

State of Nevada
Department of Transportation
Materials Division

**METHOD OF TEST FOR EVALUATION OF PAVEMENT RIDE QUALITY USING INERTIAL
PROFILING SYSTEMS**

SCOPE

This test method describes the procedure used for determination and verification of the ride quality of a pavement surface using an inertial profiler and Mean Roughness Index (MRI) as the quality measure and by using the International Roughness Index (IRI) to determine Areas of Localized Roughness.

EQUIPMENT

Use an approved inertial profiling system that meets the requirements of the Standard Specifications for Road and Bridge Construction.

EQUIPMENT CALIBRATION

Inertial profilers need to be calibrated prior to each use as required by manufacturer's recommendations.

The Inertial profiler equipment and host vehicle should be warmed up in accordance with the manufacturer's recommendations before beginning the calibration tests. Tire pressures on the host vehicle should be inflated to the tire manufacturer's specifications.

The calibration and/or verification procedure may vary somewhat from manufacturer to manufacturer. Review the operator's manual for the inertial profiler that is furnished in order to become familiar with the actual procedure.

The following is a guideline of typical calibration and/or verification tests to be performed for inertial profilers:

1. Accelerometer Calibration:

The accelerometer calibration is performed by placing the inertial profiler on a relatively level surface and allowing the accelerometer or accelerometers to stabilize. Next, follow the steps as

directed by the profiler's operating system. The profiler's software will determine whether or not the calibration was successful.

2. Longitudinal Distance Calibration:

The longitudinal distance calibration is performed by operating the inertial profiler on a straight and relatively level section of the roadway measuring at least 528 feet or 0.100 mile in length. The actual length of the test section will be measured using a temperature-compensated steel survey measurement tape, electronic survey instrument or other method as approved by the Engineer. The distance shown by the inertial profiler's computer display shall be within 0.10 percent of the actual length of the test section. If the distance measured is out of specification tolerance, adjust the inertial profiler's distance measurement subsystem in accordance with the manufacturer's specifications and perform the calibration test again.

3. Vertical Height Verification:

The vertical height verification is performed by placing the inertial profiler on a relatively level surface and placing first, a reference plate or plates, then a series of blocks of known thickness under the vertical height sensor. The reference plate or plates and blocks shall be provided by the inertial profiler manufacturer. Unless otherwise directed by the profiler manufacturer, complete the vertical height calibration by performing the following steps:

- a) Position the reference plate under the height sensor or sensors of the inertial profiler and allow the system to determine an elevation for the reference plate. Check to see that the plate rests solidly on the pavement surface in a relatively level position without any wobble before obtaining measurements. The reference plate should have adjusting bolts to allow for leveling.
- b) Position a 0.250 in. thickness block on top of the reference plate in the laser path beneath the height sensor and allow the system to determine an elevation to the top of the block.
- c) Remove the 0.250 in. thickness block from the reference plate and replace with a 0.500 in. thickness block and allow the system to determine an elevation to the top of the block.
- d) Remove the 0.500 in. thickness block from the reference plate and replace with a 1.000 in. thickness block and allow the system to determine an elevation to the top of the block.
- e) Remove the 1.000 in. thickness block from the reference plate and replace with a 2.000 in. thickness block and allow the system to determine an elevation to the top of the block.

If the inertial profiler is equipped with multiple vertical height sensors, this test shall be repeated for each sensor. Multiple sensors may be tested simultaneously if the profiler is equipped with enough blocks and plates and the inertial profiler's operating system allows for it.

Determine the difference between each measurement of each size of block and the average of ten measurements of the elevation of the reference plate to determine the thickness of each block as determined by the inertial profiler. Determine the absolute values of the difference between the measured thickness and the block known thickness. The average of the absolute differences for each block shall be less than or equal to 0.010 in. If the average of the absolute differences for each block exceeds specification tolerance, adjust the inertial profiler's height measurement subsystem in accordance with the manufacturer's recommendations and perform the calibration test again.

4. Bounce Test:

The bounce test is performed by placing the inertial profiler in a relatively level area, ensuring that the surface being referenced is smooth and free of significant defects or irregularities. If a smooth surface is not obtainable, the reference plates as used for the vertical height verification may be placed under the height sensors. Initiate a data collection run using the inertial profiler's normal data collection software operating at a simulated travel speed equivalent to approximately the midpoint of the profiler manufacturer's recommended range for acceptable data collection. The simulated collection run will be performed over a simulated distance of 2,184 feet. Once the simulated collection run is initiated, allow the inertial profiler to collect a static profile over a simulated distance of 828 feet with the host vehicle as motionless as possible. Next, move the sensors approximately 1-2 in. vertically by gently "bouncing" the host vehicle up and down for a simulated distance of 528 feet. Every effort should be made to limit forward/backward movement of the vehicle and to keep the sensors as close to perpendicular as possible during the vertical movement. Finally, allow the host vehicle to return to a motionless state and collect a static profile for the remaining 828 feet of simulated distance.

Once the simulated run is completed, save and analyze the simulated collection data using the profiler software for each profile collected. Ensure that the static portions of the simulated run result in an IRI of less than 3.000 in./mile and the dynamic or bounce portion of the simulated run is less than 8.000 in./mile.

A log of the results for calibrations and verifications shall be kept with the inertial profiler and made available to the Engineer upon request.

METHOD OF MEASUREMENT

PREPARATION FOR MEASUREMENT

1. Prior to operating the inertial profiler, ensure the roadway is dry and free of any debris.
2. Locate and mark the location of any exception or leave out areas. Ensure that all exception or leave out areas are accounted for prior to beginning the measurement process.
3. Mark the location of the beginning of the lead-in section and the location of the beginning of the measurement run. A lead-in section length of roadway surface of up to 450 ft may be required to allow the filters on the inertial profiler to stabilize before measurement begins so that the accuracy of the first 0.100 mi is consistent with the rest of the measured section. The operator should carefully consider the safety of the starting location when marking the beginning of the lead-in section.
4. Mark the location of the end of the measurement run and the end of the lead-out section. A lead-out section length of roadway surface of up to 450 ft may be required to allow the operator of the inertial profiler to maintain a constant speed at the point where the measurement ends, so that the accuracy of the last 0.1000 mi is consistent with the rest of the measured section. The operator should carefully consider the ability to stop the inertial profiler safely when marking the end of the lead-out section.
5. Set Analysis Parameters to report in Mean Roughness Index (MRI).
6. Input the segment length to 528 ft or 0.100 mile
7. Input a reporting interval of less than or equal to 1.000 in. for each measurement run.
8. Input filter settings as “None”.
9. Set Localized Roughness to read bump and dip defect data in International Roughness (IRI) with the maximum threshold as determined by the Special Provisions and a base length of 25 ft.
10. Enable collection of Global Positioning System (GPS) data for each measurement run of the inertial profiler.
11. Input the beginning location of the measurement run.
12. Select appropriate “measure up” or “measure down” setting for distance measurement.

LIMITATION OF MEASUREMENT

1. When the new pavement surface elevation is the same as the existing pavement surface elevation, mark the beginning of the measured section at least 15 ft before the beginning of the new section of pavement and mark the end of measured section at least 15 ft past the end of new section of pavement. This measured section is intended to include the take-off and/or landing joints in the evaluation of ride quality.
2. When the new pavement surface elevation does not match the existing pavement surface elevation, mark the beginning of the measured section at least 15 ft past the beginning of the new section of pavement and mark the end of the measured section at least 15 ft before the end of the new section of pavement. This measurement is intended to exclude the takeoff and/or landing joints in evaluation of ride quality due to the disparity in elevation.

MEASUREMENT

1. Move the inertial profiler to the beginning of the measurement section.
2. Proceed with measurement as directed by the inertial profiler manufacturer. Measurement data shall be obtained in the same direction as the normal flow of traffic.
3. Measure Profiles within each traffic lane with the left or right side sensor path at 3 ft from and parallel to the respective left or right traffic lane line. The spacing between sensor paths shall be between 66 in. and 72 in.
4. Stop measurement at any exceptions or leave out areas. Resume measurement using the correct location as indicated on the other end of the exception or leave out area. Repeat this process as needed to complete the measurement run.
5. Re-measure any pavement segment where the travel speed of the profiler is outside of the manufacturer's recommended operational speed at any point during the measurement, or if any operator and/or equipment errors are encountered during the measurement process.
6. Upon completion of measurement run, move the inertial profiler to a safe location, then save any relevant data to a file using an approved unfiltered electronic format that can be easily retrieved for review and submittal. The profile data must be compatible with ProVAL Pavement Profile Viewing and Analysis software. ProVAL is produced by the Transtec Group in cooperation with the Federal Highway Administration and is available for download by going to <http://www.roadprofile.com/>.
7. Submit the saved profile data to the Engineer within 24 hours of the completion of the measurement.

8. Include the following within the submitted electronic profile data:
 - Raw profile data for each lane measured.
 - Ride quality analysis report of MRI for overall run of each lane measured.
 - Localized Roughness report for each wheel path of each lane measured.
 - GPS data file for each lane measured.
 - Current calibration and verification test results.

9. In addition to the electronic format file, a printout of the report of calibration for the profiler, the results of a measurement run and evaluation, and a printed summary report shall be provided to the Engineer within 24 hours of the completion of a measurement run. The printed report shall be in a .pdf format.

EVALUATION OF PROFILES

1. Evaluate the entire length of the profile measurement section for compliance with MRI requirements found in the Special Provisions for the pavement being measured with the following exceptions:
 - Do not evaluate any measurements obtained within the lead-in and lead-out sections.
 - Do not evaluate any measurements obtained within 15 ft of a cattleguard or some other break in the continuous pavement surface.
 - Do not evaluate any measurements obtained within 15 ft of a concrete bridge deck (including approach slabs) unless the bridge deck also is to be overlaid with a new riding surface.

EVALUATION FOR AREAS OF LOCALIZED ROUGHNESS

1. Analyze the submitted profile data to determine any areas of IRI - Localized Roughness in excess of specification tolerances found in the Special Provisions for the pavement surface being measured.
2. Create a summarized list of areas that are in excess of the limits for IRI – Localized Roughness. Upon request, submit the summarized list to the Contractor for their review and determination of the best method of correction for the defective areas.

REPORTING

1. The following information shall be submitted with the printed inertial profile report:
 - Name of data file.
 - Contract or Project No.
 - County.
 - Contractor.
 - Highway or route no.
 - Surface being tested.
 - Date of placement.
 - Date of testing.
 - Direction of traffic (northbound, eastbound, southbound, westbound).
 - Direction of placement (northbound, eastbound, southbound, westbound).
 - Lane designation (1, 2, 3...Inside, Outside, Middle, etc.).
 - Name of Tester.
 - Calibration results.
 - Filter settings.
 - Localized Roughness settings.
 - Summary Report of Mean Roughness Index for each 0.1 km (0.1 mi) segment.
 - Certification of the report by the profiler operator.
 - The title of the person certifying the report.

2. The following information shall be submitted with the report of any Areas of IRI - Localized Roughness Including:
 - A list of exception or leave out sections.
 - A list of any IRI - Localized Roughness defects in excess of specification limits.

3. Measurements are to be reported using project mileposts as appropriate. A list of project mileposts will be provided on the project plans.

4. Report the MRI and IRI in./mi to the nearest 0.001 in.

5. Report each 528 ft or 0.1 mi section to the nearest 0.001 mi.

NOTES

1. Review inertial profiler operating manual to familiarize yourself with the equipment that will be used.