3. REFERENCED DOCUMENTS

3.1. AASHTO R 56: Certification of Inertial Profiler System

3.2. AASHTO R 57: Operating Inertial Profiler System

3.3. AASHTO M 328: Standard Specification for Inertial Profiling

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

4. EQUIPMENT REQUIREMENTS

4.1. The High-Speed Inertial Profiler (HSIP) must conform to AASHTO M 328 and have a minimum of two laser sensors and two accelerometers mounted in tandem with each wheel path laser. The lasers shall be mounted between 30 and 36 inches to the left and right of the center of the host vehicle. Other equipment can be added including, but not limited to, a third laser mounted on the center line of the host vehicle for rut evaluation. The HSIP shall be equipped with a data acquisition system that collects and stores elevation profile data and a Distance Measuring Instrument (DMI) for measuring traveled distance. The HSIP may also incorporate a Global Positioning System (GPS) unit. The host vehicle shall not exceed the axle loads specified by the vehicle manufacturer.

4.2. The HSIP shall be equipped with an automated triggering system capable of detecting a reference mark to start, stop, and event mark the data collection process.

4.3. All measuring requirements shall comply with AASHTO R 56. The resolution of the vertical measurement shall be a minimum of 0.001 inches. The accelerometer range shall be large enough to accommodate the levels expected from the bounce motions of the measuring vehicle. The DMI shall produce a sufficient series of pulses, the intervals which represent a distance along the traveled surface that would result in a resolution of less than or equal to 1.0 inch. The data acquisition system shall also operate at a sufficient speed and capacity in order to display the sensors' outputs in real time.

4.4. All electronic and mechanical components of the profiling system shall be adequately designed and built to meet or exceed the requirements set forth in AASHTO M 328.

5. SAFETY PRECAUTIONS

5.1. The HSIP, all attachments, and host vehicle shall comply with all applicable State and Federal Laws. Additional precautions shall be taken beyond those imposed by law to ensure the safety of all personnel and the general public. At minimum the following conditions must be followed when testing with a HSIP:

1. All test lanes must be free of any debris and obstructions.
2. Heavy acceleration and deceleration should be avoided while testing.
3. All lanes must remain open to traffic unless deemed unsafe.
4. Testing should not be done during peak traffic hours.
5. Testing should only be conducted at speeds recommended by the manufacturer.

6. CALIBRATION AND VERIFICATION

6.1. Calibration Locations

6.1.1. Distance Calibration Test Location – The test section(s) used to calibrate the distance measuring instrument (DMI) shall be tangent and require a minimum length of 528 feet with minimal grade. The test section should have little to no traffic with areas for the HSIP to turn around on either end. The test section shall include a minimum of 528 feet lead in and lead out sections as well as at least 528 feet for the calibration testing and verification. The pavement shall be free of standing water and debris during testing and calibration. The length of the test section shall be measured using a measuring wheel capable of measuring distances to the nearest 1.0 inch accuracy. The triggering mechanism (i.e. reflective tape) shall be placed at the beginning and end of the test section to signal the location of section limits.

6.1.2. Pre Operation Calibration and Verification – Pre-operation calibration and verification should be done on a flat and smooth surface while there is little wind. Pre-operation calibrations and verification includes:

1. Tire Pressure Check (Section 6.2.1)
2. Block Test (Section 6.2.3)
3. Accelerometer Calibration (Section 6.2.4)
4. Bounce Test (Section 6.2.5)

6.2. Calibration and Verification Procedures

6.2.1. Tire Pressure Check – The cold tire pressure shall be checked and maintained as set by the inertial profiler Manufacture. The check shall be performed before warm-up and according to Table 6.3.

6.2.2. Distance Check and Calibration – After checking the cold tire pressure and before calibrating the DMI, the tires and electronic equipment shall have enough time to warm-up as specified by the manufacturer. The operator shall measure the longitudinal distance traveled using the DMI on the HSIP on a test section measuring at least 528 feet with an accuracy of ±0.15 percent. If the measured distance is out of tolerance, (for a 528 feet test section the acceptable limits are ± .792 feet) the DMI must be recalibrated. The calibration passes shall be done at a constant speed above 15 mph by traveling the test section in three repeat passes or as recommended by the manufacturer. All passes should be done in the same direction as the section was measured. The passes must be auto triggered at the beginning and end of the test section. If the operator deems any pass questionable, such pass shall be discarded and the distance measurement repeated until sufficient number of runs with consistent accuracy is achieved. This calibration data and distance calibration factor shall be saved and used for distance data collection.

6.2.3. Block Test – Before completing the block test the accelerometer calibration shall be done while no one is inside the HSIP. The block test shall be performed according to manufacturer's procedures while meeting or exceeding the requirements outlined in AASHTO R 57. Using a minimum of three-gauge blocks that measure at three different heights. The thickness of each gauge block shall be measured at three different positions on each side of the block with a device capable of measuring to the nearest 0.001 inch. For each block, nominal thickness shall be determined as an average of the measurements made and recorded. The average distance between nominal thickness of the block and measured values for each block shall not exceed 0.01 inch. The equipment shall have the capability to display and report the error for the operator's acceptance. In the absence of manufacturer's procedures, the block check shall be performed as specified in AASHTO R 57.

6.2.4. Accelerometer Calibration – Prior to the accelerometer calibration, the HSIP shall be warmed-up as specified by the manufacturer Must be done according to manufacturer's procedures with operator and other personnel present for daily data collection seated in the HSIP.

6.2.5. Bounce Test – Prior to the Bounce test, the HSIP shall be warmed-up as specified by the manufacturer. In addition, the accelerometer calibration shall be completed while no-one is inside the HSIP and the vehicle's motor is turned off. The bounce test shall be performed by positioning the HSIP on a level and flat surface with no wind present. The HSIP's engine must be turned off with the emergency brake applied and with the transmission in park. In some cases, it may also be necessary to place tire chalks on either side of the front tires and a thin non-glossy surface, such as a sheet of paper placed under both wheel path lasers. The data shall be collected by simulating the DMI at the manufacturer's recommended speed. At minimum, data collection shall be performed with a 0.1 mile of lead-in, a 0.1 mile static portion of the test, a 0.5 mile bounce portion, followed by another 0.1 of static collection. During the bounce

portion, the laser sensors shall be vertically displaced in a smooth motion for a total displacement between 1 and 2 inches. The bounce test shall be analyzed using the IRI interval report with a segment length of 528 feet. The static portion of the test shall be less than 3 inches/mile and the bounce portion IRI results shall be less than 8 inches/mile. If the system fails to meet these requirements repeat this procedure three additional times. If thresholds cannot be achieved in all three interactions, contact the manufacturer for troubleshooting before additional testing is performed. The bounce test shall be done according to the schedule outlined in Table 6.3 After the bounce test is successfully completed and recorded, accelerometer calibrations shall be redone with operator and other personnel present for daily data collection seated inside the HSIP and done according to Section 6.2.4.

6.3. Frequency of Calibration and Test Procedures – The frequency of calibration procedures described in Section 6.2 shall be performed in accordance with Table 6.3 at minimum.

Table 6.3- Frequency of Calibration Procedures

Calibration Procedure	**Frequency**		
	Before Every Project	Daily	Weekly
Tire Pressure and Safety Lights (Section 6.2.1.2)		x	
Distance Calibration/Check (Section 6.2.1)			x
Accelerometer Calibration (Section 6.2.2)	x		
Block Test (Section 6.2.3)			x

7. OPERATOR AND EQUIPMENT CERTIFICATION

7.1. All HSIP operators must be certified by the West Virginia Division of Highways. To obtain certification or recertification, contact the WVDOH Quality Assurance Training Program Administrator at qaschoolscoordinator@wv.gov. Proof of certification must be available upon request.

7.2. The equipment must be certified at a facility approved by the Materials Control, Soils and Testing Division. Proof of certification must be available upon request. For more information contact the Pavement Analysis and Evaluation Section at DOHMCSnTRoadway@wv.gov.

8. DATA COLLECTION

8.1. Bring the HSIP to the desired speed and alignment prior to the section being tested. Speed should be maintained as constant as possible throughout the test.

8.2. Turn the Distance Measurement Instrument (DMI) on approximately 500 feet before the start of the test section.

8.3. At the beginning milepost of the project, reset the DMI and begin data collection.

8.4. After marking the end of the project, continue driving the lane that is being tested for a minimum of an additional 200 feet after the ending milepost and then turn the DMI off.

8.5. Do not test pavement if debris or standing water is present.

8.6. Perform testing per manufacturer's operating procedures.

8.7. It is recommended that areas that will be removed from analysis (bridges, intersections, etc.) be flagged and noted.

8.8. Areas where the HSIP is operated below the manufacturer's recommended operating speed shall be flagged and noted.

8.9. Raw data, equipment maintenance, and calibrations records shall be maintained in a logbook located within the host vehicle or on the data collection system and made available upon request.

8.10. The data shall be collected and exported with the 250-mm filter turned off.

9. ANALYSIS

9.1. All analysis shall be completed using the most recent version of ProVAL.

9.2. All applicable runs for the project shall be imported to one ProVAL file and renamed to reflect lane and direction (i.e: EB Traffic Lane)

9.2.1. The name of the project must be the Contract ID for the project followed by "RQ Analysis".

9.3. Unless otherwise noted, analysis should be done using Ride Quality analysis in a fixed interval length of 0.1 miles. Analysis shall be done for both the right and left wheel-paths as well as the average IRI of both wheel paths or Mean Roughness Index (MRI).

9.3.1. The 250mm filter shall be checked when running analysis.

9.4. The lead in/out sections, areas where the HSIP is operated below the manufacturer's suggested speed, as well the areas that are not part of the project shall be removed from analysis. The data shall be analyzed in accordance with WVDOH Specification 720.4 unless otherwise noted.

10. REPORTING AND SUBMITTING

10.1. All Ride Quality data for a particular project shall be submitted to the project engineer with the following information:

1. One ProVAL project with all data analyzed
2. Excel and .pdf Reports created from ProVAL
3. The WVDOH Road Profile Log Sheet completed for each project. Please see the WVDOH MCS&T Webpage[1] Toolbox for the most current version of the fillable form for the WVDOH Road Profile Log Sheet (non-fillable sample form is attached.)

10.2. All raw data does not need to be submitted, however shall be available upon request.

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MP 720.10.01 Steward – Pavement Analysis and Evaluation Section
MM:Aw
ATTACHMENT

[1] https://transportation.wv.gov/highways/mcst/Pages/tbox.aspx

West Virginia Department of Transportation

Project Road Profile Log Sheet

Contractor / Company Name: _____ Profile Operator Name and WV Operator ID. Number: _____

Federal Project Number: _____ State Project Number: _____

Profile Make: _____ Inertial Profiler Certifed by: _____ Date: _____

Contract ID: _____ County: _____ Route Number: _____

Bounce Test Performed (Date): _____ Block Check Performed (Date): _____ Check Long. Distance (Date): _____

File Name	Dir	Lane	Begin Mile Post	End Mile Post	Begin GPS (decimal)	End GPS (decimal)	Begin Physical Feature	Ending Physical Feature

Notes: WVDOH MCS&T Profile Log Location : https://transportation.wv.gov/highways/mcst/Pages/tbox.aspx