Standard Test Method for

Measurement of Pavement Rideability using the Dynatest 5051 Mark III Road Surface Profiler

SCDOT Designation: SC-T-125 (13)

1. SCOPE

1.1. This test method covers the operation of a high-speed inertial profiler for the purpose of measuring the longitudinal profile of a road surface and converting that profile to International Roughness Index (IRI).

1.2. This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCED DOCUMENTS

2.1. ASTM Standards:
E 950, Measuring the Longitudinal Profile of Traveled Surfaces with an Accelerometer Established Inertial Profiling Reference

2.2. Texas DOT Standards:
Tex-1001-S, Operating Inertial Profilers and Evaluating Pavement Profiles

2.3. FHWA Documents:
ProVal Software Users Guide, Current Edition

2.4. Other Documents:
Dynatest RSP Model 5051 Mark III Operation Manual

3. SIGNIFICANCE AND USE

3.1. This practice provides standardized procedures for measuring and reporting pavement rideability.

3.2. If the measurements are made and evaluated as stipulated herein, the resulting information may be used for acceptance testing of the rideability of new and rehabilitated pavement.

4. TERMINOLOGY

4.1. Definitions:

4.1.1. *Inertial Profiler* – In the context of this test method, a highway vehicle-mounted profiling

device manufactured by Dynatest International (Model 5051, Mark III) that uses at least two laser sensors to measure the distance between the road surface and a reference beam simultaneously in two wheelpaths. Accelerometers are used to calculate the vertical motion of the reference beam caused by suspension movement of the profiling vehicle, thus providing an inertial plane of reference.

4.1.2. *International Roughness Index (IRI)* – A quarter-car roughness statistic that predicts the cumulative suspension deflection of a simulated mechanical system with a response similar to a passenger car. For this test method, IRI is expressed in units of inches/mile.

4.1.3. *ProVal Software* – ***Pro***file ***V***iewing and ***A***na***l***ysis Software was developed under the sponsorship of the Federal Highway Administration (FHWA). It is used for viewing, analysis, and reporting of longitudinal road profile data generated by inertial profilers. This software is available free of charge and may be downloaded from www.roadprofile.com.

4.1.4. *Wheelpath* – In the context of this procedure, each lane to be tested is considered to have two wheelpaths. One wheelpath is located approximately 36 inches from the edge of the lane closest to the shoulder. The other wheelpath is located approximately 102 inches from the edge of the lane. If active lanes or shoulders border the tested lane on both sides, the wheelpaths are approximately located 33 inches from the lane centerline.

5. APPARATUS

5.1. *Inertial Profiler* – The inertial profiler shall be a Dynatest RSP Model 5051 Mark III 5.2G or better. If another device is used for referee purposes, it shall meet the requirements of ASTM E 950, Class 1 and shall be a regular production model of a type that has previously been certified by the Texas Transportation Institute under the Texas DOT's equipment certification program as eligible to perform quality assurance testing for Texas DOT and meets the requirements of Tex-1001-S. The profiler's distance measuring subsystem shall be accurate to within 2 feet per 528 feet of distance traveled. The profiler shall be capable of providing the required accuracy and precision at constant speeds ranging from 25 to 70 miles per hour. The profiler shall provide output in a computerized format that is readable by ProVal software.

5.2. *Vertical Verification Base Plate* – A stiff, flat, smooth metal plate approximately 12 inches by 12 inches. The plate shall provide a planar surface such that, when a vertical verification blank is placed on it, the blank does not rock and is in full contact with the surface.

5.3. *Vertical Verification Standards* – A set of three metal blocks, approximately 4 inches by 4 inches, of varying thickness. The nominal thicknesses of the blocks are 0.25 inches, 0.5 inches, and 1 inch. The actual thickness of the block, measured to the nearest 0.001 inch, shall be stamped on the side.

5.4. *Caliper* – A NIST-traceable caliper capable of measuring the thicknesses of the vertical verification blanks to the nearest 0.0001 inch shall be used.

5.5. *Horizontal Verification Test Section* – A straight, unobstructed test section of 528 feet. The test section shall be surveyed such that the beginning and ending markings are accurate to within 0.2 feet.

5.6. *Tire Pressure Gauge* – A tire pressure gauge with a digital readout to the nearest psi and a manufacturer's stated accuracy of 1 psi or better.

6. TESTING REQUIREMENTS

6.1. *Test Sections* – In order to be tested under this procedure, the following conditions must be met.

6.1.1. The profiler must be able to safely maintain a constant speed of at least 30 miles per hour throughout the test section.

6.1.2. Acceleration and braking areas of at least 200 feet are required at each end of the test section. If these areas are not available (such as at a "T" intersection) then the first and/or last 200 feet will not be included.

7. EQUIPMENT CALIBRATION

7.1. Perform the following checks on a daily basis prior to commencement of testing:

7.1.1. *"Bounce" Test* - Perform a bounce test to ensure that the accelerometers and sensors are functioning as detailed in the operator's manual for the profiler.

7.1.2. *Tire Pressure* – Check the cold tire pressure with a digital tire pressure gauge that measures at least to the nearest psi. Adjust all tires to the pressure indicated on the vehicle's tire placard.

7.2. Perform the following checks on a biweekly basis or whenever problems are suspected:

7.2.1. *Vertical Calibration Verification*

7.2.1.1 Park the vehicle on a flat and level surface. Under windy conditions, this procedure should be conducted indoors.

7.2.1.2 Place the base plate under the inertial profiler's non-contact height sensor. The inertial profiler's height measurement subsystem takes a height measurement. Record this measurement. This measurement will be used as the reference height for subsequent measurements.

7.2.1.3 Place the nominal 0.25-inch standard under the sensor. Record the height measurement. Verify that the new height measurement is equal to the reference height plus the actual thickness of the standard to the nearest 0.01 inch.

7.2.1.4 Remove the 0.25-inch standard and verify that the system returns to the reference height established in subsection 7.1.1.2.

7.2.1.5 Repeat steps 7.1.1.3 and 7.1.1.4 for the nominal 0.5 and 1-inch verification standards.

7.2.1.6 If the inertial profiler has more than two sensors, vertical calibration verification is only required for the wheelpath sensors unless the other sensors are being used to concurrently measure rutting.

7.2.1.7 If any of the sensors fail to indicate the proper height for the standards or fail to return to the original reference height, do not perform any testing until the cause of the discrepancy is found and repaired.

7.2.2. *Horizontal Calibration Verification*

7.2.2.1 While the tires are cold, check the tire pressures using a digital tire inflation gauge. Adjust the pressure of any tire that is out of tolerance from the pressure shown on the vehicle's tire inflation placard. Drive the vehicle at least 5 miles, of which at least 2 miles are at a speed of 60 mph or greater.

7.2.2.2 Navigate the profiler over a measured test section of 528 feet in length.

7.2.2.3 Verify that the inertial profiler's distance measuring subsystem measures the length of the test section within 2 feet of its actual length.

7.2.2.4 If the distance measuring system fails to measure the test section within the specified tolerance, adjust the subsystem according to the manufacturer's guidelines and repeat steps 7.2.2.1 through 7.2.2.3.

7.2.2.5 After adjustment, if the indicated distance is still outside of tolerance, do not perform testing until the distance measuring subsystem is repaired.

7.3. Perform the following checks every six months or whenever problems are suspected:

7.3.1. *Vertical Calibration Standards* - Check the vertical calibration standards using a suitable caliper and visually inspect to ensure that they are not worn or damaged. If the standard varies from the stamped thickness by more than 0.005 inches, it should be replaced.

7.3.2. *Accelerometer and Laser Sensor Calibration* – Calibrate the accelerometers and laser distance sensors as detailed in the Dynatest Operator's Manual.

8. LONGITUDINAL PROFILE MEASUREMENT

8.1. *Profiler settings*

8.1.1. *Data Collection* – The profiler shall be configured to record the actual elevation of the pavement surface. Do not use the profiler's internal IRI calculation mode.

8.1.2. *Filtering* – The profile data shall be filtered with a cutoff wavelength of 200 feet.

8.1.3. *Reporting Interval* – The interval at which relative profile elevations are reported shall be 1 inch.

8.2. *Speed* – Profiles may be recorded at any nominal speed between 30 and 65 mph, however the speed should be constant to within ± 3 mph of the intended speed and any required acceleration should be as gradual as possible. For example, if the intended speed were 30 mph, the acceptable range of speeds for testing would be 27 to 33 mph.

8.3. *DMI Triggering* – Two methods of DMI triggering are acceptable.

8.3.1. *Manual Triggering* – Manual triggering may be used when the profiler can be brought to a full stop before the beginning of a test section. A distance measuring wheel or other measuring device may be used to determine the appropriate distance at least 200 feet, but not more than 1000 feet, from the beginning of the test section. The profiler is then stopped on the measured point and the DMI is reset to the negative distance of the point. The profiler is then programmed to begin testing when the DMI reads 0. The profiler must be accelerated to the nominal testing speed prior to the start of the test section.

8.3.2. *Automated Triggering* – When the Manual Triggering mode is not practical, the automatic triggering method must be used. A tape stripe or traffic cone wrapped with reflective material may be used to alert the profiler's automatic triggering sensor to begin data collection. The automatic triggering mode does not have to be used to terminate data collection; the data collection may be stopped manually.

8.4. *Repeat Runs* – Unless otherwise specified, multiple runs are not necessary for data collection for quality assurance purposes.

8.5. *Structures and No-Test Areas* – Mark the limits of structures and other special areas to be excluded from testing using the profiler's event identifier such that the exact DMI locations can be extracted from the profile data file during processing.

9. DATA ANALYSIS

9.1. *Storage* – After testing, transfer the profile data in compressed format from the profiler portable computer's hard drive to the SCDOT's server for storage. Make certain that the server copy is readable and complete before erasing the original copy from the hard drive. Ensure that the file structure allows for easy reference. Maintain the data in the file in accordance with Departmental document retention policies.

9.2. *Calculation of IRI* – Detailed instructions on the use of ProVal software can be found in the ProVal Software Users Guide. Calculate IRI using ProVal software using the following general steps:

9.2.1. Load the profile data into ProVal and examine the profile trace for any unusual data or

other irregularities. Ensure that the unit system is set to “USCS”, distance units are “Miles”, and elevation units are “Inches”. Check to make sure that the “Use Point Reset” box is not checked. Note the locations of exclusions marked in the field.

9.2.2. From the Analysis menu, select “Ride Stats at Intervals”.

9.2.3. From the “Ride Stats at Intervals” window, select both wheelpaths. Ensure that the “Apply 250mm Filter” box is selected, the “Use Point Reset” box is not selected, Pre-Processor filter is set to “None”, vehicle velocity is 49.7 mph (i.e., 80 km/hr), and the segment length is 528 feet. Then, select the “Analyze” button.

9.2.4. After the analysis is complete, select the “Reports” window.

9.2.5. From the “Reports” window, select “Ride Stats at Intervals” and select the “Create” button.

9.2.6. When the report appears in the preview window, use the mouse to highlight the milepost and ride data. Then right-click and select “Copy” to copy the highlighted information to the Windows Clipboard.

9.2.7. Open Microsoft Excel and paste the information into a spreadsheet.

9.2.8. Delete the columns containing ride indices other than left wheelpath (LWP) and right wheelpath (RWP) IRI.

10. REPORT

10.1. Prepare a report of the results in a format essentially equivalent to that shown in Figure 1. Calculate the segment IRI as the average of the LWP and RWP IRI. Highlight all sections that exceed the target IRI value as given in the contract documents specific to the project. Also indicate any segment that contains a bridge or portion of a bridge or other excluded area. Report wheelpath IRI to the nearest 0.1 inches per mile. Report segment IRI rounded to the nearest whole number, rounding up if the decimal value if 0.50 or greater.

Profiler Quality Acceptance Data

File No.:	88.101B	**PIN:**	12345	**Lab No.:**	88.101BM1	**Road:**	I-96
County	Johnson	**Surface:**	OGFC			**Date:**	6/19/2006
RCE:	Ima R. Seee	**Contractor:**	Acme			**Status:**	Final

Note: The sections of roadway highlighted below DO NOT MEET contract requirements for rideability. When corrective measures are completed, please schedule additional profiler testing or otherwise notify the Materials and Research Engineer of final disposition of these sections.

From MP:	To MP:	Section Length:	IRI Left:	IRI Right:	Segment IRI:	Percent Payment	Notes:
	Inside Westbound Lane:						
37	36.9	0.1	36.2	38.4	37	1.05	
36.9	36.8	0.1	35.8	37.2	37	1.05	
36.8	36.7	0.1	36.3	34	35	1.05	
36.7	36.6	0.1	44.1	35.1	44	1.05	
36.6	36.5	0.1	52.6	54.1	53	1.01	
36.5	36.4	0.1	64.5	64.2	64	1	
36.4	36.3	0.1	71.8	70.5	71	0.9	
36.3	36.2	0.1	31.6	29.9	31	1.05	
36.2	36.1	0.1	33.6	32.1	33	1.05	
36.1	36	0.1	77	76.3	77	0.8	
36	35.9	0.1	46.2	46.5	46	1.03	
35.9	35.8	0.1	33.3	37.4	35	1.05	
35.8	35.7	0.1	38	32.9	35	1.05	
35.7	35.6	0.1	41.4	35.5	38	1.05	
35.6	35.5	0.1	69.2	68.5	69	0.95	
35.5	35.4	0.1	36.1	33.9	35	1.05	
35.4	35.3	0.1	31.5	33.1	32	1.05	
35.3	35.2	0.1	33.7	28.4	34	1.05	
35.2	35.1	0.1	41.4	34.4	41	1.05	
35.1	35	0.1	80.2	79.8	80	0.8	
35	**34.9**	**0.1**	**81.6**	**80.5**	**81**	**Review**	
34.9	34.8	0.1	47.2	46.5	47	1.03	
34.8	34.7	0.1	36	32.5	34	1.05	
34.7	34.6	0.1	36.4	34.2	35	1.05	
34.6	34.5	0.1	36.5	33.8	35	1.05	
34.5	34.4	0.1	41.5	40.5	41	1.05	
34.4	34.3	0.1	34.7	34.7	35	1.05	
34.3	34.2	0.1	103.7	98.6	101	N/A	Bridge
34.2	34.1	0.1	89.2	91.2	90	N/A	Bridge
34.1	34	0.1	39.6	39.1	39	1.05	
34	33.9	0.1	35.2	32.8	34	1.05	
33.9	33.8	0.1	38.9	32.8	39	1.05	
33.8	33.7	0.1	38.7	31.9	39	1.05	
33.7	33.6	0.1	38	36.6	37	1.05	
33.6	33.5	0.1	31.7	32.5	32	1.05	
33.5	33.4	0.1	32.4	31.4	32	1.05	
33.4	33.3	0.1	33	31.4	32	1.05	
33.3	33.2	0.1	35.1	33	34	1.05	

Figure 1 - Sample Profiler Report