LONG TERM PAVEMENT PERFORMANCE PROGRAM DIRECTIVE

For the Technical Direction of the LTPP Program

Program Area:	Monitoring	Directive Number:	P-12
Date:	September 13, 1996	Supersedes:	n/a
Subject:	New/Old Profiler - Dipstick Comparison Tests		

This directive presents guidelines on the conduct of a comparison of the new profilers, old profilers, and Dipsticks used to measure longitudinal profile for the LTPP program. The thrust of these comparisons is to provide base-line data on which differences in the measurements provided by each device under representative field operating conditions can be assessed.

Overview

The following process shall be followed:

1. Locate and mark test sections.
2. Prior to commencement of profile testing with the profilers, perform the following initial calibrations:
   - calibrate DMI on the DMI calibration test section
   - calibrate static height sensors
   - calibrate accelerometers
3. Within a two-week (14-consecutive day) period (weather permitting), perform the following profile measurements:
   - longitudinal Dipstick measurements - 1 measurement per test section
   - longitudinal profiler measurements - 3 measurement sequences, 1 sequence per day on each test section
4. On each profiler measurement day, perform the following:
   - one measurement sequence on the DMI test section
   - static height measurements
   - all calibration checks required for normal profile operations

Test Sections

Four profile and one DMI test section shall be used. Where convenient, one of the profile test sites maybe used for the DMI test section.

Profile Test Sections

The four profile test sections shall have the following attributes:

- Section 1 (AC-1): Asphalt concrete pavement structure with an IRI <1.600 m/km (100 inches/mile)
- Section 2 (AC-2): Asphalt concrete pavement structure with an IRI > 2.200 m/km (140 inches/mile)
- Section 3 (PCC-1): Jointed portland cement concrete pavement structure with an IRI < 1.600 m/km (100 inches/mile)
- Section 4 (PCC-2): Jointed portland cement concrete pavement structure with an IRI > 2.200 m/km (140 inches/mile)
- The asphalt concrete pavement sections shall be reasonably consistent with the criteria for GPS 1, 2 and 6 test sections. AC overlays on PCC pavements shall not be used.
- The jointed PCC test sections shall be reasonably consistent with GPS 3 and 4 guidelines. PCC overlay test sections shall not be used.
- The test sections shall have a marked outside lane edge stripe that can be used as an outside lane edge reference.
- All test sections shall be located on flat tangent sections with sufficient length at each end to allow for acceleration to a constant speed prior to the section and safe deceleration past its end.
- Each test section shall be 152.4-m (500-ft) in length, with the beginning and end mark in compliance with LTPP test section marking guidelines. (There is no need for marking internal station locations.)
- Where possible, test sections should be located within a centralized locale with short travel distances between each test section to reduce travel time.
- Test sections do not have to be located on LTPP test sections; however, LTPP test sections can be used when convenient.

DMI Test Section

An accurately measured section, 305-m (1,000-ft) long, shall be used as the DMI test section. A standard surveying tape, or equally accurate electronic method, shall be used in conformance with standard surveying practice to accurately locate the end point relative to the start point. The DMI test section shall be located on reasonably level pavement suitable for such testing (i.e. low traffic volume, adequate sight distances, operator safety, etc.).

Dipstick Measurements

Dipstick measurements shall be performed using non-automated procedures in compliance with LTPP Directive P-9. These measurements shall be performed within 14-days of the profiler measurements. On PCC test sections, the Dipstick measurements shall be performed at the same approximate time of day as expected for conduct of the profiler measurements. Only one set of Dipstick measurements, satisfying the P-9 Directive, are required on each profile test section.

Profiler Measurements

Coupled sets of new and old profiler measurements shall be performed on each test section on the same day. Where possible, two operators should be used so that nearly concurrent measurements can be made with a minimum time lag between new and old profiler measurements. Alternating new/old profiler measurements should be conducted. On each profile survey day, routine checks and measurement procedures shall be performed in accordance with current LTPP operational field guidelines for profile measurements, protocols and directives, except as follows:

- All data processing, including data from the Dipstick, old and new profilers, shall be performed using the PROQUAL v2.0 software.

- It is desired that a single measurement sequence be performed on each test section on three consecutive days (weather permitting). The measurement sequences should be performed at the same approximate time of day, particularly on the PCC test sections. Each measurement sequence shall consist of two run sets; one set of runs at 56-kph (35-mph) and the other at 80-kph (50-mph). However, if severe overriding operational considerations make this infeasible, then it is permissible to perform all 3 measurement sequences on the same day on three of the test sections. However, on at least one test section, preferably one of the PCC sections, the 3 measurement sequences shall be conducted on consecutive days.

- The number of runs to include in each run set shall be determined in accordance with standard LTPP practice on acceptability of runs as contained in section 2.2.4 Number of Runs, **Manual for Profile Measurement: Operational Field Guidelines,** Report SHRP-

P-378, Strategic Highway Research Program, National Research Council, Washington, DC, 1994.

- In the North Central region, the height sensor locations on the new profiler shall **not** be moved to match with the spacing on the old profiler for the conduct of the initial set of tests. The profiler drivers should attempt to match right wheel path locations and not sensor paths. If, after analysis of all of the Profiler measurements, it is found that the bias between the mean IRI computed from old and new profiler measurements, is $t > \pm 2.78$ **and** the difference between the mean IRI from each device is greater than ±6.5% of the larger value, on all test sections, then the height sensors on the new profiler should be set to the same approximate location, relative to the right wheel, as those on the old profiler, and all profiler measurements repeated.

DMI Calibration and Measurements

Immediately preceding conduct of profiler measurements, an initial DMI calibration shall be performed on each vehicle's DMI following the appropriate procedures relative to each vehicle. The DMI calibration factor should be reset to the computed value for this calibration if it is outside the stated tolerances. On each day that profiler measurements are performed, perform one measurement sequence on the DMI test section. The DMI measurement sequence shall consist of six repeat consecutive measurements. The DMI calibration factors computed as a result of these measurements should be reset if they are found to be outside of the tolerances. A log should be kept on the results of all distance measurements conducted on the DMI test section, and any changes to the DMI calibration coefficients.

Static Height Sensor Calibration and Measurements

Immediately preceding the conduct of profiler measurements, static calibration of the height sensors shall be performed. These calibrations shall be performed indoors. On each profiler measurement day, static height sensor measurements shall be performed using the base plate, top leveling plate, and one of the calibration blocks provided with the new profiler. These measurements should also be performed indoors, or in a location adequately sheltered from wind and other climate effects. Static measurements shall be performed for the following four positions:

Position 1. Base Plate + Block 1 (75 mm vertical) + Leveling Plate

Position 2. Base Plate + Block 1 (50 mm vertical) + Leveling Plate

Position 3. Base Plate + Block 1 (25 mm vertical) + Leveling Plate

Position 4. Base Plate + Leveling Plate

The average and standard deviation resulting from the measurements performed at each height shall be recorded and used for later analysis.

Accelerometer Calibration

At the same time that the static height sensors are calibrated prior to the start of profile measurements, the accelerometer on each profiler shall also be calibrated following standard procedures. All calibration shall be performed indoors. On each profile measurement day, accelerometer calibration checks shall be performed in accordance with standard LTPP guidelines. During this test period, the accelerometers should only be recalibrated if they are found to fall outside of tolerances.

Report

Within 30-days after completion of the comparison testing, but prior to commencing LTPP profiler data collection with the new Profilers, a report shall be submitted to the FHWA LTPP Office containing the following information:

Test Section Description:	Provide a description of the pavement test section location, physical and structural attributes, distress condition, and type of facility. Detail should be given on those attributes of the test section which are suspected of influencing the profile measurements, such as meandering cracks in the wheel paths, highly variable transverse profile, etc. Detailed measurements are not required. Subjective based descriptions are satisfactory.
Equipment Description:	Provide a brief description of the equipment used for the various measurements performed. In addition to the profile instrument, included a description of the distance measurement device used on the DMI test section.
Test Procedure:	Provide a calendar and summary description of all tests performed and procedures used.
Test Results:	Provide tables containing the following information based on statistics computed using the PROQUAL v2.0 software for the five runs that would have been normally selected for upload to the LTPP IMS in accordance with standard procedures: 1. IRI summary table - for each test section, measured IRI values in each wheel path, average and standard deviation of the measurements conducted at the same speed on the same day.

2. DMI measurements table - for each test date, individual length measurements of DMI test section and average and standard deviation from the five individual runs.

3. Static height sensor measurements table - for each test date, average of 200 readings for the six required positions and calculated height of blocks for Positions 1 through 3. (Note: subtract average of readings for Positions 1 through 3 from average of readings for Position 4 to determine measured block heights).

Format requirements for each table are are presented in Table 1-IRI Summary, Table 2-DMI Measurements, and Table 3-Static Height Sensor Measurements.

Analysis of Results: Review the results summarized in Tables 1 through 3 and compare with the following bias and precision criteria:

IRI Values

Bias:	± 0.16 m/km relative to Dipstick value
Precision:	2F # 0.08 m/km

DMI Values

Bias:	# 0.05% over 305-m (1,000-ft) test section
Precision:	2F # 0.05% over 305-m (1,000-ft) test section
t-test:	five-sample bias from absolute distance measurements should be within confidence limits of -2.78 # t # 2.78

Static Height Test Values

Bias:	± 0.25 mm
Precision:	2F # 0.25 mm

On completion, discuss the results of the review and comparison; i.e., do all units yield similar IRI values on both wheel paths?, has the bias and precision criteria specified above been met?, etc.

Other Data and Files: Provide all files paper work normally required for field profile operations, including Profiler Field Activity Report, Profiler Calibration Log, Daily Check List, Major Maintenance or Repair Report (during the test period). Also submit printed out and computer files generated by the PROQUAL software and, for the new profilers, the on-board profiler software. Also submit profiler calibration log files from the new profiler.

Raw Data: Submit the collected raw data on diskette. Provide documentation permitting identification of data files with device and measurement date. A copy of all data and forms from these tests shall be kept at the RCOC offices for future reference.

The length of the report shall be kept to a minimum unless major problems are encountered. If major problems are encountered, they shall also be reported using the profiler problem report (PROFPR) form. **ALL RESULTS SHALL BE REPORTED IN SI (METRIC) UNITS**.

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Table 1. IRI Summary

Test Section ID: _____ Test Speed: _____ (KPH)

Profiler Unit	Survey Sequence	Survey Date	IRI Value (m/km) -- Left Wheel Path										
			Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Average	Std. Dev.
Dipstick	4												
Old Profiler	3												
New Profiler	1												
	2												
	4												

Profiler Unit	Survey Sequence	Survey Date	IRI Value (m/km) -- Right Wheel Path										
			Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8	Run 9	Average	Std. Dev.
Dipstick													
Old Profiler	1												
	2												
	3												
New Profiler	1												
	2												
	3												

Notes: (1) report IRI values to the nearest 0.001 m/km.
(2) although space is provided in the above table for nine separate runs, the actual number of measurements shall be performed in accordance to standard LTPP procedures.
(3) recommended bias is $\pm$ 0.16 m/km relative to Dipstick value and precision is 2-Std.Dev. < 0.08 m/km.

Table 2. DMI Measurements

Test Section ID: DMI Test Section

Profiler Unit	Sequence Number	Measurement Date	Section Length (m)						
			Run 1	Run 2	Run 3	Run 4	Run 5	Average	Std. Dev.
Old Profiler	4								
	3								
	2								
	3								

Table 3. Static Height Measurements

Test Date: _____

Profiler Unit	Position	Left Sensor		Middle Sensor		Right Sensor	
		Avg. of Readings	Block Height	Avg. of Readings	Block Height	Avg. of Readings	Block Height
Old Profiler	4						
	3						
	2						
	1						
New Profiler	4						
	3						
	2						
	1						

Notes: (1) report height measurements to the nearest 0.01 mm
(2) recommended bias is $\pm$ 0.25 mm and precision is 2-Std.Dev. < 0.25 mm