Long-Term Pavement Performance Program Manual for

Profile Measurements and Processing

FOREWORD

The Long-Term Pavement Performance (LTPP) program is a study of pavement performance at nearly 2,500 in-service pavement sections in the United States and Canada. LTPP's goal is to improve pavement performance and cost-effectiveness.

Toward accomplishing these objectives, LTPP is collecting data on in-service pavement sections over a 20-year period. The data collected at the test sections are stored in the LTPP Pavement Performance Database (PPDB). These data are being used and will continue to be used to achieve the goal and objectives of the LTPP program.

This manual describes operational procedures to be followed when measuring longitudinal pavement profiles for the LTPP program using the International Cybernetics Corporation (ICC) road profiler, Face Company Dipstick®, and the rod and level. This manual also describes procedures to be followed in the office when processing profile data that were collected in the field as well as guidelines for performing interregional comparison tests among the four LTPP profilers.

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16. Abstract
This manual describes operational procedures for measuring longitudinal pavement profiles for the Long-Term Pavement Performance (LTPP) Program using the International Cybernetics Corporation (ICC) road profiler, Face Company Dipstick®, and the rod and level. It also contains procedures for measuring transverse profiles of the pavement using the Face Company Dipstick®. Procedures for calibration of equipment, data collection, record keeping, and maintenance of equipment for each of these profiling devices are described in this manual. This manual also describes procedures to be followed in the office when processing the profile data that were collected in the field as well as guidelines for performing inter-regional comparison tests among the LTPP profilers.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact degrees)				
^oC	Celsius	1.8C+32	Fahrenheit	^oF
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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LIST OF ABBREVIATIONS

AC	Asphalt Concrete
ACF	Accelerometer Calibration Factor
AIMS	Ancillary Information Management System
DCF	Distance Calibration Factor
DMI	Distance Measuring Instrument
FHWA	Federal Highway Administration
GPS	General Pavement Studies
ICC	International Cybernetics Corporation
IRI	International Roughness Index
LTPP	Long Term Pavement Performance
PCC	Portland Cement Concrete
PPDB	Pavement Performance Database
RSC	Regional Support Contractor
SHRP	Strategic Highway Research Program
SMP	Seasonal Monitoring Program
SPS	Specific Pavement Studies
TSSC	Technical Support Services Contractor
WIM	Weigh-in-Motion
UPS	Uninterruptible Power Supply

CHAPTER 1. INTRODUCTION

1.1 OVERVIEW OF THE LTPP PROGRAM

The Strategic Highway Research Program (SHRP) was a five-year research program that had a budget of $150 million and began in 1987. The research areas targeted under SHRP were asphalt concrete (AC), pavement performance, portland cement concrete (PCC) and structures, and highway operations. SHRP's Long Term Pavement Performance (LTPP) program was the first ever effort to study pavement performance in different climates and soil conditions at nearly 2,500 in-service pavement sections in all 50 States of the United States and in participating provinces in Canada. The LTPP program was designed as a 20-year study. The first five years of this program from 1987 to 1992 were administrated by SHRP, and since 1992, this program has been administrated by the FHWA.

For purposes of pavement data collection and coordination, the United States and participating Canadian provinces have been subdivided into four regions—North Atlantic, North Central, Southern, and Western—each served by a Regional Support Contractor (RSC). The boundaries defining the jurisdiction of each RSC are shown in figure 1.
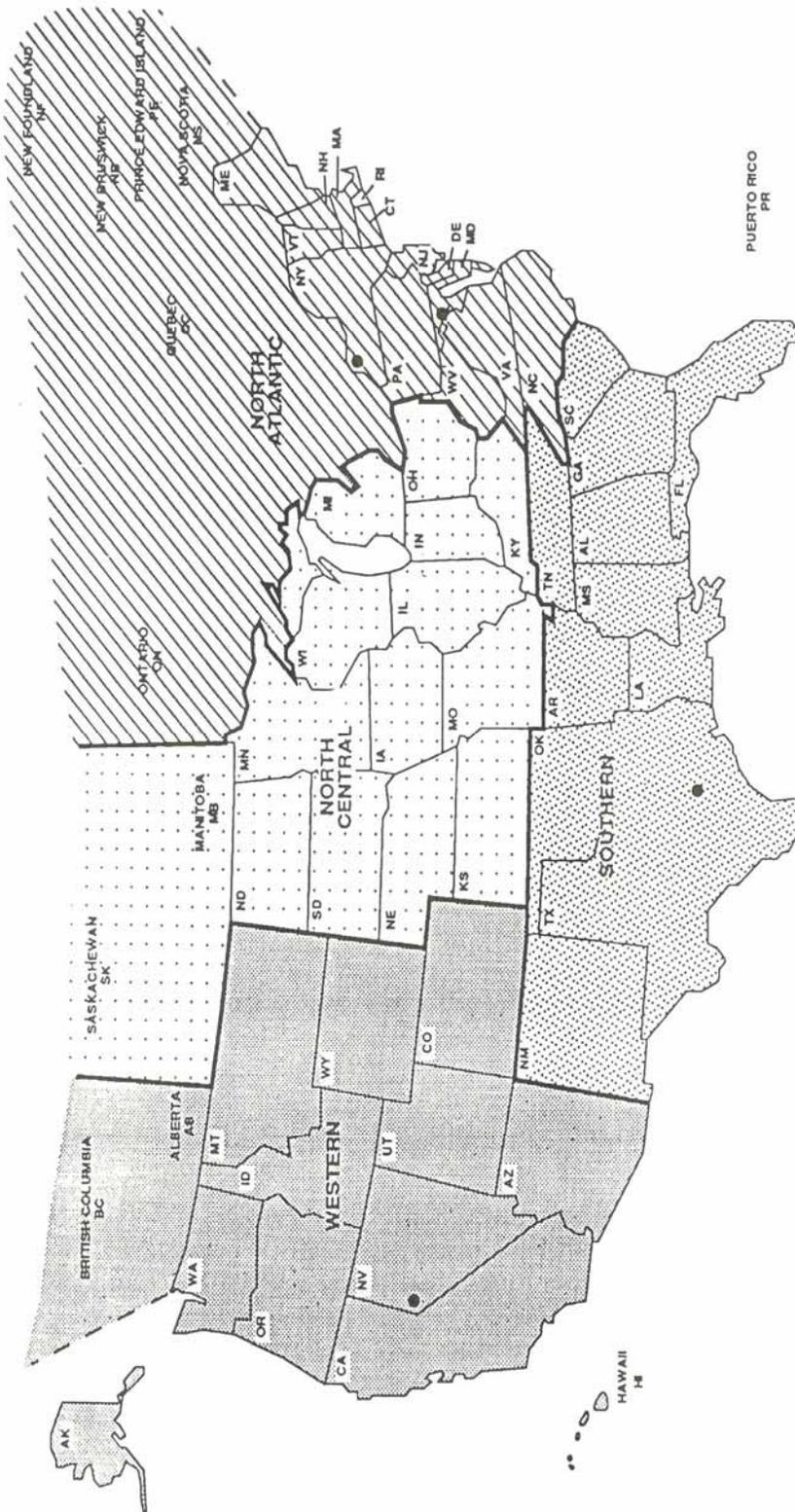
Figure 1. Map. LTPP regions.

1.2 SIGNIFICANCE OF PAVEMENT PROFILE MEASUREMENTS

The longitudinal profile along the wheel paths in a pavement can be used to evaluate the roughness of the pavement by computing a roughness index such as the IRI. The change in longitudinal pavement profile over time, which is directly related to the change in roughness with time, is an important indicator of pavement performance. Hence, one aspect of the LTPP program is to collect pavement profile data at in-service pavement sections for use in many applications such as improving the prediction of pavement performance.

1.3 PROFILE DATA COLLECTION

The primary method used to obtain pavement profile measurements for the LTPP program is to profile test sections using a road profiler. Each RSC operates a profiler to collect data within its region. From the inception of the LTPP program until the end of 1996, profile data at test sections were collected using a model DNC 690 inertial profiler manufactured by K. J. Law Engineers, Inc. In late 1996, each RSC replaced their model K.J. Law DNC 690 profiler with a Model T-6600 inertial profiler manufactured by K. J. Law Engineers, Inc. In September 2002, each RSC replaced their K. J. Law T-6600 profiler with an ICC MDR 4086L3 inertial profiler. The operation and maintenance of the profiler and storage of collected data are the responsibility of each RSC.

When a profiler is not available, LTPP has elected to use the Dipstick®, which is a hand operated digital profiler manufactured by Face Company, as a backup device to collect longitudinal profile data. The Dipstick® is also used also to obtain transverse profile data at most sites. The North Atlantic, North Central, and Western RSCs are in possession of three Dipsticks®, while the Southern RSC has two Dipsticks®. A rod and level can be used to measure pavement profiles if a profiler or a Dipstick® is not available, or where other special circumstance or requirements rule out the profiler or the Dipstick®. However, this method is very labor intensive and is not typically used within the LTPP program.

1.4 OVERVIEW OF THE MANUAL

This manual describes procedures to be followed when measuring pavement profiles for the LTPP program using the ICC road profiler, the Dipstick®, and the rod and level. Procedures for calibration of equipment, data collection, record keeping, and maintenance of equipment for each of the profiling devices are described in this manual. This manual also describes procedures to be followed in the office when processing profile data collected in the field as well as guidelines on performing interregional comparison tests among the four LTPP profilers.

This document addresses those aspects of profile measurements that are relatively unique to the LTPP program. Other references (see references 1 to 14) should be consulted for general information.

CHAPTER 2. PROFILE MEASUREMENTS USING ICC PROFILER

2.1 INTRODUCTION

The ICC MDR 4086L3 profiler is a modified cargo van that is equipped with specialized instruments to measure and record road profile data. The MDR 4086L3 profiler contains three laser height sensors, an accelerometer located above each laser height sensor, a longitudinal distance measuring transducer, a computer system, signal conditioning electronics, and power control equipment. The three laser height sensors are mounted on a sensor bar that has been installed on the front of the vehicle. One sensor is located at the center of the vehicle, while the other two sensors are located along each wheel path. The longitudinal distance measuring transducer is mounted on the differential of the vehicle, and measures the distance traveled by the vehicle.

Laser height sensors measure the distance from the sensor to the road while the accelerometers measure vertical acceleration. Signals from the laser height sensors, accelerometers, and distance measuring instrument (DMI) are fed into a computer, which computes the profile of the pavement along the path traversed by each laser height sensor. Profiles along the paths traversed by the three sensors are displayed on the computer monitor during profile measurement. Data recorded by the height sensors, accelerometers, and DMI are stored in the hard disk of the computer. These data can be processed to obtain the profile along the path that was traversed by each sensor.

The profiler is also equipped with two photocells. One photocell is mounted vertically to sense reflections from pre placed marks on the road surface. The other photocell can be rotated around a horizontal axis, and can be positioned so it can sense reflections from pre placed cones with reflective markings that are placed on the side of the road. The photocell is used to perform a reference reset when it is triggered, and the location where it is triggered is stored in an event file. The profile vehicle is also equipped with both a heater and an air conditioner to provide a uniform temperature for the electronic equipment in the vehicle. According to ICC, the profiler can measure road profiles at speeds ranging from 10 to 112 km/h. The test speed normally used to profile LTPP sections is 80 km/h.

This section presents procedures that should be followed for collecting data with the ICC profiler. Most of the operating procedures that are specific to the equipment have been taken from the *ICC Profiler Operation Manual*.[1] This document and other ICC documents (see references 2, 3, 4, 5) should be consulted for additional details about the equipment and troubleshooting procedures.

2.2 OPERATIONAL GUIDELINES

2.2.1 General LTPP Procedures

2.2.1.1 Accidents

The operator shall inform the RSC as soon as possible after the mishap. Details of the accident should be reported in writing to the RSC. The corporate policy of the RSC should be followed in event of an accident. A police report of the accident should be obtained. Photographs showing damage to the vehicle should also be obtained.

2.2.1.2 Maintenance of Records

The operator is responsible for preparing and forwarding the forms and records to the RSC as described in section 2.8, which relate to testing and maintenance of the profiler.

2.2.1.3 Safety

Safety of the operators and traveling public is of great concern to LTPP, and safe driving and roadside practices are expected from LTPP operators.

2.2.1.4 Problem Reports

A profiler problem report (PROFPR) must be submitted whenever there are problems with equipment that affect the quality of data, data collection or data processing software, data collection guidelines, or any other problem related to profiling activities. The procedures described in appendix A must be followed when submitting a problem report.

2.2.2 Test Frequency and Priorities

Profile measurement frequency and priorities described in the latest applicable FHWA directive should be followed when profiling General Pavement Studies (GPS), Specific Pavement Studies (SPS), Seasonal Monitoring Program (SMP), and Weigh-in-Motion (WIM) sites.

2.2.3 General Operations

The following guidelines related to the operation of the profiler should be followed.

2.2.3.1 Laser Height Sensors

The profiler is equipped with three Selcom laser height sensors. The operator shall not let the laser beam strike his or her eye, as it can damage the eyesight. Furthermore, because it is not known if the reflection of the laser beam from a surface such as a polished base plate, a gauge block, or a watch can damage the eyesight, the operator shall take steps to avoid a reflected laser beam to come in contact with the eye. The FHWA will keep the RSCs informed of information on this safety issue as it becomes available. Always make sure that lasers are turned off when inspecting the sensor glass, cleaning the sensor, or performing maintenance on the sensors. The

switch for turning the lasers on and off is located on the panel adjacent to the driver's seat (see figure 2).

Figure 2. Photo. Laser on/off switch.

The Selcom laser height sensors in the profiler can malfunction at elevated temperatures. At approximately 50 °C the laser sensors will begin to produce errors, and at approximately 60 °C the laser sensors will turn off to prevent damage. Practical experience with the LTPP profilers has shown that the combination of ambient air temperature, radiant heat from the pavement, and internally generated heat of the laser sensors will cause the laser sensors to produce errors when the air temperature is approximately 39 °C. It is recommended that profiling be performed only when the air temperature is less than 38 °C. When it is necessary to schedule profile testing at sites where the air temperature is expected to exceed 38 °C, it should be anticipated that the testing may have to be scheduled for early morning or after-sunset hours.

2.2.3.2 Sensor Bar and Sensor Spacing

The sensor bar located in front of the vehicle is not designed to support the weight of the operator or other persons. Do not sit or stand on the sensor bar at any time. Sensors located along each wheel path should be at a distance of 838 mm from the center of the vehicle. This sensor setup results in a spacing of 1,676 mm between left and right sensors. The center sensor should be at the center of the vehicle, with the distance from left and right sensors to the center sensor being 838 mm.

2.2.3.3 Photocell Positioning

The profiler is equipped with two photocells. One photocell is mounted vertically to sense reflections from pre placed marks on the road surface. The other photocell can be rotated around a horizontal axis, and can be positioned so it can sense reflections from pre placed cones with reflective markings that are placed on the side of the road. The photocell is used to perform a reference reset when it is triggered, and the location where it is triggered is stored in an event file.

The two photocells in the profiler should be positioned such that the distance to the photocell from the edge of the right side of the profile sensor bar matches the distances shown in figure 3.

The following sections give further details on the mounting of the horizontal and vertical photocell.
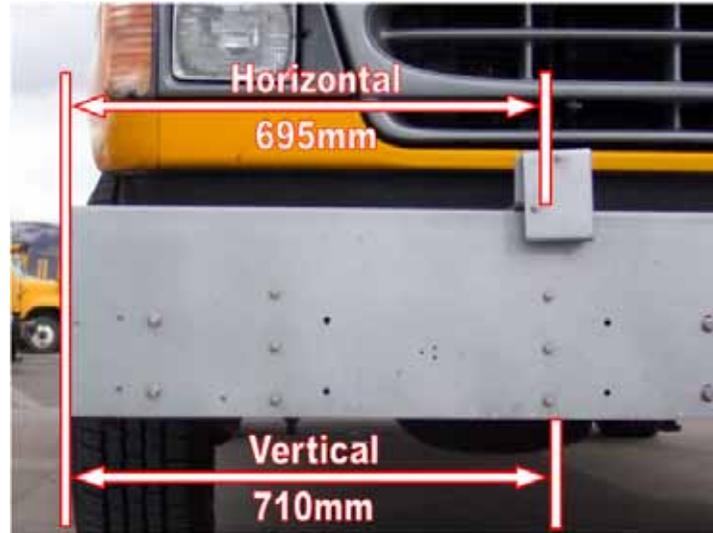
Figure 3. Photo. Locations of horizontal and vertical photocells.

2.2.3.3.1 Horizontal Photocell:

The horizontal photocell consists of a 90-degree mounting bracket that attaches to the top of the sensor bar and holds the photocell head (and cover plate) on a pivot bolt. This arrangement allows the photocell to be rotated up or down in order to detect the photocell target. The 90-degree bracket should be fastened to the sensor bar in its stock position, where the pivot bolt for the photocell is 695 mm from the right edge of the sensor bar. The mounting of the horizontal photocell is illustrated in figure 4.
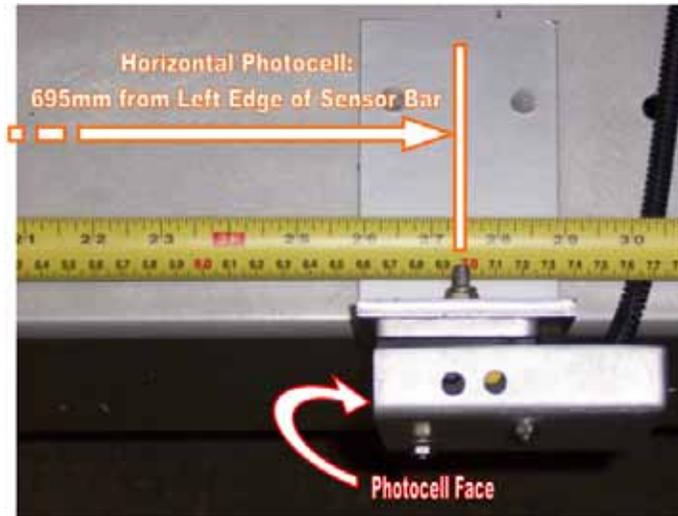
Figure 4. Photo. Position and mounting of horizontal photocell.

2.2.3.3.2 Vertical Photocell:

The vertical photocell consists of a 90-degree mounting bracket that holds the photocell vertically to a support bracket inside the profile sensor bar. The photocell bracket should be bolted to the right side of the sensor bar support bracket. The placement of the photocell bracket to the right side of the support bracket will center the photocell at 710 mm from the right side of the profile sensor bar. The photocell bracket can be mounted to elongated holes at the center of the support bracket (which centers the photocell front to back in the profile sensor bar). The photocell bracket should be adjusted so that the face of the photocell is approximately even with the underside of the profile sensor bar. Figure 5 illustrates the mounting and position of the vertical photocell from the underside of the profile sensor bar.
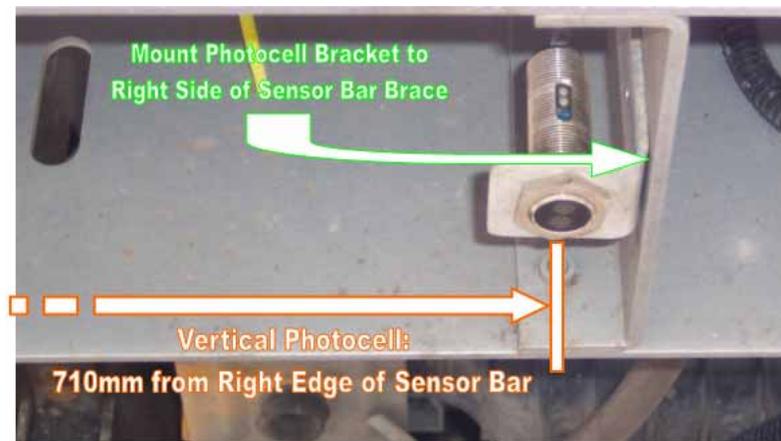
Figure 5. Photo. Position and mounting of vertical photocell.

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2.2.3.4 Tire Pressure

The tire pressure should be checked prior to driving the vehicle in the morning to see if it is at the vehicle manufacturer's recommended values that are listed on the door and the fuel cover, which are 380 kPa (55 psi) for the front tires and 550 kPa (80 psi) for the rear tires (these are cold tire pressure values).

The tires should be sufficiently warmed up prior to testing. If the vehicle has traveled about 8 km at highway speeds after being parked, the tires are considered to have warmed up sufficiently. However, the distance for warming up tires may need to be changed depending on local weather conditions. Warming up the tires will cause a slight increase in the tire pressure (compared to cold tire pressure).

The DMI is affected by the tire pressure of the rear tires. The operator should have a copy of the Distance Calibration Report that was printed when the DMI of the profiler was last calibrated. This report will indicate the tire pressure of the rear tires during calibration. The tire pressure of the rear tires of the vehicle for all data collection runs should be within ±13.8 kPa (2 psi) of the tire pressure that was recorded when the DMI was last calibrated. Before performing a profile data collection run at a test section, the operator should adjust the tire pressure of the rear tires to ensure that the tire pressure is within this specified limit. The same tire pressure gauge should be used to measure tire pressure during both calibration and testing.

2.2.3.5 Major Repairs to Profile System Components

LTPP Major Maintenance/Repair Activity Report (see section 2.8.5) should be completed whenever repairs are performed on the profile system components such as the laser sensors, accelerometer, DMI, and data acquisition system. This report should also be completed if a laser sensor is replaced. DMI and accelerometers should be calibrated whenever repairs are performed on these components or the computer cards associated with these components. A full calibration check must be performed on the laser sensor when a laser sensor is replaced. A bounce test must be performed after a laser sensor or an accelerometer is replaced, when repairs are performed on the accelerometer, or when repairs are performed or replacements made to computer cards associated with these components.

After replacing a laser sensor, data collected by the profiler should be checked using the following procedure to ensure that accurate data are being collected:

1. Select a test section that has been profiled recently and is close to the current location of the profiler. When selecting the site, review comments that were made when the site was profiled to make sure that profile data available for this site is free of errors and that no unexplained spikes are present in the data. It is recommended that GPS-3 and SPS-2 sites be avoided, as significant variations in profile can occur on these sections due to temperature effects. The RSC should use his or her judgment in selecting an appropriate site to perform this comparison, taking into account the current location of the profiler and availability of a suitable site close to the location of the profiler.

2. Profile the selected site and obtain an acceptable set of runs as described in section 2.2.8.

3. Compare the profile data, as well as the IRI values, with the previously collected data for left and right sensors. If the repaired or replaced sensor is the center sensor, only the comparison of profiles can be performed, as IRI values for the center sensor cannot be computed. If evaluation indicates that the collected data is comparable with the previously collected data, the profile system components are considered to be functioning correctly.

4. Perform the comparison at another section if discrepancies are noted. If discrepancies are still noted, contact ICC to resolve the problem.

If a malfunction is detected in a sensor located along a wheel path, it may be replaced by the center sensor to continue data collection. The procedure to move a sensor is described in section 20 of the *ICC Road Profiler Operations Manual*.[1] (Warning: Each laser sensor is matched with a processing unit that is located at the back of the profiler. If a laser is switched (i.e., a wheel path sensor replaced by the center sensor) without the required changes in connection made to the processing unit, it will damage the laser. Such damages will not be covered by warranty. Therefore, operators should be aware that they need to clearly understand the procedure for switching a laser sensor and/or get technical assistance from ICC prior to switching a sensor.)

Once the repaired or replacement sensor is available, the center sensor that is now located at an outer position (left or right wheel path) should be moved back to the center position. A repaired or replaced sensor should be installed at the location of the defective sensor (either left or right wheel path). A full calibration check (see section 2.5.4) should be performed on the replacement sensor. Thereafter, the accelerometers should be calibrated (see section 2.5.3) and a bounce test (see section 2.3.3) should be performed. Procedures that were described previously (i.e., profiling at a previously profiled section) should be followed to ensure that the repaired or replaced sensor is functioning correctly.

2.2.3.6 Sensor Covers

The three laser sensors in the profiler are equipped with covers. Covers should be in place when testing is not being performed to protect the sensors. Covers should be taken off when performing sensor checks, performing bounce test, and collecting profile data.

2.2.3.7 Data from Previous Profile Visit

After collecting profile data at a site, the operator is required to compare the profile data, as well as IRI, with the data collected during the previous site visit as described in section 2.2.8. The profile data comparison between the visits is made using the Graphic Profiles feature in ProQual.[6] Prior to setting out to profile a site, the operator must ensure that the data files that are required to do this comparison for the previous site visit are available. The operator should also have the IRI values for the site from the previous visits.

2.2.4 Computer System

2.2.4.1 Computer System in Profiler

The ICC profiler is equipped with two computers that are networked together. These two computer systems are referred to as system 1—Windows computer (Windows side), and system 2—DOS/MDR computer (DOS side).

Software for operating the profiler is located in system 2. This software is DOS based, and must be loaded from the DOS prompt. Data collected by the laser height sensor, accelerometer, and DMI during profiling are saved in system 2. System 1 contains Windows XP. The Windows based WinGraph software that displays a plot of the profile data while the data are being collected is located in system 1. The graphical plot of the profile created by WinGraph is saved in system 1.

There is a switch in the keyboard, video, and mouse (KVM) switch box that will switch the monitor between system 1 and system 2 (see figure 6). System 2 also has Windows 98 installed on it to enable sharing of the CD-ROM drive, Zip drive, and hard drive with the Windows XP system. System 2 must be in Windows 98 if it is to be accessed from system 1. Further details on use of the KVM switch to switch between the two systems during operation of the profiler will be presented in following sections of 2.2 and 2.3.

Figure 6. Photo. Keyboard, video, and mouse (KVM) switch.

Basic Input/Output System (BIOS) settings of system 1 and system 2 are described in the *ICC Road Profiler Operation Manual.*[1]

2.2.4.2 Temperature Range for Computer Operation

Interior vehicle environment is critical to the operation of the onboard computers. The vehicle is equipped with a heater and an air conditioner to maintain interior temperatures within the required range. The interior of the vehicle should be between 10 and 35 °C before power is applied to the electronic equipment and the computer to protect them from damage. On cold days when the van has been parked outside, it can take up to 45 minutes to warm up the equipment inside the vehicle to 10 °C. If the interior temperature is below 10 °C, the computers will not boot up correctly. Even when the interior temperature in the van is greater than 10 °C, the

computers may not boot up because the Uninterruptible Power Supply (UPS) that is located on the floor behind the driver's seat is at a temperature less than 10 °C. If such conditions are encountered, more time should be allowed for the interior of the vehicle to warm up.

2.2.4.3 Hardware and Software

The operator should maintain a copy of the ICC software and the ProQual software in the vehicle in case software problems occur in the software installed in the computer. If either of these software programs is reinstalled, the operator should go through the setup menus described in section 2.2.6 of this manual to make sure that appropriate parameters have been set to the correct values. ICC software programs that are installed in the profiler computer are the following:

- p90xfhwa.exe: Profiler runtime data collection program. This is a DOS program that is installed in system 2.
- WinGraph.exe: Runtime graph program. This is a Windows program that is installed in system 1.
- Winrp90l.exe: Report program and file converter. This is a Windows program that is installed in both systems 1 and 2.
- FHWA_Eval.exe: Profile graphing, analysis, and IRI evaluation program. This is a Windows based program that is installed in both systems 1 and 2.

Do not add any hardware (extra drives or other device) to the computer system before contacting ICC through the FHWA and its Technical Support Services Contractor (TSSC) to determine if they will interfere with the profile programs. Interference of profile programs due to additional devices may not be readily apparent.

Software supplied with the ICC profiler is tightly integrated. Other software installed into the computer can seriously degrade the performance and accuracy of the system. Apart from ProQual, other software should not be loaded onto the computer, unless specifically approved in writing by the FHWA.

Procedures for installing the ProQual program are described in the ProQual manual.[6] ProQual may be installed in either system 1 or system 2. It has been reported by its developers that ProQual will run more efficiently in Windows XP, and printing of plots is much quicker when ProQual is run in Windows XP. If ProQual is installed in system 1, the data files should be copied from system 2 to system 1, and then processed by ProQual. Details on file copying procedures are presented in section 2.2.6.2

Profiler data files should be organized into subdirectories in the hard drive as outlined in LTPP directive GO-41 "Submission of Electronic Data for Customer Support and Ancillary Information Management System (AIMS)" (or current version of that directive).

2.2.5 Power Up, Booting, and Shutdown Procedures

2.2.5.1 Power Sources

There are two batteries in the profiler vehicle, one located under the hood of the vehicle (No. 1 battery), and one located in the rear right side of the vehicle (No. 2 battery). The rear battery

supplies power to the computer and the electronic equipment in the profiler through an inverter. The computer and the electronic equipment in the profiler can also be powered through an external alternating current power source (house power). The rear battery should be charged when the profiler is connected to house power.

Both batteries in the profiler are charged when the vehicle engine is running. When the engine of the vehicle is not running, these batteries can be charged through a 15/2 fully automated battery charger connected to an external power source. In order to charge a battery when connected to an external power source, the House Power/Inverter Power switch (see figure 7) should be set to the "Inverter Power" position. The battery charger switches should be set to the 12 V and 10 AMP positions. The battery charger can be switched between No. 1 battery and No. 2 battery using the switch just below the House Power/Inverter Power switch (see figure 7). The battery charger has to be set to the battery that needs to be charged. The charger has automatic charge sensing capabilities that will not overcharge the battery.
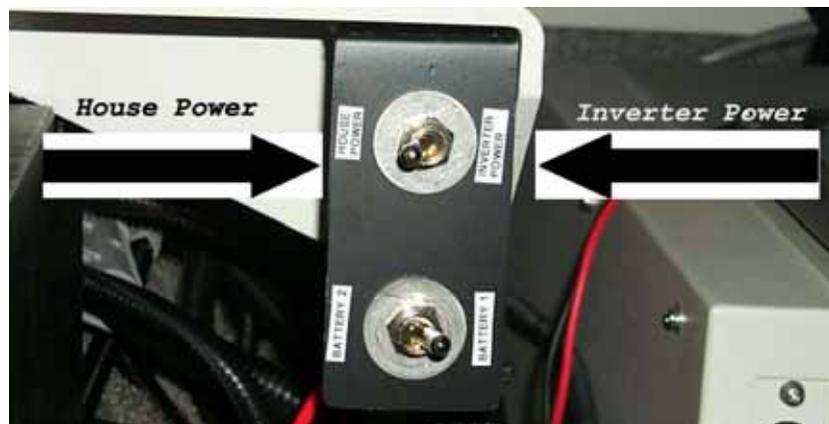
Figure 7. Photo. Power switch positions.

During data collection, power will be supplied through the inverter. When the engine is turned off (e.g., for monthly calibration check, troubleshooting, or operating computer when parked in office) an external power source can be used to supply power. The UPS in the van also makes it possible to switch from one power source to another (i.e., house power to inverter power) without having to shutdown the computer. The UPS will supply power to the system using its internal battery when making the switch. When the UPS is used without house or inverter power, the UPS battery is not being charged, and will drain down eventually to a point where it can no longer run the computers.

2.2.5.2 Switch Positions

The power switch in front of the inverter must always be left in the "Off" position (see figure 8).

Figure 8. Photo. Inverter switch.

A remote switch located near the driver's seat controls the "On" and "Off" positions of the inverter. The No. 2 battery, which provides power for the MDR system (including inverter), is connected to the No. 1 battery and charges the system through a 70A continuous solenoid (with a diode to prevent voltage leakage) that is activated through a Ford van relay. This is a security feature to ensure that the No. 1 battery will not be drained if the remote inverter switch remains on when the vehicle is not running. If the remote inverter switch is accidentally left in the "On" position, the No. 2 battery will drain, and will have to be charged prior to operating the profiler. If the battery is not brought to a sufficient charge level prior to turning on the inverter, it is possible that the 70A continuous solenoid, that separates the No. 1 and 2 batteries, will burn out as the alternator attempts to bring the No. 2 battery to full charge. The laser power switch, inverter power switch, and computer power switch that are located on the computer case should always be kept in the "On" position (see figure 9). Power to these systems will be turned on or off from switches that are located near the driver's seat.

Figure 9. Photo. Switches on computer case.

2.2.5.3 Power-Up Procedure

Procedures for powering up the system using house power as well as inverter power are described in this section.

2.2.5.3.1 Power Up Using House Power:

1. Flip the power switch located in the back of the van to house power (see figure 7).

2. Make sure that the external 120 V power source is grounded. Plug the power cord into the port on the passenger side of the van.

3. Make sure the laser, inverter power, and computer power switches located on the computer case are in the "On" position (see figure 9).

4. Push the "On" button on UPS (see figure 10). The UPS is located behind the driver's seat.

5. Turn on the computer monitor (see figure 11).

2.2.5.3.2 Using Inverter Power:

1. Flip the power switch in the back of the van to inverter power (see figure 7).

2. Start the engine of the van.

3. Make sure the laser, inverter power, and computer power switches located on the computer case are in the "On" position (see figure 9).

4. Turn the power inverter on using the switch located on the panel below the monitor (see figure 12).

5. Push the "On" button on UPS (see figure 10).

6. Turn on the computer monitor (see figure 11).

Figure 10. Photo. UPS on/off switch.

Figure 11. Photo. Monitor on/off switch.

Figure 12. Photo. Remote switch for inverter power.

2.2.5.4 Computer Booting Procedure

Follow the instructions below to complete the computer booting procedure:

1. Supply power to the system using either house power or inverter power as described in section 2.2.5.3.

2. Allow the computer to come up to the Login screen for Windows XP. Login using LTPP as the user name and LTPP as the password. The monitor will show that Windows XP is running.

3. Double click the ICC icon for WinGraph if the computer system is powered up to collect profile data or to perform the bounce test, else go to step 4. If the WinGraph icon is double clicked, WinGraph will run on system 1.

4. Switch the KVM to system 2 (see figure 6).

5. Allow the DOS-MDR system to proceed to the DOS prompt.

6. Check the date and time on system 2 and adjust to correct local time, if needed.

7. Type m and then press the Enter key at the c:\ prompt to run the MDR data collection program. The main menu of the MDR program should now be shown on the computer monitor (see figure 13).
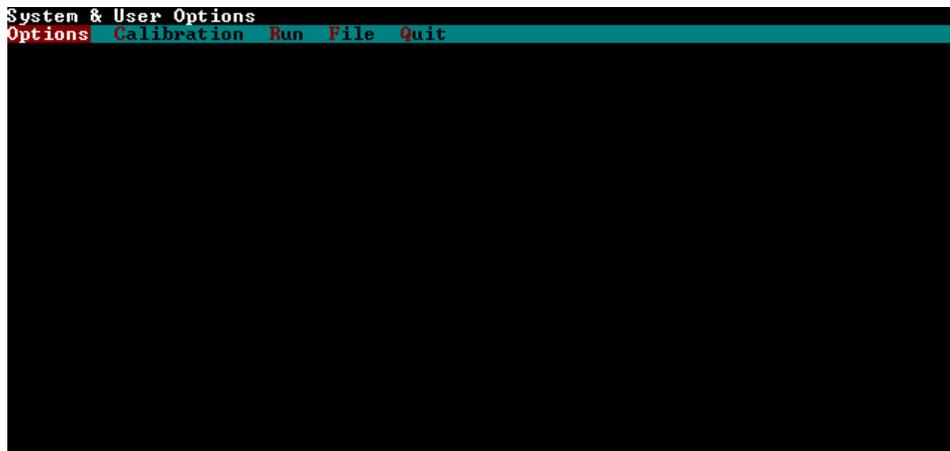
Figure 13. Screen shot. MDR main menu (1).

The MS-DOS commands Date and Time should be placed in the AUTOEXEC.BAT file in system 2 so that when the computer is turned on it will prompt the operator for date and time. This will ensure that data files have the correct date and time stamp. Time should correspond to that of the time zone where the section is located. When the computer prompts for date and time, the operator should check if current values are correct. If they are correct, the operator can press the Enter key at each prompt. If they are incorrect, correct values should be entered.

2.2.5.5 Shutdown Procedure

Follow the instructions below to complete the shutdown procedure:

1. Remove the CD-ROM if it is present in a drive and remove any flash drives that are attached to the computer.

2. Turn off power to the lasers by flipping the switch on the monitor stand (see figure 2) to the down position.

3. Use the KVM switch (see figure 6) to go to system 2 if the monitor shows that the computer is not in system 2. System 2 could be either in Windows 98 or in the MDR program.

4. Select Quit from main menu, and then enter Y to confirm the quit request if the MDR program is running. The C:\ prompt will then be displayed on the screen. If the system is in Windows 98, exit all programs, select the "Start" button at the bottom left hand side of the screen, select "Shutdown," and then indicate you want to shutdown the system. Wait until the screen says "Its now safe to turn off your computer."

5. Use the KVM switch (see figure 6) to get to system 1.

6. Exit all programs, select the "Start" button at the bottom left hand side of the screen, and select "Turn Off Computer." Confirm the request to turn off the computer. Wait until the screen says "Its now safe to turn off you computer."

7. Turn off the UPS located behind the drivers seat (see figure 10). The power to the computers will now been turned off.

8. *Unplug the house power input from the profiler if shutting down when the system is being powered by house power. If shutting down when being powered by the vehicle (through the inverter), turn off power inverter by flipping the switch on the monitor stand to the down position (see figure 12).*

2.2.6 Software Setup Parameters

The MDR software is used to collect and save profile data. Collected profile data is processed using the ProQual software. Most settings in the MDR program were set at appropriate values when the software was installed in the profiler. However, these settings need to be checked to make sure they are correct, and if incorrect, necessary corrections must be made. These settings should be checked if the software is reinstalled in the computer or if problems are encountered with software. There are some fields in ProQual that have to be set by the user once the software is installed. Settings in the MDR program and ProQual program that need to be checked and/or updated are presented in sections 2.2.6.1 and 2.2.6.2, respectively.

2.2.6.1 Settings in MDR Software

The settings in the MDR software should be checked to ensure that they are set at correct values. There are some settings that the user will have to set or update once the software is installed.

These settings are specific to the data collected for the LTPP program. The following steps take the operator through the different settings that need to be checked and/or updated:

1. Follow the procedures described in section 2.2.5.4 to launch the MDR software, omitting step 3. MDR main menu should now be displayed on the screen (see figure 13).

2. Select "Options" in the MDR main menu and the drop down menu shown in figure 14 will be displayed on the monitor. The Reference Post Display Mode should show "Meter," the User should show "LTPP," and the Version should correspond to that shown in figure 14. If any of these fields are different, reset the values to the previously described values.

3. Highlight "ICC System Parameters" in the Options Menu (see figure 14) and press the Enter key. The screen shown in figure 15 will be displayed.
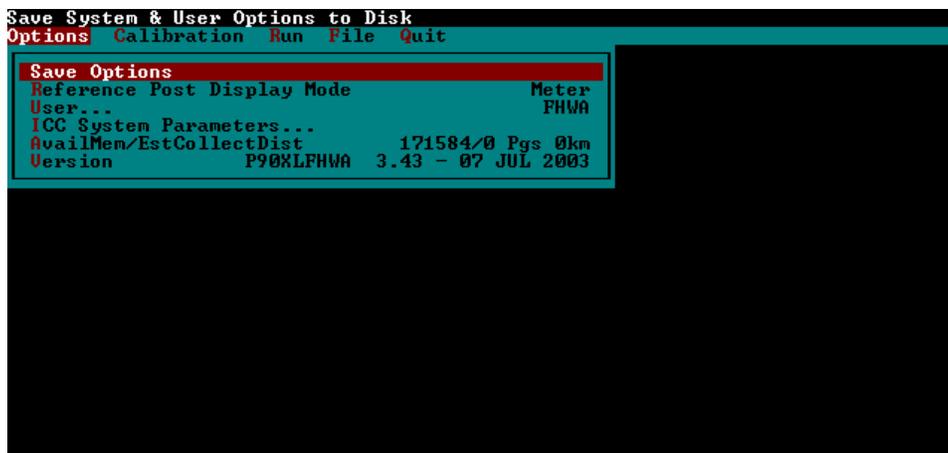
Figure 14. Screen shot. Options menu (1).
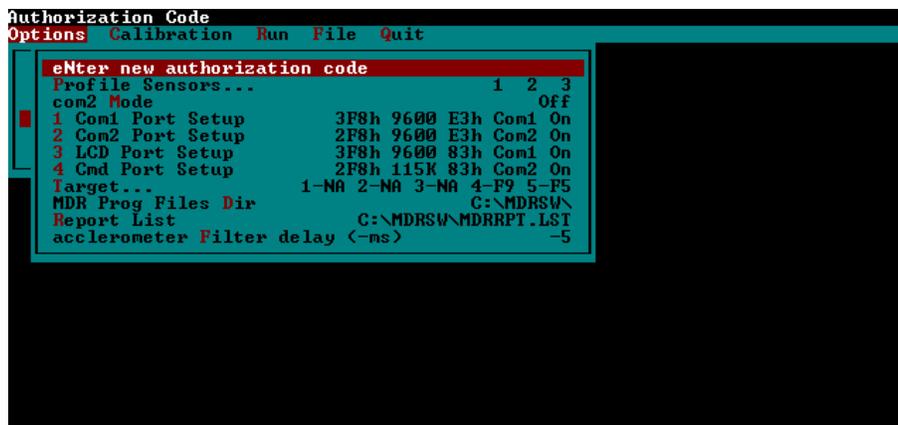
Figure 15. Screen shot. ICC system parameters screen.

The parameter settings should match the following values (Note: Parameter settings for Target may be different depending on the photocell that will be used for testing).

Parameter settings that are shown in figure 15 are as follows, and the parameter settings shown in the monitor should match these values (except for four and five of the Target, which may have a different value).

Profile Sensors   1 2 3
Com2 Mode   Off
1 Com1 Port Setup   3F8h 9600 E3h Com1 On
2 Com2 Port Setup   2F8h 9600 E3h Com2 On
3 LCD Port Setup   3F8h 9600 83h Com1 On
4 Cmd Port Setup   2F8h 115K 83h Com2 On
MDR Prog Files Dir   C:\MDRSW\
Report List   C:\MDRSW\MDRRPT.LST
Accelerometer Filter delay (-ms)   -5

If any of the parameters shown on the monitor are different, reset the parameters so they correspond to the previously described values.

Target one, two, and three should show NA. Target four and five will show the photocell that has been selected. Refer to step 3 in section 2.3.4.1 on how to select photocells.

After the parameter settings have been checked, press Escape key twice to get back to the MDR main menu (see figure 13).

4. Select "Calibration" in the main menu and the drop down menu shown in figure 16 will be displayed. Highlight "Sensors" in this menu, and press the Enter key. The Sensor Calibration menu shown in figure 17 will be displayed on the monitor.
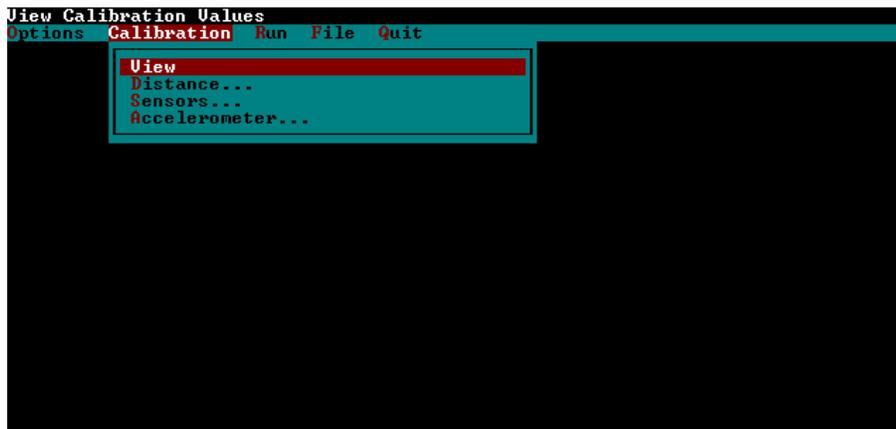
Figure 16. Screen shot. Calibration menu (1).
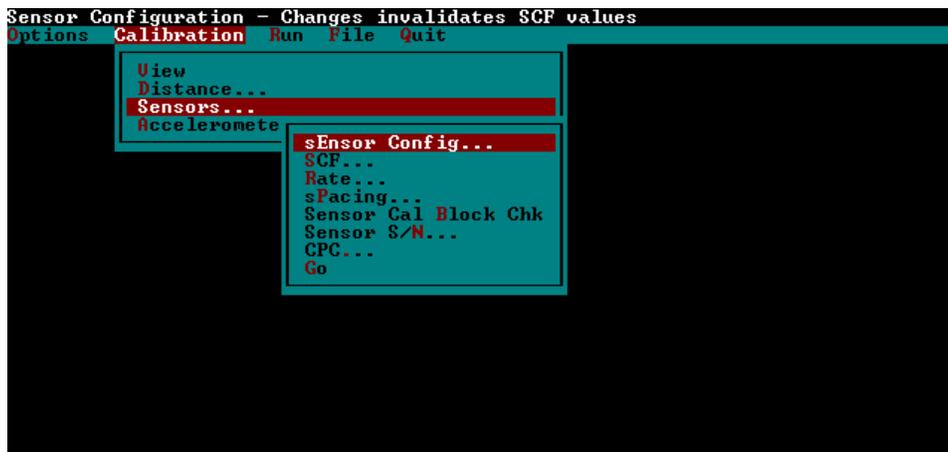
Figure 17. Screen shot. Sensor calibration menu (1).

In this menu, highlight "Sensor Config" and press the Enter key. The sensor configurations will be displayed on the monitor (see figure 18).
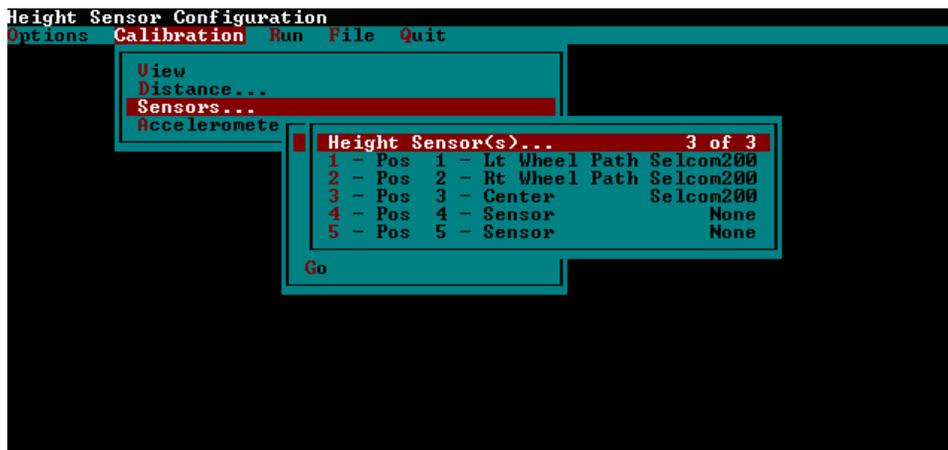
Figure 18. Screen shot. Sensor configurations.

The parameter settings shown on the monitor should match the values shown in figure 18, which are the following:

Height Sensor(s)…   3 of 3
1 – Pos   1 –   Lt Wheel Path   Selcom200
2 – Pos   2 –   Rt Wheel Path   Selcom200
3 – Pos   3 –   Center   Selcom200
4 – Pos   4 –   Sensor   None
5 – Pos   5 –   Sensor   None

If the parameters shown on monitor are different, reset the parameters so they correspond to the previously described values. After checking the values of the parameters, press the Escape key to get to the Sensor Calibration menu.

5. Highlight "Spacing" in the Sensor Calibration Menu (see figure 17) and press the Enter key. This will bring up the Sensor Spacing submenu that has three choices: Key Rut Positions, Rutting Order, and Spacing (see figure 19).
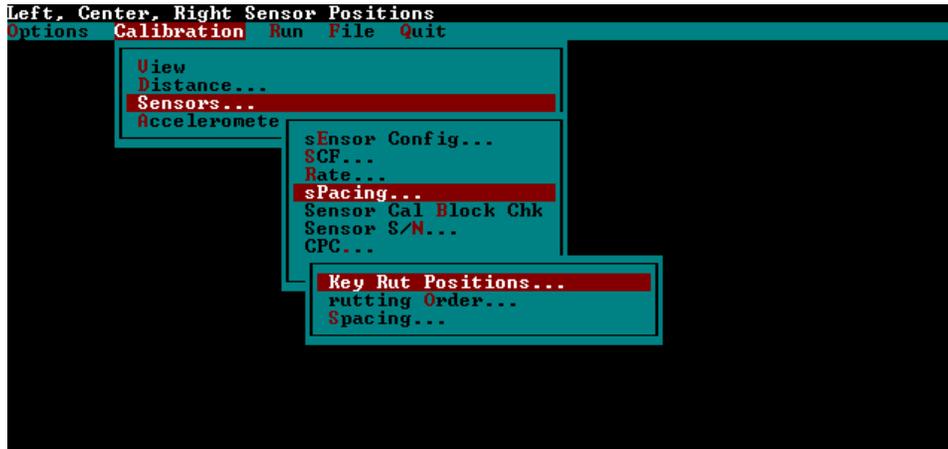
Figure 19. Screen shot. Sensor spacing submenu.

Highlight "Key Rut Positions" and press the Enter key. The Key Rut Positions screen shown in figure 20 will be displayed on the monitor. Values shown on the monitor should match the values shown in figure 20, which are:

1 –   Left Pos   1
2 –   Center Pos   3
3 –   Right Pos   2
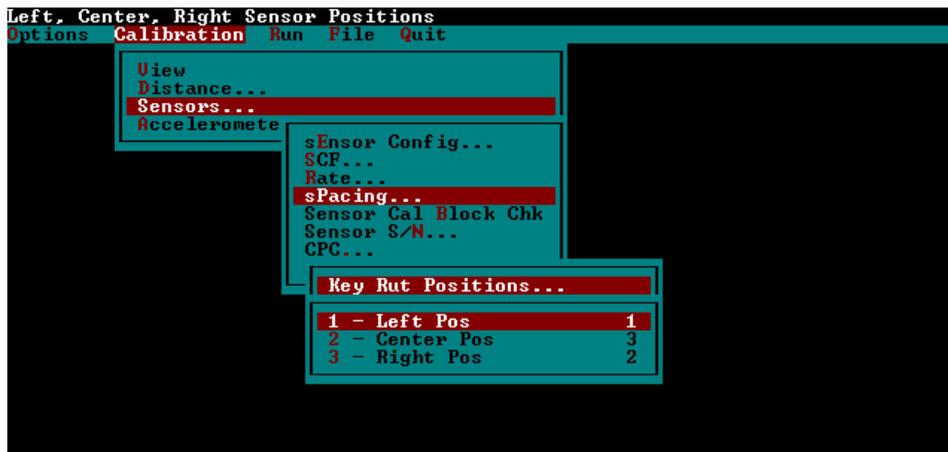
Figure 20. Screen shot. Key rut positions screen.

If any of the parameters are different, reset the parameters to the values that were indicated. After checking the parameters, press the Escape key to get back to the Sensor Spacing submenu (see figure 19).

6. Highlight "Rutting Order" in the Sensor Spacing submenu (see figure 19) and press the Enter key. The monitor will show the Rutting Order screen shown in figure 21. Values

for the parameters shown on the monitor should match the values shown in figure 21, which are the following:

1 –   Sensor Pos #   1
2 –   Sensor Pos #   3
3 –   Sensor Pos #   2
4 –   Sensor Pos #   0
5 –   Sensor Pos #   0

Figure 21. Screen shot. Rutting order screen.

If any of the parameters are different, reset the parameters to the indicated values. After checking the parameters, press the Escape key to get back to Sensor Spacing submenu (see figure 19).

7. Highlight "Spacing" in the Sensor Spacing submenu and press the Enter key. The monitor will show the sensor spacing screen shown in figure 22.

Figure 22. Screen shot. Sensor spacing screen.

The values displayed on the monitor should be identical to the values shown in figure 22, which are the following:

1 –   Spacing   1   –   1   0 mm
2 –   Spacing   1   –   3   838 mm
3 –   Spacing   1   –   2   1676 mm
4 –   Spacing

If any of the parameters are different, set the parameters to the indicated values by highlighting the parameter, pressing the Enter key, entering the correct value in the window that opens, and pressing the Enter key again to close the window. After checking the parameters, press the Escape key twice to get back to the Sensor Calibration Menu (see figure 17).

8. Highlight "Sensor S/N" in the Sensor Calibration Menu (see figure 17) and press the Enter key. The Sensor Serial Number screen shown in figure 23, which shows the serial numbers of the sensors, will be displayed.
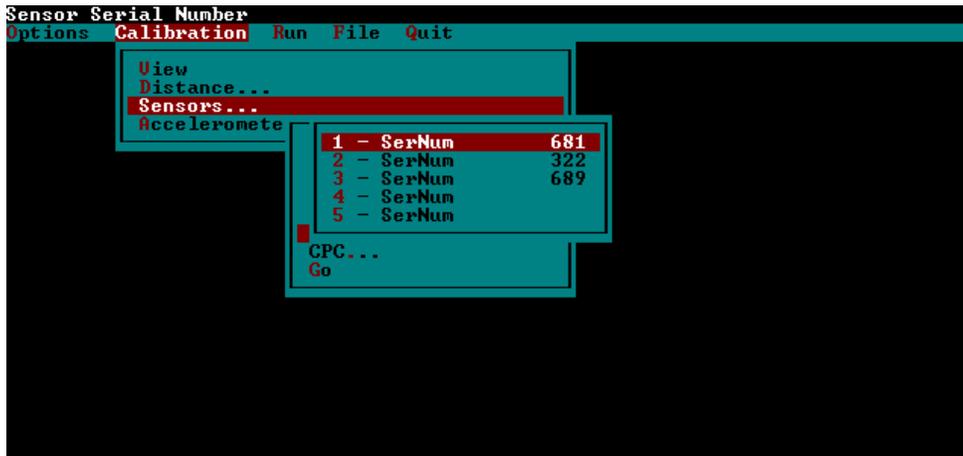
Figure 23. Screen shot. Sensor serial number screen.

The serial numbers shown on the monitor will be different from those shown in figure 23. Check to see if the serial numbers displayed match the serial numbers of the lasers in the profiler. In the profiler, position one is the left wheel path, position two is the right wheel path, and position three is the center sensor. The laser sensor serial numbers are marked on the front of each laser's processor unit, which is located to the right of the computer chassis. If the displayed serial numbers are not correct, highlight the appropriate sensor, press the Enter key, type the correct serial number in the window that opens, and press the Enter key again to close the window. When done, press the Escape key three times to get to the MDR main menu (see figure 13).

9. Select "Run" in the MDR main menu (see figure 13) and the Run Menu shown in figure 24 will be displayed on the monitor.

Figure 24. Screen shot. Run menu (1).

Select "Options" in this menu and the Run Options menu shown in figure 25 will be displayed on the monitor.
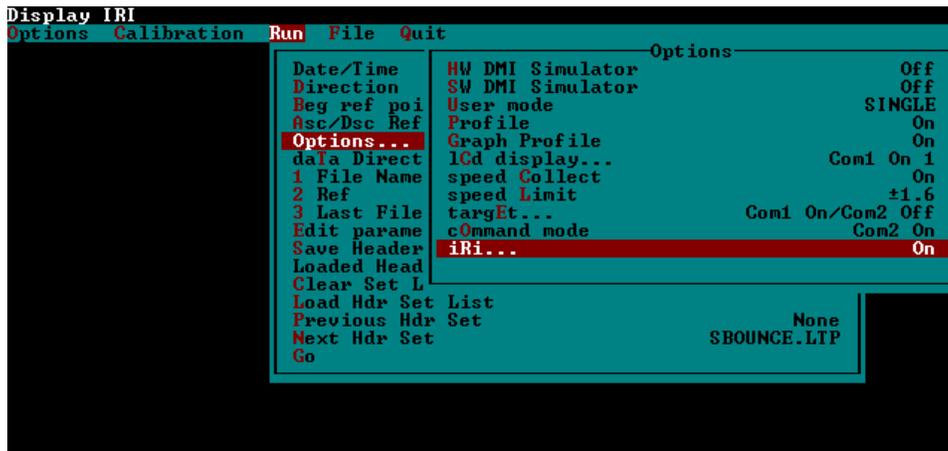
Figure 25. Screen shot. Run options menu (1).

The values for parameters shown on the monitor should match the values shown in figure 25, which are the following:

HW DMI Simulator	Off
SW DMI Simulator	Off
User mode	SINGLE
Profile	On
Graph Profile	On
LCD Display	Com1 On 1
Speed Collect	On
Speed Limit	± 1.6
Target	Com1 On/Com2 Off
Command Mode	Com2 On
IRI	On

If the value shown on the monitor for Speed Limit is different, highlight Speed Limit and press the Enter key. Next, type 1.6 in the window that opens and press the Enter key to close the window. The HW DMI Simulator should indicate "On" only when the bounce test is performed, and should indicate "Off," as shown in the figure, at other times. If the DMI Simulator indicates "On," highlight the DMI Simulator and press the Enter key to make it "Off." If the values shown for any of the other parameters are different, reset the parameters to the values that were indicated previously.

10. Select "IRI…" in the Run Options Menu (see figure 25) and the IRI Options screen shown in figure 26 will be displayed on the monitor.

Figure 26. Screen shot. IRI options screen (1).

The values of the parameters shown on the monitor should match the values shown in figure 26, which are the following:

Mode	On
HCS/Avg IRI	Avg
iri Scale	1000
Negative rut	On
Filter	On
Wavelength	100.0
moving Average	1
section control	On
interval Control	On
Interval	152
interval Reset	Off
speed Limit	24.1
ride Number	Off

Highlight "Interval," press the Enter key and check if the value shown in the box that opens up is 152.4. If not, edit the value so that it is set to 152.4, and press the Enter key to close the window. If Speed Limit does not show a value of 24.1, highlight Speed Limit, press the Enter key, type 24.1 in the window that opens, and press the Enter key to close the window (value for Speed Limit represents the speed below which data will not be

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included in the file). If any of the other parameters shown on the monitor are different from the values shown on figure 26, reset the parameter to the appropriate value. After checking the parameters, press the Escape key three times to get back to the MDR main menu.

2.2.6.2 Settings in ProQual Software

As indicated in section 2.2.4.3, ProQual may be installed in either system 1 or system 2. If ProQual is installed in system 1, the data files should be copied from system 2 to system 1, and then processed by ProQual. In order for files to be copied from system 2 to system 1, system 2 must be booted in Windows 98. Use the following procedure to copy files from system 2 to system 1:

1. Switch to the Windows XP computer.

2. Explore the "C on DOS/Windows (G:)" disk drive.

3. Copy the raw profile data folder (folder containing files with extensions p, v, and e) to a known location on the Windows XP hard disk drive (C drive).

4. Run ProQual and select the files with extension p on the Windows XP hard disk (C drive) to load the data files when processing files.

After ProQual is installed, there are several parameter settings that have to be entered (or set) and others that have to be checked. Use the following procedure to set/check the parameter settings:

1. Start ProQual and then select System to bring up the System menu shown in figure 27.
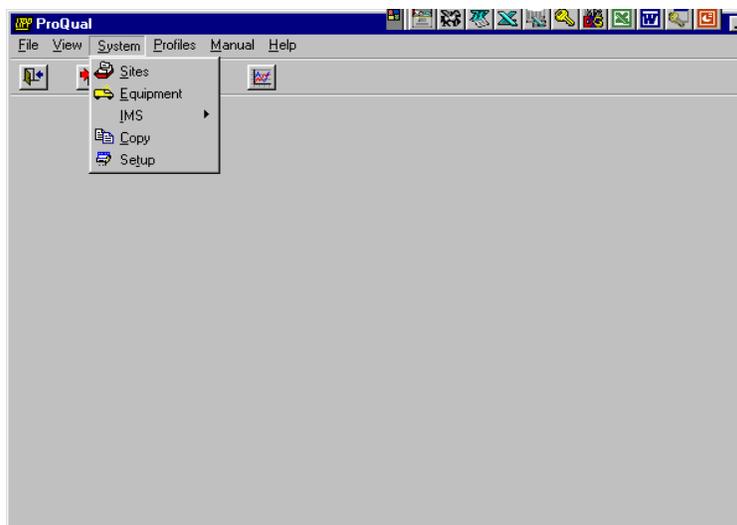
Figure 27. Screen shot. ProQual system menu.

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2. Select "Equipment" and the monitor will display a screen similar to that shown in figure 28. Entries for Serial # and photocell offsets displayed on the monitor will be different from the values shown in figure 28.
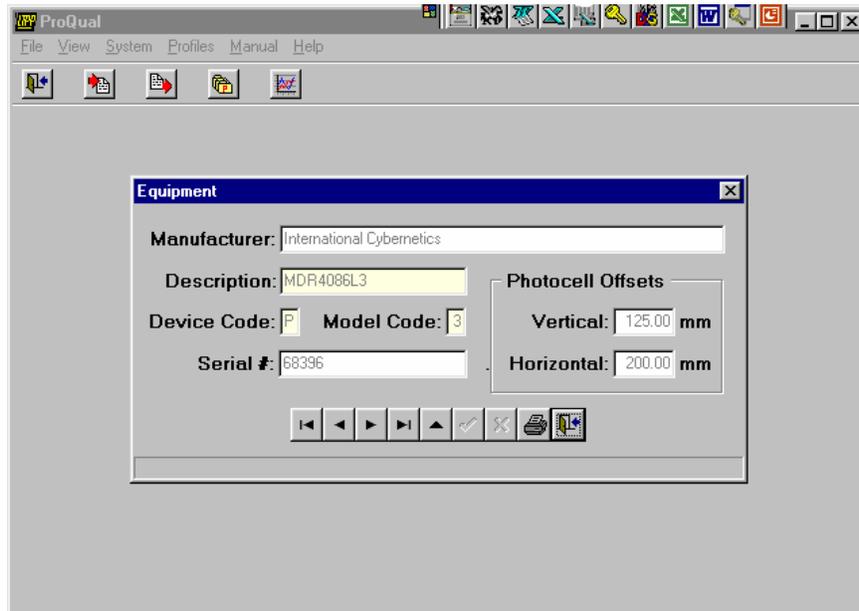
Figure 28. Screen shot. Equipment screen in ProQual.

3. Check the Serial Number and Photocell Offsets. Adjust the settings if needed for serial number and photocell offsets using following procedure:

   a. Use the second button from the left at the bottom (prior equipment record) or third button from the left (next equipment record) to scroll through screens until the Serial Number matches last five digits of the VIN number of profiler. (Note: when the mouse is on a button, a message will appear at the bottom of screen that describes the function of that button). The Manufacturer field should now show "International Cybernetics."

   b. Check to see if the vertical and horizontal photocell offsets shown match the offset values for the profiler. These photocell offsets values for the profiler are determined annually using the procedure described in section 2.6.3. If the photocell offset values shown are not correct, click the fifth button from left at the bottom of the screen (edit equipment report). This will allow the values shown for photocell offsets to be edited. Use the mouse to click on the appropriate offset field(s) and type the correct offset value(s). Click on the sixth button from the left (save equipment changes) to save the changes.

   c. Click on the rightmost button at the bottom of the screen to exit to the main menu.

4. Select Setup in the Systems menu (see figure 27). The Analysis Parameters screen shown in figure 29 will then be displayed on the monitor.
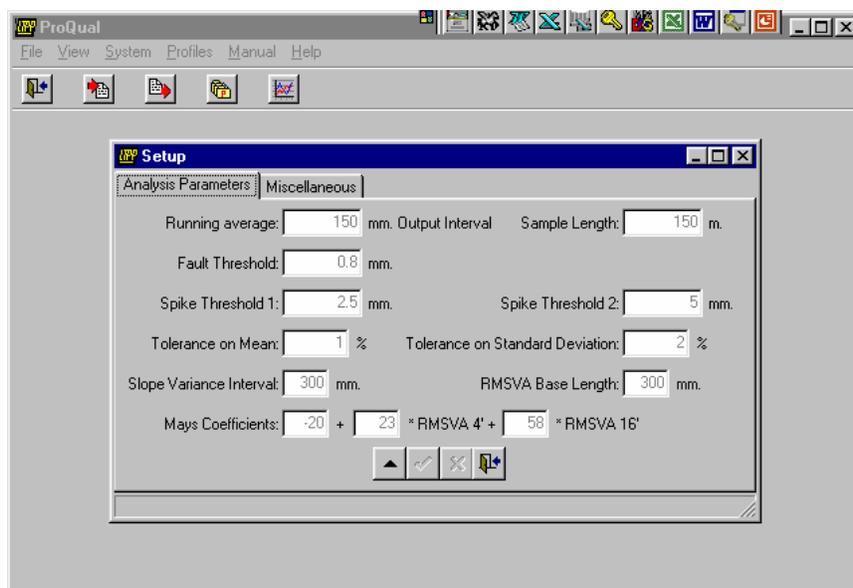
Figure 29. Screen shot. Analysis parameter screen in ProQual.

The value for each parameter should exactly match the values shown in figure 29. These values are set to the correct value when ProQual is installed. It is possible to edit these values using the first button at the bottom of screen. However, the operator should never edit any of the values shown on this screen, unless directed by the project engineer.

The following parameters shown in figure 29 are not currently used in any computations: Sample Length, Fault Threshold, and RMSVA Base length. The other parameters are used in computations, and a brief description of each of these parameters follows:

- Running Average: This is the interval at which profile data is output in ProQual.
- Spike Threshold 1: Threshold for double elevation spikes.
- Spike Threshold 2: Single elevation spike threshold.
- Tolerance on mean: Tolerance on mean IRI that is used to determine if IRI of a set of profile runs is acceptable.
- Tolerance on standard deviation: Tolerance on standard deviation of IRI that is used to determine if a set of profile runs is acceptable.
- Slope Variance Interval: Base length used to compute slope variance.
- Mays Coefficients: Coefficients used to compute the Mays Coefficient.

2.2.7 Field Operations

2.2.7.1 Turnarounds

Applicable laws in each State regarding use of median turnarounds must be followed.

2.2.7.2 Strobe Bar, Flashing Signal Bar, and Signs

The profiler is equipped with a strobe bar in front and a flashing signal bar in the rear. Both the strobe bar and flashing signal bar should be turned on during testing. In addition, the magnetic

sign "Caution Road Test" should be mounted at the back of the vehicle during testing. This sign should be taken off when traveling between sites to alleviate any confusion that may be perceived by other road users.

2.2.7.3 File Naming Convention

The file naming convention to be used in specifying the name of data file in the LTPP Menu of the profiler software (see section 2.3.4.1) for GPS, SPS, and SMP sections are described in this section (for file naming conventions for WIM sites, refer to section 2.4.2.3). Failure to adhere to the file naming convention could produce errors when running ProQual, and will cause problems when archiving files. The file name should consist of eight characters as follows:

1. Characters one and two: State code of the State in which the site is located (e.g., 27 for Minnesota).

2. Characters three to six: Four-digit site number. For GPS and SMP sites, this is the four-digit LTPP identification number (e.g., 1023). For SPS sites, the third character should be zero, A, B, etc., depending on project code (e.g., 0300, A300, B300, etc.). The fourth character for SPS sites is the experiment number (e.g., 2 for SPS-2 projects), while the fifth and sixth characters should be zero. However, if an RSC elects to do so, for SPS sites it is permissible to use the fifth and sixth character to indicate the first section encountered when the SPS section is profiled.

3. Character seven: Letter code defining section type. This is G for GPS, S for SPS, M for SMP or C for Calibration test sections.

4. Character eight: Sequential visit identifier code that indicates the visit code for the current profile data collection. This identifier indicates the number of times a set of profile runs has been collected at a site since the site was first profiled with the K. J. Law T-6600 profiler. When the site was first profiled with the K. J. Law T-6600 profiler, the letter A was used for the eighth character. Use an appropriate letter for the current profiling. For example, if the site is being profiled for second time use letter B, use C for the third time, H for eighth time and so on. For rigid pavement test sections in the SMP, a different character shall be used each time a set of profiles is obtained during the day. If a site is being profiled for the first time (it has not been profiled by K. J. Law profiler before, as is the case for some GPS-6B or GPS-7B sites), the letter A should be used for the eighth character. Thereafter, this letter should be sequentially increased (B, C, and so on) during subsequent profile data collection visits. If a region has been using the sequential visit identifier to indicate the number of times a set of profiles has been obtained at the site since its inception into the LTPP program, that procedure is also acceptable. In such case, the letter A is used to denote the first time the site was or is profiled by the RSC, whether with the DNC690, T-6600 or the ICC profiler. Thereafter, this letter should be sequentially increased (B, C, and so on) during subsequent profile data collection visits.

After the sequential visit identifier code has been assigned as Z, use the following procedure for file naming when the site is profiled the next time:

    a. If the site is a SMP site, change character seven to N, and assign the site visit identifier to be A. For subsequent profile visits, maintain character seven as N and change the sequential visit identifier to be B, C, D, etc.

    b. If the site is a GPS site, change character seven to H, and assign the site visit identifier to be A. For subsequent profile visits, maintain character seven as H and change the sequential visit identifier to be B, C, D, etc.

    c. If the site is a SPS site, change character seven to T, and assign the site visit identifier to be A. For subsequent profile visits, maintain character seven as T and change the sequential visit identifier to be B, C, D, etc.

The following are examples of valid data file names:

- 171002GD: GPS section 1002 in Illinois (State code = 17), profiled for the fourth time.
- 260200SB: SPS-2 site in Michigan (State code = 26), profiled for the second time.
- 271018MB: Seasonal monitoring site 1018 in Minnesota (State code = 27), profiled for second time.
- 27A300SC: SPS-3 sites having project code A in Minnesota (State code = 27), profiled for the third time.

If a long SPS project is not profiled continuously, but profiled in groups of sections, the sixth character in the file name should be replaced by a character for each group. For example, consider the SPS-2 project in State 26 that is profiled as two groups of sections. The file name for the first group could be 26020ASA, while that for the second group could be 26020BSA.

The first two digits of the file name for a section must be valid State codes when generating file names for demonstration purposes or comparative studies. ProQual will not operate on data files that do not follow this convention.

2.2.7.4 Operating Speed

A constant vehicle speed of 80 km/h should be maintained during a profile measurement run. If the maximum constant speed attainable is less than 80 km/h due to either traffic congestion or safety constraints, then a lower speed should be selected depending on prevailing conditions. If the speed limit at the site is less than 80 km/h, the site should be profiled at the posted speed limit. If traffic traveling at high speeds is encountered at a test site, it is permissible to increase the profiling speed to 88 km/h. If a site is relatively flat, cruise control should be used to maintain a uniform speed. It is important to avoid changes in speed during a profile run that may jerk the vehicle or cause it to pitch on its suspension. A change in throttle pressure or the use of brakes to correct vehicle speed should be applied slowly and smoothly.

2.2.7.5 Event Initiation

During profile data collection, the data collection program uses an event mark to record a Reference Reset in the event file. Event marks are generated by the photocell. The vertical photocell detects the white paint stripe or reflective tape at the beginning of the test section and sends a signal to record that event in the event file. This information is used to generate the data corresponding to the test section. In those instances in which existing paint mark on pavement is not able to trigger the vertical photocell, the horizontal photocell should be used. A cone with a reflective marker or an FHWA approved device should be placed on the shoulder at the beginning of the test section to activate the horizontal photocell. The leave edge of the reflective marker should be aligned with the leave edge of the stripe at the beginning of the test section.

2.2.7.6 Loading and Saving Files

Saving files to the hard disk, flash drive, zip disk or floppy disk, or loading files from the hard disk, flash drive, zip disk, floppy disk or CD ROM should not be done when the vehicle is in motion. At the completion of a profile run, driver should pull over to a safe location and come to a complete stop, enter end of run comment, and then save data file to a hard disk.

2.2.7.7 Inclement Weather and Other Interference

Inclement weather conditions (e.g., rain, snow, heavy cross winds) can interfere with the acquisition of acceptable profile data. Profile measurements should only be performed on dry pavements. In some cases, it may be possible to perform measurements on a damp pavement with no visible accumulation of surface water. Under such circumstances, the data should be monitored closely for run to run variations and potential data spikes. ProQual should be used to detect spikes. This program uses a threshold value of 5 mm to identify single elevation spikes. When reviewing data, the operator should keep in mind that spikes could occur due to pavement conditions (e.g., potholes, transverse cracks, bumps), and electronic interferences.

Changing reflectivity on a drying pavement due to differences in brightness of pavement (light and dark areas) may yield results inconsistent with data collected on uniformly colored (dry) pavements. Run to run variations in data collected under such conditions should be carefully evaluated. If problems are suspected, profile measurements should be suspended until pavement is completely dry.

Electromagnetic radiation from radar or radio transmitters may affect data recorded by the profiler. If this occurs, the operator should attempt to identify and to contact the source to learn if a time will be available when the source is turned off. If such a time is not available, it may be necessary to schedule a Dipstick® survey of the test section.

2.2.7.8 End of Run and Operator Comments

The profiler software allows the operator to enter comments at the end of each profile run, and those comments are hereafter referred to as end of run comments. If required, these comments can be edited in ProQual when the data files are imported. The operator can also enter comments about the profiled site after profile data is imported to ProQual and those comments are hereafter referred to as operator comments. Both sets of comments can be up to 55 characters in length

and are uploaded into the LTPP PPDB. Examples are provided in this section separately for end of run comments and operator comments with the suggested format for the comment.

2.2.7.8.1 End of Run Comments:

End of run comments entered for a group of sections profiled in one run (e.g., SPS site) are put into an individual file that is subsectioned from that profile run. Similarly, if a GPS section is profiled in conjunction with a SPS site in one run, end of run comments are common to all sections subsectioned from that profile run. Therefore, the operator should ensure that end of run comments that are entered when several test sections are profiled in one run are valid or applicable to all sections in that run (e.g., weather related comment). End of run comments should be typed in capital letters.

To ensure uniformity between the end of run comment that is made when a group of sections are profiled together (e.g., SPS section) and when a section is profiled as an individual section (e.g., GPS section), end of run comments have been grouped into the following three categories:

- Good Profile Run: Comment used to indicate that the profile run was good and that no problems were encountered. Example comment: RUN OK.
- Environment Related Comments: Profile testing should not be performed when environmental conditions are such that they can affect the quality of the data. If the operator believes there is a possibility that environmental conditions may have affected the quality of the data, a comment should be entered.
  Example comment: HEAVY WINDS.
- Speed Related Comments: The following are examples where a comment related to speed of testing should be entered:

  o Speed limit at site is lower than the 80 km/h specified for profile data collection.
    Example comment: SPEED LIMIT AT SITE IS 60 KM/H.
  o Heavy traffic makes it difficult to maintain a constant speed.
    Example comment: TRAFFIC CONGESTION: SPEED VARIABLE.
  o Grade (uphill or downhill) makes it difficult to maintain constant speed.
    Example comment: DIFFICULT TO MAINTAIN CONSTANT SPEED: UPGRADE.

End of run comments are made at end of the run prior to saving the data. ICC software offers six end of run comments that the user can select at the end of a run. If none of these comments are applicable, the user can type any desired comment. The six end of run comment options that are available in the ICC software are as follows:

- RUN OK.
- PAVEMENT SURFACE DAMP.
- TRAFFIC CONGESTION SPEED VARIABLE.
- DIFFICULT TO MAINTAIN CONSTANT SPEED: UPGRADE.
- DIFFICULT TO MAINTAIN WHEEL PATH LOCATION.
- LATE PHOTOCELL INITIATION.

There should always be an end of run comment. If no problems were encountered during the run, the comment "RUN OK" should be entered as an end of run comment. If there were weather/environmental related comments, or speed related comments, these should be entered following the guidelines that were presented previously. If a late photocell initiation is suspected, an additional run to replace that run should be obtained.

2.2.7.8.2 Operator Comments:

Operator comments are entered after profile data has been imported into ProQual and reviewed. Operator comments should be typed in capital letters. They can fall into one of the following six categories:

1. Pavement Distress Related Comment: A comment should be made if there are pavement distresses or features within the section that can affect the repeatability of profile data. Comment should specify the distress(es) present that the operator believes to be causing non-repeatability of profile data. The following are examples where such comments may be entered:

    a. For AC pavements, distresses such as rutting, fatigue/alligator cracking, potholes, patches, longitudinal and transverse cracking.
       Example comment: _____ IN SECTION (enter distress type for blank).

    b. For concrete pavements, distresses such as faulting, spalling, longitudinal and transverse cracking.
       Example comment: _____ IN SECTION (enter distress type for blank).

    c. For pavements with a chip seal, a comment should be entered if chips are missing in areas within the section.
       Example comment: CHIP SEAL SECTION. CHIPS MISSING.

    d. For sections with dips, comment should be made if there are dips within the section.
       Example comment: DIPS IN SECTION.

2. Maintenance Related Comments: A comment should be made if the operator is familiar with the test section and notes that recent maintenance and/or rehabilitation activities (e.g., overlays, patches, crack filling, or aggregate seals) have been performed on that section. The operator should specifically make a note if overband type crack filling has been performed on the section.
   Example comment: RECENT MAINTENANCE IN SECTION, PATCHES.

3. Wheel path Tracking Related Comments: A comment should be entered if the operator encountered problems in tracking the wheel path. Such comment should be entered if one or more of the following conditions are encountered:

a. During profile run, path followed was either to the left or to right of wheel path.
   Example comment: RUN RIGHT OF WHEEL PATH.

b. Difficulty in holding wheel path due to pavement distress(es) such as rutting.
   Example comment: DIFFICULT TO HOLD WHEEL PATH, RUTTING.

c. Difficulty in holding wheel path due to truck traffic.
   Example comment: DIFFICULT TO HOLD WHEEL PATH, TRAFFIC.

d. Difficulty in holding wheel path due to wind.
   Example comment: DIFFICULT TO HOLD WHEEL PATH, WINDY.

e. Difficulty in holding wheel path because of grade, either uphill or downhill.
   Example comment: DIFFICULT TO HOLD WHEEL PATH, UPHILL.

f. Difficulty in holding wheel path because section is on a curve.
   Example comment: DIFFICULT TO HOLD WHEEL PATH, CURVE.

4. Location of Test Section Comments: A comment should be entered if the location of a section has a potential impact on obtaining repeatable profile runs. Such conditions include the following:

   a. Section or approach to section is on a curve.
      Example comment: APPROACH TO SECTION ON CURVE.

   c. Section or approach to section is on a grade (uphill or downhill).
      Example comment: SECTION ON A DOWNHILL.

5. Miscellaneous Other Comments: A comment should be entered if conditions other than those not covered previously are encountered during profiling that may affect quality of the data. Such conditions include the following:

   a. Contaminants on road such as sand/gravel or dead animals.
      Example comment: SAND ON ROAD.

   b. Traffic or WIM loops within test section.
      Example comment: WIM LOOPS WITHIN SECTION OR TRAFFIC LOOPS IN SECTION.

   c. Color variability of the pavement because of salt application.
      Example comment: COLOR VARIABILITY CAUSED BY SALT.

   d. Excessive vehicle movements just prior to test section because of pavement condition.
      Example comment: CORE HOLES ON WHEEL PATH BEFORE SECTION.

6. Spike Related Comments: After ProQual has processed the data, the operator should look for presence of spikes in the data. If spikes are present, enter comment indicating whether or not the spikes are pavement related.
Example comment: PAVEMENT RELATED SPIKES IN PROFILE.

After data is processed using ProQual, an operator comment can be entered for each run by going to the Run Details Tab in ProQual. ProQual offers six comments that can be selected by the operator. These comments are the following:

- EQUIPMENT OK.
- ROUGH SURFACE TEXTURE / RAVEL & STONE LOSS.
- MODERATE TO SEVERE SURFACE FLUSHING.
- NOTICEABLE DISTRESS IN WHEEL PATH.
- MODERATE TO SEVERE RUTTING.
- FAULTING AND SPALLING OF JOINTS / CRACKS.

The operator also has the option of typing any desired comment. The operator can also select one of the default comments available in ProQual, and type an additional comment at the end of the selected comment.

Operator comments can be up to 55 characters in length. If spikes are observed in the profile, it is mandatory for the operator to enter a comment regarding these spikes after running ProQual to indicate whether or not the spikes are pavement related. Because of the 55 character constraint, it may not be possible to type in all of the applicable factors from the list of factors that were described previously. Therefore, when entering comments, it is recommended that the following order of priority (with the first factor listed being given the highest priority) be followed:

1. Wheel path tracking related comments.

2. Pavement distress related comments.

3. Maintenance related comments.

4. Miscellaneous other comments.

5. Location of test section comments.

It should be noted that comments are used to indicate factors that could affect the quality of data or to indicate factors that cause variability between profile runs. Depending on conditions encountered in the field, the recommended priority order may be changed, with the factor having greatest effect on quality or repeatability of profile data being listed first. If there are factors that cannot be entered because of space constraints, such factors should be entered in the LTPP Profiler Field Activity Report under the field Additional Remarks Regarding Testing (see section 2.8.1). (Note: If a factor has been entered as an operator comment into ProQual, it should not be repeated in the Field Activity Report).

2.2.8 Number of Runs

This section describes procedures to be followed to obtain an acceptable set of profile data at a site.

2.2.8.1 Evaluating Acceptability of Runs

Once the operator is confident that a minimum of five error free runs has been obtained, ProQual is used to evaluate acceptability of profile runs based on LTPP criteria. Procedures for running ProQual are described in the ProQual manual.[6] ProQual uses collected profile data to compute the IRI values for the left and right wheel paths, as well as the average IRI of the two wheel paths. ProQual also generates a report of spikes present in the pavement profile. Profiler runs at a site are accepted if the average IRI satisfies the following LTPP criteria:

- IRI of three runs is within 1 percent of mean IRI of the five selected runs.
- Standard deviation of IRI of the five selected runs is within 2 percent of mean IRI of the five selected runs.

For an SPS site, acceptance criteria have to be met at each section within the SPS project. If ProQual indicates that the five runs are not acceptable, procedures described in section 2.2.8.2 should be followed.

If ProQual indicates that the five runs are acceptable, but spikes are present in the data, the operator should determine if the spikes are pavement related or the result of equipment or operator error. The operator should examine plots of all profile runs for discrepancies and features that cannot be explained by observed pavement features, and also study the spike report. The operator should select the "Graphic Profiles" tab in ProQual to do this comparison. If there are spikes that are believed to be caused by operator or equipment error, the operator should correct the cause of the anomalies and make additional runs until five runs free of equipment or operator errors are obtained.

The operator should use ProQual to perform a visual comparison of profile data collected by the left, right, and center sensors for one profile run. If there is a malfunction in the center sensor, this will be seen from comparison of the three profiles. It is important that this comparison be made, as it is the only quality control check that is performed on data collected by the center sensor.

As a further check on the data, the operator should compare the current profile data with those obtained during previous site visit. The operator should also be familiar with the troubleshooting guide included in appendix B. The material presented in this appendix describes common errors that occur during profiling and is a valuable tool for identifying problems when profiles are being evaluated.

As specified in section 2.2.3.7, the operator must have profile data for the site from a previous site visit. A comparison between current profile data and those from the previous visit should be performed by selecting the "Graphic Profiles" tab in ProQual and selecting the desired data sets in ProQual. This comparison should be performed separately for the left and right wheel paths.

The operator should select a minimum of one profile run from the current set of profile runs and compare it with one profile run collected during the previous site visit.

When the ICC profiler data are compared to data collected with K. J. Law T-6600 profilers, differences in long wavelengths may be seen. However, the profile features for both devices should be similar. When the comparison involves only the ICC profiler data, both profile features, as well as profile shapes, should be similar.

If differences are observed between profiles, further comparisons should be made using remaining runs from both the current and previous visits. If there are still discrepancies between profiles from the current visit and previous visit, the operator should verify that these differences are not caused by equipment problems or due to incorrect subsectioning of SPS test sections. The operator should also explore if differences are due to pavement maintenance activities on the test section.

After the profile comparison is completed, an IRI comparison of current versus previous site visit data should be performed using procedures described in section 2.2.8.3. If IRI from profiler runs meet LTPP criteria (as seen in the ProQual output) and the operator finds no other indication of errors, no further testing is needed at that site.

2.2.8.2 Non-Acceptance of Runs by ProQual

The operator is responsible for carefully reviewing profile data to determine if a high degree of run-to-run variability is indicative of bad data or indicative of a pavement with a high degree of transverse variability. If runs do not meet LTPP criteria, the operator should perform the following steps to determine if variability is the result of equipment or operator errors, environmental effects, or pavement factors:

1. Review end of run comments and determine if passing trucks, high winds, or rapid acceleration or deceleration of the vehicle could have affected collected data.

2. Review spike report generated by ProQual to determine if spikes are a result of field related effects (e.g., potholes, transverse cracks, bumps) or due to electronic failure or interference. This can be determined by reviewing the ProQual reports and observing if spikes occur at the same location in all runs. The operator should also examine profile plots for discrepancies and features that cannot be explained by observed pavement features. ProQual provides users with the capability to compare all repeat runs collected at the site. This feature should be used to compare data between runs when analyzing differences between profiler runs.

3. Compare current profile data with those collected during the previous site visit. This comparison can be performed by selecting the "Graphic Profiles" tab and selecting the desired data sets in ProQual. This comparison may indicate potential equipment problems.

If variability between runs or spikes are believed to be operator related or equipment error, identify and correct cause(s) of anomalies and make additional runs until a minimum of five runs free of equipment or operator errors are obtained.

Where data anomalies are believed to be caused by pavement features rather than errors, a total of seven runs should be obtained at that section and evaluated using ProQual. If data from the last two runs are consistent with those from the first five runs in terms of variability and presence of pavement related anomalies, no further runs are required. If data from the last two runs differ from those for first five runs, the operator should reevaluate the cause of variability or apparent spike condition. If no errors are found, obtain two additional runs and terminate data collection at that section.

Thereafter, IRI values along the left and the right wheel paths should be compared with IRI values obtained during previous visit to test section as described in section 2.2.8.3.

2.2.8.3 Comparison of IRI with Previous Values

The operator should have IRI values obtained along the left and the right wheel path for the previous profile test dates for all test sections. Once the operator obtains an acceptable set of runs at a test section, IRI values along the left and right wheel paths should be compared with IRI values that were obtained for the previous test date for the section. The operator should determine if current IRI value along either the left or right wheel path is higher or lower than 10 percent of IRI value at the test section from the previous test date. If the difference in IRI is greater than 10 percent, the operator should see if the cause for change in IRI could be related to a pavement feature (e.g., maintenance activity, cracks or patches along wheel path). If the cause for change can be observed, it should be noted in the comments field in ProQual.

2.2.8.4 Graphical Outputs

Although not mandatory, the RSC may request the operator obtain a graphical plot of data recorded by the left, right, and center sensors for one profile run for archiving and/or quality control purposes. If a printout is obtained, the plot should be attached to the Profiler Field Activity Report (see section 2.8.1). The graphical plot can be obtained using either WinGraph or ProQual. If there are significant differences between profile runs, it is recommended that a graphical plot of profile data be obtained and attached to the Profiler Field Activity Report. In such cases, a plot of all profile runs for each path in one plot or a plot of questionable runs may be obtained.

2.3 FIELD TESTING

2.3.1 General Background

Procedures to be followed each day prior to and during data collection with respect to daily checks of the vehicle and equipment, start up procedures, setting up the software for data collection, and using software for data collection are described in the following sections.

These sections will describe the procedures to be followed when testing GPS or SMP sections. Some of the procedures for testing SPS and WIM sections are different than procedures for GPS sections. Section 2.4.1 describes procedures for SPS sections that differ from those for GPS sections, while section 2.4.2 describes procedures for WIM sections that differ from those for GPS sections.

2.3.2 Daily Checks on Vehicle and Equipment

The operator should follow the "Daily Check List" form included in appendix C and perform all checks outlined at the start of the day. It is not necessary to complete this form. This form can be placed inside a plastic cover, and the operator can go through items listed and make sure that everything is in proper working condition. The operator should maintain a log book in the profiler to note problems identified when going through the checklist. Suggested format of the logbook is included in appendix C (form PROF–3).

In order to maintain the computer and various associated equipment, care must be taken to either cool or warm equipment to the operating temperature described in section 2.2.4.2 prior to turning on the power. Electronic equipment in the profiler should be turned on for about 15 minutes prior to performing daily checks, as well as profile testing, in order for the electronics to warm up and stabilize.

2.3.3 Daily Equipment Checks

The following equipment checks should be performed daily before profile measurements are taken:

1. Laser sensor check.

2. Accelerometer check.

3. Bounce test.

2.3.3.1 Laser Sensor Check

This check is a test of laser sensors to determine if they are within tolerance. The check should be carried out in an enclosed building or at a location where the vehicle is protected from wind (e.g., vehicle can be parked on the side of a building). The vehicle should also be parked on a level surface. This test may be conducted using an external power source or with the engine of the vehicle running. The laser sensor check can be performed on all three sensors at the same time, or each sensor can be checked separately. Procedures for both methods are described in this section.

2.3.3.1.1 Selecting Calibration Blocks:

Handle the calibration blocks with care. The surfaces of calibration blocks are measured precisely, and if they are damaged they will not be suitable to perform the calibration check.

If sensors are to be checked individually, only one block is needed to perform the check. If all three sensors are to be checked simultaneously, three blocks are needed to do this test. The 25 mm side of the block is placed vertically when performing this test. If all three sensors are to be checked simultaneously, use the following procedure to select three blocks to do this test:

- The exact dimension of the 25 mm side of the block is engraved to three decimal places on each block. Round the dimension of the 25 mm side of the six blocks to the second decimal place. For example, say the dimensions of the six blocks are 25.022, 25.024, 25.024, 25.025, 25.028, and 25.010. When thicknesses are rounded to the second decimal place the values are 25.02, 25.02, 25.02, 25.03, 25.03, and 25.01. Select three blocks that have the same dimension to do the test, and when prompted to enter the block size, enter the block height rounded to the second decimal place. For the example given, the block size should be entered as 25.02.

- If only two blocks have the same dimensions when rounded to second decimal place, select these two blocks and another block that has the dimension closest to the two blocks for the sensor check. For example, if the block heights when rounded to second decimal place are 25.00, 25.01, 25.02, 25.02, 25.03, and 25.0, then select the two blocks with the height of 25.02 and a block with a height of 25.03 to do the test. When the computer prompts for block size when doing the test, enter the height that was common to two of the blocks, rounded to second decimal place. For the above example, block height should be entered as 25.02.

- If rounded dimensions for the blocks are all different from each other, select three blocks that are closest to each other in height to do the test. For example if the block heights when rounded to the second decimal place are 24.98, 24.99, 25.00, 25.01, 25.02, and 25.03, then select the blocks with dimensions of 25.00, 25.01, and 25.02 to do the test. When the computer prompts for block size when doing the test, enter the height of block that is between the heights of the other two blocks. For the above example, block height should be entered as 25.01.

2.3.3.1.2 Setting up for Performing Laser Sensor Check:

Use the following procedure to setup the profiler to perform the laser sensor check:

1. Park the profiler on a level surface.

2. Make sure that the lasers are turned off. Remove the covers from sensors and inspect the sensor lenses. Gently clean each lens with a damp cloth or towel. If excessive dirt is noted on the lenses, wash off loose particles using compressed air or water applied through a sprayer, and then clean the lenses using a damp cloth or towel. When cleaning the lenses, use extreme care to prevent scratching of the lenses.

3. Boot up the computer following the procedure described in section 2.2.5.4. The MDR main menu (see figure 13) should be displayed on the monitor at this stage. Turn on the lasers.

2.3.3.1.3 Performing Laser Sensor Check:

The computer and lasers should be turned on for about 15 minutes to allow the electronic equipment to warm up and stabilize prior to performing this check. Do not enter, bounce or bump, or lean on the vehicle when this check is performed. The operator should adjust the computer monitor so that it can be seen from outside the vehicle, and the keyboard should be placed on one of the front seats. As described previously, the sensor check can be performed simultaneously on all three sensors, or it can be performed individually on one sensor at a time. The recommended procedure is to perform the check simultaneously on all three sensors. Procedures for both methods are described separately.

2.3.3.1.4 Performing Check Simultaneously On All Sensors:

Use the following procedure to perform the laser sensor check on all the lasers simultaneously:

1. Select the Calibration option in the MDR main menu. Move the highlighted bar to the "Sensors" option, and press the Enter key. The monitor should now display the sensor calibration menu shown in figure 30.
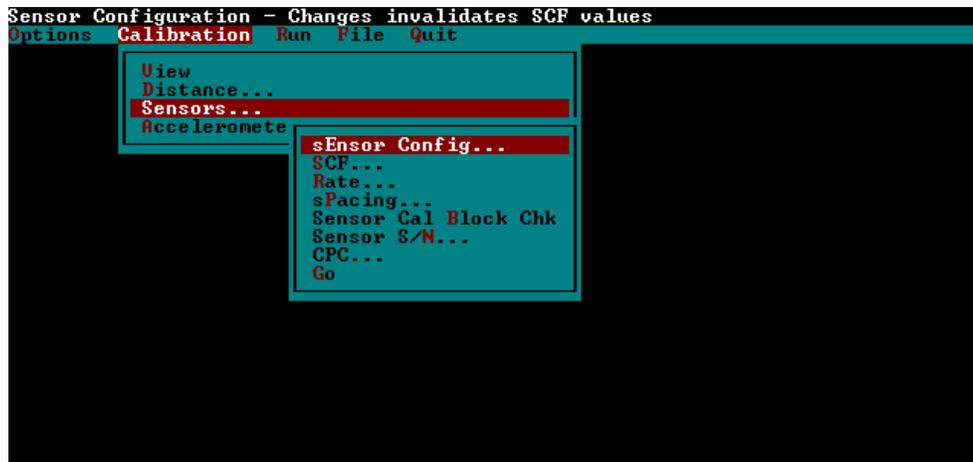
Figure 30. Screen shot. Sensor calibration menu (2).

2. Highlight "Sensor Cal Block Chk" and press the Enter key. The monitor will display the calibration check screen shown in figure 31.
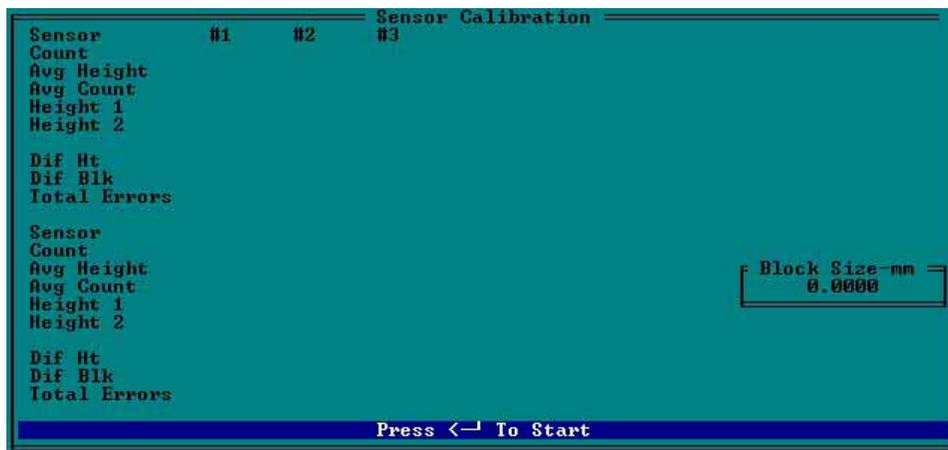
Figure 31. Screen shot. Calibration check screen (1).

3. Enter the block size in the window that is open. Type the block size based on the value decided in section "Selection of Calibration Blocks," and press the Enter key to close the window.

4. Clean the top of the calibration base plates, as needed (base plate is the plate with three feet). Place a calibration base plate on the ground below each sensor, such that the red laser dot is centered on the base plate (see figure 32).

Figure 32. Photo. Laser dot centered on base plate (1).

5. Place a calibration surface plate on top of each calibration base plate, with the long dimension of the calibration surface plate parallel to the long dimension of the profiler sensor bar. Center each calibration surface plate so that the red laser dot of each sensor is centered on the calibration surface plate (see figure 33).

Figure 33. Photo. Calibration surface plate on top of base plate (1).

6. Press the Enter key to begin sampling by the system. The number of samples taken is displayed at the bottom of the screen. The computer monitor at this stage will look similar to figure 34. (Note: values displayed on monitor for count, Avg Height, Avg Count, Height 1, Height 2, Dif Ht, Dif Blk will be different from values shown in figure 34). Allow the system to take at least 500 samples and then press the Backspace key to stop sampling.
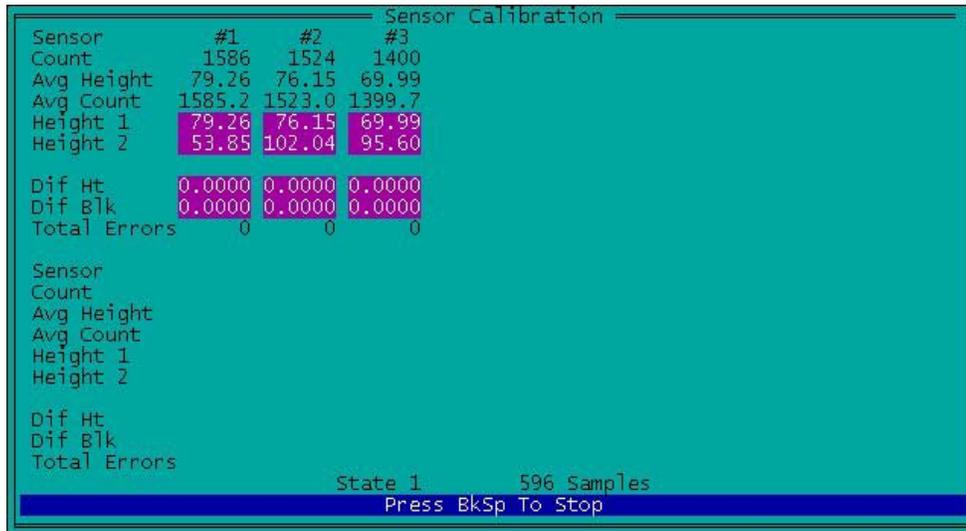
Figure 34. Screen shot. Readings taken on base plate (1).

7. Remove the calibration surface plate from calibration base plate for left sensor, then place one of the blocks selected for test on top of the base plate such that the 25 mm side of the block is vertical. Adjust the block so that the red laser dot is at the middle of the block. Place the calibration surface plate on top of the block and adjust the surface plate to ensure the red laser dot is at the middle of the calibration surface plate (see figure 35). Repeat this procedure for the center and right sensors.

Figure 35. Photo. Block on top of base plate with calibration plate on top of block (1).

8. Press the Enter key, allow system to take at least 500 readings, and press the Backspace key to stop sampling. The computer monitor at this stage will look similar to figure 36. (Note: Values displayed on monitor for Count, Avg Height, Avg Count, Height 1, Height 2, Dif Ht, Dif Blk will be different from values shown in figure 36).

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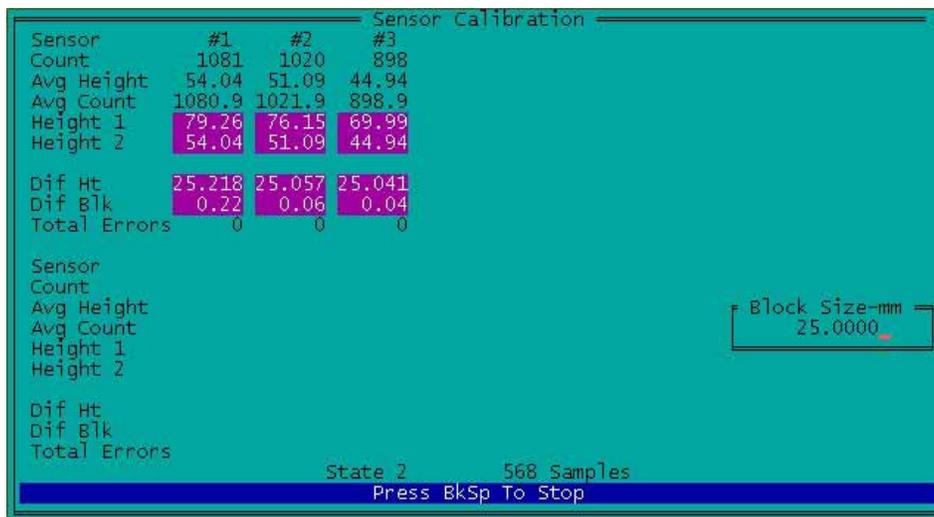
Figure 36. Screen shot. Readings being taken on 25-mm blocks (1).

Notations #1, #2 and #3 refer to the left, right, and center sensors, respectively. The value shown in the "Dif Ht" field is the height of block as measured by the data acquisition system in the profiler. The value shown in "Dif Blk" field is the difference between height of block as measured by data acquisition system of the profiler and block height that was entered into the computer in step 3.

9. Repeat the check for sensor(s) that do not meet specified tolerance if the value displayed in "Dif Blk" for any sensor is outside tolerance of ±0.25 mm. If the value displayed in the field "Dif Blk" for all three positions (#1, #2 and #3) is between +0.25 and -0.25 mm, all three sensors are considered to be functioning satisfactorily. Make sure the system is warmed up, sensor glass is clean, blocks are level, van is steady, and lighting conditions are consistent prior to repeating the test. If the sensor(s) are still outside the tolerance, repeat the test three more times. If tolerance cannot be achieved, turn the engine off, repeat the check, and see if the required tolerance can be achieved. If sensor(s) are still outside the tolerance, move the vehicle to another location and repeat the test. If the operator feels that sunlight may have had an effect on results, move the van to a shaded location and repeat test. If sensor(s) are still outside tolerance, call the RSC to decide on a course of action.

2.3.3.1.5 Performing Check Individually On a Sensor:

Use the following procedure to perform the laser sensor check on the lasers individually:

1. Select the Calibration option in the MDR main menu, move the highlighted bar to the "Sensors" option, and press the Enter key. The monitor should now display the Sensor Calibration menu shown in figure 30.

2. Highlight "Sensor Cal Block Chk" and press the Enter key. The monitor will display the calibration check screen shown in figure 31.

3. Enter the block size in the window that is open. Type size of block that will be used for the test, and press the Enter key.

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4. Clean the top of the calibration base plate, as needed (base plate is the plate with three feet). Place the calibration base plate on the ground below the sensor that is being checked, such that the red laser dot is centered on the base plate (see figure 32).

5. Place the calibration surface plate on top of calibration base plate, with the long dimension of the calibration surface plate parallel to long dimension of the profiler sensor bar. Center the calibration surface plate so that the red laser dot is centered on the calibration surface plate (see figure 33).

6. Press the Enter key to begin sampling by the system. The number of samples taken is displayed at bottom of the screen. The computer monitor at this stage will look similar to figure 37. (Note: Values displayed on the monitor for count, Avg Height, Avg Count, Height 1, Height 2, Dif Ht, Dif Blk will be different from values shown in figure 37). Allow the system to take at least 500 samples and then press the Backspace key to stop sampling.
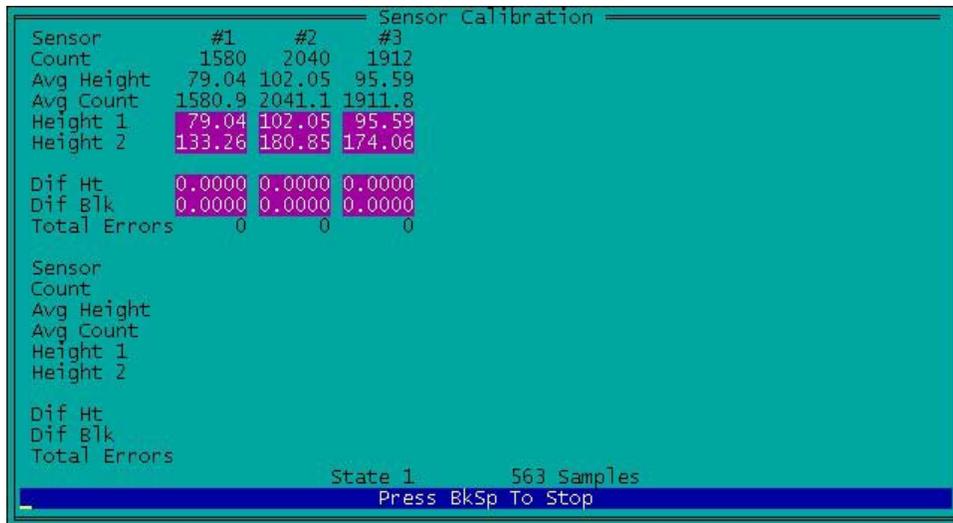
Figure 37. Screen shot. Reading taken on base plate for single block test.

7. Remove the calibration surface plate from the calibration base plate, then place the block selected for the test on top of the base plate, such that the 25 mm side of the block is vertical. Adjust the block so the red laser dot is at the middle of block. Place the calibration surface plate on top of the block, and adjust the surface plate to ensure the red laser dot is at the middle of the calibration surface plate (see figure 35).

8. Press the Enter key, allow the system to take at least 500 readings, and press the Backspace key to stop sampling. The computer monitor at this stage will look similar to figure 38. (Note: The values displayed on the monitor for Count, Avg Height, Avg Count, Height 1, Height 2, Dif Ht, Dif Blk will be different from the values shown in figure 38).
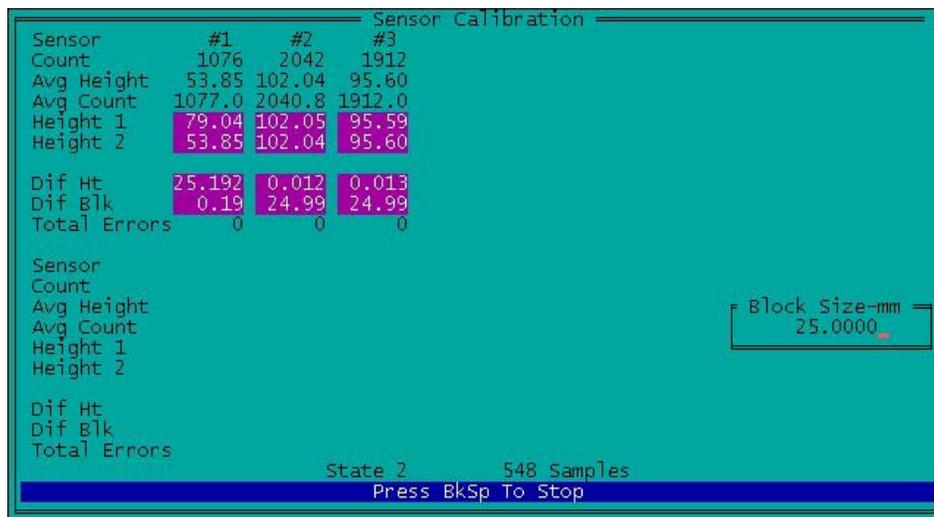
Figure 38. Screen shot. Readings being taken on 25-mm block—single block test.

Notations #1, #2 and #3 refer to the left, right, and center sensors, respectively. The value shown in the "Dif Ht" field is the height of the block as measured by the data acquisition system in the profiler. The value shown in the "Dif Blk" field is the difference between the height of the block as measured by the data acquisition system of the profiler and the block height that was entered into the computer.

9. Go to step 11 if the value displayed in "Dif Blk" is not within -0.25 mm and +0.25 mm, else go to step 12. If the value displayed in "Dif Blk" for the sensor being checked is between -0.25 mm and +0.25 mm, that sensor is considered to have passed laser sensor check.

   Repeat the laser sensor check for the sensor if the value displayed in "Dif Blk" for the sensor is outside the tolerance of ±0.25 mm. Make sure the system is warmed up, the sensor glass is clean, the block is level, the van is steady and the lighting conditions are consistent prior to repeating the test. If the sensor is still outside the tolerance, repeat the test three more times. If tolerance cannot be achieved, turn the engine off, repeat the check, and see if the required tolerance can be achieved. If the tolerance cannot be achieved, move the vehicle to another location and repeat the test. If the operator feels that sunlight may have had an effect on the results, move the van to a shaded location and repeat the test. Once the sensor passes the laser check, go to step 12. If a sensor is still outside tolerance, call the RSC to decide on a course of action.

10. Repeat steps 3 through 10 for the other two sensors.

2.3.3.2 Accelerometer Calibration Check

This check should be performed daily prior to data collection to check if calibration values of the accelerometers are within allowable limits. The operator may elect to do a daily accelerometer calibration, following procedures listed in section 2.5.3, instead of a daily accelerometer check.

The accelerometer check should be performed while the vehicle is parked on a level surface. The location where the check is made should be free of any vibrations. Do not bounce or bump the vehicle during this check. The operator may be inside the vehicle with the engine running when this check is performed. The computer should have been turned on and the system warmed up at least 15 minutes prior to performing this check. The following procedure should be used to perform the check:

1. Select "Calibration" to bring up the Calibration menu in the MDR main menu. Next, use the arrow keys to move the highlighted bar to "Accelerometer" and press the Enter key. The Accelerometer Calibration Menu shown in figure 39 will be displayed on the monitor. Make sure the settings shown on the monitor match the values shown in figure 39.
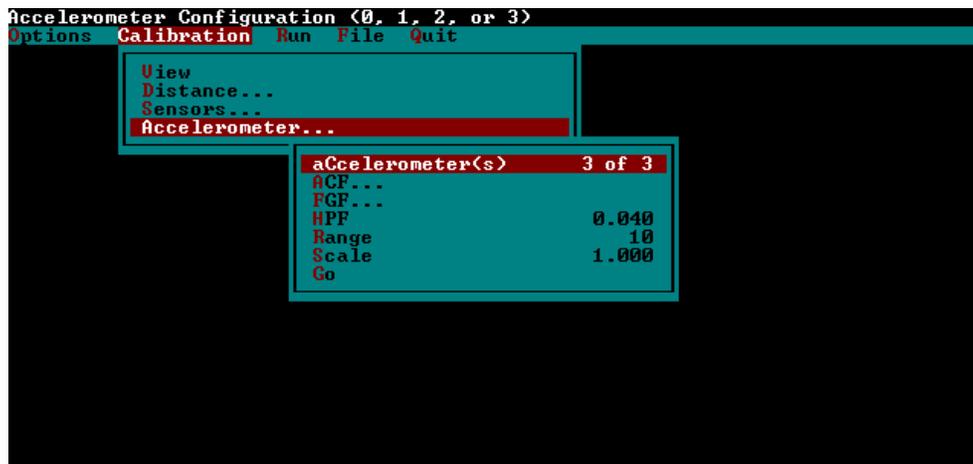
Figure 39. Screen shot. Accelerometer calibration menu (1).

2. Use the arrow keys to move the highlighted bar to the "Go" option and press the Enter key. The Accelerometer Calibration screen shown in figure 40 will be displayed on monitor (values shown on the monitor will be different from values shown in figure 40).

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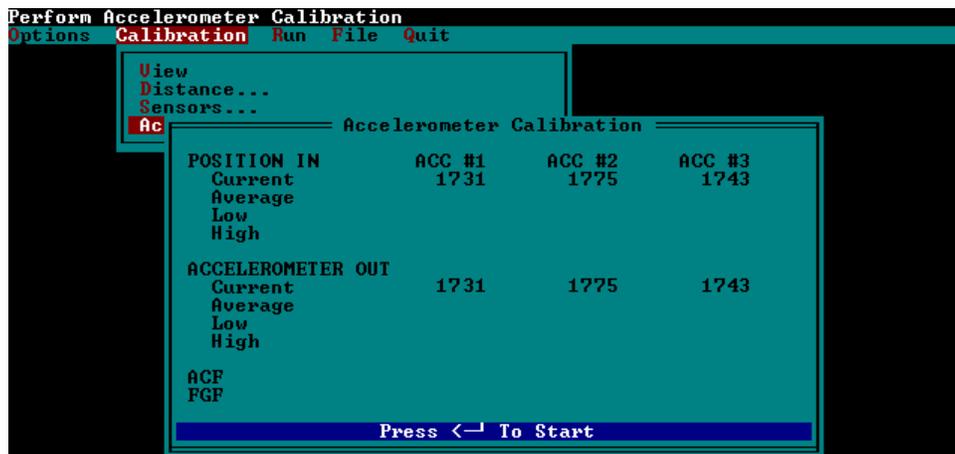
Figure 40. Screen shot. Accelerometer calibration screen (1).

3. Press the Enter key and the accelerometer will begin collecting data. After about 5,000 samples have been taken, press the Backspace key to end calibration.

4. Check the values that are displayed on the monitor for the three accelerometers to see if they are within the allowable range. The allowable range for an accelerometer is normally between 1710 and 1790. However, if during step 25 of the Accelerometer Signal Conditioning Test (see section 2.6.1), the accelerometer calibration factor (ACF) range of an accelerometer was not between 1710 and 1790, a new allowable range for that accelerometer would have been determined as described in section 2.6.2. If any of the displayed values is outside the range from 1710 and 1790, the value must be compared to the range determined according to the procedure described in section 2.6.2 to see if it falls within the allowable range.

5. Press the "n" key to exit back to the Calibration Menu when the system asks if new values should be accepted. If displayed values are outside the allowable range indicated in step 4, an accelerometer calibration should be performed following the procedures described in section 2.5.3.

2.3.3.3 Bounce Test

The bounce test is performed to verify that height sensors and accelerometers in the profiler are functioning properly. The bounce test should be performed every day prior to data collection. This test must be performed immediately after the laser sensor check and accelerometer calibration check have been performed. The bounce test consists of two separate tests, a static test and a dynamic bounce test. In the static test, the sensors in the vehicle are turned on while the vehicle is parked, and the generated profile is recorded and evaluated. In the dynamic bounce test, the vehicle is bounced while it is stationary, and generated profile is recorded and evaluated. The vehicle engine may be on or off when performing the static and dynamic bounce tests. Both the static and dynamic tests can be combined into one test. The recommended method for performing the bounce test is the combined test. Procedures for performing the combined test, as well as procedures for performing static and dynamic bounce test separately are described in this section.

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2.3.3.3.1 Setup Procedure for Bounce Test:

The following procedures should be followed to setup the profiler prior to performing the bounce test:

1. Park the profiler on a level surface.

2. Boot up the computer following procedures described in section 2.2.5.4. After the computer has been booted up, WinGraph should be running in system 1, while the monitor should show the MDR main menu (see figure 41). If the computer has already been turned on, use KVM switch and go to system 1. If WinGraph is not running in system 1, double click on the ICC icon to run WinGraph. Then use the KVM switch to go back to system 2.
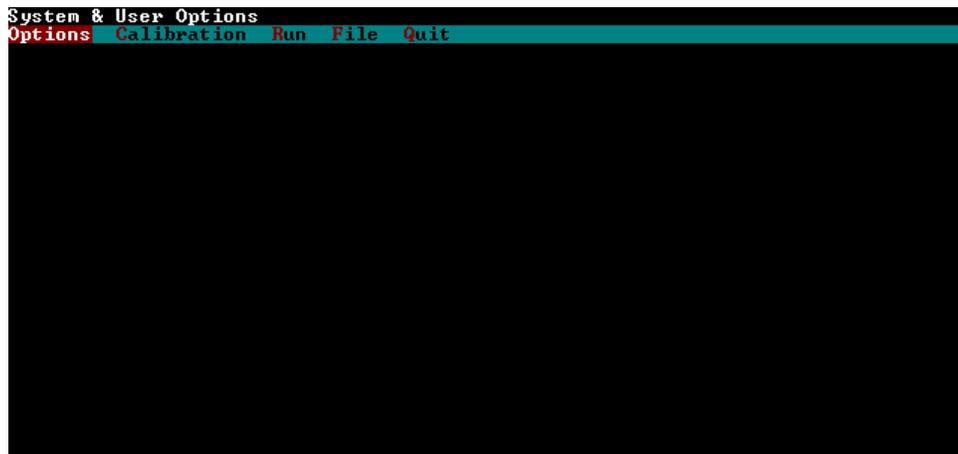
Figure 41. Screen shot. MDR main menu (2).

3. Turn on the lasers if the lasers have not been turned on.

4. Select the "Run" option in the MDR main menu and the Run Menu shown in figure 42 will be displayed on monitor.

Figure 42. Screen shot. Run menu (2).

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5. Move the highlighted bar to "Options" using arrow keys and press the Enter key. Next, highlight "IRI…" and press the Enter key. The screen shown in figure 43 will be displayed on the monitor. Check to see if Interval is set to 152.4. If not, highlight the Interval, press the Enter key, type 152.4 in the window that opens up, and press the Enter key to close the window. When done, press the Escape key three times to get back to the MDR main menu (figure 41).

Figure 43. Screen shot. IRI options screen (2).

6. Place a brown masonite clipboard below each sensor. This procedure is used because pavement surface texture can affect the IRI values obtained from the bounce test, and placing a clipboard ensures that all three sensors take readings on a smooth and similar surface.

2.3.3.3.2 Performing Combined Bounce Test:

Power to the computer and lasers should be turned on about 15 minutes prior to conducting the test for electronic equipment to warm up. Use the following procedure to perform combined test, which consists of the static test and dynamic bounce test:

1. Select the "Run" option in the MDR main menu. A Run Menu similar to that shown in figure 42 will be displayed on monitor.

2. Move the highlighted bar to the "File Name" option and press the Enter key. This will cause a window to open. Type the file name that will be used to save data from the combined test and press the Enter key to close the window. A suggested file name format to follow is YYMMMDDC, where YY—last two digits for current year, MMM – current month (use first three letters of month), DD—current day, and C indicates the test is a combined test.

3. Select "Options" in the Run Menu (figure 42) and the Run Options screen shown in figure 44 will be displayed on the monitor. Highlight "HW DMI Simulator" and press the Enter key to turn the simulator "On." Press the Escape key once to get to the Run Menu (see figure 42).

Figure 44. Screen shot. Run options screen.

4. Highlight the "Go" option in the Run Menu (see figure 42) and press the Enter key. The monitor should now display a MDR Run screen similar to that shown in figure 45 (values shown on monitor for POS1, POS2, POS3, SEN1, SEN2, SEN3, and filename will be different from that shown in figure 45). The green part of the screen should now display the message OnLineCk. This message indicates that system 2 is connected to WinGraph in system 1. If this message is not displayed, exit the program and go to system 1 and see if WinGraph is running.
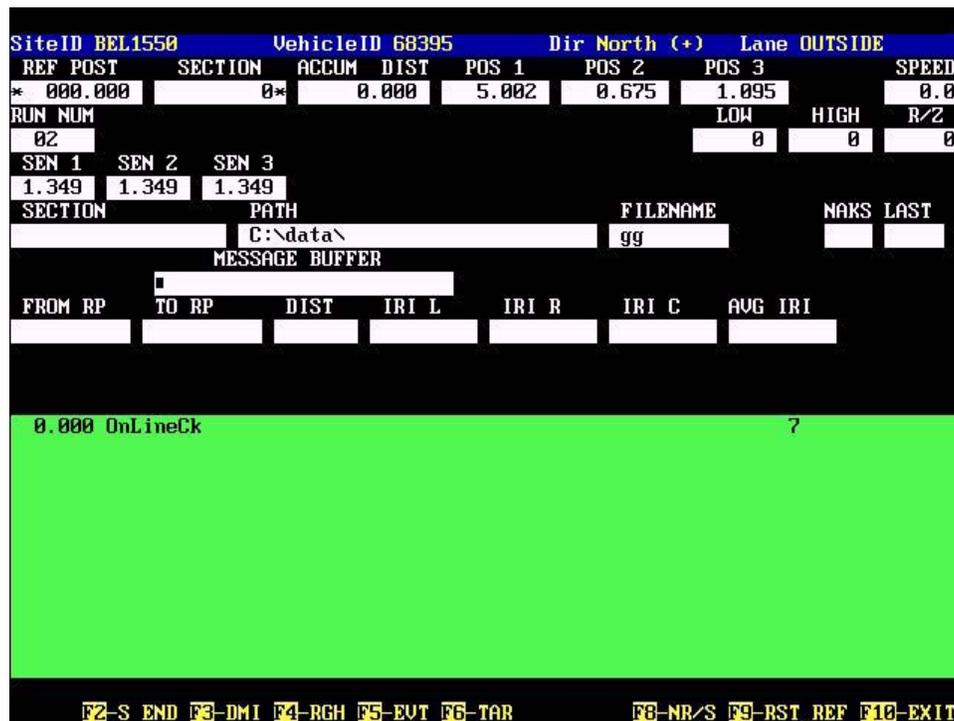
Figure 45. Screen shot. Run screen of MDR program (1).

5. Stand outside the vehicle for the static portion of combined test. There should be no motions induced on the vehicle during this test. Press the F3 key to start the DMI simulator. Let the system show a travel of about 600 m, press the F9 key to send a reference reset, and then let the simulator travel for 200 m.

6. Stand on the rear bumper of the van for the dynamic bounce portion of the test. Bounce the profiler to induce a pitching motion. This motion should pitch the vehicle along the longitudinal direction with no sideways motion. Motion should correspond to a 25 mm displacement of rear bumper for each bounce (i.e., distance from highest position to lowest position is 25 mm during bouncing). For the dynamic bounce test, the IRI value over a distance of 152.4 m within which bouncing motions were induced is evaluated (e.g., this distance may be selected between 304.8 m and 457.2 m, or between 457.2 and 609.6 m). The operator should do some trial runs with another person in order to get an idea about time needed in order to achieve a distance of 152.4 m over which the bouncing motions are performed. Once the operator is sure that bouncing motion was performed between 304.8 and 457.2 m or between 457.2 and 609.6 m, stop bouncing and press the F3 key to stop the DMI.

7. Go to system 1 using the KVM switch to display the bounce test profile in WinGraph. Move the mouse pointer to the down arrow beside the Y-Scale window on the upper left hand side of the WinGraph window and click on it once with the left mouse button. Move the mouse pointer to the number 1 on the y-scale drop down menu and click it once with the left mouse button (see figure 46). A screen similar to that in figure 47 will be shown at the end of test (IRI values shown on monitor after the test will be different from values shown on figure 47).
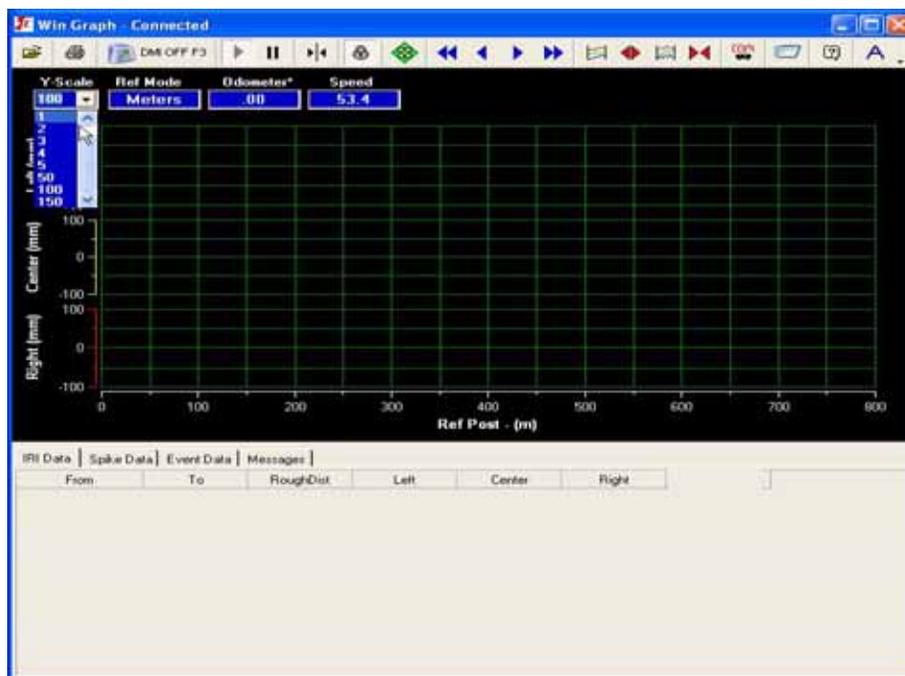
Figure 46. Screen shot. Adjusting scale of graph in WinGraph.

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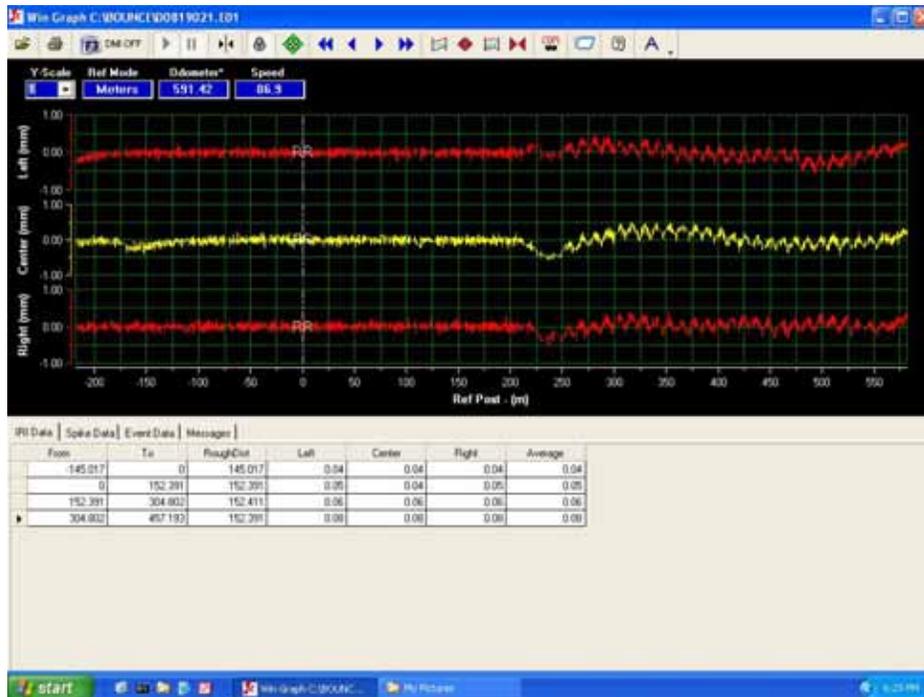
Figure 47. Screen shot. Output from combined bounce test.

8. Evaluate profiles that are displayed for the three sensors. The graph should show that the bouncing motion was induced between the limits of 304.8 and 457.2 m or between 457.2 and 609.6 m. If not, the test should be repeated.

9. Compare profile plots between the three sensors for both the static part and dynamic part of the test. The profile corresponding to dynamic bounce part will show more movement when compared to static portion of the test. Evaluate the profile for the presence of spikes. Spikes in the profile may indicate problems with sensors. Repeat the test if spikes are observed in the profile.

10. Verify that IRI values from 0 to 152.4 for the left, center, and right sensors are less than or equal to 0.08 m/km. If so, all three sensors are within the tolerance for the static test. If IRI values for the static portion of the test are outside the specified limit, repeat the test. If after repeating the test several times, the IRI value of the sensor(s) is outside the specified limit, decide on a course of action by contacting the RSC. Also, see subsection "Failure of Bounce Test Criterion," which is located after the sections "Performing Static Test" and "Performing Dynamic Bounce Test" in this section.

11. Select a 152.4 m interval that is shown at the bottom of the graph over which bouncing motions have been performed. This interval may be between 304.8 and 457.2 m or between 457.2 and 609.6 m. Note the IRI value for each sensor for the selected 152.4 m interval, which is IRI of the dynamic bounce part of the test.

12. Compute the difference between the dynamic bounce IRI and static test IRI for each sensor (left, center, and right). If the difference in IRI is less than or equal to 0.10 m/km for all three sensors, the profiler is considered to have successfully passed the bounce test. If not, repeat the test until all three sensors are within the specified tolerance. If the

specified criterion is not satisfied after repeating test several times, decide on a course of action by contacting the RSC. Also, see subsection "Failure of Bounce Test Criterion," which is located after the sections "Performing Static Test" and "Performing Dynamic Bounce Test" in this section.

13. Obtain a printout of the profile plot if both the static and dynamic IRI criteria are satisfied for all three sensors and note the static test IRI and dynamic bounce test IRI values for each sensor on the graph.

14. Go to system 2 using the KVM switch. The MDR green color screen will be displayed on the computer monitor.

15. Press the F10 key to exit program and save data. The system will ask for an End of Run Note. Since none of the given choices are appropriate, press 7 then press the Enter key and type an end of run comment if needed, and press the Enter key.

16. Press the Enter key if the path and file name to save data that are displayed are acceptable. If a different path and/or file name is needed, use the Backspace key to edit and press the Enter key. After saving the file, the system will revert back to the MDR main menu.

17. Highlight "Run" in the Main Menu to show the Run menu. In the Run Menu, select "Options" (figure 42) and the Run Options screen shown in figure 44 will be displayed on the monitor. Highlight "HW DMI Simulator" and press the Enter key to turn the simulator "Off." Press the Escape key twice once to get to the Main Menu.

2.3.3.3.3 Performing Static Test:

The power to the computer and lasers should be turned on for about 15 minutes for electronic equipment to warm up prior to conducting the static test. Use the following procedure to perform the static test:

1. Perform steps 1 through 5 described under the Combined Bounce Test Procedure. In step 3, type an appropriate file name to save the static test data. A suggested file name format to follow is YYMMMDDS, where YY—last two digits for current year, MMM—current month (use first three letters of month), DD—current day, and S to indicates the test is a static test.

2. Stand outside the vehicle while the static test is being performed. There should be no motions induced on the vehicle during this test. Press the F3 key to start the DMI simulator. Let the system show a travel of about 600 m, press the F9 key to send a reference reset, let the simulator travel for 200 m, and press the F3 key to stop the DMI.

3. Switch to system 1 using the KVM switch. Move the mouse pointer to the down arrow beside the Y-Scale window on the upper left hand side of the WinGraph window and click on it once with left mouse button. Move the mouse pointer to the number 1 on the y-scale drop-down menu and click once on it with the left mouse button (see figure 46).

4. Evaluate the profile for the presence of spikes. A screen similar to figure 48 will be shown at the end of the test (IRI values shown on monitor after the test will be different from values shown in figure 48). Spikes in the profile may indicate problems with sensors. Repeat the test if spikes are observed in the profile.
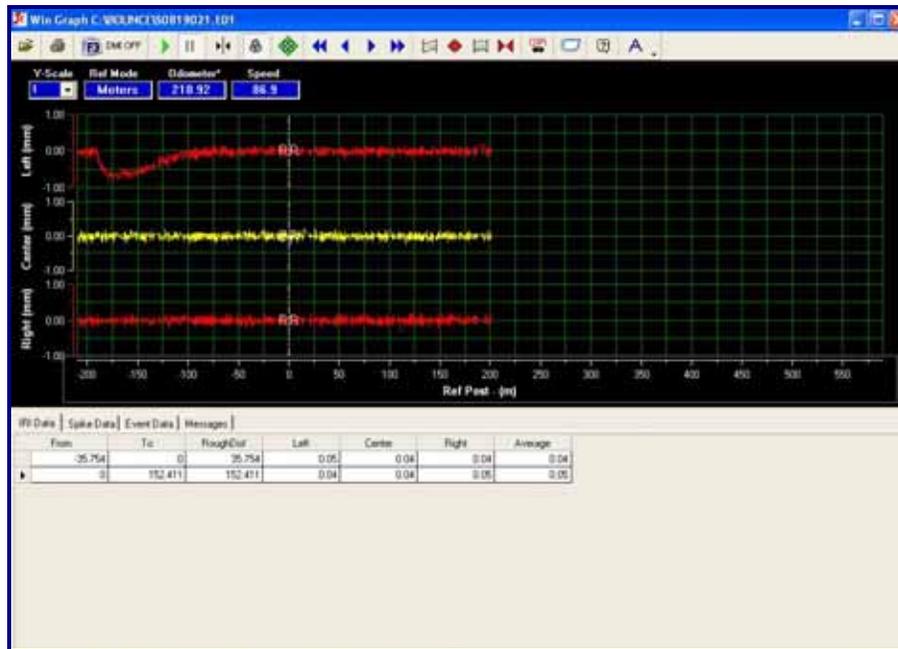
Figure 48. Screen shot. WinGraph screen after static test has been terminated.

5. Verify if IRI values from 0 to 152.4 for the left, center, and right sensors are less than or equal to 0.08 m/km. If so, all three sensors are within tolerance. Print the graph and note IRI values from 0 to 152.4 m for the three sensors on the graph. Repeat the test if IRI for any sensor is greater than 0.08 m/km. If after several tests, the IRI value is still outside tolerance, decide on a course of action by contacting the RSC. Also, see section "Failure of Bounce Test Criterion" which follows subsection "Dynamic Bounce Test" in this section.

6. Switch to system 2 using the KVM switch. The MDR run screen (green colored screen) will be displayed on the computer monitor.

7. Press the F10 key to exit the program and save data. The system will ask the operator to enter an End of Run Note. Since none of the given choices are appropriate, press 7 then press the Enter key and type an end of run comment if needed, and press the Enter key.

8. Press the Enter key if the path and file name displayed on monitor are acceptable. If a different path and/or file name is needed, use the Backspace key to edit and press the Enter key. After saving the file, the system will revert back to the MDR main menu.

9. Turn off the DMI simulator if the Dynamic Bounce test is not being performed after the static test. To turn off the DMI Simulator, highlight "Run" in the Main Menu to show the Run menu. In the Run Menu, select "Options" (figure 42) and the Run Options screen shown in figure 44 will be displayed on the monitor. Highlight "HW DMI Simulator" and

press the Enter key to turn the simulator "Off." Press the Escape key twice once to get to the Main Menu.

2.3.3.3.4 Performing Dynamic Bounce Test:

The dynamic bounce test should be performed after static test has been completed. Use the following procedure to perform the dynamic bounce test:

1. Perform steps 1 through 5 described under the Combined Bounce Test Procedure. In step 3, type an appropriate file name to save data. A suggested file name format to follow is YYMMMDDD, where YY—last two digits for current year, MMM—current month (use first three letters of month), DD—current day, and D indicates test is a dynamic test. The system is now ready to perform dynamic bounce test.

2. Press the F3 key to start the DMI simulator. Let the simulator travel for about 600 m and then press the F9 key to send a reference reset. Next, stand on the rear bumper of the van and bounce the profiler to induce a pitching motion. This motion should pitch the vehicle along the longitudinal direction with no sideways motion. The motion should correspond to a 25 mm displacement of the rear bumper for each bounce (i.e., distance from highest position to lowest position is 25 mm during bouncing). For the dynamic bounce test, the IRI values between 152.4 m and 304.8 m are evaluated. It will take some time for the operator to get on the bumper and start bouncing after pressing F9 key. Make sure that bouncing motions on the vehicle are induced before a distance of 152.4 m has been reached (the operator should do some trial runs with another person in order to get an idea about time needed in order to achieve this requirement). If bouncing motions started after 152.4, then the bounce test should be continued so that the bouncing motion is induced between distances of 304.8 m and 457.2 m.

3. Stop bouncing and press the F3 key to stop DMI After a simulated distance of 304.8 m (or 457.2 m if the operator feels that bouncing motions started after 152.4 m). When bouncing the vehicle, the computer monitor cannot be seen. Therefore, estimate the time of bouncing such that the simulator will travel a distance greater than 304.8 m (do some trial runs with another person to estimate time the vehicle should be bounced in order to achieve the specified distance).

4. Go to system 1 using the KVM switch to display the bounce test profile in WinGraph. Move the mouse pointer to the down arrow beside the Y-Scale window on the upper left hand side of the WinGraph window and click on it once with left mouse button. Move the mouse pointer to the number one on the y-scale drop down menu and click once on it with the left mouse button (see figure 46).

5. Evaluate the profiles that are displayed for the three sensors. A screen similar to that shown in figure 49 will be shown on the monitor at end of the test (IRI values shown on monitor will be different from values shown in figure 49). The graph should show that the bouncing motion was induced between limits of 152.4 and 304.8 m. If the bouncing motion started after 152.4 m or if the bouncing motion was terminated before 304.8 m, the dynamic bounce test should be repeated. However, if the bouncing motions were continued between the limits of 304.8 to 457.2 m, IRI values within these limits can be used as dynamic bounce test IRI values. In the graph shown in figure 49, bouncing

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motions started after 152.4 but were continued to a distance greater than 750 m. IRI values between 304.8 and 457.2 m can be used in this case as dynamic bounce test IRI values.
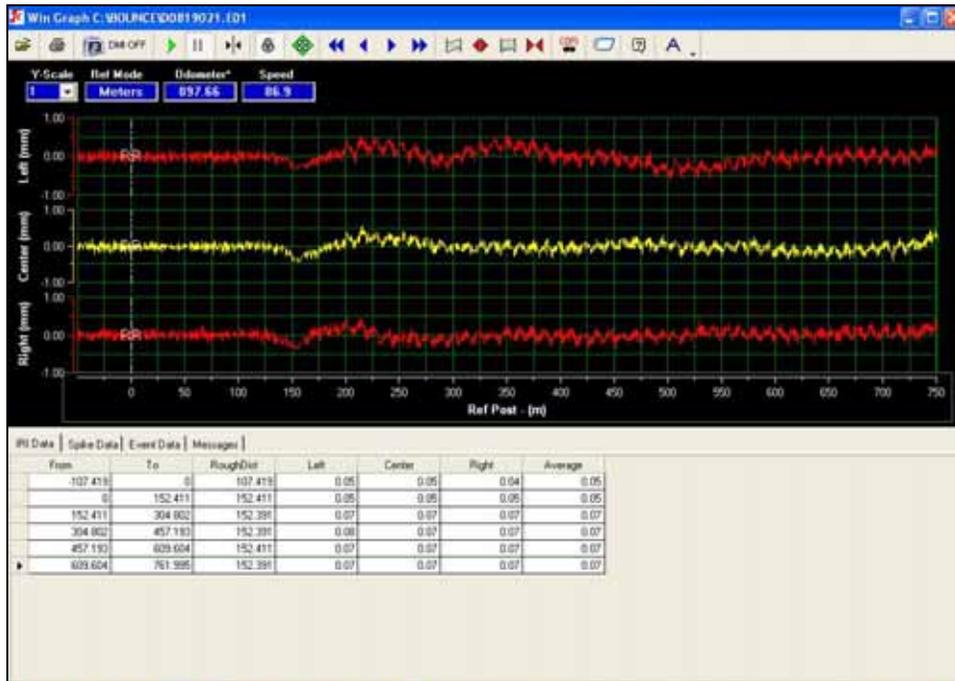
Figure 49. Screen shot. WinGraph screen after dynamic bounce test has been terminated.

6. Compare profiles between the left, center and right sensors. As there is a time delay after pressing the F9 key and the start of bouncing, the first part of the graph will show the profile recorded during static conditions. A comparison between the static profile and the dynamic bounce profile can also be made by observing the graph. Evaluate the profiles for the presence of spikes. Repeat the test if spikes are noted in the profile. If the bounce test appears to have been performed satisfactorily, note IRI values for the left, center, and right sensors for the distance between 152.4 m and 304.8 m. If bouncing motions commenced after 152.4m and bouncing was performed between 304.8 and 457.2 m, note IRI values between these limits. Print the graph and write down IRI values for the three sensors on the graph.

7. Compute the difference between the dynamic bounce test IRI and static test IRI for each sensor (left, center, and right). If the difference in IRI is less than or equal to 0.10 m/km for all three sensors, the profiler is considered to have successfully passed the bounce test. If not, repeat the test until all three sensors are within the specified tolerance. If the bounce test criterion is not satisfied after repeating test several times, see the following subsection "Failure of Bounce Test Criterion" in this section.

8. Go to system 2 using the KVM switch. The MDR green color screen should be shown on the computer monitor.

9. Press the F10 key to exit the program and save data. The system will ask for an End of Run Note. Since none of the given choices are appropriate, press seven then press the Enter key and type an end of run comment if needed, and press the Enter key.

10. Press the Enter key if the path and file name to save data are acceptable. If a different path and/or file name is needed, use the Backspace key to edit and then press the Enter key. After saving the file, the system will revert back to the MDR main menu.

11. Highlight "Run" in the Main Menu to show the Run menu. In the Run Menu, select "Options" (figure 42) and the Run Options screen shown in figure 44 will be displayed on the monitor. Highlight "HW DMI Simulator" and press the Enter key to turn the simulator "Off." Press the Escape key twice once to get to the Main Menu.

2.3.3.3.5 Failure of Bounce Test Criterion:

If the operator is unable to obtain a static bounce test IRI of less than or equal to 0.08 m/km for a sensor, or if difference in IRI between the dynamic bounce test IRI and the static bounce test IRI exceeds 0.10 m/km, the operator should contact the RSC to decide on a course of action. If an error in the equipment is found and fixed, the operator should reevaluate the profile data that were collected during the previous day. If the problem was in a sensor that is located either in left or the right wheel path, IRI values obtained during the previous day, as well as the profile data, should be compared with those obtained from the last visit to that site. If data problems are suspected, such sections should be reprofiled after equipment repairs.

2.3.4 Data Collection

2.3.4.1 Entering Header Information

Prior to collecting profile data at a site, the operator has to enter header information related to the site. This section describes procedures to be followed to enter header information for a site into the computer, and describes procedures to be followed to get the computer system ready for data collection. Use the following procedures to enter header information at a site:

1. Go to step 2 if the computer has been booted up, otherwise boot up the computer system (using steps outlined in section 2.2.5.3 and 2.2.5.4).

2. Make sure system 2 is showing the MDR main menu (see figure 50). Use the KVM switch to switch to system 1 and check if WinGraph is running in system 1 (see figure 51). If not, double click on the ICC icon to start WinGraph and use the KVM switch to get back to system 2.
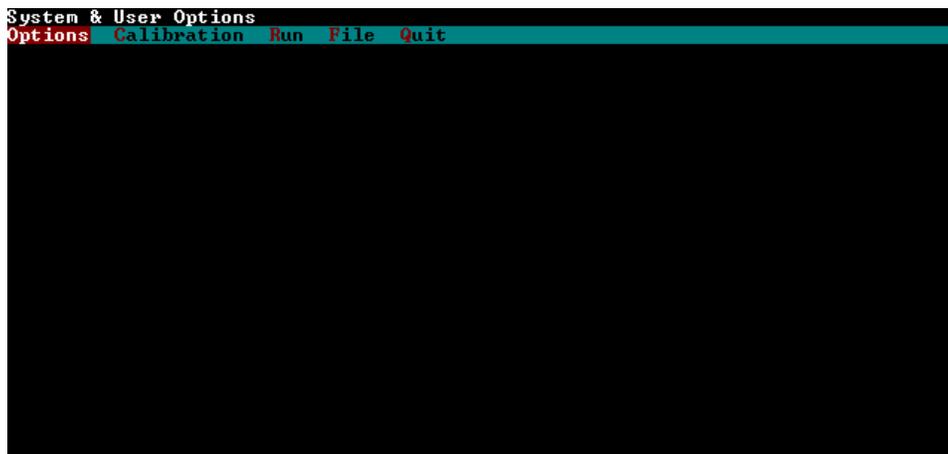
Figure 50. Screen shot. MDR main menu (3).
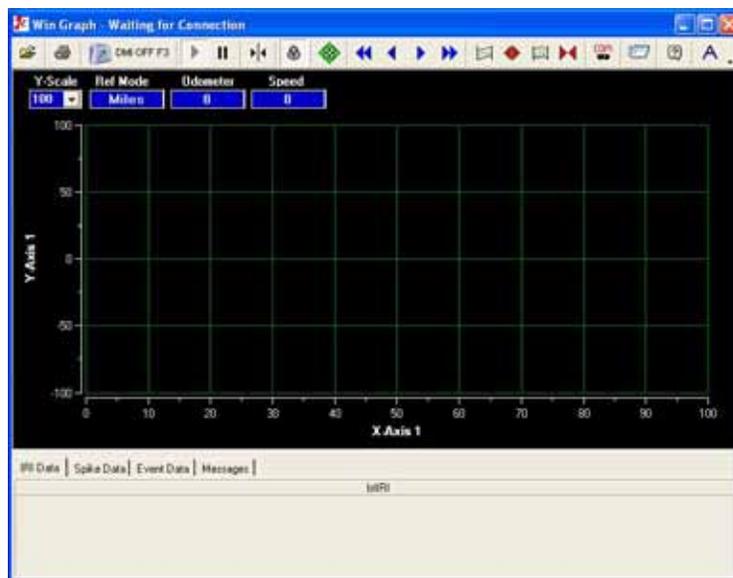
Figure 51. Screen shot. WinGraph program running in system 1.

3. Select the Photocell. In the MDR main menu (see figure 50), select Options. The Options Menu shown in figure 52 will be displayed on the monitor. Select "ICC System Parameters" and a screen similar to that shown in figure 53 will be displayed on monitor.
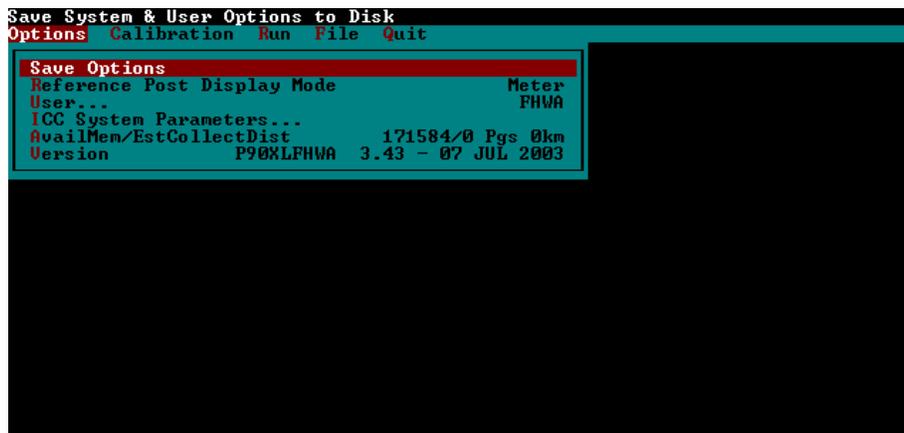
Figure 52. Screen shot. Options menu (2).
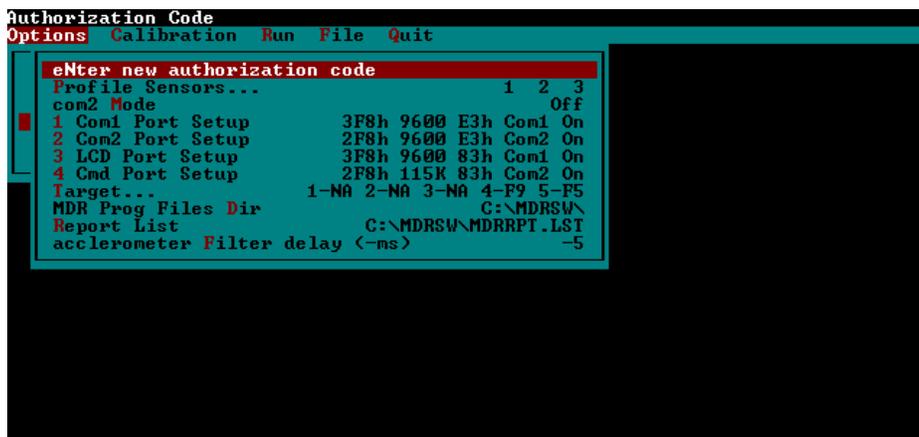
Figure 53. Screen shot. ICC systems parameters screen.

The target option in the ICC Systems Parameter Menu (see figure 53) determines which target will send which function key to the data acquisition system when it is tripped. Targets one through three are not used, four is the horizontal photocell, and five is the vertical photocell. F5 refers to an event trigger and F9 refers to the reference reset trigger. Use one of the following procedures to select either the vertical or horizontal photocell to send a reference reset:

a. Highlight "Target" in the ICC Systems Parameter menu (see figure 53) and press the Enter key. Highlight "Target 5," and use the Enter key to toggle through the available options to select F9. If Target four is showing NA, then press the Escape key twice to get back to the Options Menu (see figure 52). If Target 4 is not showing NA, highlight Target four and use the Enter key to toggle through the available options to select NA, then press the Escape key twice to get back to the Options Menu. Available options when toggling for either Target four or five are NA, F5, F8, F9, and F2. When done, highlight Save Options and press the Enter key to save parameters that were assigned.

b. Highlight "Target" in the ICC Systems Parameter menu (see figure 53) and press the Enter key. Highlight "Target 4," and use the Enter key to toggle through the available options to select F9. If Target five is showing NA, then press the Escape key twice to

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get back to the Options Menu (see figure 52). If Target 5 is not showing NA, highlight Target 5 and use the Enter key to toggle through available options to select NA, then press the Escape key twice to get back to the Options Menu. Available options when toggling for either Target four or five are NA, F5, F8, F9, and F2. When done, highlight Save Options and press the Enter key to save parameters that were assigned. It has been reported that although the photocell to send a Reference Reset is selected as described above, both photocells still remain active. For example, if Target five (vertical photocell) is set to F9 to send a reference reset with Target four (horizontal photocell) set to NA, the system will still send a reference reset if Target 4 detects a condition that generates an event mark. Therefore, the operator should use a piece of tape to cover the photocell that is not being used. For example, if the operator is specifying the vertical photocell to send a Reference Reset, the horizontal photocell should be covered with a piece of tape.

c. Select the Run option in the MDR main menu. The Run Menu similar to that shown in figure 54 will be displayed on the monitor.

Figure 54. Screen shot. Run menu (3).

4. Highlight "Options" in the Run Menu to bring up the Run Options Menu (see figure 55). In this menu, select IRI and press the Enter key. The IRI options menu shown in figure 56 will be displayed on the monitor. Check if the Interval is set at 152.4. If not, highlight Interval and press the Enter key. When a window opens up, type 152.4 in the window and press the Enter key. Press the Escape key twice to get back to the Run Menu (see figure 54).
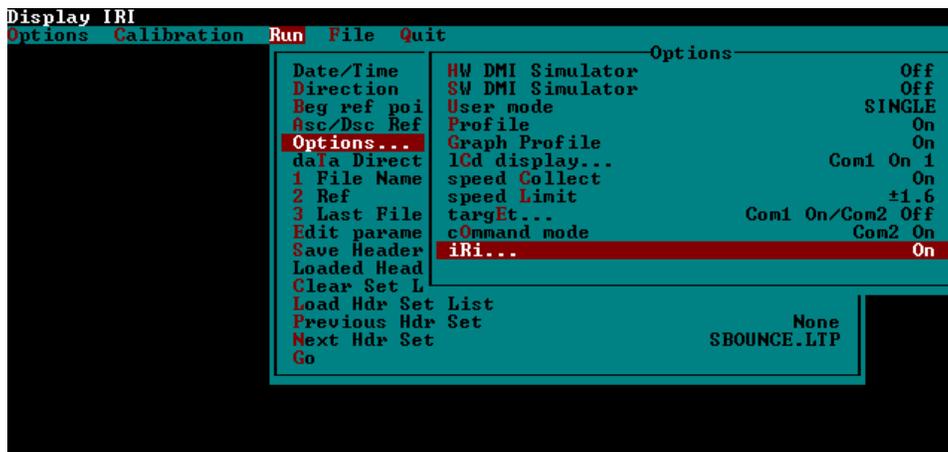
Figure 55. Screen shot. Run options menu (2).

Figure 56. Screen shot. IRI options screen (3).

5. Select the Data Directory. In the Run Menu (see figure 54), check to see if the data directory that is shown is appropriate to save profile data. If the directory needs to be changed, highlight "Data Directory" and press the Enter key. This will open a window that shows the current data directory. Use the backspace key to edit the entry shown, type the path (e.g., c:\data\ohio), and press the Enter key to close the window. If the directory that was typed does not exist, the program will automatically create it when it saves the first file.

6. Retrieve the header file. If a header file for the site does not exist, go to step 8. If a header file has already been created for the site during the previous site visit, load the header file using the following procedure:

   a. Highlight "Load Hdr Set List" in the Run Menu (see figure 54) and press the Enter key. A window will open as shown in figure 57 that shows all the header files that have been created.

   b. Highlight the appropriate header file and press the Enter key, then press the Escape key. The selected header file name will be shown under "Next Hdr Set."

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c. Select "Edit Parameters – LTPP" and press the Enter key. The LTPP parameters screen similar to that shown in figure 58 will be displayed on the monitor (values for parameters shown on the monitor will be different from the values shown in figure 58).

d. Go to step 9.
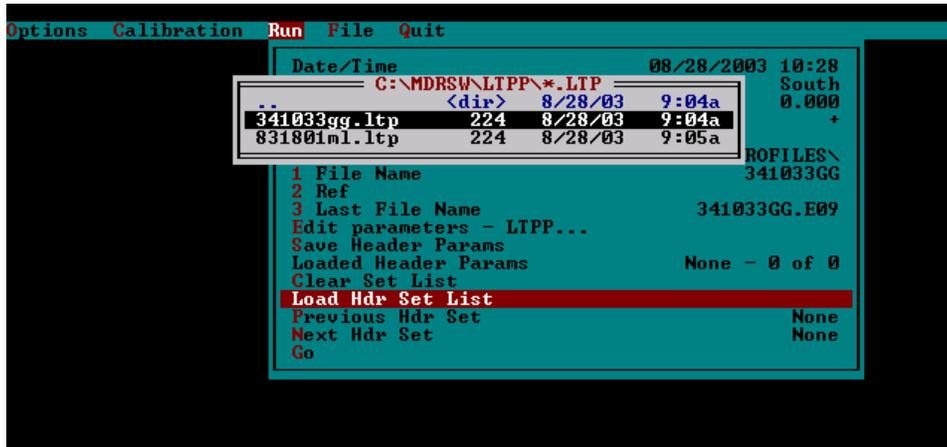
Figure 57. Screen shot. Header file list.

7. Highlight the "Edit Parameters – LTPP" option in the Run Menu (see figure 54) if a header file is not available for the site, and press the Enter key. The monitor will display a LTPP Parameters screen similar to that shown in figure 58 (values for parameters shown on monitor will be different from the values shown in figure 58).
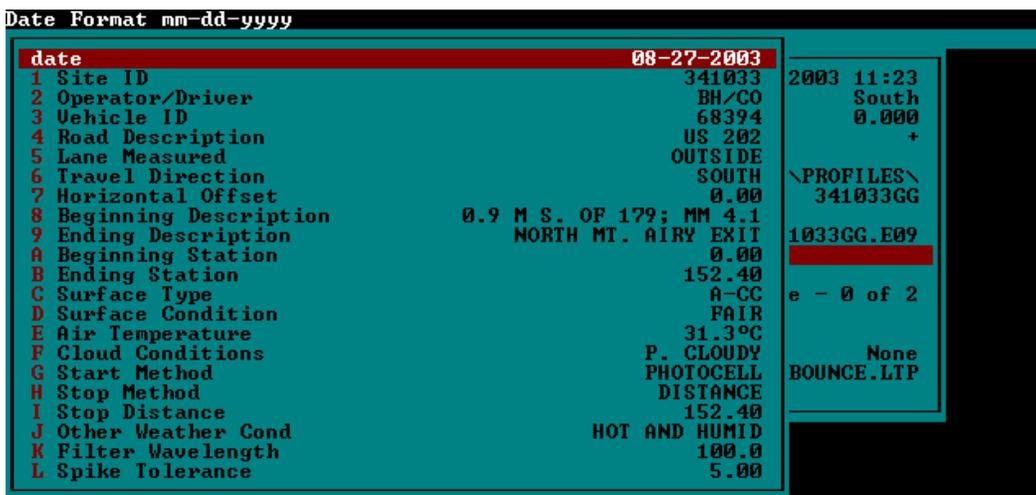
Figure 58. Screen shot. LTPP parameters screen.

8. Change selected fields in the LTPP parameter screen to reflect the parameters appropriate for the current data collection if the header file has already been created. The fields that need to be checked for changes are: Operator/Driver, Surface Condition, Air Temperature, Cloud Conditions, and Other Weather Conditions. However, it is a good practice to check all the header fields to make sure they are correct.

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If a header file for the site is not available, all header fields have to be entered/checked to ensure that parameters that are appropriate for the current profile data set are shown in the header.

The up and down arrow keys can be used to highlight any item in the LTPP Parameter screen that needs to be changed. After the item is highlighted and the Enter key is pressed, a window will open for some items (e.g., Site ID, Operator/Driver). The required value can then be entered in the window and when the Enter key is pressed the window will close. The typed value will be shown for that parameter. Some of the parameters have a specified set of input values, and when these parameters are highlighted, the Enter key can be used to cycle through input options that are available for those items. For example, valid entry for Lane is either Inside or Outside. When Lane is highlighted and the Enter key is pressed, the parameter for lane will cycle between Inside and Outside. The following sections will describe the parameters to be entered or selected for each of the items shown in the LTPP Parameters Menu:

a. Site ID: Highlight "Site ID" and press the Enter key. Type the site ID in window (e.g., 451024) and press the Enter key to close the window. Follow the procedure described in steps 1 and 2 of section 2.2.7.3 to obtain the appropriate six-digit code for the Site ID. For WIM sites, follow the procedure specified in section 2.4.2.3.

b. Operator/Driver: The operator and driver should be identified by two digit characters, the first letter of their first and last names. Operator and driver names should be separated by a backslash and typed in capital letters (e.g., CK/RS). If the profiler is used as a one person operation, the operator and driver name would be the same (e.g., CK/CK). If the current entry in this field does not correspond to the operator/driver, highlight "Operator/Driver," press the Enter key, type the operator and driver initials in the window, and press Enter key to close window.

c. Vehicle ID: The last five digits of the VIN should be shown in this field. Once this parameter has been set to the correct value, it does not need to be changed. To set the value the first time, highlight "Vehicle ID" and press the Enter key. In the window that opens, type the last five digits of the VIN and press the Enter key to close window.

d. Road Description: Highlight "Road Description" press the Enter key, type the route number where section is located (e.g., I-88), and press the Enter key to close the window. All letters should be capital.

e. Lane Measured: The valid entries for the field are INSIDE or OUTSIDE. The outside lane is the lane adjacent to shoulder at right edge of road. Highlight "Lane Measured," use the Enter key to toggle between INSIDE and OUTSIDE, and select the appropriate value. For nearly all LTPP sections, the lane measured is OUTSIDE.

f. Travel Direction: Select appropriate lane direction (NORTH, EAST, SOUTH, or WEST) by highlighting the field and using the Enter key to bring up the Direction window. Type the first character of direction to add the direction.

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g. Horizontal Offset: The value for horizontal offset should be 0 (zero) for all sections. This value has to be set only once, as the system will retain the specified value. Highlight the field, press the Enter key, type 0 in window that opens, and press the Enter key again to close the window.

h. Beginning Description: Enter the milepost at the beginning of the section in this field. If the milepost is not known, enter NONE in this field. An entry in this field can be edited by highlighting "Beginning Description" and pressing the Enter key, which will cause a window to open up containing the current entry in this field. After editing, press the Enter key again to close the window.

i. Ending Description: This field should indicate NONE. An entry in this field can be edited by highlighting "Ending Description" and pressing the Enter key, which will cause a window to open up containing the current entry in this field. After editing, press the Enter key again to close the window.

j. Beginning Station: This field should be set to 0 for all sections. An entry in this field can be edited by highlighting "Beginning Station" and pressing the Enter key, which will cause a window to open up containing current entry in this field. After editing the current value to set the value in field to 0, press the Enter key again to close the window.

k. Ending Station: This field should be set to the length of test section. For GPS and SMP sections, the ending station will always be 152.4. For WIM sections, the ending station should be 305 m. For SPS sections, the ending station will be the total length of the SPS project that is being profiled. An entry in this field can be edited by highlighting "Ending Station" and pressing the Enter key, which will cause a window to open up containing the current entry in this field. After setting the entry in the field to desired value, the Enter key should be pressed again to close the window.

l. Surface Type: Valid entries for road surface type are A-CC for asphalt surfaced pavements and P-CC for PCC surfaced pavements. When "Surface Type" is highlighted, pressing the Enter key will toggle the entry in this field between P-CC and A-CC. Select the appropriate entry.

m. Surface Condition: This describes the surface condition of pavement. Valid entries are V. GOOD (Very Good), GOOD, FAIR, or POOR. When "Surface Condition" is highlighted, the Enter key will toggle between V.GOOD, GOOD, FAIR, and POOR. Select the appropriate entry. Severity levels that are described correspond to the definitions given in the LTPP Distress Identification Manual.[10] The following guidelines should be used to determine road conditions:

1) V. GOOD: Pavement does not show any distress.
2) GOOD: Pavement exhibits few visible signs of surface deterioration. Asphalt surfaced pavements may show low severity cracks, and Portland Cement Concrete (PCC) pavements may show low severity cracks and spalling.

3) FAIR: Typical distresses on AC surfaced sections can include the following distresses in a low to medium severity: rutting, block or edge cracking, transverse and longitudinal cracking, and patching. Typical distresses on PCC pavements can include the following distresses in a low to medium severity: spalling, transverse and longitudinal cracking, faulting, and patching.

4) POOR: Pavements in this category have deteriorated to such an extent that they affect the speed of free flow traffic. Typical distress on asphalt-surfaced sections includes the following distresses in a medium to high severity: rutting, transverse and longitudinal cracking, alligator cracking, and potholes. Typical distress on PCC pavements can include the following distresses in a medium to high severity: spalling, transverse and longitudinal cracking, faulting and patching.

n. Air Temperature: Air temperature (in degrees Centigrade) at time of test should be entered in this field. Obtain air temperature from the temperature display gauge. Highlight "Air Temperature," press the Enter key, enter the air temperature value in the window, and press the Enter key to close the window. If no change to this field is made during subsequent runs, the entered temperature value is saved with profile data for subsequent runs. The operator should note the air temperature prior to the start of each profile run. If the temperature display gauge indicates a temperature that is not within ±2°C of that measured during the previous run, the operator should enter the new value to the software prior to commencing the profile run.

o. Cloud Conditions: Valid entries for this field are CLEAR, P. CLOUDY (Partly Cloudy), or CLOUDY. Use the following guidelines: Clear—sunny sky, Cloudy—sun cannot be observed, P. Cloudy—sun is sometimes covered by clouds. Highlight "Cloud Conditions" and press the Enter key to toggle between CLEAR, P. CLOUDY, and CLOUDY. Select an appropriate entry.

p. Start Method: The start method should always be Photocell. When "Start Method" is highlighted and the Enter key is pressed, entries will toggle between PHOTOCELL and PENDANT. Once this entry is set to PHOTOCELL, it does not need to be changed again.

q. Stop Method: The stop method should always be DISTANCE. When "Stop Method" is highlighted and the Enter key is pressed, entries will toggle between PHOTOCELL, PENDANT, and DISTANCE. Once this entry is set to DISTANCE, it does not need to be changed again.

r. Stop Distance: The stop distance for GPS and SMP sections should be 152.40 m. The Stop Distance for WIM sites should be 305 m. The distance to be entered for SPS sections is presented in section 2.4.1.2. Highlight "Stop Distance," press the Enter key, enter the value in the window, and press the Enter key to close window.

s. Other Weather Conditions: Valid entries for this field are CONDITIONS OK, STEADY CROSSWIND, WIND GUSTS, HOT AND HUMID, HAZY, and LOW

SUN ANGLE. Highlight "Other Weather Cond," press the Enter key to toggle through the available entries, and select an appropriate entry.

t. Filter Wavelength: The filter wavelength should be set to 100. Once this value is set, it should not be changed again, as the system will retain this value (value can be changed by highlighting "Filter Wavelength," pressing the Enter key, then typing a value in the window that opens, and again pressing the Enter key to close the window).

u. Spike Tolerance: The required value for spike tolerance is 5.0. To set the value, highlight "Spike Tolerance," press the Enter key, type the value in the window that opens and press the Enter key to close the window.

v. Save Header File: Press the Escape key to get out of the LTPP Parameters screen and to get back to the Run Menu (figure 54). Then highlight "Save Header Params" and press the Enter key. In the window that opens, type the file name to save the header file. The six digit site ID (State code plus the four digit site number) or the file naming convention described in section 2.2.7.3 can be used as the file name to save the header.

2.3.4.2 Profiling Test Section

Once header information has been entered and equipment has warmed up sufficiently (allow 15 minutes after turning power to computers and lasers for equipment to warm up), the profiler is ready to begin profiling. In these procedures, function keys (e.g., F3, F6) have to be pressed. Keys in either the keyboard or the handheld event pad can be used to enter function keys. The following procedures should be followed to get an acceptable set of runs at GPS, SMP, and SPS sites (some of the procedures for profiling WIM sites are different from the procedures presented in this section, see section 2.4.2.3 for procedures for profiling WIM sections):

1. Check if WinGraph is running in system 1. If not, double click on the ICC icon to run WinGraph (if in system 2, use the KVM switch to go to system 1, and use this switch again to get back to system 2 from system 1).

2. Select "Run" in the MDR main menu to bring up the Run Menu shown in figure 59 (the values shown for the various parameters on the monitor will be different from the values shown in figure 59).

Figure 59. Screen shot. Run menu (4).

3. Highlight "Go" in the Run Menu and press the Enter key. The monitor will display the MDR run screen shown in figure 60. The message "OnLineCK" should appear on the green part of the screen. This message indicates the MDR program has successfully linked up with WinGraph (the values shown for POS1, POS2, POS3, SEN1, SEN2, SEN3, and filename on the monitor will be different from the values for these parameters shown in figure 60). The path and filename that are shown will be path and file name that were typed in steps 6 and 7 of section 2.3.4.1.
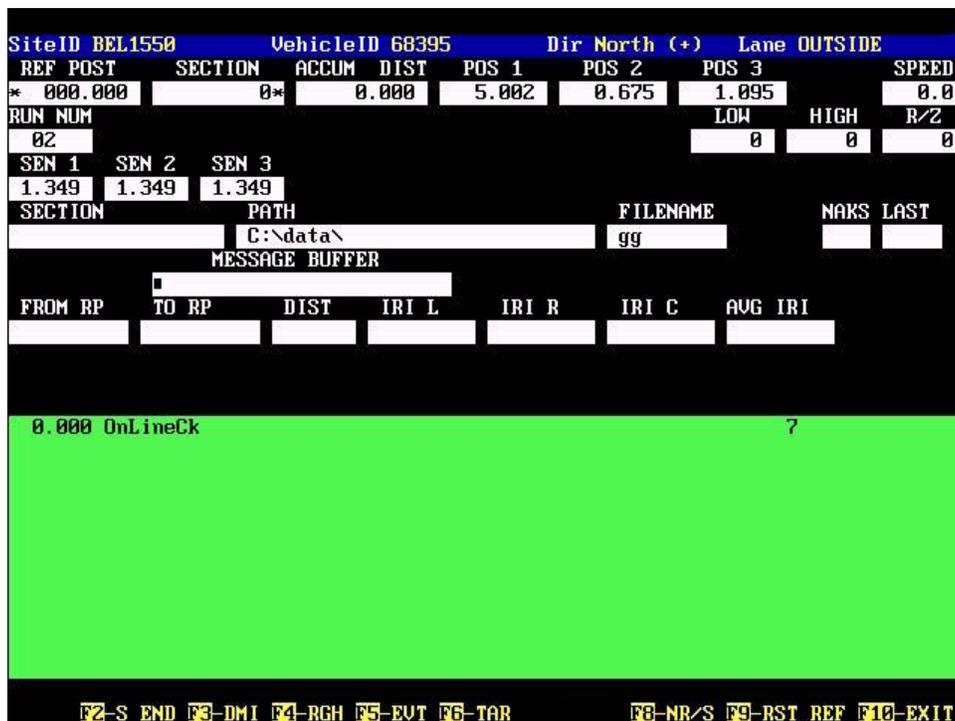
Figure 60. Screen shot. Run screen of MDR program (2).

4. Attain a constant test speed of 80 km/h at least 175 m before the beginning of the test section and align the vehicle along the wheel paths (as described in section 2.2.7.4, a

speed different from 80 km/h may be used depending on site conditions). Then press the F3 key to start the DMI about 150 m before the start of the test section. (Note: The profiler should have attained its testing speed prior to pressing the F3 key).

5. Press the F6 key about 40 m before the start of the section (after passing the lead in stripe of the section). When the F6 key is pressed, the asterisk beside the zero in the section field will disappear. When the F6 key is pressed, the photocell is armed and will be looking for the reflective mark on the pavement surface or a cone with reflective marking (depending on photocell that was selected) to record an event mark and perform a reference reset.

6. Clean the photocell and repeat the run to see if the photocell triggers if vertical photocell is not triggered when event mark is passed. When the photocell detects a target, the green part of screen will show the message "Reference Reset," and a beep will be heard. If the vertical photocell still fails to trigger, adjust the threshold control for the photocell and see if photocell will trigger. If this is not successful, use the horizontal photocell. Follow the procedure described in step 3 of section 2.3.4.1 to select the horizontal photocell to send a Reference Reset.

7. Press the F3 key to end data collection after the end of the section is passed. (Note: The operator should press the F3 key while the profiler is still traveling at the testing speed.)

8. Bring the vehicle to a stop at a suitable location to enter an end of run comment, evaluate the collected data, and save the data to hard disk. After stopping the vehicle, use the KVM switch to go to system 1. A graphical output of the profile data collected along the left, center, and right paths will be displayed on the monitor. A vertical line will be present at locations where spikes exceeding the specified spike height (specified in step 30 of section 2.3.4.1) are present. Evaluate profile data for the left, center, and right paths to see if they are satisfactory. IRI for the left, center, and right paths of the section will also be displayed below the graph. Evaluate IRI values and see if they are reasonable. If data appears to be reasonable, go to system 2 using the KVM switch. If the profile data are unreasonable, investigate and correct the problem, and restart data collection.

9. Press the F10 key to enter the End of Run Note and save the data. When F10 is pressed, the end of run note screen shown in figure 61 will appear on the computer monitor.
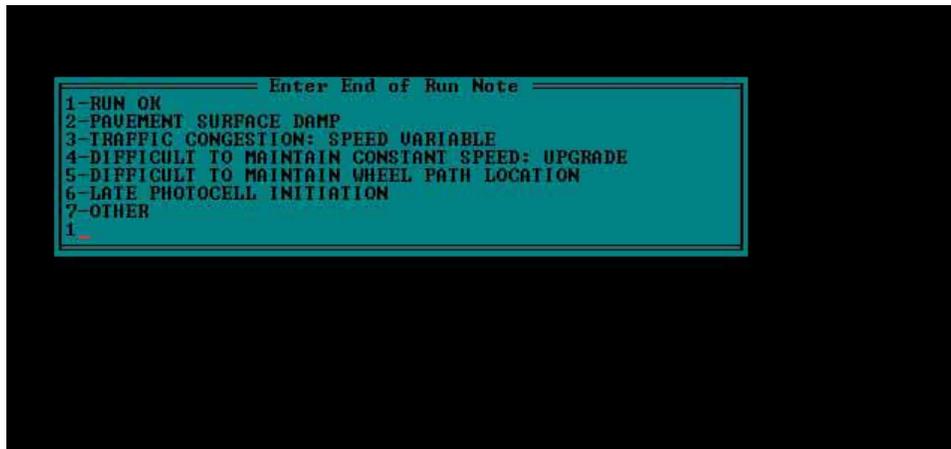
Figure 61. Screen shot. End of run note screen.

Evaluate the following six end-of-run comments that are displayed:

    a. RUN OK.

    b. PAVEMENT SURFACE DAMP.

    c. TRAFFIC CONGESTION: SPEED VARIABLE.

    d. DIFFICULT TO MAINTAIN CONSTANT SPEED: UPGRADE.

    e. DIFFICULT TO MAINTAIN WHEEL PATH LOCATION.

    f. LATE PHOTOCELL INITIATION.

Use guidelines presented in section 2.2.7.8 to select an appropriate end of run comment. The end of run comment should be based on conditions during the profile run, and not based on observations noted in the profile when the profile is evaluated in step 8. If one of the displayed comments is appropriate for the profile run, type the appropriate number and press the Enter key. If none of the displayed comments are appropriate for the profile run and the operator wants to type a different comment, type 7 and press the Enter key. This will open a window where the operator can type an end of run comment. After typing the comment, press the Enter key to close the window.

10. Save the data. The oath and filename for saving profile data will now be displayed on the monitor. If these are acceptable, press the Enter key. If any changes are needed, use the Backspace key to correct the path and/or file name, and press the Enter key. After the file is saved, the computer screen will show the MDR main menu.

11. Repeat steps 2 through 10 to obtain five error free runs.

12. Use ProQual to evaluate the collected data using procedures described in section 2.2.8. As ProQual is a Windows based program, Windows has to be loaded to system 2. Use the following procedure to load Windows to system 2:

a. Use the KVM switch to go to system 2 if the monitor is showing WinGraph instead of the MDR main menu.

b. Highlight "Quit" in the MDR main menu and press the Enter key.

c. Press "y" to exit system when the MDR Program asks, "Do you want to Exit system?" The C:\ prompt will appear on the monitor.

d. Press the Ctrl – Alt – Delete keys simultaneously to restart the computer.

e. Use the arrow keys to select the Windows option when the Windows 98 menu comes on the screen and press the Enter key.

f. Log in to the system when Windows finishes loading, using LTPP as the user name and LTPP as the password.

g. Start ProQual and evaluate the collected data using procedures described in 2.2.8.

13. Go to step 14 if five runs are acceptable. If not, obtain additional runs as described in section 2.2.8, and review these runs using ProQual.

14. Use Windows Explorer to backup data to a flash drive or CD ROM. The ICC profile data files that should be backed up are files with file extensions P, V, and E, which were collected at the site. All files generated by ProQual when the profile data were processed (site files) should also be backed up. See section 2.3.5 for a description of ProQual files that should be backed up.

15. Verify that the LTPP Profiler Field Activity Report Form (see section 2.8.1) and "Status of Regions Test Section" (see section 2.8.2) forms are filled before leaving test site.

2.3.5 Data Backup

Profile data collected at a site by the profiler and the files generated by ProQual when these data were processed (site files) should be backed up to a flash drive or CD ROM. The computer in the profiler is equipped with a recordable CD drive as well as an Iomega Zip™ disk drive.

The ICC profile data files that should be backed up are files with file extensions P, V, and E, which were collected at the site.

ProQual data that should be backed up are the site files that were created when the ICC profile data files were processed. The following guidelines for backup of ProQual files are general in nature since there could be variations between directory structures used for ProQual by the different regions. Location of the site files will depend on the directory structure that is employed by the regions to store files generated by ProQual. Figure 62 shows an example of the location of site files that need to be backed up. For this example, data for site 370204 are stored in the directory Sites\37\0204.
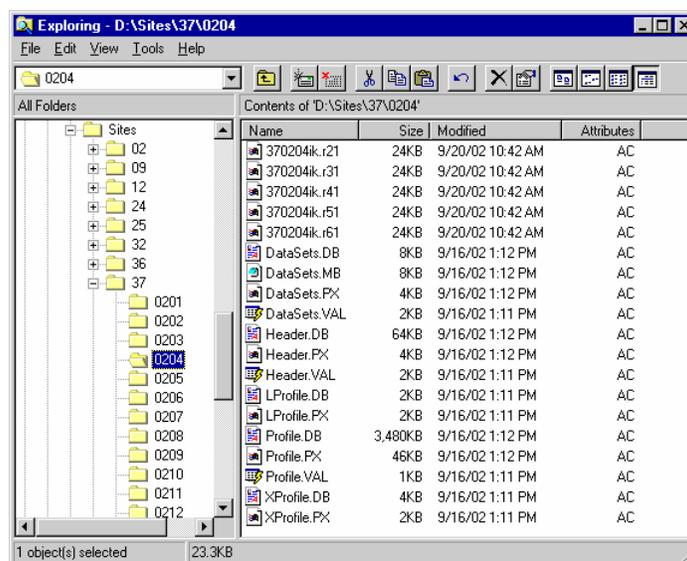
Figure 62. Screen shot. Site files in ProQual.

A recommended procedure to follow during the backup of data for a site is to create separate directories in the backup media (flash drive or CD ROM) for each site.

When a SPS site is processed, separate subdirectories are created for each of the subsectioned sites. The ProQual files created for each of these sections, as well as the raw profile data collected at the SPS site (the P, E, and V ICC files), should be backed up.

The operator should maintain a log to document files that are in each flash drive or CD ROM. The profiler should not leave a test site unless all data have been backed up. At the end of each day, an additional backup copy of all profiler test data collected on that day should be made. Therefore, at the end of each test day, there should be two backup copies that contain profile data that were collected on that day. One of these backups (profiler copy) should be kept in the profiler, while the other copy (RSC copy) should be forwarded to the RSC. Until the RSC copy is forwarded, the profiler copy must be removed from the vehicle whenever testing is not in progress. No collected profile data should be deleted from the hard disk until the RSC has informed the operator that the RSC copy has been received and processed by the RSC. If flash drives are used as a backup medium, the profiler copy of the flash drive can be recycled once the RSC informs the operator that data have been received, processed, and backed up. The RSC should backup the data following procedures outlined in LTPP directive GO-41 "Submission of Electronic Data for Customer Support and AIMS" (or current version of that directive).

WinGraph will save graphical data that are displayed during a profile run, as well as data displayed during the bounce test. These data will be saved in system 1. The path that is specified in system 2 for saving profile data files will be used in system 1 to save the WinGraph data. The WinGraph files do not need to be backed up. They can be deleted after data for the site have been processed by the RSC.

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2.4 PROFILING SPS AND WIM SECTIONS

2.4.1 Profiling SPS Sections

2.4.1.1 General Background

This section describes field testing procedures to be followed when testing SPS sites, which are different than the procedures used for GPS sections. However, other than the exceptions described in this section, all other information presented in earlier sections of this manual are valid when SPS sites are being tested. A SPS site consists of a number of test sections with a transition area between adjacent sections. During a profiler run at a SPS site, profile data are collected for entire site, which includes test sections as well as transition areas.

2.4.1.2 Length of Test Sections

Unlike GPS test sections that are always 152.4 m in length, the total length of a SPS project that will include test sections and transition areas will vary from project to project. The operator may elect to break the SPS project into two sections for profiling, depending on the location of the test sections as well as turnaround locations. For example, if there is a large transition distance between two groups of test sections and turnaround is located in the transition area, the operator may elect to profile the SPS project as two sections.

2.4.1.3 Operating Speed

Guidelines regarding operating speed described in section 2.2.7.4 should be followed when testing SPS test sections. When SPS test sections are tested, the transition area between sections may be used to adjust vehicle speed to 80 km/h (or appropriate speed depending on site conditions as described in section 2.2.7.4) before next section is tested. If there is traffic in front of the profiler, the profiler speed can be initially decreased in the transition section to give more leeway between the vehicles in front. Thereafter, the profiler must be brought up to a constant speed of 80 km/h or appropriate speed depending on site conditions before entering next test section.

2.4.1.4 Number of Runs

Five profiler runs in each test section within a SPS project should satisfy the acceptance criteria described in section 2.2.8. ProQual is capable of computing the IRI value of individual test sections within a SPS project by identifying test sections using stationing and event marks. The procedure for subsectioning individual test sections from a profile run made at a SPS section is described in the ProQual manual.[6] The operator should study IRI computed for each run and plot data from repeat runs to ensure that repeatable data are obtained between runs. The procedure outlined in section 2.2.8 should be followed in order to obtain an acceptable set of runs at a SPS project.

2.4.1.5 Header Generation

The procedures outlined in section 2.3.4.1 for header generation for GPS test sections should also be followed for SPS test sections. However, Stop Distance that is entered in step 27 for a SPS project is different than that entered when profiling GPS sections.

The operator should refer to site layout plans and obtain the length of a SPS project that will encompass all test sections. To guard against discrepancies between layout plans and as built sections, the operator may add a distance such as 30 m to the distance obtained from site layout plan. This distance should be entered as the Stop Distance in step 27 of section 2.3.4.1.

If the operator is not certain about the length to be entered, perform a trial run to determine the length of the SPS project. Go to the MDR run screen (see figure 60) and terminate data collection once the end of the last test section is passed. The MDR Run screen will indicate the location of the Reference Reset and the location where data collection was terminated. Use this information to obtain the length of the SPS project, and enter this length as the Stop Distance.

2.4.1.6 Hardcopy of Profile

The RSC may require the operator to obtain a graphical plot of the data recorded by the left, right, and center sensors for one profiler run of the entire SPS project for archiving and/or quality control purposes. Obtain printouts using data at an appropriate interval such as 400 m. If a printout is obtained, the plot should be attached to the Profiler Field Activity Report. The graphical plot can be obtained using either WinGraph or ProQual. If there are significant differences between profile runs, it is recommended that a graphical plot of profile data be obtained and attached to the Profiler Field Activity Report. In such cases, a plot of all profile runs for each path in one plot or a plot of questionable runs may be obtained.

2.4.1.7 Data Backup

Data collected at SPS projects should be backed up using the same procedures described in section 2.3.5.

2.4.2 Profiling WIM Sections

2.4.2.1 Background

The collection of accurate traffic load (axle weight) data using WIM scales is of vital importance to achieving the LTPP program objectives. Pavement roughness affects the dynamic motion of trucks and therefore the accuracy of traffic load measurements at the WIM scale. Therefore, a smooth pavement section prior to and immediately after the WIM scale is required to minimize those motions.

The pavement smoothness specifications that must be met at WIM sections are not described in this manual. This section describes procedures that should be followed by the RSCs to collect longitudinal profile data at SPS-1, -2, -5, and -6 WIM sections using the LTPP profiler. The resulting profile data will be used to determine if a WIM section meets the LTPP pavement

smoothness specifications. (Note: This manual does not contain the procedures to make this determination).

The RSCs are responsible for working with the relevant highway agency to locate and correctly identify the WIM location for each SPS project. Working WIM equipment is not a condition for profiling. SPS projects for which more than one WIM site exist will only be profiled at the site most recently used for data collection. Profiling for SPS projects that are out-of-study will not be done without the explicit direction of the FHWA.

2.4.2.2 WIM Section

A WIM section is defined as a section of pavement that is 305 m long, with the distance from the centerline of the WIM scale to the beginning of the test section being 275 m and the distance from the centerline of the WIM scale to the end of the test section being 30 m.

The WIM section should be marked as shown in figure 63. Monuments (in the form of nails, spikes, or re-bars) should be installed in the shoulders, exactly at the beginning and end of the test section, and at the WIM centerline as shown in figure 63. These monuments will serve as section markers in case of paint wear. The monument at the beginning of the section should be located 275 m prior to the centerline of the WIM scale. The monument at the end of the section should be located 30 m after the centerline of the WIM scale. The distances measured should be accurate to within ±0.10 m. The centerline of the WIM scale is dependent on the sensor used and which of a series of multiple sensors is currently working. For a single sensor installation, the centerline is the middle of the sensor. For a multiple weight sensor array (i.e., bending plates staggered in alternate wheel paths) the centerline is the distance halfway between the approach edges of the first and last weight sensors in the array. Marking the centerline with a monument must avoid all electronics and other elements of the WIM scale installed below the pavement. When the WIM section does not overlap an active LTPP pavement test section, it should be marked by two white stripes, nominally 150 mm wide, across the test lane at the beginning and end of the WIM section. The leave edge of the stripes should be next to the applicable monument. If the WIM section overlaps an active LTPP pavement test section it should not be marked with white stripes.

NOT TO SCALE

Traffic

Shoulder

Fence line
or ROW →

White paint stripe 150 mm wide ,
At end of test section, 30 m
From centerline of WIM scale

Spike or nail, 2.4 m
From edge of travel lane

Location of WIM Scale

Monitoring
Section
305 m

WIM SHRP ID or letters
WIM painted with white
letters on shoulder at
centerline of WIM weight
sensor array

Spike or nail 2.4 m
From edge of travel lane

White paint stripe 150 mm wide,
275 m from centerline of WIM scale,
At beginning of test section

Figure 63. Illustration. Layout of WIM site.

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At the centerline of the WIM weight sensor array, one of the following shall be painted near the outside shoulder for permanently marked sites: A WIM SHRP ID of the format PP99, where PP is the Project ID (first two characters of the project SHRP ID) and 99 is the section number assigned for WIM beginning with 99 and decreasing for every new or separate location at which WIM equipment is installed for the project, or the letters WIM.

For example, the Maryland SPS-5 project presently has a piezo system installed in hot-mix AC. The SHRP ID and appropriate marking for this WIM section is 0599. If the piezo system is replaced with the same or a different sensor at another location, the new SHRP ID (and appropriate new marking) for this new WIM section is 0598.

If permanent markings are not in place at the WIM sections, temporary markings such as tape, cones, or other means appropriate to the requirements of the LTPP inertial profilers may be used to trigger the start of data collection. However, the RSCs are responsible for working with the relevant highway agency to ensure that their WIM sections are permanently marked prior to the second visit to the site.

2.4.2.3 Profile Measurements

2.4.2.3.1 General:

Longitudinal profile measurements for smoothness evaluation of LTPP SPS-1, -2, -5, and -6 WIM sections fall into one of the following categories:

1. Verification of existing WIM sections: These WIM sections are already in operation, but they will be evaluated to determine if they satisfy the specified smoothness criteria.

2. Acceptance of newly constructed WIM sections: Newly constructed WIM sections will be evaluated to determine if they satisfy the specified smoothness criteria.

3. Annual check of WIM sections: Newly constructed WIM sections that are accepted into the LTPP program, as well as existing WIM sites that have been verified and accepted into the LTPP program, will be monitored once a year to determine if they satisfy the specified smoothness criteria.

Profile measurements for use in the first two applications will typically be required only once unless special circumstances exist. Furthermore, they will not be done without explicit instructions from the FHWA. Longitudinal and transverse profile measurements using a straightedge will also be made for acceptance testing of newly constructed WIM sections, but applicable data collection procedures are not described in this manual.

With respect to the third category, installed SPS-1, 2, -5, and -6 WIM sections should be profiled during scheduled profile visits to their associated SPS projects. An installed section is a location at which sensors currently exist and at which data has been or is currently being collected. It may or may not be located within the project limits or immediate proximity to the SPS project. Only the LTPP lane will be profiled. In cases where the WIM site is not in the immediate proximity of the project or is in a different direction, the outside lane will be considered equivalent to the LTPP lane.

All profile measurements shall be done exclusively with the LTPP inertial profilers; the Dipstick® cannot be used as a substitute for the inertial profilers. In addition, the profile measurements shall be performed in accordance with the guidelines and procedures described previously in this manual, except that the procedure for profiling a section and the number of acceptable runs that are required at a WIM section are different from the procedures described in this manual. Procedures for profiling a WIM section and the number of profile runs that are required at a WIM section are described in the next sections.

2.4.2.3.2 Profiling Paths and File Naming Convention:

Profile data collected at three lateral positions are used to evaluate pavement smoothness at WIM sections. The three lateral positions along which the profiler shall be driven to collect the data are the following:

1. Along the wheel paths.

2. Close to the shoulder (right of the wheel path).

3. Close to the inner edge of the lane (left of the wheel path).

The following convention should be followed for naming files. Failure to adhere to this file naming convention could produce errors when running ProQual, and will cause problems when archiving files. The filename should consist of eight characters as follows:

SSDXLPEV

Where:

SS = State code in which the site is located (e.g., 27 for Minnesota).
D = First character of the SPS project SHRP ID, which should be 0, A, B, etc., depending on project code (e.g., 0600, A600, B600, etc.) if profiling in the same direction as the SPS project. If profiling in a different direction from SPS site, this character should indicate the direction traveled (i.e., E, W, N, S).
X = SPS experiment number, which should be the same number as the second digit of the SPS project SHRP ID (e.g., 5 for project A500).
L = Lane identification. Use O for outer, C for center, or I for inner on two or three lane facilities. In the event that there are more than three lanes in the travel direction, use successive numbers starting with 1 as the outer lane.
P = Path followed along the lane which is right, center, or left (i.e., R, C, or L).
E = Letter code defining section type; for WIM sites, this should always be W.
V = Sequential visit identifier that indicates the visit code for the current profile data collection. This identifier indicates the number of times a set of profile runs has been collected at a site since the site was first profiled. Use an appropriate letter for the current profiling with A used for the first visit, B for the second, etc.

For example, the following are valid data filenames:

- 05A6OCWB: Arkansas SPS-6 WIM site profiled in the travel direction of the SPS project in the outer lane along the center path for the second visit.
- 30S1OLWA: Montana SPS-1 WIM site profiled in the southbound direction in the outer lane along the left path for the first visit.
- 29W6ORWC: Missouri SPS-6 project 29A6 profiled in the westbound direction in the outer lane along the right path at the third visit.

2.4.2.3.3 Data Collection Procedure:

Prior to profile data collection at WIM sections, the RSC should either perform or take steps to ensure the following conditions are met:

- Daily checks should be performed on the equipment (i.e., laser sensor check, accelerometer calibration check, bounce test).
- Highway agency procedures relating to safety issues should be strictly followed (i.e., strobe bar and flashing signal bar on, use of turnarounds, etc.).
- Operating speed for collecting profile data should be 80 km/h. If maximum constant speed attainable is less than 80 km/h due to either traffic congestion, or safety constraints, then a lower speed depending on prevailing conditions should be selected. If the speed limit at the site is less than 80 km/h, the site should be profiled at the posted speed limit. If traffic traveling at high speeds is encountered at a test site, it is permissible to increase the profiling speed to 88 km/h.
- Photocell should always be used to initiate data collection at the beginning of test section.
- Section number assigned to the WIM should be entered as the Site ID when entering header information into the software.
- "Stop Distance" in software should be specified as 305 m.

An acceptable set of profile runs is three error free runs in the wheel path and one error free run offset to both the right and the left of the wheel path. On completion of the above steps, the following procedure should be followed to obtain an acceptable set of profile runs at WIM sections:

1. Make sure that the end of the WIM section is passed before terminating profile data collection.

2. Obtain at least three but no more than five profile runs by driving the profiler along the wheel paths.

3. Obtain at least one but not more than three profile runs by driving the profiler along a path that is as close as possible to the right edge of the traffic lane (i.e., right tire of vehicle aligned as close as possible to white stripe along the edge of the lane). The driver of the profiler should judge the path to be followed based on the site conditions, such that the path followed does not cause any safety concerns.

4. Obtain at least one but not more than three profiler runs by driving the profiler along a path that is as close as possible to the left edge of the traffic lane (i.e., left tire of vehicle

aligned as close as possible to lane divider along the edge of the lane). The driver of the profiler shall judge the path to be followed based on the site conditions, such that the path followed does not cause any safety concerns.

5. Review the profile runs that were collected along each path after completing data collection. Evaluate the profiles for equipment related spikes following the procedures described in section 2.2.8.2. If the operator has determined that at least three error free runs along the wheel paths and one error free run along each of the other two paths have been obtained at the site, terminate data collection. If the operator believes that at least three error free runs along the wheel paths and one error free run along each of the other two paths have not been obtained, repeat data collection along appropriate path(s) and evaluate the profile data using the procedures described previously. Up to a maximum of five runs along the wheel paths and three runs along the other two paths should be performed.

6. Use "Profiling of WIM Sites: Data Summary Sheet" included in appendix C to maintain a log of the runs**.**

7. Backup the data prior to leaving the site following procedures described in section 2.3.5.

2.5 CALIBRATION

2.5.1 General Background

As a minimum, a full calibration check of the laser sensors (see section 2.5.4) must be performed at an interval of 30 days. A full calibration check of the laser sensors must also be performed whenever problems are suspected with the laser sensors, or when a sensor is repaired or replaced.

Accelerometers in the profiler should be calibrated if the accelerometer check (see section 2.3.3.2) indicates ACFs are outside the allowable range or if the bounce test (see section 2.3.3.3) indicates a potential problem with accelerometer(s). The operator may elect to calibrate accelerometers daily prior to performing the bounce test. The accelerometers should be calibrated when repairs are performed on the accelerometer(s) or on computer cards associated with the accelerometer(s). The accelerometers should be calibrated at the time a full calibration check (see section 2.5.4) is performed on the laser sensors.

As a minimum, the DMI should be calibrated (see section 2.5.2) at an interval of 30 days or whenever problems are suspected. The DMI should also be calibrated when tires are replaced, suspension repairs are performed, or when wheels are rotated or aligned. The DMI should be calibrated when repairs are performed on the DMI or to computer cards associated with the DMI.

As a minimum, a calibration check must be performed at an interval of 30 days on the temperature probe.

Power to the electronic equipment should be turned on for about 15 minutes prior to performing any calibration or calibration checks so that the electronic equipment is allowed to warm up and stabilize.

2.5.2 Calibration of DMI

The DMI is calibrated by driving vehicle over a known distance to calculate the Distance Calibration Factor (DCF). The operator enters the actual distance traveled in the calibration menu and the computer calculates the DCF.

An accurately measured section of 300 m should be used to calibrate the DMI. This section should be located on a straight portion of roadway that is reasonably level and has low traffic volume. The speed limit at site should be at least 80 km/h. This section should be in an area where the vehicle can be driven at a constant speed without interruptions. This section should be measured with a standard surveying tape using standard surveying procedures. Reflective tape that will trigger the photocell should be placed on the pavement at the start and end of the section, such that the distance between leave edges of the two reflective tapes is 300 m. The reflective tape should be placed on the lane such that the vertical photocell will traverse over the tape when the profiler traverses the test section.

Prior to driving the vehicle in the morning, the operator should check the tire pressure (cold) to ensure that the tire pressure of the rear tires is at 550 kPa (80 psi), which is the manufacturer's recommended value that is listed on the door and the fuel cover. Adjust the tire pressure if needed to make it 550 kPa (80 psi).

The operator should drive the vehicle for about 6 to 8 km at highway speeds prior to calibration so that the tires can warm up. Based on local weather conditions (e.g., cold weather) the operator may need to increase the distance the vehicle should be driven to warm up the tires. The following procedure should be used to calibrate the DMI:

1. Power up the system and boot up the computer using procedures outlined in section 2.2.5.3 and 2.2.5.4.

2. Select the photocell. The vertical photocell should be selected following the procedures described in step 3 in section 2.3.4.1.

3. Adjust the tire pressure. Although the cold tire pressure was set to 550 kPa (80 psi), the tire pressure will increase when the tires are warmed up. Adjust the tire pressure of the rear tires so that the tire pressure is between 551 and 586 kPa (80 and 85 psi). Note the tire pressure.

4. Bring up the calibration menu. In the MDR main menu, choose "Calibration" to bring up the Calibration Menu shown in figure 64.

5. Enter the distance and tire pressure. In the Calibration Menu highlight "Distance" and press the Enter key. The screen will display the current DCF and the "Go" option. Highlight "Go" and press the Enter key. The system will then prompt the operator for the Calibration Distance. Enter the length of the calibration section, which should be 300, and press the Enter key. The system will prompt user for tire pressure. Enter the tire pressure of the rear tires in psi and press the Enter key (the tire pressure should be between 80 and 85 psi). The distance calibration screen shown in figure 65 will now be displayed on the monitor.

Figure 64. Screen shot. Calibration menu (2).
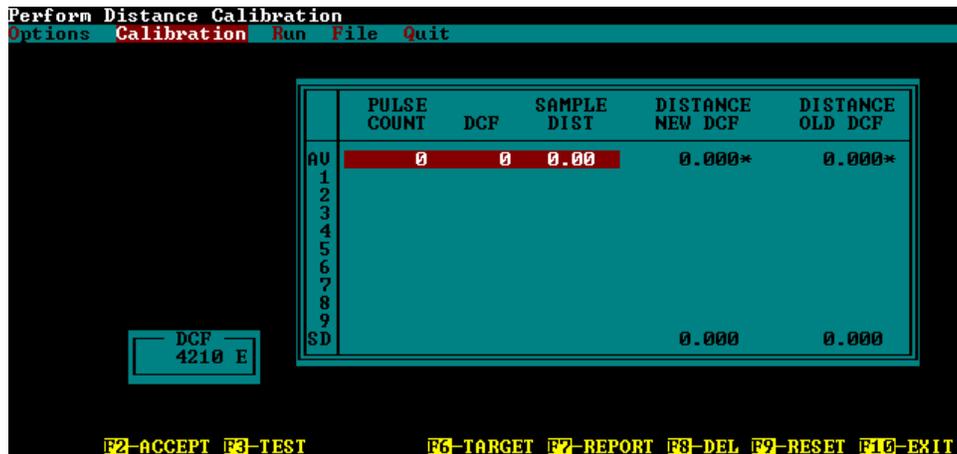
Figure 65. Screen shot. Distance calibration screen.

6. Bring the vehicle up to a speed of 80 km/h about 150 m prior to start of the section. Then press the F3 key (to start DMI) followed by the F6 key (to activate the photocell).

7. Clean the photocell and repeat the run if the photocell fails to trigger. As the profiler crosses the start of the section, a beep will be heard when photocell is triggered by the reflective tape, which is located at the start of the section. When the profiler crosses the reflective stripe at the end of the section, the distance calibration screen will display the new DCF value. If the photocell still fails to trigger, adjust the threshold control for the photocell. If this is not successful, use the horizontal photocell. To use the horizontal photocell, in step 2, select the horizontal photocell as the active photocell. Place two cones on the side of the road at the beginning and the end of the section. Cones placed at the beginning and end of the section should be aligned such that the leave edge of the reflective mark on the cone is aligned with the leave edge of the mark that is on the pavement surface.

8. Repeat the calibration procedure (steps 6 and 7) five more times so that six calibration runs are obtained. At the start of each run, adjust the tire pressure to the value noted in

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step 3. If the operator feels that a calibration run was not done properly, move the highlighted bar with the arrow keys to the results and press F8 to delete the run. When six calibration runs have been obtained, the monitor will display a screen similar to that shown in figure 66 (actual values shown on monitor will be different from those shown in figure 66).

Figure 66. Screen shot. Calibration screen after obtaining six runs.

9. Evaluate the Average Distance (as shown in the first line as AV) and standard deviation (as shown at the bottom as SD) under the column "Distance New DCF." If the average distance is within ±0.15 m of actual distance of the site (300 m), and the standard deviation is less than 0.075 m, the DMI calibration has been performed successfully. If the values are outside specified tolerances, obtain additional runs until six runs that meet specified criteria have been obtained. If six runs that meet specified criteria cannot be obtained, contact the RSC to decide on a course of action.

10. Save the new DCF value that was computed during DMI calibration. Use the arrow keys to highlight the average that is shown at the top and press the F2 key to accept the new DCF value. The system will ask, "Set DCF to Accepted Value?" Press the Y key to save the calibration factor. The program will also save a report for distance calibration. The location of the report (path and file name) will be displayed on the top of the screen when the file is saved.

11. Press the F10 to exit Distance Calibration. The system will ask "Do You Want to Exit?" Press the Y key to do so, and the MDR main menu will now be displayed on the screen.

12. Print the Distance Calibration Report that was saved.

2.5.3 Calibration of Accelerometers

Calibration of the accelerometers should be performed while the vehicle is parked on a level surface. The location where calibration is being performed should be free of any vibrations. Calibration of the accelerometers should not be performed when the engine of the van is running. The operator should be outside of the vehicle when calibration is performed. The operator should adjust the computer monitor so that it can be seen from outside the vehicle and the keyboard

should be placed on the seat of the van. Do not enter the vehicle, bounce or bump the vehicle, or lean on the vehicle during calibration. The power to the system should have been turned on for about 15 minutes for the system to warm up prior to calibrating the accelerometers. The following procedure should be used to calibrate accelerometers:

1. Boot up the computer following procedures described in section 2.2.5.4. The MDR main menu should now be displayed on the monitor.

2. Select "Calibration" in the MDR main menu to display the calibration menu (see figure 67). In the Calibration Menu, highlight "Accelerometer" and press the Enter key, and the Accelerometer Calibration Menu shown in figure 68 will be displayed on the monitor. The settings for parameters displayed on monitor should match values shown in figure 68.
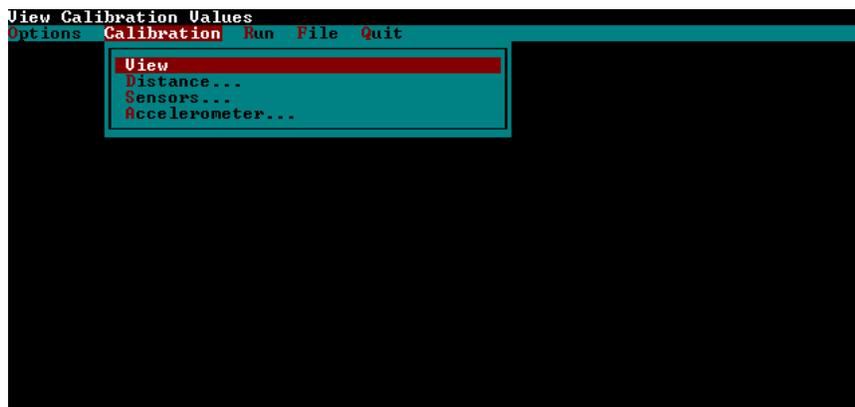
Figure 67. Screen shot. Calibration menu (3).
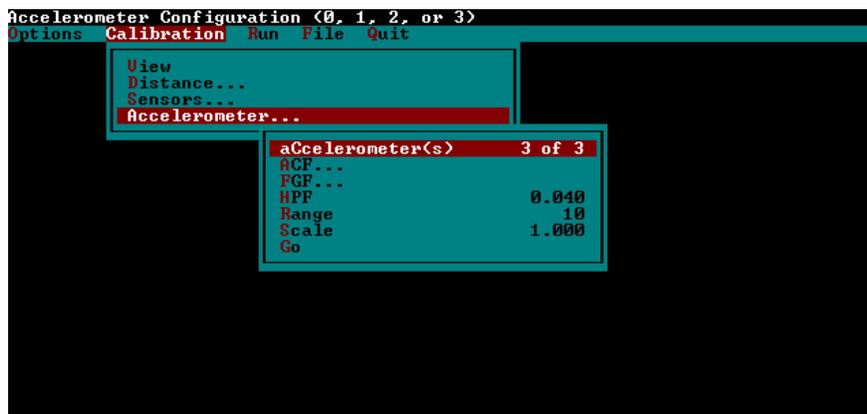
Figure 68. Screen shot. Accelerometer calibration menu (2).

3. Highlight "Go" in the Accelerometer Calibration Menu (see figure 68) and press the Enter key. The monitor will display an Accelerometer Calibration Screen similar to that shown in figure 69 (values displayed on the monitor will be different from those shown in figure 69).
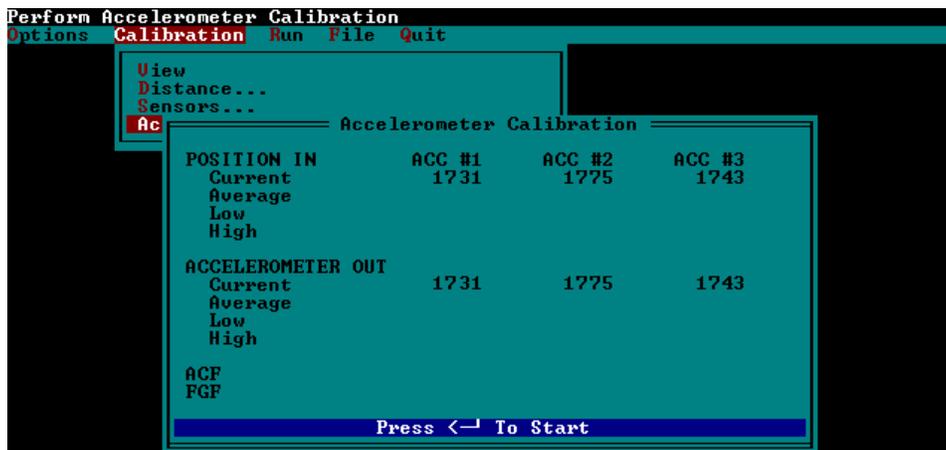
Figure 69. Screen shot. Accelerometer calibration screen (2).

4. Press the Enter key and the accelerometer will begin collecting data. After about 5,000 samples have been taken, press the Backspace key to end calibration.

5. Press the N key to repeat the calibration procedure when the system asks if new values should be accepted if test was not valid. If the test appears to be valid, check if all calibration factors are within the allowable range. The allowable range for an ACF is normally between 1710 and 1790. However, if during step 26 of the Accelerometer Signal Conditioning Test (see section 2.6.1), the ACF of an accelerometer was not between 1710 and 1790, a new allowable range for that accelerometer would have been determined as described in section 2.6.2. If any displayed calibration factor is not between 1710 and 1790, check to see if the value is within the range determined according to the procedure described in section 2.6.2. If the calibration factors are within the allowable range, press Y key to accept the values.

When the Y key is pressed, calibration values are saved and these values will be recorded in the log file. This log file is called cal_log.txt, and it is located in the directory C:\mdrsw\mdr_cal. (Note: The accelerometer calibration screen in the MDR software displays results from accelerometers as positive values. The ACFs are values computed by the software to "zero" the accelerometer reading. The ACFs stored in the MDR software and the calibration log file are negative values.)

2.5.4 Full Calibration Check of Laser Sensors

The laser sensors have been calibrated in the factory and operators cannot calibrate these sensors. A calibration check of the laser sensors is performed prior to data collection (see section 2.3.3.1). In the calibration check, laser sensors are checked to see if they can accurately measure the height within a specified tolerance by using a 25 mm gauge block. However, this procedure only checks the accuracy of the laser sensor over a 25-mm distance within its measuring range. A more comprehensive check of laser sensors should be performed at a minimum interval of 30 days, which will check the accuracy of the laser sensors over a 100-mm measuring range. This check is referred to as the Full Calibration Check of laser sensors to distinguish it from the Calibration Check of laser sensors that is performed prior to data collection in the field. The laser sensor is attached to the sensor bar such that the mid point of the measuring range of the laser sensor is at the ground surface. During a full calibration check, the vehicle is elevated so that the

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accuracy of the laser sensor over a distance from below the mid point of the measuring range to above the mid point of the measuring range can be checked.

2.5.4.1 Supplies for Calibration Check

2.5.4.1.1 Van Support Blocks:

As described previously, the van is elevated when the full calibration check is performed. This is accomplished by driving the tires of the van over four wooden support blocks, so that all four tires on the van rest on the support blocks. A van support block is made by using two stacked 38-mm by 254-mm by 915-mm boards screwed together on the 254-mm by 915-mm face. One 254-mm end should be beveled to allow the profiler to be driven up onto the blocks. Figure 70 shows an example of a van support block.

Figure 70. Photo. Support blocks.

2.5.4.1.2 Calibration Base Plates:

These are polished steel 100-mm by 100-mm by 9-mm steel plates, with feet installed on the bottom of the plates for stability. Three base plates are provided for each profiler.

2.5.4.1.3 Calibration Surface Plates:

These are polished gray polymer 5-mm by 25-mm by 75-mm plates used as the top reflective surface for the calibration check. Three plates are provided for each profiler.

2.5.4.1.4 Calibration Blocks:

These are polished black polymer blocks having nominal dimensions of 25-mm by 50-mm by 75-mm. Each profiler is provided with six calibration blocks. Each block is engraved with its exact dimension on each face to three decimal places in millimeters.

2.5.4.2 Setup Profiler

Ideally, the full calibration check of laser sensors should be performed in an enclosed building with a level concrete floor, with an external power source (house power) used to power the profiler system. If a full calibration check is performed in the field, the location where the check is performed should protect the profiler from wind and other vibrations. The pavement surface should be as level as possible and lighting conditions should be consistent from sensor to sensor (i.e., face van away from the sun). An external power source should be used, if possible. The following procedures should be used to setup the profiler to perform the full sensor calibration check:

1. Check Sensor Height: The tire pressure can have a significant impact on the sensor height that is obtained. Therefore, the cold tire pressure of all tires must be checked to ensure that they are at the values specified in section 2.2.3.4 prior to performing this check. Make sure power to the laser sensors has been turned off. Remove the sensor covers. With the tires of the profiler resting on floor, measure the distance from the floor to the glass face of the laser sensor. This distance should within ±5 mm of 325 mm. The distance from the ground to the face of the sensor should not change between calibration checks that are performed monthly, unless sensors have been moved or replaced since the previous calibration check. Adjust the sensor if required so that height from the glass face of the sensor to the ground is 325±5 mm.

2. Clean Sensor Glass: Gently clean each lens with a damp cloth or towel. If excessive dirt is noted on the lenses, wash off loose particles using compressed air or water applied through a sprayer, and then clean the lenses using a damp cloth or towel. When cleaning the lenses, take extreme care to prevent scratching the lenses.

3. Elevate Vehicle: Place a van support block in front of each tire, and then drive vehicle onto the blocks such that all four tires rest on the van support blocks. Figure 71 shows the van in the elevated position.

Figure 71. Photo. Profiler on top of support blocks.

4. Warm Up Electronics: After connecting to house power, turn on the computer (see sections 2.2.5.3 and 2.2.5.4) and lasers. The monitor should show the MDR main menu. Let equipment warm up for at least 15 minutes.

2.5.4.3 Performing Full Calibration Check

There are two methods that can be used to perform the full sensor calibration check. In the first method, the calibration check on all three sensors is performed simultaneously. In the second method, the calibration check is performed separately on each sensor. Performing a full sensor calibration check simultaneously on all three sensors will reduce the time required to do this check. Both of these procedures are described in this section.

2.5.4.3.1 All Three Sensors at Same Time:

The following procedures should be used to check all three sensors at the same time:

1. Stand outside the vehicle when the calibration check is performed. Adjust the computer monitor so that it can be seen from outside the vehicle, and place the keyboard on the seat of the van. Do not enter the vehicle, bounce or bump the vehicle, or lean on the vehicle during the calibration check.

2. Clean the top of the calibration base plates, as needed, and place a calibration base plate on the ground under each laser sensor, so that the red laser dot on each plate is centered within the plates (see figure 72).

Figure 72. Photo. Laser dot centered on base plate (2).

3. Place a calibration surface plate on top of each calibration base plate, with the long dimension of the calibration surface plate parallel to the long dimension of the profiler sensor bar. Center each calibration surface plate so that the red laser dot of each sensor is centered on the calibration surface plate (see figure 73).

Figure 73. Photo. Calibration surface plate on top of base plate (2).

4. Select "Calibration" in the MDR main menu to display the Calibration Menu. In this menu, highlight "Sensors" and press the Enter key to display the Calibration Sensor Menu that is shown in figure 74.
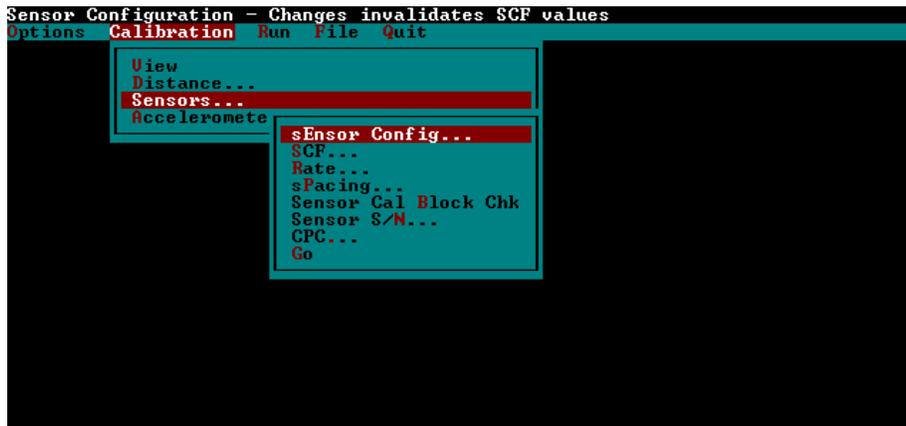
Figure 74. Screen shot. Sensor calibration menu (3).

5. Highlight "Sensor Cal Block Chk" in the Calibration Sensor Menu and press the Enter key. The monitor will display the sensor calibration screen shown in figure 75.

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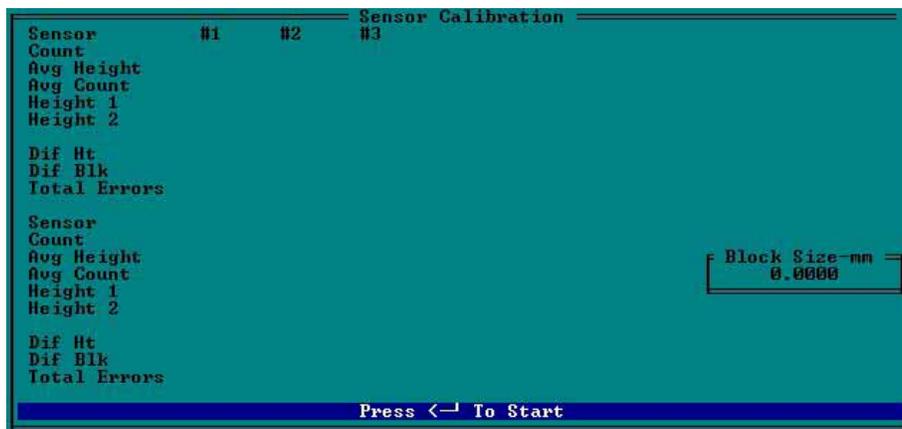
Figure 75. Screen shot. Calibration check screen (2).

6. Enter the height of block as 25.0 in the window that opens and press the Enter key (when performing the check with the 50-mm, 75-mm, and 100-mm blocks, enter values of 50.0, 75.0, and 100.0, respectively).

7. Press the Enter key so that the system will begin sampling (i.e., taking measurements on the calibration surface plates that are below each sensor). The number of samples taken is displayed at the bottom of the screen. The computer monitor at this stage will look similar to the screen shown in figure 76. (Note: Values displayed on the monitor for Count, Avg Height, Avg Count, Height 1, Height 2, Dif Ht, and Dif Blk will be different from those shown in figure 76). Allow the system to take at least 500 samples and then press the Backspace key to stop sampling.
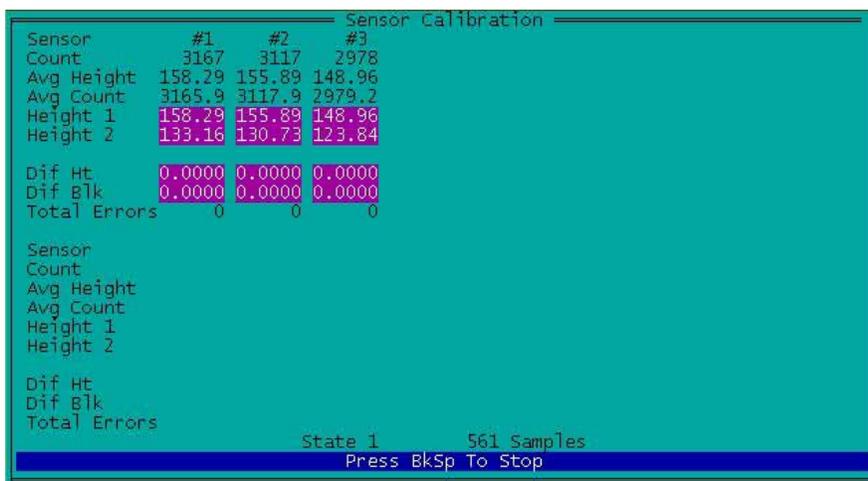
Figure 76. Screen shot. Readings taken on base plate (2).

8. Remove the calibration surface plate from the calibration base plate, place the block on top of the calibration base plate such that the 25 mm side of block is vertical, and red laser dot is at the center of the block. Place the calibration surface plate on top of the block and adjust the calibration surface plate such that the red laser dot will be centered on the calibration surface plate. Repeat the procedure for the other two sensors. Figure 77 shows the 25-mm block on the calibration base plate with the calibration surface plate on top of the 25-mm block.

Figure 77. Photo. Block on top of base plate with calibration plate on top of block (2).

9. Press the Enter key, allow the system to take at least 500 readings, and press the Backspace key to stop sampling. The computer monitor at this stage will look similar to the screen shown in figure 78. (Note: Values displayed on monitor for Count, Avg Height, Avg Count, Height 1, Height 2, Dif Ht, and Dif Blk will be different from those shown in figure 78).
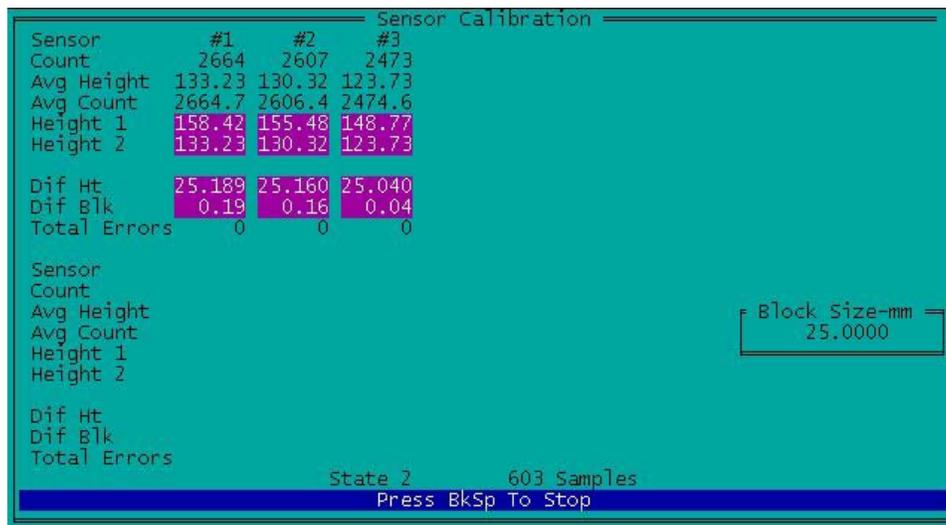
Figure 78. Screen shot. Readings being taken on 25-mm blocks (2).

10. Enter the value shown in field "Dif Blk" in the computer to field "Dif Blk From Computer" in form PROF-5 that is included in appendix C (enter for 25-mm block position). Fields #1, #2, and #3 refer to the left, right, and center sensor, respectively. The field "Dif Ht" indicates the height of the block as measured by the data acquisition system in the profiler. The field "Dif Blk" indicates the difference between the height of block as measured by the data acquisition system of the profiler and the block height that was entered into the computer. As the actual heights of the blocks that were placed below the three sensors are not exactly 25 mm, values shown in "Dif Ht" and "Dif Blk" fields have to be adjusted to get correct values.

11. Enter the height of the blocks that were placed below the left, right, and center sensors in the field "Actual Block Height" in form PROF-5 (values should be entered in columns corresponding to the 25-mm block position with the height of the block entered to three decimal places). Perform computations shown on the form to get values in row numbers three and five.

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12. Repeat the test until the specified tolerance level is achieved for all sensors. If values computed in form PROF-5 for "Adjusted Dif Blk" for all three sensors are between -0.25 mm and +0.25 mm, all three sensors are considered to have passed the full calibration check at the 25-mm position, and the operator should proceed to step 13. If the value for "Adjusted Dif Blk" is outside the specified tolerance of ±0.25 mm, the sensor is out of tolerance. If a sensor is out of tolerance, make sure the system is warmed up, all connections inside the vehicle and outside the vehicle related to the affected sensor are tight, the sensor glass is clean, the blocks are level, the van is steady, and the lighting conditions are consistent. If after five attempts, the sensor(s) is still out of tolerance, contact the RSC and decide on a course of action to resolve the problem.

13. Repeat steps 6 through 12 for block heights of 50, 75, and 100 mm (in step 6, type in the appropriate block height). For the 50 mm block check, place the blocks under each sensor such that the 50-mm side of the block is vertical. For the 75-mm block check, place the block under each sensor such that the 75-mm side of the block is vertical. For the 100-mm block check, place two 50-mm blocks on top of each other. In step 6, enter block heights as 50, 75, and 100 for the 50-mm, 75-mm, and 100- mm block positions, respectively. When computing "Adjusted Dif Blk" value in form PROF-5, use appropriate columns for each block position. If "Adjusted Dif Blk" at any of these height positions on any sensor is outside the allowable tolerance of ±0.25 mm, resolve the issue following procedures described in the previous step.

2.5.4.3.2 One Sensor at a Time:

The following procedures should be used to check one sensor at a time:

1. Stand outside the vehicle when the calibration check is performed. Adjust the computer monitor so that it can be seen from outside the vehicle and place the keyboard on the seat of the van. Do not enter the vehicle, bounce or bump the vehicle, or lean on the vehicle during the calibration check.

2. Clean the top of the calibration base plate, as needed, and place the calibration base plate on the ground under the laser sensor being checked, so that the red laser dot on the plate is centered within the plate (see figure 72).

3. Place the calibration surface plate on top of the calibration base plate, with the long dimension of the calibration surface plate parallel to the long dimension of the profiler sensor bar. Center the calibration surface plate so that the red laser dot of the sensor is centered on the calibration surface plate (see figure 73).

4. Select "Calibration" in the MDR main menu to display the Calibration Menu. In this menu, highlight "Sensors" and press the Enter key to display the Calibration Sensor Menu shown in figure 74.

5. Highlight "Sensor Cal Block Chk" and press the Enter key. The monitor will display the sensor calibration screen shown in figure 75.

6. Type the dimension of the block to three decimal places in the window that opens. After typing the value, press the Enter key. When starting this test, the shortest dimension of

the block that is being used must be entered (the value will be close to 25 mm). The dimension of the block is engraved on the block (when performing the test with other block sizes, the guidelines given in step 13 must be followed).

7. Press the Enter key to trigger the system to begin sampling (i.e., to obtain measurements on the calibration surface plate). The number of samples taken is displayed at the bottom of the screen. The computer monitor at this stage will look similar to screen shown in figure 79. (Note: Values displayed on the monitor for Count, Avg Height, Avg Count, Height 1, Height 2, Dif Ht, and Dif Blk will be different from those shown in figure 79). Allow the system to take at least 500 samples and then press the Backspace key to stop sampling.
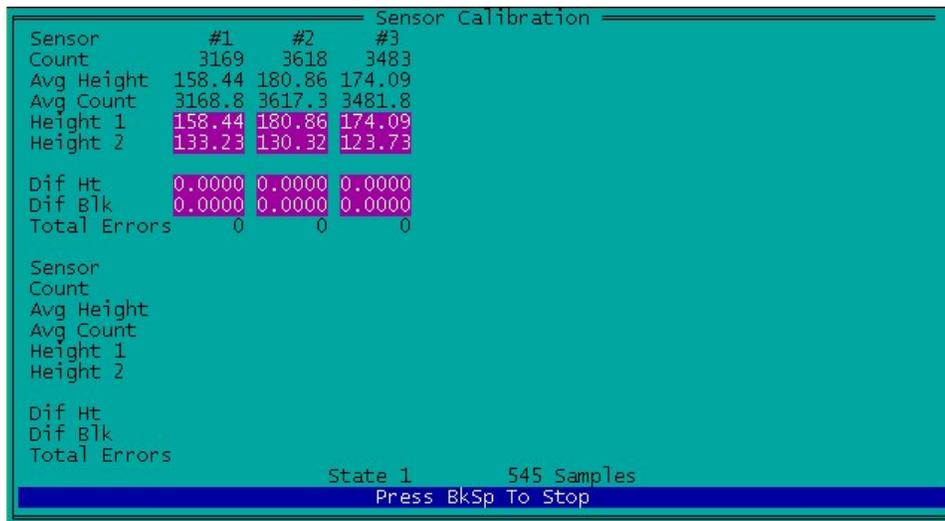
Figure 79. Screen shot. Readings taken on base plate (base plate below sensor #1).

8. Remove the calibration surface plate from the calibration base plate, place the block on top of the calibration surface plate such that the 25-mm side of the block is vertical, and the red laser dot is centered on the block. Place the calibration surface plate on top of the block and adjust the calibration surface plate such that the red laser dot will be centered on the calibration surface plate.

9. Press the Enter key to allow the system to take at least 500 readings, and press the Backspace key to stop sampling. The computer monitor at this stage will look similar to that shown in figure 80. (Note: Values displayed on monitor for Count, Avg Height, Avg Count, Height 1, Height 2, Dif Ht, and Dif Blk will be different from those shown in figure 80).
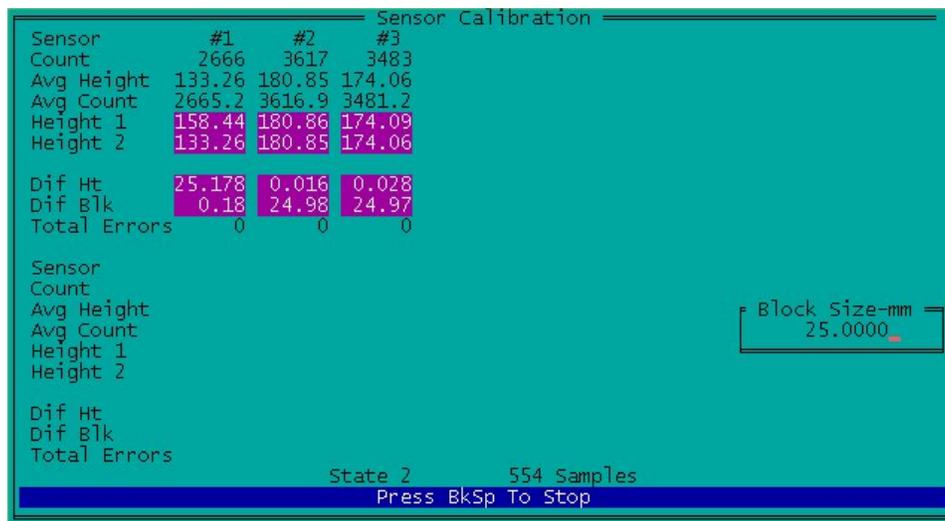
Figure 80. Screen shot. Readings taken with 25-mm block below sensor #1.

The field "Dif Ht" indicates the height of the block as measured by the data acquisition system in the profiler. The field "Dif Blk" indicates the difference between the height of the block as measured by the data acquisition system of the profiler and the block height that was entered into the computer. Values displayed for #1, #2, and #3 correspond to left, right, and center sensors, respectively (as the actual block height was entered when doing this test, values for "Dif Ht" and "Dif Block" do not need to be adjusted).

10. Repeat the test until the specified tolerance level is achieved. If the value displayed in field "Dif Blk" for the sensor being checked is between -0.25 mm and +0.25 mm, the sensor is considered to have passed the full calibration check for the specific block position. If the sensor is within the tolerance, go to step 12. If the value shown in the field "Dif Blk" is outside the specified ±0.25 mm tolerance, make sure the system is warmed up, all connections inside the vehicle and outside the vehicle related to the affected sensor are tight, the sensor glass is clean, the blocks are level, the van is steady, and the lighting conditions are consistent, and repeat the test. If after five attempts the specified tolerance cannot be achieved, contact the RSC and decide on a course of action to resolve the issue.

11. Record the value displayed in the field "Dif Blk" in the appropriate field of form PROF-6, which is included in appendix C.

12. Repeat steps 6 through 12 using block heights of 50, 75, and 100 mm for the same sensor, using the following procedure to place blocks and enter values in step 6. For the 50-mm block check, place the block under the sensor such that the 50-mm side of the block is vertical. For the 75-mm block check, place the block under the sensor such that the 75-mm side of the block is vertical. For the 100-mm block check, place two 50-mm blocks on top of each other. At step 6, for each block position, enter the appropriate block height that is engraved on the block (enter the value to three decimal places). For the 100-mm position, add the heights for the two blocks that are being used for the check and enter the value.

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13. Repeat the calibration check for the other two sensors following the procedures described in steps 1 through 13.

2.5.5 Calibration Check of Temperature Probe

A calibration check on the air temperature probe should be carried out at 30-day intervals. This check can be performed at the time when the full calibration check on the profiler sensors is performed. A temperature probe calibration check log should be maintained in the profiler (form PROF-5 can be used as a log when the laser sensors are checked simultaneously and form PROF-6 can be used when the laser sensors are checked individually). The procedures outlined for the temperature probe calibration check should be followed whenever the operator observes suspicious temperature readings. A National Institute of Standards and Technology (NIST) traceable mercury thermometer is required to perform this test. This test should be performed in the shade, using the following procedure:

1. Park the profiler in the shade and allow some time for the vehicle to cool off if the profiler was exposed to the sun.

2. Place a thermometer close to the temperature probe and observe the reading of the thermometer.

3. Record the reading of the temperature displayed by the temperature display gauge in the profiler. If the difference between the two temperature readings are less than or equal to 2 °C, the temperature probe is considered to be acceptable.

4. Repeat steps 2 through 4 if the difference between the two temperatures is greater than 2 °C. If the difference is still greater than 2 °C, repeat steps 2 through 4 again. If the difference between the temperatures is still greater than 2 °C consider the air temperature probe to be unacceptable and contact the manufacturer of the probe to resolve the problem.

If there are any questions regarding the accuracy of the temperature probe, a cold temperature check should be performed on the probe. In this check, a plastic bag containing crushed ice is placed around the temperature probe. After allowing a sufficient time for the temperature probe to stabilize, check the reading displayed. The temperature should be within 2 °C of 0 °C.

2.6 EQUIPMENT CHECKS

2.6.1 Accelerometer Signal Conditioning Test

This Accelerometer Signal Conditioning Test checks the power supply, accelerometer filters, and cables to ensure that the analog-digital accelerometer interface card in the profiler is working properly. This test should be performed annually, when problems are encountered with accelerometer readings, or if any repairs have been carried out on the accelerometers or any components associated with the accelerometers. This test is performed using the accelerometer test tool (see figure 81), which consists of a switch with resistors.

Figure 81. Photo. Accelerometer test tool.

After the accelerometer is unplugged, the test tool is plugged into the accelerometer circuit to perform this test. The following procedure should be followed when performing the test:

1. Park the profiler on a level surface and power up the computer system following the procedures outlined in sections 2.2.5.3 and 2.2.5.4 of this manual. Allow the electronics to warm up for 15 minutes per normal operating procedure.

2. Calibrate the accelerometers following the procedure described in section 2.5.3 of this manual, and accept the new ACF.

3. Record the accepted ACF values for the left, right, and center accelerometers in row number 1 on form PROF-8, which is included in appendix C.

4. Turn off the profiler computer system following the procedures described in section 2.2.5.5.

5. Unplug the cable from each accelerometer carefully (located under the front bumper near the laser sensors). Attach an accelerometer test tool to each accelerometer cable for the left (driver side), right (passenger side), and center accelerometers, with the switch in position C (or middle position).

6. Reboot the computer system and launch the MDR program. Ignore the "Invalid Accelerometer Configuration" message and do not recheck the system. Enter Y to operate "with probable error conditions."

7. Perform an accelerometer calibration following the procedure described in section 2.5.3, but do not accept the ACF values.

8. Record the ACF values for the left, right, and center accelerometers in row number 2 on form PROF-8.

9. Move the switch in the accelerometer tool to position A. Perform an accelerometer calibration following the procedure described in section 2.5.3, but do not accept calibration values. ACF values should be negative. If not already indicated on the test tool, mark this position on each accelerometer test tool with permanent ink or with an identification sticker for future tests.

10. Record the ACF values for the left, right, and center accelerometers in row number three on form PROF-8.

11. Move the switch in the accelerometer tool to position B. Perform an accelerometer calibration following the procedure described in section 2.5.3, but do not accept calibration values. ACF values should be positive.

12. Record the ACF values for the left, right, and center accelerometers in row number 4 on form PROF-8.

13. Move the switch in the accelerometer tool back to position C. Perform an accelerometer calibration following the procedure described in section 2.5.3, but do not accept the calibration values.

14. Record the ACF values for the left, right, and center accelerometers in row number five on form PROF-8.

15. Turn off the computer system in the profiler following the procedure described in section 2.2.5.5.

16. Remove all three accelerometer test tools and reconnect each cable to the accelerometer.

17. Turn on the profiler computer system using the procedure described in sections 2.2.5.3 and 2.2.5.4 and wait for 10 minutes. Calibrate the accelerometers following the procedure described in section 2.5.3 and accept the new ACF values.

18. Record the ACF values for the left, right, and center accelerometers in row number six on form PROF-8.

19. Perform calculations one through five indicated on form PROF-8, and record the values for left, right, and center accelerometers in rows numbered 7 through 11, respectively.

20. Under Calculation one (row number seven), the computed difference in offset values should be within ±10. If not, this may mean that the internal electronics could be drifting and the RTI-X may need to be replaced. If offset values are not within the range, repeat this test. If accelerometers fail the test again, contact ICC for advice (the accelerometer board may need to be replaced).

21. The values from Calculations 3 and 4 (rows 9 and 10) should be within ±48. If the resulting values are outside these limits for an accelerometer, a possible problem exists with that accelerometer. Contact ICC to resolve this issue.

22. The value obtained from Calculation 5 (row number 11), which indicates the difference between post- and pre-test ACF values, should be within ±24 for each accelerometer. If not, there may be too much drift in the accelerometer. Repeat the test, and if an accelerometer fails the test again, ICC should be contacted for further testing/monitoring with the test tool and possible board or accelerometer replacement.

23. The values obtained when the accelerometer test tool is connected in position A (row number 3) and B (row number 4) should satisfy the following ICC provided criteria:

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(a) ACF values for Position A should be between -2552 and -2088 (±10 percent of -2320), and (b) ACF values for Position B should be between 1908 and 2332 (±10 percent of 2120).

24. If any accelerometer fails to satisfy the previously described two criteria, additional observations or testing should be done as follows: (a) If the reason for the failure cannot be determined, contact ICC, (b) If one channel fails while the others pass, examine the wiring for that accelerometer to determine if an open power wire is creating a problem, (c) If all channels are failing, examine all wiring to ensure that a short circuit between the connector pins is not causing the failure. These types of failures generally will change the numbers over 25 percent. If the numbers are less than 25 percent different, but greater than 10 percent, the power supply could be drifting, which indicates an RTI-X problem. Determine the drift using the following procedure: (a) reinstall the test tools (if already removed) following the procedures described previously and (b) repeat the tests for positions A and B two times at two minute intervals to determine the drift. Once drift has been determined, contact ICC to determine if additional testing is required or if any parts need to be replaced.

25. After the first test is performed with the accelerometer test tool, each subsequent test result for offset 1 and offset 2 should be compared with the prior test value. The test values should be within ±32 (ICC's current estimate). Contact ICC if the difference is outside the allowable range.

26. Check the ACFs using the procedure described in section 2.3.3.2. If the calibration factor of an accelerometer is not between 1710 and 1790, compute a new allowable range for the ACF following the procedure outlined in section 2.6.2.

2.6.2 ACF Range

The calibration factor of all accelerometers must be checked to ensure that they fall within the allowable range during the daily accelerometer check (see section 2.3.3.2) and after calibrating the accelerometers (see section 2.5.3). The allowable range of the ACF that was specified by ICC when LTPP took delivery of the profilers was between 1710 and 1790. However, at that time, the ACFs of all accelerometers were not close to the mid-point of the allowable range (i.e., 1750). Some accelerometers had calibration factors that were between the lower bound of 1710 and the mid-range value of 1750. Over time, the ACFs in some accelerometers have been drifting towards the lower bound of the allowable range and may fall below the allowable value of 1710. If the ACF of an accelerometer falls below the lower limit of 1710 or exceeds the upper limit of 1790, the following procedure should be followed to determine a new allowable ACF range:

1. Perform the Accelerometer Signal Conditioning Test described in section 2.6.1. If one or more accelerometers fail the criteria established for that test, follow the recommended procedures to address and resolve the issue.

2. Go through the records and obtain the calibration factors for the first 10 times the accelerometer was calibrated. If the accelerometer has not been replaced, the values will correspond to the 10 calibration values after the region started to operate the ICC profiler.

If an accelerometer has been replaced, the values will correspond to the 10 calibration values after the new accelerometer was installed.

3. Average the 10 calibration values to obtain an average initial calibration factor value for the accelerometer.

4. Compute the allowable ACF range for the accelerometer as the average initial calibration factor value (from step 3 above) ± 40.

5. Use the ACF range computed in step 4 when performing the daily accelerometer check (see section 2.3.3.2) and checking the range of the ACFs after calibrating the accelerometers (see section 2.5.3).

2.6.3 Photocell Offset Determination

2.6.3.1 Overview

The K. J. Law T-6600 profilers that were used in the LTPP program to collect profile data from 1996 to August 2002 obtained the first data point at a distance of 114 mm from the leave edge of the section start stripe. When the data collected by the ICC profilers are processed by ProQual, in order to be consistent with the data collection procedure used by the K. J. Law T-6600 profilers, the first data point in the test section is assigned a location that is 114 mm from the leave edge of the section start stripe.

ProQual needs a parameter called the photocell offset in order to process that profile data such that the first data point is at the previously indicated location. Separate photocell offsets are needed for the vertical photocell and the horizontal photocell. When ProQual processes profile data, the program uses the vertical photocell offset for cases where data collection was initiated with the vertical photocell, and the horizontal photocell offset for cases where the data collection was initiated with the horizontal photocell.

Each RSC should annually determine the vertical and horizontal photocell offset values using the procedure that is described in sections 2.6.3.2 to 2.6.3.4 and the values must be entered into the ProQual equipment table. The equipment table in ProQual is accessed through the System menu in ProQual (see figure 82). The ProQual copy in the profiler, as well as all ProQual copies in the RSC office that are used to process profile data, should be updated with the photocell offset values that are determined annually.
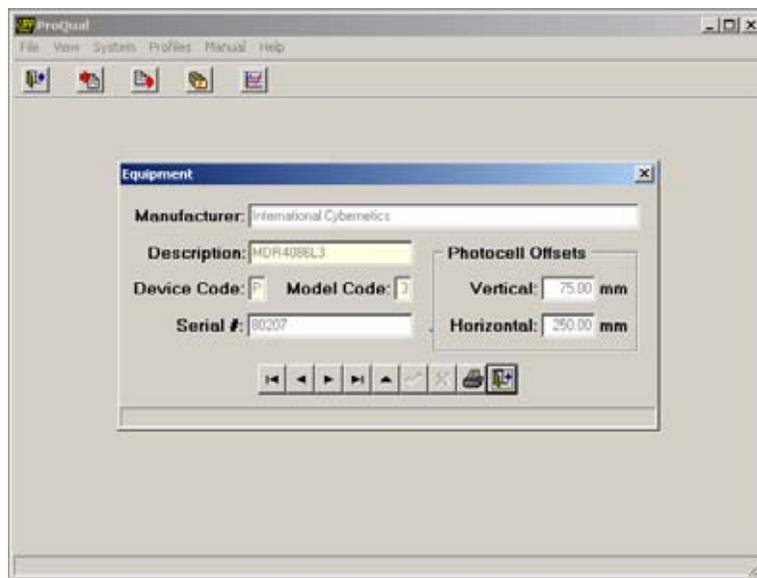
Figure 82. Screen shot. Equipment table in ProQual.

Each RSC should maintain a log that indicates the following related to photocell offsets: date when testing was performed to determine photocell offsets, values obtained for vertical and horizontal photocell offsets, and date when photocell offset values were updated in ProQual.

The following sections describe the field procedure for performing the test and the procedure to perform the computations using the collected data.

2.6.3.2 Site Preparation

The test procedure involves attaching an artificial bump target to the pavement and then collecting a series of profiles with the center laser sensor passing over the bump. The testing location should be a straight stretch of road with very low traffic volume where it is possible to safely attain a profile speed of 80 km/h. As operator safety is of utmost concern, the site location should not place the operator in harm of traffic while attaching the target to the pavement, nor should the traffic at the location present the possibility of disturbing the target while the testing is being performed. The ideal location should be a new or a recently overlaid pavement surface with no significant pavement distresses within 15 m of the target point. Pavements with rough surface textures, such as chip seals or severe raveling, should be avoided.

Once a location for testing has been selected, it is necessary to establish a beginning section mark. Place a 52 to 102 mm wide strip of white or silver adhesive tape at the testing location on the pavement, such that it is perpendicular to the direction of travel and in a location that will be detected by the vertical photocell when the profiler is driven over the location. Select a suitable bump target from a length of wood with the dimensions 13 mm thick, 38 mm wide, and 750 mm long. Place the bump target on the pavement parallel to the previously established starting stripe in a manner such that the 13 mm dimension is vertical to the pavement, the approach edge of the 38 mm dimension is 114 mm from the leave edge of the starting stripe, and the target spans the path that will be traversed by the center laser sensor (approximately mid-lane). The bump target should be positioned in such a way that the right or left tires will not run over it during profile runs. Affix the bump target to the pavement with an appropriate adhesive tape such that the

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adhesive tape will not affect the profile collected by the center laser. Figure 83 illustrates the positioning of the section stripe and bump target.
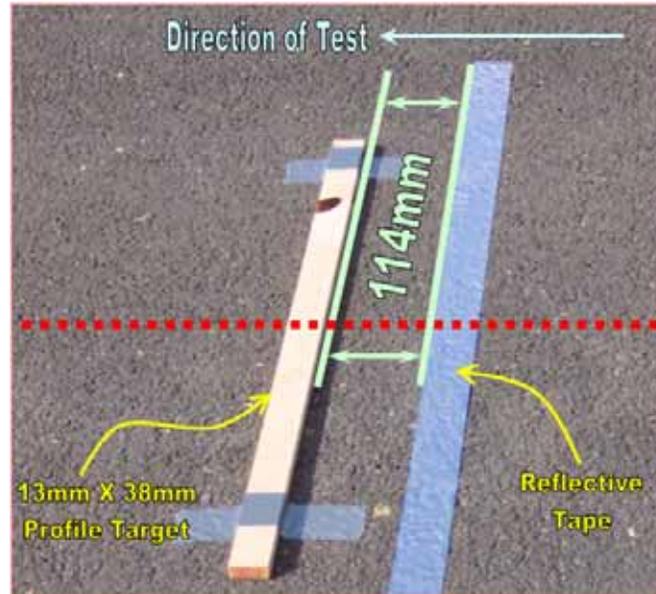
Figure 83. Photo. Section starting stripe and bump target placed on the pavement.

Thereafter, the horizontal photocell target has to be established in relation to the starting stripe. Place the horizontal photocell target on the shoulder of the road in a position that will minimize the potential for disruption during testing. Align the horizontal photocell target such that the leave edge of the reflector is in line with the leave edge of the stripe placed on the pavement. The placement of the vertical and horizontal photocell targets is intended to replicate standard profile operations. Figure 84 illustrates the proper placement of the horizontal photocell target in relation to the starting stripe and bump target.

Figure 84. Photo. Placement of vertical photocell target in relation to section starting location.

2.6.3.3 Profile Data Collection

The photocell offset determination is performed in a manner consistent with standard LTPP profile data collection procedures. It is important that the DMI has been calibrated beforehand in accordance with section 2.5.2 of this manual, and the tires in the profiler are sufficiently warmed up with air pressures matching the pressure noted during the DMI calibration. Ideally, the full range calibration check of the profiler's laser sensors should have been performed, in accordance with section 2.5.4 of this manual prior to performing this testing. However, if the full calibration check has not been performed within two days of this testing, perform the standard daily height sensor check and bounce test in accordance with section 2.3.3 of this manual. For this testing, both photocells will be active simultaneously, but two sets of profiles (five runs each set) will be collected for computing offsets for each photocell. For this testing, the profile data of concern is primarily in the region of the bump target. Therefore, it is not necessary to collect a large amount of profile data during each run. Only 40 to 50 m of profile data before and 20 m of profile data after the section start stripe need to be collected. Although processing of the profiles collected during this testing will be described in the next section, verification of the suitability of the profiles should be performed by reviewing the profiles in the ICC WinGraph software and by examining the occurrences of events in the MDR data collection software.

The following procedure should be followed for collecting data:

1. Select the "ICC System Parameters…" option from the "Options" menu of the ICC MDR data collection software to set the desired photocell parameters. In the "Target…" option, set the photocell parameters as follows:

   a. For the horizontal photocell offset runs, set Target 4 = F9 and Target 5 = F5 as shown in figure 85.

   b. For the vertical photocell offset runs, set Target 4 = F5 and Target 5 = F9 as shown in figure 86.
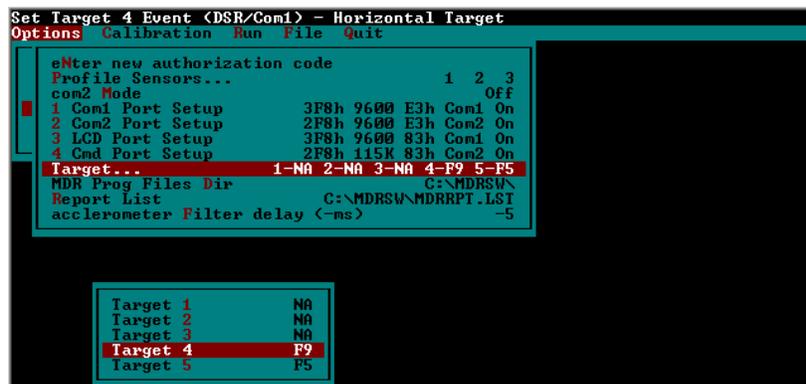
Figure 85. Screen shot. Photocell target parameters for determining horizontal photocell offset.
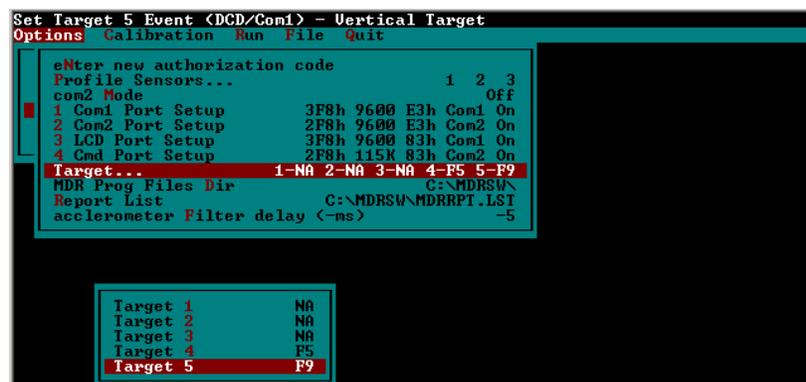
Figure 86. Screen shot. Photocell target parameters for determining vertical photocell offset.

2. Specify an appropriate data directory from the "Run" menu of the MDR software where the profile data can be stored for easy access and backup.

3. Specify an appropriate file name from the "Run" menu of the MDR software for the profiles to be collected. Although the format of the file name is not critical for the purpose of this testing, it is necessary that the file name be logical so that the analysis described in next section can be completed. It is recommended that the file naming format from section 2.2.7.3 of this manual be used, with the visit identifier indicating which photocell is being tested.

4. Set any relevant parameters in the "Edit parameters – LTPP…" option from the "Run" menu of the MDR software.

5. Make five profile runs over the artificial bump target using the following procedure:

   a. Attain a speed of 80 km/h at least 300 m before the bump target.

   b. Select the "Go" option from the "Run" menu of the MDR software to enter the Run screen well in advance of the target.

   c. Press the F3 key at least 40 m prior to the start stripe to start the DMI and the F6 key to arm the photocells.

   d. Profile over the bump target, and once the profiler is 20 m past the target, press the F3 key to stop data collection.

   e. Review the Reference Reset and other events in the run screen for logic and to assure that the assigned photocell in step 1 performed the reference reset.

   f. Press the F10 key to exit the run screen and save the data files to the hard disk drive.

   g. Repeat steps a through f until five acceptable runs for the assigned photocell have been collected.

6. Repeat steps 1 through 5 for the other photocell.

2.6.3.4 Photocell Offset calculations

The profile data should be analyzed using the ICC Road Profiler Reporting Program, Winrp90l.EXE (WinReport) Version 1.09, which is stored in system 2. WinReport is a Windows™ based program and requires that system 2 be booted in Windows 98 in order to run it. The program is capable of using configuration files to store frequently used report parameters, but this procedure does not require that a configuration file be used. The following steps describe the procedures for determining the horizontal and vertical photocell offset values:

1. Launch WinReport by navigating to the C:\mdrsw\directory and opening the Winrp90l.EXE program. WinReport launches a window that is similar to that shown in figure 87.
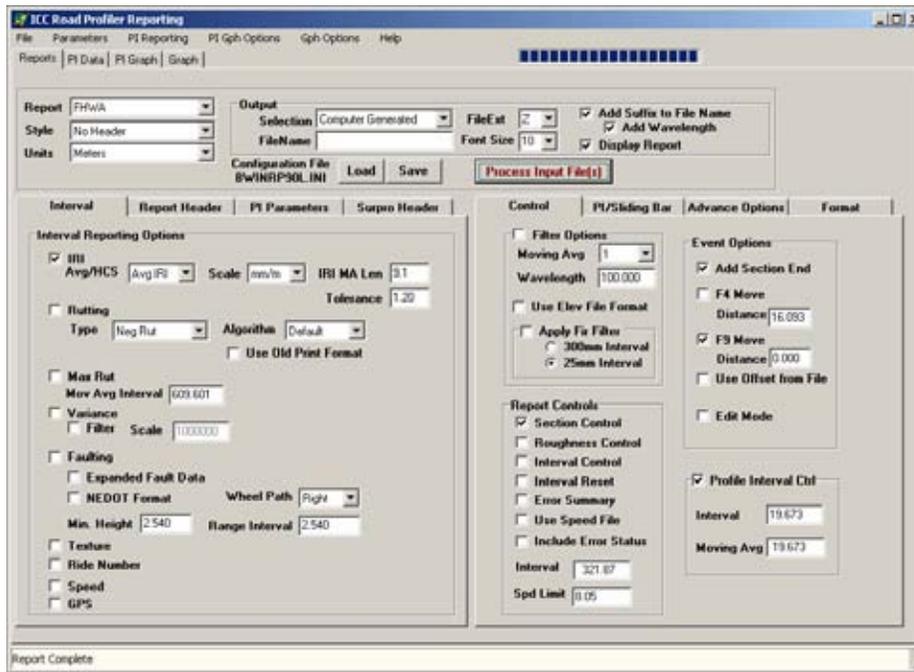
Figure 87. Screen shot. WinReport program menus.

2. Select the following parameters in WinReport on the Reports, Interval, and Control tabs as shown in figure 87 (the Reports tab is the primary tab on this window, and the Interval and Control tabs are the left and right secondary tabs, respectively). Select the following parameters:

    a. Select FHWA from the Report dropdown list.

    b. Select No Header from the Style dropdown list.

    c. Select Meters from the Units dropdown list.

    d. Select Computer Generated from the Selection dropdown down list.

    e. Select Z from the FileExt dropdown list.

    f. Check the Display Report Box.

    g. Verify that Font Size is 10, the Add Suffix to File Name box is checked, and the Add Wavelength box is checked.

    h. Verify that only the IRI box is checked on the Interval tab. Items on the Interval tab will not influence the outcome of this analysis and the IRI box is checked because some versions of this software require at least one box on this tab be checked, while some versions may work with no boxes checked. Parameters in the Report Header, PI Parameters, and Surpro Header tabs are not used for this analysis.

    i. Verify that the Filter Options check box is not selected on the Control tab.

j. Verify that the Section Control box is checked on the Control tab and that no other items in the Report Controls section are checked. The values in the fields Interval and Spd Limit are not used in this analysis.

k. Verify that the Add Section End and F9 Move boxes are selected on the Control tab in the Event Options section. The F9 Move Distance should be 0.0. Verify that the F4 Move, Use Offset from File, and Edit Mode are not selected. The value in F4 Move Distance has no impact on the data analysis.

l. Verify that the Profile Interval Ctrl section is checked and that the Interval and Moving Avg are set to 19.673.

3. Go to the "Advanced Options" tab as shown in figure 88 and select the following parameters:

   a. Verify that the Height Data Only box is checked.

   b. Check the From/To Section box and set the first value to -1 and the second value to five.

   c. Verify that the Max Delta Profile value is 0.07620.

   d. Verify that all other boxes are not checked and that the Position SF value is left blank.
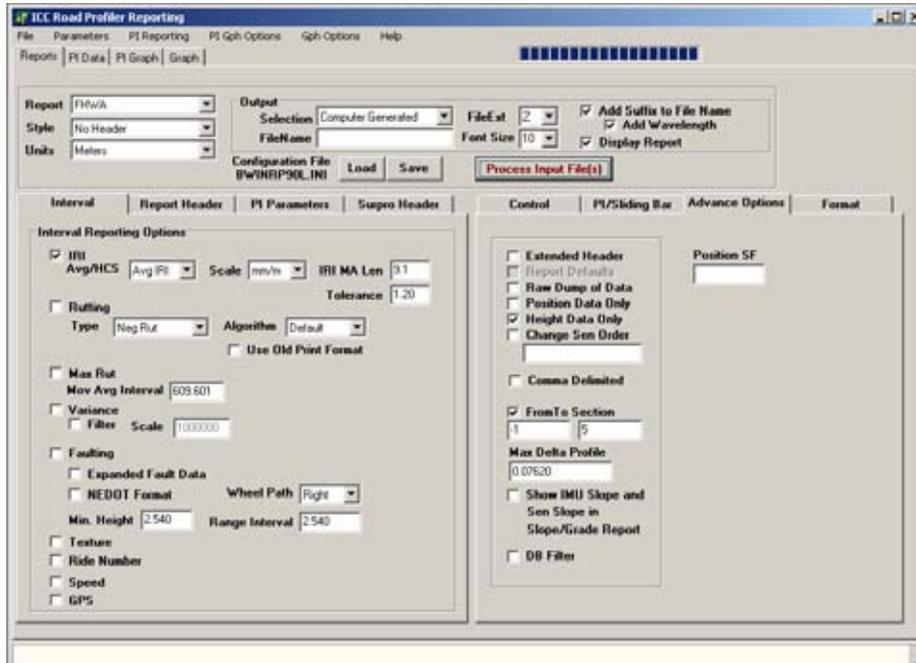
Figure 88. Screen shot. Parameters set in the advanced options tab.

4. Select the "Process Input File(s)" button. A file selection window similar to that shown in figure 89 will appear.
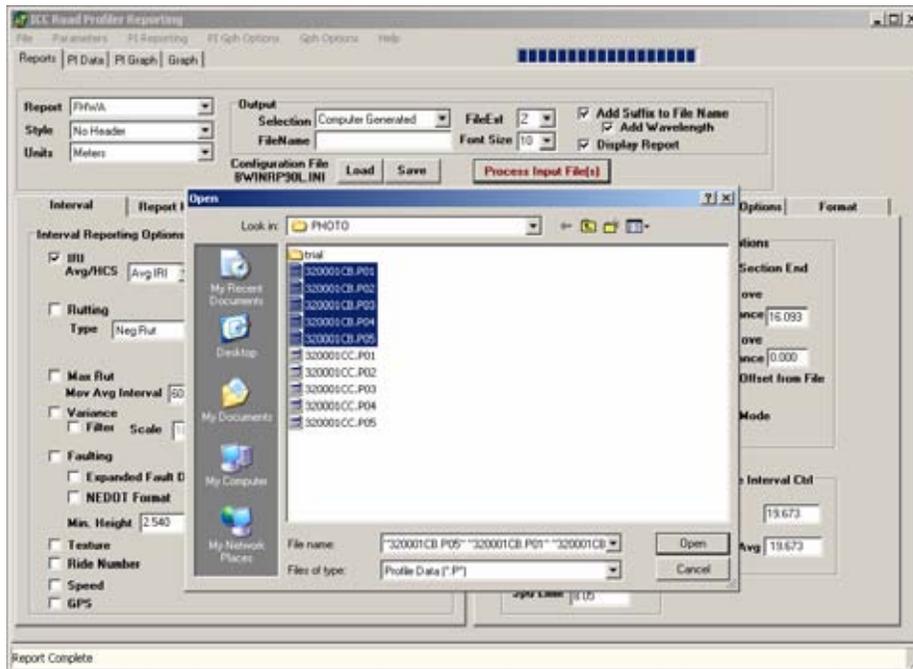
Figure 89. Screen shot. File selection window in WinReport program.

5. Highlight the five profile data files that were collected for the horizontal photocell offset determination and select the "Open" button. The software will perform the analysis on each data file individually. At the conclusion of the data analysis, WinReport will open WordPad windows to display the profile data in text format for the five runs, similar to as shown in figure 90.
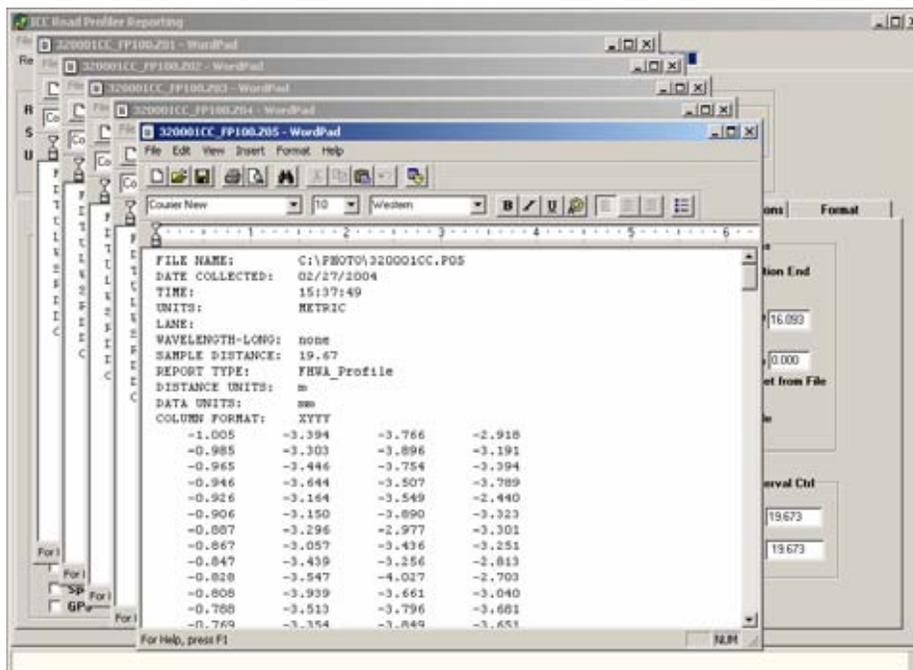
Figure 90. Screen shot. Text format profile data displayed in WordPad window.

6. Scroll down through the profile elevations in each WordPad window until the reference reset (REF_RST) event mark is visible as shown in figure 91.

7. Scan the center profile elevations (third column from left in text file) for the point after the reference reset where the 13 mm bump is apparent in comparison to the remainder of the profile elevations (as highlighted in figure 91).

8. Record the distance (first column from left in text file) for the first profile elevation that shows the elevation change for the bump target for each of the five profile runs. (Note: The REF_RST may appear on a line that precedes the actual 0.0 m distance. For the purposes of this analysis, all distance measurements are referenced from the zero distance point indicated in the file). In figure 91 this value is 0.256 m.
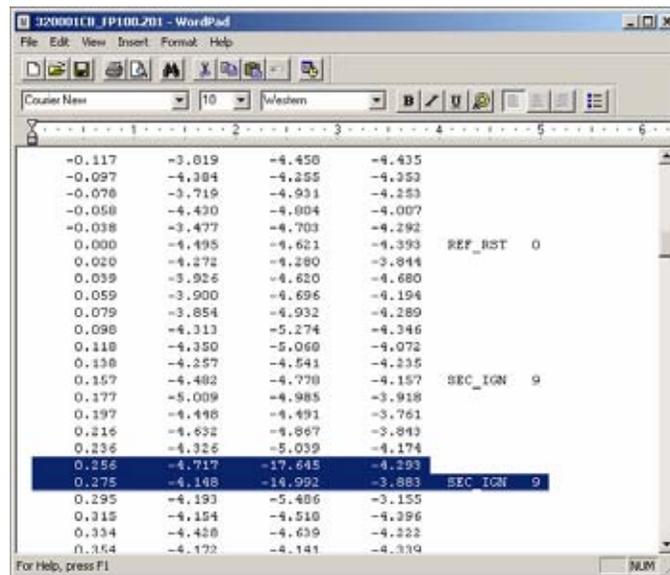
Figure 91. Screen shot. Profile data displayed in WordPad window—horizontal photocell test.

9. Average the five values if all five distance values are within 20 mm of each other. If one of the values differs by more than 20 mm from the other four values, discard that value and average the remaining four values. If more than one value differs by more than 20 mm from the remaining values, discard the data, assess the condition of the bump target and photocell target positioning, and perform the testing again as described in section 2.6.3.4.

10. Repeat steps 4 through 10 for the set of profiles collected for vertical photocell offset determination. The files displayed in the WordPad window for this photocell will be similar to that shown in figure 92.

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Figure 92. Screen shot. Profile data displayed in WordPad window—vertical photocell test.

The results from step 10 provide the photocell offsets for each photocell. The target bump was placed on the pavement 114 mm upstream of the section starting stripe and the offset values obtained from this experiment reflect the distance at which the first profile elevation value falls on the bump (within an acceptable range). The computed offset values when rounded to the nearest 25 mm are the vertical and the horizontal photocell offsets.

2.7 EQUIPMENT MAINTENANCE AND REPAIR

2.7.1 General Background

Responsibility for equipment maintenance and repair rests with each RSC. Decisions required for proper maintenance and repair should be based on the testing schedule and expedited as necessary to prevent disruption of testing. Maintenance activities on the profiler should be performed prior to mobilization for testing. During a testing period, there will be little time to do more than the required daily checks prior to testing. Specific detailed maintenance procedures are contained in the manuals provided with each piece of equipment (see References). The operator must become familiar with the maintenance recommendations contained in all equipment manuals. Maintenance or repair work to be performed can be classified as routine maintenance, preventive maintenance, and unscheduled maintenance.

2.7.2 Routine Maintenance

Routine maintenance includes work that can be performed by the operator. The Daily Check List (see appendix C) includes a list of maintenance activities to be performed every day. These procedures include checking the vehicle lights, checking under the vehicle for fluid leaks, checking fluid levels in the vehicle, and cleaning the glass covers of the sensors and photocell. These items are the most basic and easily performed maintenance measures and should always be done prior to using equipment every day. If any problems are noted, they should be entered in the Profiler Log (section 2.8.4), which should be maintained in the vehicle, and appropriate action should be taken to correct the noted problems.

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Laser height sensors are sealed units and they will not function correctly if the seals are broken. Cracked or chipped glass in the lasers may cause moisture damage to occur and this can lead to failure of the sensor. If any sign of physical damage is noted on the sensor glass, ICC should be contacted to decide on a repair procedure.

2.7.3 Scheduled Major Preventive Maintenance

Scheduled major preventive maintenance services are those that are performed at scheduled intervals. Scheduled preventive maintenance activities on the vehicle should be performed following the manufacturer's heavy use guidelines. These include activities such as oil changes. Drive belts, hoses, battery cable connections, etc., should be checked when the oil is changed in the vehicle.

The LTPP Major Maintenance/Repair Form (see appendix C) should be used by the operator to report the necessary services performed and also serves to inform the RSC of the condition of the profiler on a regular basis.

2.7.4 Unscheduled Maintenance

These are unscheduled repairs. These repairs must be reported on the LTPP Major Maintenance/Repair form as an unscheduled maintenance activity. The LTPP Major Maintenance/Repair form should be completed whenever a sensor is replaced or repaired. The procedures described in section 2.2.3.5 should be followed after a sensor is replaced or repaired.

2.8 RECORD KEEPING

There are eight types of records that should be forwarded to the RSC by the operator. They are

1. LTPP Profiler Field Activity Report.

2. Status of the Regions Test Sections.

3. Profiler Log.

4. LTPP Major Maintenance/Repair Form.

5. Profiler Calibration and Calibration Check Reports.

6. Profiling of WIM Sites: Data Summary Sheet.

7. Accelerometer Signal Conditioning Test Form.

8. ProQual Reports and Profile Plots.

A description of each of these forms/reports is presented in the following sections. If items described for the Profiler Log or the LTPP Major Maintenance/Repair form are recorded by the operator following standard operating procedures of the RSC, the completion of these forms may be omitted. It is acceptable for a region to use forms that have a different format as long as the modified form contains all of the items indicated in the forms included in this manual.

2.8.1 LTPP Profiler Field Activity Report

The Field Activity Report (form PROF-1 in appendix C) records all activities to and from a site, as well as activities at the test site. This report should be filled out for all travel and testing days. For travel only days, the section for which traveling is being done should be noted. Entering IRI readings requested on this form is optional. However, the IRI values should be entered if a region keeps this form in the vehicle and uses IRI values as a check when the section is profiled subsequently.

2.8.2 Status of the Regions Test Sections

The Status of the Regions Test Sections form (form PROF-2 in appendix C) should be filled out at every test section. Recent maintenance or rehabilitation activities, condition of paint marks, missing LTPP signs and delineators, as well as any other comments regarding the test section should be recorded on this form.

2.8.3 Profiler Log

The operator should maintain a Profiler Log in the vehicle. The format of the log is shown in form PROF-3 in appendix C. When the operator performs daily checks on equipment, items that need attention should be noted on the Profiler Log.

2.8.4 LTPP Major Maintenance/Repair Form

The LTPP Major Maintenance/Repair form (see form PROF-4 in appendix C) should be completed when scheduled or unscheduled maintenance or repairs are performed on the profiler. Vehicle and equipment operating costs are monitored with this form. This form should be submitted along with all receipts for maintenance activities.

2.8.5 Profiler Calibration Reports

Each time a full calibration check is performed on the laser sensors, either form PROF-5 (if all sensors are checked simultaneously) or PROF-6 (if sensors are checked individually) should be completed. Both forms are included in appendix C. The appropriate form (PROF-5 or PROF-6) should also be used to record information related to DMI calibration, accelerometer calibration, and the calibration check on the temperature gauge. After a calibration is performed on the DMI, a printout of the calibration report should be obtained and attached to the calibration form (PROF-5 or PROF-6). The Profiler Calibration Reports should be maintained in a three ring binder.

The operator should regularly backup the calibration log file, as past accelerometer calibration values are stored in this file. The log file is called cal_log.txt, and it is located in the directory C:\mdrsw\mdr_cal.

2.8.6 Profiling of WIM Sites: Data Summary Sheet

The operator is required to complete the Profiling of WIM Sites: Data Summary Sheet (see form PROF-7 in appendix C) when profile data are collected at a WIM site.

2.8.7 Accelerometer Signal Conditioning Test

The form PROF-8 in appendix C should be completed when performing the Accelerometer Signal Conditioning Test.

2.8.8 ProQual Reports and Profile Plots

The Site Visit Report generated by ProQual contains a statistical summary of IRIs for different runs at a test site. The Site Visit Report must be attached to the associated Field Activity Report. If a graphical output of profile data is obtained at a site, the printout should be attached to the associated Field Activity Report. RSCs may elect to print the Site Summary Report generated by ProQual in addition to the Site Visit Report. If the Site Summary Report is printed, it must also be attached to the Field Activity Report. RSCs may also elect to print the Spike Report generated by ProQual and attach it to the Field Activity Report.

CHAPTER 3. PROFILE MEASUREMENTS USING THE FACE DIPSTICK®

3.1 INTRODUCTION

The Dipstick®, which is manufactured by Face Company, is a manually operated device for collection of precision profile measurements, and can collect data at rates greater than traditional rod and level survey procedures. However, the profile obtained from Dipstick® measurements may have a vertical shift from the true profile because of systematic cumulative errors in the Dipstick® readings. The body of the Dipstick® houses an inclinometer (pendulum), LCD panels, and a battery for power supply. The Dipstick® sensor is mounted in such a way that its axis and line passing through the footpad contact points are co-planar. The sensor becomes unbalanced as the Dipstick® is pivoted from one leg to the other as it is moved down the pavement, causing the display to become blank. After the sensor achieves equilibrium, the difference in elevation between the two points is displayed. Swivel footpads having an approximate diameter of 32 mm should be used for all measurements.

Each RSC is in possession of at least one manual Dipstick® (Model 1500) and two automated Dipsticks® (Model 2000 and Model 2200). Both the manual and the automated Dipsticks® display data in millimeters. The spacing between the two feet of the Dipstick® is approximately 304.8 mm for both models. When the automated Dipstick® is used for data collection, it should be used in manual mode, with data recorded manually.

Profile measurements on GPS and SPS sites that cannot be obtained using the LTPP profiler should be obtained using the Dipstick®. Decisions with respect to the need for Dipstick® measurements at these test sections should be made on a case-by-case basis by responsible RSC personnel.

3.2 OPERATIONAL GUIDELINES

3.2.1 General Procedures

Dipstick® measurements are to be taken by personnel who have been trained in using the device and are familiar with the procedures described in this manual. Data collection using the Dipstick® is a two person operation, with one person operating the Dipstick® and the other person recording the data. However, a single person can collect the data if that person uses a voice activated tape recorder to record the readings.

Detailed scheduling and traffic control at test sites must be coordinated by the RSC. Traffic control at test sites will be provided by either the State highway agency (in the United States) or provincial highway agency (in Canada). Layout of the site should not be undertaken until all applicable traffic control equipment and devices are in place.

3.2.2 LTPP Procedures

3.2.2.1 Maintenance of Records:

The operator is responsible for forwarding all data collected during testing (see forms in appendix D). In addition, the operator is also required to forward other records related to Dipstick® operation, which are described in section 3.6, to the RSC.

3.2.2.2 Equipment Repairs:

RSCs are responsible for ensuring that LTPP owned equipment is properly maintained. Decisions required for proper maintenance and repair should be made based on the testing schedule and expedited as necessary to prevent disruption of testing.

3.2.2.3 Accidents:

In event of an accident, the operator will inform the RSC of the incident as soon as practical after the mishap. Details of the event shall subsequently be reported in writing to the RSC.

3.2.3 Footpad Spacing of Dipstick®

Field studies performed with Dipsticks® have indicated that the actual spacing between the centerline of the two footpads is not exactly 304.8 mm. Testing has shown that the footpad spacing for the various Dipsticks® used by the RSCs can vary between 304.280 and 306.176 mm.

RSCs are required to determine the footpad spacing of all Dipsticks® in their possession annually using the procedures described in appendix E. The RSC should maintain a log documenting the test date and the computed footpad spacing for each Dipstick®.

Note: The RSCs performed the test specified in appendix E in December 2003, and should know the footpad spacing of each Dipstick® in their possession. For RSCs that do not routinely perform longitudinal Dipstick® measurements, it is acceptable to perform this test annually only on the Dipstick® that has the footpad spacing closest to 304.8 mm. If during this test, the offset at the end of the section is not within ±25 mm of the offset obtained from the previous year's test, the procedure described in appendix E should be used to obtain the footpad spacing of all Dipsticks® operated by the RSC.

When performing longitudinal Dipstick® measurements, the RSCs should select the Dipstick® in their possession that has a footpad spacing that is closest to 304.8 mm.

3.3 FIELD TESTING

3.3.1 General Background

The following sequence of fieldwork tasks and requirements provides an overall perspective of the typical workday at a test section:

1. Task 1: Personnel Coordination.

    a. Dipstick® crew (operator and recorder).

    b. Traffic control crew supplied by highway agency or traffic control contractor working for the highway agency.

    c. Other LTPP, State or Provincial highway agency, and RSC personnel (they are observers and are not required to be present).

2. Task 2: Site Inspection.

    a. Assess general pavement condition (within test section limits).

    b. Identify wheel paths (when performing longitudinal measurements).

3. Task 3: Dipstick® Measurements.

    a. Mark wheel paths (when performing longitudinal measurements).

    b. Perform operational checks on the Dipstick®.

    c. Obtain Dipstick® measurements.

    d. Quality control
       (includes post data collection check and closure error computations (see 3.3.3)).

4. Task 4: Form Completion.

    a. Complete forms DS-1 through DS-7 (see appendix D) for longitudinal profile measurements.

    b. Complete form DS-7 and DS-8 (see appendix D) for transverse profile measurements.

On arrival at a site, the operator will carefully plan activities to be conducted to insure the most efficient utilization of time. While many activities can only be accomplished by the operator and/or recorder, it may be necessary to enlist the assistance of other personnel at the site to mark wheel paths. In general, arrangements for this assistance should be made in advance by the RSC.

Assuming that a manual distress survey is also to be performed at the site, traffic control typically should be available for six to eight hours. This should provide adequate time for Dipstick® measurements in both wheel paths, as well as for the manual distress survey, to be completed. Experienced Dipstick® operators can obtain approximately 500 readings per hour.

Collecting profile data is the primary responsibility of the operator. In order to ensure that data collected in the four LTPP regions are identical in format, certain guidelines and standards have been established for data acquisition and handling.

3.3.2 Site Inspection and Layout—Longitudinal Profile Measurements

The pavement must be clear of ice, snow, and puddles of water before profile measurements can be taken with the Dipstick®, as such conditions can affect profile measurements. Pools of water can cause the feet of the Dipstick® to get wet, resulting in a potential for slippage and can also possibly damage electronics in the Dipstick®.

The longitudinal Dipstick® measurement procedure consists of performing an elevation survey in each wheel path, and using transverse measurements at the section ends to form a closed loop. As illustrated in figure 93, measurements start at Station 0+00 in the right wheel path and proceed in the direction of traffic toward the end of the section. At end of the section, transverse measurements are made to the end point of the survey line in the left wheel path. A 0.61-m diameter closure circle around this point is used to close transverse measurements on this start location for measurements in the left wheel path. Longitudinal measurements are then performed in the left wheel path back to Station 0+00. Transverse measurements and the closure circle are used to close the survey on the starting point. This procedure is designed for a 152.4-m test section; however, the concept can be applied to test sections of any length.
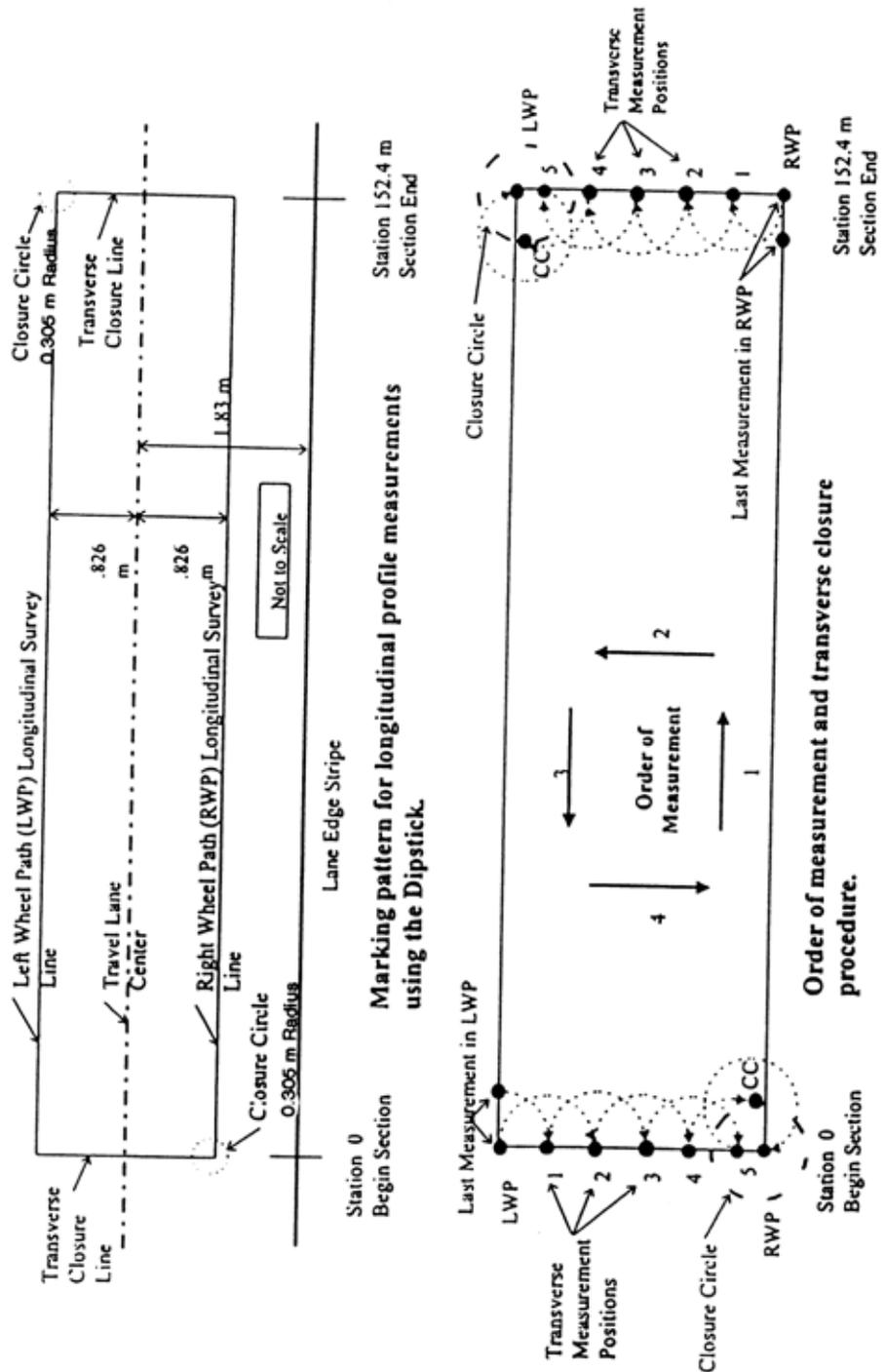
Figure 93. Illustration. Site layout and measurement procedure for measuring longitudinal profiles with the Dipstick®.

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If acceptable conditions are present to perform the Dipstick® measurements, clean both wheel paths of loose stones and debris to prevent slippage of the Dipstick® footpads during measurements. The first step in the site layout is to locate the wheel paths, where each wheel path is located at a distance of 0.826 m from the center of the travel lane. Use following procedure to locate center of travel lane:

- Case I: If wheel paths are easily identified, the midway point between the two wheel paths should be used as the center of the lane.
- Case II: If wheel paths are not clearly identifiable, but two lane edges are well defined, the center of the travel lane is considered to be midway between the two lane edges.
- Case III: If wheel paths are not apparent and only one lane edge can be clearly distinguished, the center of the lane should be established at 1.83 m from that edge.

Once center of travel lane has been identified, use following procedure to layout the site:

1. Establish a transverse chalk line to define the beginning of the test section if this location is not marked with a stripe. Dipstick® measurements along the right wheel path will begin with the back edge of the Dipstick® footpad located immediately adjacent to leave edge of white stripe at the beginning of the monitoring portion of the test section. At a 16 mm offset (radius of footpad of Dipstick®) in front of the leave edge of the white stripe at the beginning of the section (or in front of the transverse line that was marked if the white stripe was missing), use a chalk line to mark a transverse line parallel to the start line of the section. This transverse line is considered to be Station 0+00. Identify the location of two longitudinal elevation survey lines 0.826 m from the center of the lane. Mark these locations at intervals equal to the length of the chalk line used for marking. Use the chalk line to mark a straight line between previously established points. Using a tape measure (measuring wheels are not acceptable), carefully measure the length of each longitudinal elevation survey line to establish end points at 152.4 m, or at a specified length for test sections that are not 152.4 m long, from the previously established Station 0+00. An accurate measurement of this length is required since it is used as a quality control check on the measurement process. Mark a transverse chalk line to connect the end points of two longitudinal lines.

2. Mark a 0.61 m diameter circle centered on the intersection of the marked transverse line and the longitudinal survey line at the end of the section in the left wheel path. At the beginning of the section on the right wheel path, mark a 0.61 m diameter circle centered on the intersection of the longitudinal survey line and the transverse line connecting the left and right wheel paths at Station 0+00. This closure circle will be used for completion of the elevation survey loop.

3. Note the method used to establish the location of the lane center and any discrepancies between painted and measured section end locations on data collection sheet or in the field notebook. This information will help to collect consistent data in future profile measurements at that section.

3.3.3 Dipstick® Operation for Longitudinal Profile Measurements

3.3.3.1 Pre-operational Checks on Dipstick®

Perform the following checks on the Dipstick® prior to testing:

1. Check the condition of footpads and replace if necessary with an extra set in the Dipstick® case. Clean and lubricate ball and socket joints on the footpads to insure smooth pivoting of the instrument. When a joint is dirty, pivoting becomes difficult and slippage of the footpad can occur. A cleaning agent such as WD-40 or a light oil for lubrication will work for the ball and socket joint.

2. Install a fresh set of rechargeable batteries in the instrument and securely close battery compartment if using a Model 1500 Dipstick®. The batteries in this unit have to be taken out in order to recharge them. The Model 2000 and 2200 Dipstick® is equipped with rechargeable batteries that can be charged while the batteries are still within the unit. If the batteries have not been charged overnight, install a fresh set of rechargeable batteries in the instrument and securely close the battery compartment. Batteries in either of these units should be changed after four hours of usage to insure continuity of measurements. The Model 1500 Dipstick® is powered with 9-volt batteries, while the Model 2000 and 2200 Dipsticks® are powered with AA size batteries. An extra set of rechargeable batteries should be kept on hand for each of these units.

3. Check and, if necessary, retighten the handle on the instrument.

4. Perform Zero Check and Calibration Check, which are described below. According to the manufacturer, the calibration check is needed only if adjustments were required during the zero check. However, for LTPP related measurements, both the zero and calibration checks are required at the beginning of data collection. The Dipstick® should be fully assembled, turned on, and allowed to warm up for several minutes prior to performing these two checks.

3.3.3.1.1 Manual Dipstick® (Model 1500):

The operator must perform the zero check on the manual Dipstick®. Form DS-7 (included in appendix D) should be filled when this test is carried out. A zero verification is performed by this test. The test should be performed on a relatively level, smooth, clean, and stable location where instrument can be properly positioned. A suitable fabricated plate or a wood board that can be fitted inside the Dipstick® case can be utilized to perform this check. After positioning the Dipstick®, draw two circles around the footpads and note the reading on the display at the switch end (reading = R1). The instrument should then be rotated 180 degrees and the footpads placed on the two circles that were drawn earlier; note the reading obtained at switch end (reading = R2). If readings from the two placements (R1 and R2) add up to within ±0.1 mm, the Dipstick® has passed the zero check. If they do not fall within these limits, zero adjustment is necessary.

The zero adjustment should be performed using the following procedure:

1. Obtain the average of two Dipstick® readings; e = 0.5 (R1 + R2).

2. Subtract the average value from R2 to obtain R2o; R2o = R2 - e

3. Loosen the set screw and adjust start/end pin up or down with the Dipstick® still in the R2 reading position so that display reads R2o.

4. Tighten the set screw, rotate the Dipstick® back to the R1 reading position, and read the display at the switch end (reading = R1o).

5. Repeat the adjustment procedure until the R1o and R2o readings are within the tolerance.

This is the only adjustment the operator is allowed to make on the Dipstick®.

The operator must perform the calibration check on the manual Dipstick®.Calibration of the Dipstick® is fixed during manufacture and cannot be altered by the user. The user can verify calibration against a standard calibration block that is provided with the Dipstick®. After the zero check and adjustments are performed, calibration of the device must be checked. The test should be performed on a relatively level, smooth, clean, and stable location where the instrument can be properly positioned. A suitable fabricated plate or a wood board that can be fitted inside the Dipstick® case can be utilized to perform this check. Form DS-7 (see appendix D) should be completed when this test is carried out. To check calibration, note the Dipstick® reading and place the 3.2 mm calibration block under one of the Dipstick® footpads. The reading displayed minus 3.2 should be within ±0.1 mm of the previous reading. If this tolerance is not obtained, a LTPP Major Maintenance/Repair form (form DS-10 in appendix D) should be completed and the Face Company should be contacted through the RSC office to repair the Dipstick®.

3.3.3.1.2 Automated Dipstick® (Model 2000 and 2200):

The operator must perform the zero check on the automated Dipstick®. This check should be performed on a relatively level, smooth, clean, and stable location where instrument can be properly positioned. A suitable fabricated plate or a wood board that can be fitted inside the Dipstick® case can be utilized to perform this check. Circles should be drawn around the two footpads and the CAL button should be depressed once. The instrument should then be rotated 180 degrees and the two footpads placed in the circles drawn earlier. The CAL button should again be depressed once. The display will flash CAL three times after which the error is automatically stripped out of the readings. Note the reading at switch end of Dipstick®. Rotate Dipstick® and place two footpads in the circles, and note reading at the switch end. If these two readings are within ±0.1 mm, the Dipstick® has passed the zero check. The zero check can only be performed once after the Dipstick® is turned on. If the check is not successful, the Dipstick® must be turned off and then turned on again, and the zero check repeated. A check mark should be placed on form DS-7 (see appendix D) at the appropriate location to indicate that the zero check was performed.

The operator must perform the calibration check on the manual Dipstick®. Follow the procedure described for the manual Dipstick® (Model 1500) to perform this check. Form DS-7 (see appendix D) should be completed when this test is carried out.

3.3.3.2 Longitudinal Profile Measurement

Complete the header information on form DS-1 (see appendix D). Use guidelines presented in section 3.3.5.2 to enter the header information in form DS-1, except for the air temperature. Use guidelines presented in section 3.3.3.5 to enter the air temperature before and after profile measurements.

The following procedure should be followed to collect longitudinal profile data using the Dipstick®:

1. Place the Dipstick® on the marked survey line in the right wheel path with the start arrow pointed forward in the direction of traffic and the back edge of the footpad located immediately adjacent to the leave edge of the white stripe at the beginning of the test section to start profile measurement. In this position, the center of the back footpad of the Dipstick® will be at Station 0+00.

2. Record the reading under the right wheel path (RWP) column on form DS-2 (included in appendix D) on the row corresponding to Reading Number 1 after the reading stabilizes. Then rotate the Dipstick® to the next measuring point using a clockwise rotation. The reason a clockwise rotation is specified is because with such a motion the handle of the Dipstick® will not get loose. However, if an operator has any problems in using a clockwise rotation it is acceptable to use a counter clockwise rotation to advance the Dipstick®. If a counter clockwise rotation is used, the operator should check the handle of the Dipstick® at frequent intervals to make sure it is not loose, and if the handle is loose it should be tightened. After the reading has stabilized, it should be recorded on the next row of form DS-2 labeled Reading Number 2. Repeat this procedure for the entire length of the test section. During measurements, the following precautions and procedures should be followed:

    a. Use a consistent motion to advance the Dipstick® (either clockwise or counter clockwise).

    b. Hold the handle of Dipstick® in a vertical position when taking measurements.

    c. Do not apply lateral pressure to the handle during a measurement.

    d. Avoid placing the footpad into a wide crack or a pothole in the pavement. If such a condition is encountered, offset the placement of the footpad so it will rest on the pavement that is adjacent to the feature.

    e. Draw circles around both footpads with the start arrow in the direction of traffic at last measurement position if for any reason measurements must be stopped. When restarting, the Dipstick® shall be returned to this position and adjusted so that current measurement agrees with the measurement prior to stoppage.

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f. Discard data and restart the measurement procedure if it is not possible to mark the footpad positions prior to stoppage or to successfully reposition the Dipstick® in the same position.

3. Compare the location of the back end of front Dipstick® footpad with the location of the transverse line that was marked at the end of the test section after the last measurement in the right wheel path at Station 152.4 m. If the back end of the front footpad is within 275 mm of the marked transverse line, proceed with the transverse closure measurements as indicated in step 4. If the front footpad is not within this interval, perform the following:

    a. Draw circles around each footpad and note the direction of the start arrow.

    b. Check the data sheets for skipped or missing measurements.

    c. Remeasure the length of longitudinal survey line to verify the position of the end point if no apparent anomalies are present in the data. If the remeasured location of the end point is within 304 mm of the back end of the front footpad of the Dipstick®, remark the transverse line at this location and proceed. If the end point is not within 304 mm of the back end of the front foot, discard the data as suspect and restart the survey from Station 0+00.

4. Initiate the transverse closure measurements after the location of the last measurement in the right wheel path has been verified by rotating the rear foot of the Dipstick® toward the left wheel path and placing it on the premarked transverse closure line. Measurements along the transverse closure line should be recorded in the table labeled "Transverse Closure Measurements from Right Wheel Path to Left Wheel Path at Station 152.4 m," which is at the bottom of form DS-6 (included in appendix D). When the Dipstick® reaches the point in which the next measurement along the transverse survey line passes the location of the left wheel path, it should be rotated so that the footpad rests at any point on the closure circle (CC). After recording this measurement in the column labeled 5-CC, rotate the device so that the footpad rests on top of the intersection between the longitudinal survey line in the left wheel path and the transverse closure line. Record this measurement under CC-LWP. This procedure is illustrated in figure 93.

5. Begin measurements along the longitudinal survey line in left wheel path, recording readings in column labeled LWP on forms DS-6 through DS-2. These measurements will be entered in reverse order from those in RWP.

6. Verify that the position of the back edge of the front Dipstick® foot is within 275 mm of end point when the last measurement in left wheel path is made at Station 0+00. If not, follow the procedures for end point verification previously described for the measurements in the right wheel path. If a problem is found with a missing or skipped measurement or final location of the Dipstick® in the left wheel path, measurements in the left wheel path should be discarded as suspect and the survey restarted from the beginning point in the left wheel path.

7. Initiate the transverse closure measurements by rotating the rear foot of the Dipstick® toward the right wheel path and placing it on premarked transverse closure line (located at Station 0+00) after location of the last measurement in the left wheel path has been verified. Measurements along the transverse closure line should be recorded in the table labeled "Transverse Closure Measurements from Left Wheel Path to Right Wheel Path at Station 0+00" which is at the bottom of form DS-2 (included in appendix D). When the Dipstick® reaches the point in which the next measurement along the transverse survey line passes the location of the right wheel path, it should be rotated so that the footpad rests at any point on the closure circle (CC). After recording this measurement in the column labeled 5-CC, rotate the device so that footpad rests on top of the intersection between the longitudinal survey line in the right wheel path and the transverse closure line. Record this measurement under CC-RWP. This procedure is illustrated in figure 93.

3.3.3.3. Post Data Collection Check

After completing survey, the operator must conduct the zero and calibration checks.

The following procedure should be followed for performing the zero check for both manual Dipstick® (Model 1500) and automated Dipstick® (Model 2000 and 2200):

1. Place the Dipstick® on a smooth, clean, and stable location where the instrument can be properly positioned (i.e., carrying case for the Dipstick® or a flat board will suffice).

2. Draw circles around the two footpads and note the reading at the switch end of the instrument (R1).

3. Rotate the instrument 180 degrees and place the two footpads in the circles that were drawn earlier. Note the reading at the switch end of the Dipstick® (R2). The two readings (R1 and R2) should add up to within ±0.1 mm in order to pass the zero check. If the addition of the two readings is outside these limits, the device has failed the zero check.

For both the manual Dipstick® (Model 1500) and the automated Dipstick® (Model 2000 and 2200), the calibration check should be performed as described in section 3.3.3.1 for the manual Dipstick®.

Results from the zero check and the calibration check should be entered on form DS-7 (see appendix D). Based on results from these checks, follow one of the applicable procedures presented below:

1. If the Dipstick® fails the zero check, data should be discarded as suspect and another survey should be performed.

2. If the Dipstick® passes the zero check, but fails the calibration check, data should be discarded as suspect and the Face Company should be contacted for repair, as discussed under calibration check in section 3.3.3.1.

3. If the Dipstick® passes both tests, the closure error computations that are described in section 3.3.3.4 should be performed.

If the Dipstick® failed the zero check, but can successfully be adjusted to pass the zero check and also passes the calibration check, another survey should be performed.

3.3.3.4 Closure Error Computations

The following procedures should be followed when performing closure error computations:

1. Perform the closure error computations in the field prior to leaving site.

2. Sum and record the readings in each column on forms DS-2 through 6 (see appendix D) in the last row of each column. Measurements in transverse closure measurement tables on forms DS-2 and DS-6 (see appendix D) should be summed across the row and entered in the last column.

3. Enter column summations on form DS-1 (see appendix D) in locations corresponding to labels shown in each summation cell.

4. Add together elevation sums in the RWP and LWP on form DS-1 (see appendix D) and record the result in the indicated cells.

5. Add transverse sums to each of these sums and record the result in the total row at bottom of closure calculation table.

6. Add together the two totals and enter the result into the cell labeled "closure error."

7. Discard data as suspect if the closure error is not within ±76 mm and resurvey the test section until the closure error is within the allowable limits.

3.3.3.5 Air Temperature Measurements

Air temperature measurements must be obtained at the start and end of longitudinal Dipstick data collection and recorded on form DS-1. The average of these two temperatures must also be recorded on form DS-1. Air temperature measurements must be obtained using one of the following pieces of equipment:

- K-type, 2 inch, Handheld Thermocouple Probe (Omega Model KHSS-18U-2).
- Microprocessor Thermometer Display (Omega Model HH21, HH22, HH33 or HH64).

Measurements should be taken at an adequate distance from any heat source, such as a vehicle engine, vehicle exhaust, and pavement surface. Operators must also ensure that the probe is not held in direct sunlight when allowing the probe to reach a stable value before recording it.

A calibration check of the temperature probe must be performed within 30 days prior to air temperature measurements or whenever the operator observes suspicious temperature readings. A NIST traceable mercury thermometer is required to perform the check. The check should be performed in a shaded area, using the following procedure:

1. Place the thermometer close to the temperature probe and after they have reached a stable value, observe the readings of the thermometer and probe. If the difference between the

two temperature readings is less than or equal to 2 °C, the temperature probe is considered to be acceptable.

2. Wait at least 5 minutes and repeat steps 1 and 2 if the difference between the two temperatures is greater than 2 °C. If the difference is still greater than 2 °C, wait at least five minutes and repeat steps 1 and 2 again. If the difference between the temperatures is still greater than 2 °C, consider the air temperature probe to be unacceptable and contact the manufacturer of probe to resolve the problem.

3. Perform a cold temperature check if there are any questions regarding the accuracy of the temperature probe. In this check, a plastic bag containing crushed ice is placed around the temperature probe. Allow sufficient time for the temperature probe to stabilize and check the reading displayed. The temperature should be within ±2 °C of 0 °C. If not, consider the air temperature probe to be unacceptable, and contact manufacturer of probe to resolve the problem.

4. Record the results of the calibration check on form DS-11.

3.3.4 Site Inspection and Layout—Transverse Profile Measurements

Transverse profile measurements should be performed when manual surveys are conducted on AC surfaced pavements, including rigid pavements with AC overlays. One round of transverse profile measurements should be taken on all LTPP PCC (jointed concrete and continuously reinforced concrete) test sections. The purpose of obtaining transverse profile measurements on PCC sections is to determine the transverse cross slope of pavement.

The pavement must be clear of ice, snow, and puddles of water before profile measurements can be taken with the Dipstick®, as such conditions can affect profile measurements. Pools of water can cause the feet of the Dipstick® to get wet, resulting in a potential for slippage and can also possibly damage electronics in the Dipstick®. Testing under such conditions must be avoided either through adjusting the schedule of profiling trips, or by delaying actual measurements until acceptable conditions exist. Lay out and mark straight lines for the transverse profile measurements. Lines should be perpendicular to edge of the pavement and located at 15.24 m intervals, starting at station zero and ending at station 152.4 m (or end of section if the length of the test sections is greater than 152.4 m). For each test section (GPS or SPS), eleven transverse lines will be present (or more if length of test sections is greater than 152.4 m).

For AC surfaced sections, the location of the transverse lines should be offset to avoid pavement markings and other anomalies such as patches, potholes, and areas that have high severity cracking with missing material. This offset must not exceed 1 m either way. If the anomalies cannot be avoided, the transverse profile is taken at the best location within the allowable offsets. The need for and magnitude of such adjustments must be recorded on form DS-8.
For PCC pavements, the location of the transverse lines should be offset to avoid joints, cracks, and any other localized anomalies like patches and surface defects that would cause the measurements to be nonrepresentative of the transverse profile as related to transverse surface drainage effectiveness. Unlike for AC surfaced pavements, offsets greater than 1 m are allowed for PCC pavements.

3.3.5 Dipstick® Operation for Transverse Profile Measurements

3.3.5.1 Pre-operational Checks on Dipstick®

The operator should check the equipment using procedures described in section 3.3.3.1. Checks include both the zero check and the calibration check. The operator should fill out the LTPP Dipstick® Data Collection form DS-7 (see appendix D).

3.3.5.2 Entering Header Information in Transverse Profile Form

After performing the preoperational checks on the equipment, the operator should complete the header information in the Transverse Profile Data Collection form (form DS-8 in appendix D). Guidelines for completing this form are presented in this section. As this information is used in ProQual, it is important that the operator strictly follow these guidelines. (Note: The guidelines presented in this section should also be used to complete the header information in form DS-1 that is used for longitudinal profile measurements. However, the air temperature is recorded on form DS-1, while the pavement temperature is recorded on form DS-8).

State Code: Code of State or province in which the site is located.

LTPP Section ID: Four-digit LTPP Section ID of site.

Date: Current date.

Time: Current time, use military format (e.g., 09:30, 15:30. etc).

Dipstick® Serial #: Five digit serial number on base or side of Dipstick® (e.g., 30021).

Dipstick® Model #: 1500 for manual model and 2000 or 2200 for automated model.

Operator: First and last initial of operator in capital letters (e.g., JD).

Recorder: First and last initial of recorder in capital letters (e.g., AM).

Site Type: GPS or SPS.

Visit: Sequential visit identifier. (e.g., A for first visit to site, B for second visit, C for third visit, etc).

Surface Type: A-CC for AC surfaced pavements and P-CC for PCC surfaced pavements.

Condition: Enter the condition of the pavement as either V.GOOD, GOOD, FAIR, or POOR (use capital letters). Use the following guidelines to select condition: (a) V. GOOD—Pavement does not show any distress, (b) GOOD – Pavement exhibits few visible signs of surface deterioration. Pavement may show low severity cracks, (c) FAIR—Typical distresses can include the following in a low to medium severity: rutting, transverse and longitudinal cracking, block cracking, fatigue cracking, edge cracking, and patching, (d) POOR—Typical distresses can include the

following in a medium to high severity: rutting, transverse and longitudinal cracking, block cracking, fatigue cracking, patching, and potholes.

Road Name: Highway or route designation in capital letters (e.g., INTERSTATE 57, US 395, S.R. 31).

Lane: Circle either Outside or Inside. The outside lane is the outermost traffic lane. Nearly all LTPP sections are located in the outside lane. The inside lane is any lane that is not an outside lane.

Direction: Direction should be NORTH, EAST, WEST, or SOUTH (use capital letters).

Clouds: Valid entries for this field are CLEAR, P. CLOUDY, or CLOUDY (use capital letters). Use the following guidelines to select an appropriate entry to this field: (a) CLEAR—Sunny sky, (b) P. CLOUDY—sun is sometimes covered by clouds, and (c) CLOUDY—sun cannot be observed.

Temperature: Pavement temperature in degrees Centigrade obtained using an infrared device.

Weather Comment: Any additional comments about the weather conditions at the time of testing. ProQual contains the following built in comments, but the crew is not limited to the use of these comments exclusively: CONDITIONS OK, STEADY CROSSWIND, WIND GUSTS, HOT AND HUMID, HAZY, LOW SUN ANGLE. Use capital letters for weather comments.

3.3.5.3 Transverse Profile Measurement

3.3.5.3.1 AC Surfaced Pavements:

Transverse profile measurements should be collected at the transverse lines that were laid out within the section (see section 3.3.4) starting with the transverse line marked at Station 0+00. Elevations for each transverse profile should be measured from the outside edge of the pavement and should extend over the full lane width, with the actual distance depending on the lane width and pavement striping. The starting point should be the junction of the transverse measurement line and the inside edge of the white paint stripe along the outside edge of the lane. If no outside edge stripe is present, or if the outside edge stripe is on the shoulder, then the beginning point for the measurements should be either the shoulder lane joint or a point approximately 0.91 m from the center of the outside the wheel path. A comment should be entered in the data sheet indicating how the starting point was determined. The starting point on subsequent surveys should be the same. The initial elevation is arbitrarily established as zero and subsequent readings are recorded relative to this benchmark. The combination of these measurements provides a measure of pavement cross slope.
To begin transverse profile measurements, the Dipstick® is placed at outside edge of the pavement starting at Station 0+00 with the start arrow pointed towards the pavement centerline. Measurements should be recorded on the Transverse Profile Data Collection form DS-8 (see appendix D). The operator should complete two runs per transverse profile of each LTPP section; one run up the transverse line and a return run along same line to complete a closed loop survey.

After the last transverse profile measurement is completed, enter any additional comments on the last line of the form. The comment should be entered in capital letters (e.g., ELEVEN DATA POINTS DUE TO HEAVY TRAFFIC).

3.3.5.3.2 PCC Pavements:

Transverse profile measurements should be collected at the transverse lines that were laid out within the section (see section 3.3.4) starting with the transverse line marked at Station 0+00. Measurements should be taken within the lateral extent of the test section measured from the shoulder joint to the centerline longitudinal joint. On widened test sections, the lateral extent of the test section includes the full width (4.3 m) of the slab measured from the shoulder joint to the centerline longitudinal joint.

The starting point for Dipstick® measurements should be the shoulder joint. The initial elevation is arbitrarily established as zero and subsequent readings are recorded relative to this benchmark. To begin transverse profile measurements, the Dipstick® is placed at Station 0+00 at the shoulder joint with the start arrow pointed towards pavement centerline. Measurements should be recorded on the Transverse Profile Data Collection form DS-8 (see appendix D). The operator should complete two runs at each transverse profile location; one run up the transverse line and a return run along the same line to complete a closed loop survey.

After the last transverse profile measurement is completed, enter any additional comments on the last line of the form. The comment should be entered in capital letters (e.g., ELEVEN DATA POINTS DUE TO HEAVY TRAFFIC).

3.3.5.4 Post Data Collection Check

After completing the survey, the operator must conduct zero and calibration checks.

The following procedure should be followed for performing the zero check for both manual Dipstick® (Model 1500) and automated Dipstick® (Model 2000 or 2200):

1. Place the Dipstick® on a smooth, clean, and stable location where the instrument can be properly positioned (e.g., carrying case for the Dipstick® or a flat board).

2. Draw circles around the two footpads and note the reading at the switch end of the instrument (R1).

3. Rotate the instrument 180 degrees and place the two footpads in the circles that were drawn earlier.

4. Note the reading at the switch end of the Dipstick® (R2). The two readings (R1 and R2) should add up to within ±0.1 mm in order to pass the zero check. If the addition of the two readings is outside these limits, the device has failed the zero check.

For both the manual Dipstick® (Model 1500) and automated Dipstick® (Model 2000 or 2200), the calibration check should be performed as described in section 3.3.3.1 for the manual Dipstick®.

Results of these checks should be entered on form DS-7 (see appendix D). Based on the results from these checks, follow one of the applicable procedures presented below:

1. If the Dipstick® fails the zero check then data should be discarded as suspect.

2. If the Dipstick® passes the zero check, but fails the calibration check, data should be discarded as suspect and the Face Company should be contacted for repair, as discussed under calibration check in section 3.3.3.1.

3. If the Dipstick® passes both tests, the closure error computations that are described in section 3.3.5.5 should be performed.

4. If the Dipstick® failed the zero check, but can successfully be adjusted to pass the zero check and also passes the calibration check, another survey should be performed.

3.3.5.5 Closure Error Computation

The total accumulated error in a transverse profile is established by a closed loop survey. The forward and return run along a transverse line is utilized to compute this error. At each station, sum the readings for the forward and return runs separately, and record the values in the Sum column of form DS-8. Then at each station, add the values in the Sum column for the forward and return run, and record the result in the Closure column. At each station, for each Dipstick® reading, add the reading for the forward and return run, and record the value in the field Difference.

To compute the allowable closure error for a transverse profile run, multiply the total number of Dipstick® readings (sum of number of readings for forward and return run) by 0.076 mm. The allowable closure errors for typical lane widths that are encountered are presented in table 1.

Table 1. Allowable closure errors for transverse Dipstick® measurements.

Lane Width (m)	Total Number of Dipstick® Readings	Allowable Closure Error (mm)
3.05	20	±1.5
3.35	22	±1.7
3.66	24	±1.8
3.96	26	±2.0

If the closure error for a transverse profile is outside the allowable range, the transverse profile measurements at that location must be repeated once. If the closure error for the repeat run is also outside the allowable range, then the transverse profile line should be offset no more than 1 m and the run repeated once. The value in the Difference field at a specific position gives the difference in readings between the forward and return runs at that position. This information can be used by the operator to identify locations where problem readings may be occurring. If after the offset, the closure error for a transverse profile run is still outside the allowable range, and the Dipstick® is able to pass post data collection checks, enter a comment on why the closure error is outside the allowable value (e.g., ROUGH SURFACE TEXTURE OF CHIP SEAL, MADE CLOSURE DIFFICULT). The data from the third run will be submitted to the FHWA,

with a copy to the TSSC. A decision on including that data in the database will be made on a case-by-case basis.

3.3.6 Data Backup

The importance of safeguarding Dipstick® data cannot be overstated. Backup copies of the Dipstick® data sheets for both longitudinal and transverse profile data collection must be made without exception as soon as possible. A minimum of two copies must be made for each data sheet. One copy should be transmitted by mail to the RSC office while the second copy should be retained by the operator in case first copy is lost in the mail.

3.4 ZERO CHECK AND CALIBRATION CHECK

3.4.1 General Background

The zero and calibration checks described in section 3.3.3.1 are performed to ensure that the Dipstick® is operating properly. If the Dipstick® fails the calibration check, it should be returned to the manufacturer for repair.

The RSC should ensure that the gauge block used for the calibration check is calibrated annually to an accuracy of 3.18 ± 0.03 mm using a local calibration laboratory or a calibration micrometer. Calibration of the gauge block may need to be performed more frequently, depending on the presence of oxidation, evidence of corrosion, and possible damage caused by accidental mishandling in the field. If the calibration block is not within an accuracy of 3.18 ± 0.03 mm, a new block that satisfies the criteria should be obtained.

If calibration block thickness is not within 3.18 ± 0.03 mm, all data collected since the last check of the block are suspect and may have to be disregarded.

3.4.2 Frequency of Checks

The zero and calibration checks should be conducted by the operator prior to and after Dipstick® measurements. Procedures for performing the preoperational zero check and calibration check are described in section 3.3.3.1. Procedures for performing the post operational zero check and calibration check are described in section 3.3.3.3. If the Dipstick® fails the calibration check, approval from an RSC engineer is required before shipping equipment to the manufacturer.

3.5 EQUIPMENT MAINTENANCE AND REPAIR

3.5.1 General Background

Scheduled preventive maintenance will serve as a means of ensuring the proper operation of equipment as well as identifying potential problems. Timely identification of problems will help to avoid costly delays or incomplete data that could result from onsite equipment malfunction. Time constraints on the profile testing program require that maintenance activities be performed prior to mobilization for testing. During testing, it is necessary that the operator be constantly aware of proper functioning of equipment. There will be little time to accomplish more than the

required initial checks at the site in preparation for test day. Therefore, there is a paramount need for preventive maintenance to be performed on the Dipstick® as a routine function at the end of each test day.

Minimizing the rate of equipment deterioration is the responsibility of the RSC and individual operators. Detailed maintenance procedures are contained in the equipment manuals and the operator must become familiar with these procedures. This section is intended to reinforce the concept of maximum equipment dependability, which is critical to the effectiveness of the LTPP program.

The guidelines presented in this section are not intended to supersede manufacturers' recommendations regarding maintenance, but to provide supplementary service requirements. Where there is a conflict between this guide and the manufacturers' instructions, the more stringent requirements should be followed.

3.5.2 Routine Maintenance

Routine maintenance includes those functions that can be easily performed by the operator with minimal disassembly of the device. Routine maintenance for the Dipstick® includes cleaning and lubrication of ball and socket joints on footpads, replacement of batteries, and cleaning of battery contacts. These items can be performed easily and should always be completed prior to and after operation of equipment.

The following list of pre and post operation preventive maintenance items is not complete, but is intended to show the extent and detail required before equipment checks are performed. This list of items should not supersede manufacturers' minimum requirements for warranty compliance:

1. Exterior: Check general appearance, glass display (should be clean), and ball and socket joint of footpads (should be properly lubricated).

2. Accessories: Be sure adequate supplies of consumables are on hand (e.g., Batteries, WD-40).

3.5.3 Scheduled Major Maintenance

Scheduled major preventive services should include much more than routine checks and will require some disassembly of equipment by personnel with technical capabilities beyond the skill of the operators or RSC staff. The LTPP Major Maintenance/Repair form DS-10 (see appendix D) should be used by the operator to report repairs that are performed. This form will also serve to inform the RSC of the condition of the Dipstick® on a regular basis. Items such as battery connector replacement would fall into the major maintenance category. Appropriate service intervals are outlined in the equipment manufacturer's manual.

3.5.4 Equipment Problems/Repairs

Regardless of the quality of the preventive program, there will probably be equipment failures during the LTPP program. When these occur, it is extremely important that repairs or replacement of items be accomplished in a timely fashion. Such problems can be easily handled during periods when there is no scheduled testing. However, if they occur during mobilization or while onsite, significant problems in scheduling and coordination could develop. To help minimize the impact of equipment problems, it is essential that the operator immediately notify the RSC and any other agencies or individuals about such problems.

Responsibility for equipment maintenance/repair activity rests with each RSC. However, the RSC should keep LTPP staff informed of any major problems concerning equipment. When repairs are necessary and must be performed by an outside agency, the operator should report this information on the LTPP Major Maintenance Report/ Repair form (form DS-10 in appendix D) as an unscheduled maintenance activity.

3.6 RECORD KEEPING

The Dipstick$^{®}$ operator will be responsible for maintaining the following forms/Records:

1. Longitudinal Profile Measurements: Longitudinal Profile (forms DS-1 through DS-6).

2. Transverse Profile Measurements: Dipstick$^{®}$ Data Collection form - Transverse Profile, (form DS-8).

3. Zero and Calibration Check Records (form DS-7) for both longitudinal and transverse profile measurements.

4. Major Maintenance/Repair form (form DS-10).

5. Air Temperature Probe Calibration Check form (form DS-11).

All these forms are included in appendix D. Each of these forms must be kept on files by each RSC with one complete set kept on file at the regional office. The following sections describe each of these forms.

3.6.1 Longitudinal Profile Measurements

Forms DS-1 through DS-6 should be completed at every section where longitudinal profile measurements are performed with a Dipstick$^{®}$. Follow the guidelines presented in section 3.3.5.2 to fill the header fields in form DS-1. The comments section in this form should include any downtime and any factors that might affect collected data. Names and organizations of other personnel present at the site should be included in this form. Names of these personnel will be invaluable if an accident occurs at the test site. The operator should keep originals of these forms and forward copies to the RSC.

3.6.2 Transverse Profile Measurements

The form DS-8 should be completed at every section where transverse profile measurements are performed. Follow the guidelines presented in section 3.3.5.2 to complete the header fields in this form. The operator should keep the original of this form and forward a copy to the RSC.

3.6.3 Zero and Calibration Check Form

The form DS-7 should be completed whenever the zero and calibration checks are performed.

3.6.4 LTPP Major Maintenance/Repair Form

The form DS-10 must be completed when any major maintenance or repair must be performed by an outside agency.

3.6.5 Air Temperature Probe Calibration Check Form

The form DS-11 must be completed when a calibration check is performed on the temperature probe that is used to measure the air temperature when longitudinal profile measurements are performed with the Dipstick®.

CHAPTER 4. PROFILE MEASUREMENTS USING THE ROD AND LEVEL

4.1 INTRODUCTION

The rod and level can be used to accurately measure the profile of a pavement. These data can be used to evaluate roughness of a pavement by computing a roughness index such as the IRI. In computing roughness indices, only relative elevations and not absolute elevations are needed. The guidelines in this section can be applied to conventional survey equipment such as an optical level and graduated staff, which requires readings to be manually recorded, as well as automated equipment that are capable of automatically storing measured data.

4.2 OPERATIONAL GUIDELINES

4.2.1 General Procedures

Detailed scheduling and traffic control at test sites must be coordinated by the RSC. However, all traffic control activities at test sites will be performed by personnel from either the State or provincial highway agency. Layout of the test site should not be undertaken until all applicable traffic control devices are in place.

4.2.2 Equipment Requirements

The rod and level used in routine surveying and road construction will generally not have the resolution needed for pavement profile measurements. Precision leveling instruments are required for pavement profile measurements. Instruments used for profile measurement should satisfy resolution criterion given in table 2, which was obtained from the ASTM Standard on Measuring Road Roughness by Static Level.[14]

Table 2. Resolution requirement for rod and level measurements.

IRI Range (m/km)	Resolution (mm)
$0 \leq IRI < 0.5$	0.125
$0.5 \leq IRI < 1.0$	0.25
$1.0 \leq IRI < 3.0$	0.5
$3.0 \leq IRI < 5.0$	1.0
$5.0 \leq IRI < 7.0$	1.5
$IRI \geq 7.0$	2.0

The rod used should be equipped with a bubble level so that it can be accurately held vertically. A suitable base may be selected for the rod in order to reduce sensitivity to small variations in rod placement. For smooth textured pavements, any type of base is suitable. For textured surfaces, a circular pad with a diameter of at least 20 mm is recommended.[14] As only relative elevations are required for computing roughness indices, no correction is required if a pad is attached to the bottom of a rod.

4.2.3 LTPP Procedures

4.2.3.1 Maintenance of Records

The operator is responsible for forwarding all data collected during testing to the RSC.

4.2.3.2 Accidents

In event of an accident, the operator will inform the RSC of incident as soon as practical after the mishap. Details of the event shall subsequently be reported in writing to the RSC to assist in any insurance claim procedures.

4.3 FIELD TESTING

4.3.1 General Background

The following sequences of fieldwork tasks are required:

1. Task 1: Personnel Coordination.

    a. Personnel for rod and level survey.

    b. Traffic control crew supplied by highway agency or traffic control contractor working for the highway agency.

    c. Other LTPP, State or Provincial highway agency, and RSC personnel (they are observers and are not required to be present).

2. Task 2: Site Inspection.

    a. Assess general pavement condition (within test section limits).

    b. Identify wheel paths.

3. Task 3: Rod and Level measurements.

    a. Mark wheel paths.

    b. Obtain rod and level readings.

To measure the pavement profile using a rod and level, two persons are needed. One person is needed to hold rod (rod person) and another to operate the level and take readings (instrument operator). If the level is not capable of automatically recording readings, having an additional person to record readings (record keeper) will make the process quicker.

According to the ASTM Standard on Measuring Road Roughness by Static Level,[14] an experienced crew of three would require less than 10 seconds to obtain one reading. This

involves positioning the rod by the rod person, reading the level by the instrument operator, and recording the measurements by the record keeper.

4.3.2 Site Inspection and Preparation

The two wheel paths in the outside travel lane should be marked using the following procedure:

1. Clean the area of both wheel paths of loose stones and debris to prevent slippage of rod during measurements.

2. Identify the location of two longitudinal elevation survey lines 0.826 m from the center of the lane.

   a. Case I: If the wheel paths are easily identified, the midway point between two wheels paths should be used as the center of the lane.

   b. Case II: If the wheel paths are not clearly identifiable, but two lane edges are well defined, the center of travel lane is considered to be midway between the two lane edges.

   c. Case III: If the wheel paths are not apparent and only one lane edge can be clearly distinguished, the center of lane should be established at 1.83 m from that edge.

3. Mark these locations at intervals equal to the length of the chalk line used for marking. Use the chalk line to mark a straight line between previously established points.

4. Note the method by which the wheel paths were located in the comments field of the Rod and Level Data Collection form (see appendix F). This will help in locating wheel paths used for profile measurements at a future date.

Measurements have to be taken along the wheel paths at 0.3 m intervals. The locations at which readings are to be taken can be determined by either of the following methods:

1. Lay surveyor's tape along the chalk line, with the zero mark of tape at station 0+00. Station 0+00 is at the at the leave edge of the white stripe at the beginning of the section. Mark the distances on the pavement at 0.3 m intervals using a suitable marker. Markings have to be made along entire length of section on both wheel paths.

2. Place surveyor's tape at a slight offset from the wheel path so it will not interfere with rod placement. The zero mark of tape should be at station 0+00. Station 0+00 is at the leave edge of the white stripe at the beginning of the test section. Secure both ends of the tape, as well as several intermediate points on the tape with adhesive tape. Distances along the section can be referenced from the tape. After the distance corresponding to length of tape is leveled, the tape will have to be repositioned.

4.3.3 Longitudinal Profile Measurements

The first reading taken after the level is set up is referred to as a backsight, while the last reading taken at that setup before the level is moved is referred to as a foresight. Other readings taken in between a backsight and a foresight are referred to as intermediate sights. The procedure to be followed for measuring longitudinal profile is as follows:

1. Complete the required header information in the Rod and Level Data Collection form (forms are included in appendix F).

2. Set up the level at a suitable location, taking into account the range of the level. With some instruments, it might be possible to cover the entire test length from one instrument setup, located near center of test section. The level should be set up at a position where it will not be disturbed due to passing traffic. In addition, it should be set up at a stable location that will not settle. Set the tripod as low as is practical to reduce error caused by the rod not being held exactly vertical. Thereafter, level the instrument using leveling screws.

3. Have the rod person place the rod at the zero position of the section and, using the bubble level attached to the rod as a reference, hold the rod vertically. Once the rod is held vertically, the rod person should signal to the instrument operator to take a reading. If readings are recorded manually by a third crew member, the instrument operator should call out the reading to the record keeper. Readings should be recorded in the form included in appendix F. If an automated system is being used, the instrument operator should make sure that reading is saved.

4. Have the rod person place the rod 0.3 m away from the initial reading, and record a new reading. This process should be continued until either the entire test section is surveyed or the horizontal range or vertical range of the level is exceeded. The horizontal range of the level is exceeded if the distance between the level and the rod is too short or too long to focus properly. The vertical range of level is exceeded if the rod cannot be read due to the slope of the road. When the range of the level is exceeded, the level has to be relocated.

5. Relocate the instrument if the range of the level is exceeded during measurements. Mark the location at which the rod is to be held for the last reading. This position is called a pivot point. Thereafter, place the rod at the location where the first reading was taken with the current setup of the level and take a reading. Compare this reading with first reading that was taken at this location. If they do not agree within resolution of the instrument, all readings taken from the current level position have to be repeated. If the readings agree, place the rod on the pivot point and take last reading from the current setup of the instrument (foresight). Then set up the instrument at the new location. Place the rod at the pivot point and take the reading (backsight). Continue the leveling process as before, taking readings at 0.3 m intervals. If the instrument has to be repositioned again, the procedure has to be repeated.

6. Use one of the following procedures when the end of the test section is reached, depending on how the measurements were performed:

   a. Perform the entire survey with one instrument setup: Place the rod at the zero position (point from which survey was initially started) and take a reading. This reading should agree with first reading taken at this location at the start of the survey within resolution of the instrument. If readings do not agree, the profile measurement has to be repeated.

   b. Reposition the instrument during the survey: Place the rod at the last pivot point and take a reading. This reading has to agree with the earlier reading taken at this position within resolution of instrument. If they do not agree, the profile has to be measured again from the last pivot point to the end of the section.

The measurement of pavement profiles using a rod and level is labor intensive and time consuming. Therefore, it is advisable to check the accuracy of measured data at regular intervals. This can be performed by establishing a set of control points along the wheel path, for example at 30-m intervals starting from the beginning of the section. After leveling a distance of 30 m, the rod has to be placed at the previous control point and another reading must be taken. This reading has to agree with the previous reading taken at this control point within resolution of the instrument. If readings do not agree, the distance between the control points has to be measured again. This procedure can be used if instrument setup is not changed between two control points being considered. If instrument setup is changed between two control points, the above procedure can still be applied by treating the pivot point as a control point.

4.3.4 Factors to Be Considered During Survey

The following factors have to be considered when performing profile measurements with rod and level:

- If the level is sensitive to temperature variations, it might need to be covered with an umbrella to protect it from direct sunlight.
- If conditions are windy, profile measurements should be avoided, as movement of the level could occur.
- If the level has to be set up at more than one position during profile measurements, make the length to the backsights and foresights equal. This will eliminate errors due to curvature and refraction at turning points.
- If the rod is not exactly vertical, there will be errors. Set up the level as low as possible to reduce error caused by the rod not being exactly vertical.

4.3.5 Profile Computation

During profile measurements in the field, the crew is only expected to record the readings of the level using procedures described in section 4.3.3. Computation of the elevation profile from these data will be done in the office. This section briefly describes how data recorded in field are used to obtain longitudinal profile of pavement.

For profile computations, the elevation of the location where the first reading (first backsight) was measured is needed. However, as only relative elevations are needed to compute roughness indices (such as IRI), an arbitrary value can be selected for the elevation of this point. Relative elevation of any point measured from initial instrument setup can be obtained from the following equations:

$$\text{Instrument Height (IS)} = BM + RR1 \text{ ......(4.1)}$$

$$\text{Relative Elevation of a Point} = IS - RR \text{.....(4.2)}$$ (1)

Where:

IS = Initial instrument height,
BM = Elevation of point where first backsight was taken (assume any value e.g. 30 m),
RR1 = Rod reading at first backsight, and
RR = Rod reading at any point from initial instrument setup.

Once position of level is changed, instrument height will also change. New instrument height can be obtained from the following equation:

$$Nht = Oht + BS - FS \text{........(4.3)}$$ (2)

Where:

Nht = New instrument height,
Oht = OLd instrument height,
BS = Backsight at pivot point, and
FS = Foresight at pivot point.

The relative elevation of the points measured from this new instrument location can be determined by using equation 4.2 and using new the instrument height (Nht) instead of IS.

4.3.6 Quality Control

A quality control check must be performed in the field to ensure that no movement of the level took place during current setup of the level. This check must be performed every time before the level is moved and when the end of the test section is reached. Once the last reading at the current location of the level has been taken, before moving the level, place the rod at the location at which the first reading was taken with the current setup of the level, and take a reading. Both readings have to agree within resolution of the instrument. This check can also be performed at regular intervals by establishing a set of control points as described in section 4.3.3.

4.4 CALIBRATION AND ADJUSTMENTS

The user manual of the level should be consulted about how to perform adjustments to the instrument. Different makes and models of levels will require different adjustments. The user manual should be consulted to determine if the following adjustments are needed for the level

being used and, if so, how to perform the specific adjustment. The following are some common adjustments that are required in levels in order to obtain accurate measurements:

1. Make the axis of the level bubble perpendicular to the vertical axis. After setting up the level, center the bubble. Move the telescope 180 degrees about vertical axis. If the bubble moves, the instrument needs adjustment.

2. Adjust the horizontal cross hairs. This adjustment will ensure that the horizontal cross hairs are truly horizontal when the instrument is leveled.

3. Adjust the line of sight. This adjustment will make the axis of the sight perpendicular to the vertical axis and also make it parallel to the axis of the level. The method of adjustment for this error is commonly referred to as the two peg method.

The rod has to be checked to verify the accuracy of the markings. A standardized tape should be used for this.

4.5 EQUIPMENT MAINTENANCE

Shockproof packaging should be used when transporting the instrument. Always clean the instrument after measurements are completed. Before cleaning the lenses, blow dust off the lenses, then clean the lenses using a soft cloth. Lenses should not be touched with fingers. If the instrument becomes wet in the field, make sure that it is completely dry before packing. The tripod should be inspected regularly to ensure that the connections are not loose.

4.6 RECORD KEEPING

The Rod and Level Data Collection form (see appendix F) should be used to record readings when profile measurements are performed using a rod and level. A comment should be made on this form as to how the wheel paths were located. All items in this form should be completed by the instrument operator or record keeper. Location information in this form should be completed even when an automated instrument that is capable of saving data is used.

4.7 DATA BACKUP

Backup copies of the Rod and level Data Sheets must be made without exception as soon as possible. A minimum of two copies must be made for each data sheet. One copy should be transmitted by mail to the RSC office, while the second copy should be retained by the operator in case first copy is lost in mail.

CHAPTER 5. PROCESSING OF PROFILE DATA IN THE OFFICE

5.1 INTRODUCTION

The profile data collected by inertial profilers, longitudinal profile data collected with a Dipstick®, and transverse profile data collected with a Dipstick® are sent to the RSC office for processing. In the LTPP program, ProQual is used to process data collected by these three methods, and to perform quality assurance checks on those data. After the data are processed and quality assurance tests have been performed, data files to upload to the LTPP PPDB are created by ProQual. This chapter presents guidelines for processing and performing quality assurance checks in the office for all three data types described previously to ensure consistency and uniformity amongst the RSCs.

These guidelines should be viewed as the minimum required amount of data checking to be performed by the regions. The RSCs may already have procedures in place that exceed the minimum requirements described in this chapter. In such circumstances, the RSCs should continue to use those procedures in addition to those presented in this chapter. The guidelines for processing and performing quality assurance checks are presented separately for each data type. As described previously, the processing and evaluation of profile data for all three data types is performed using ProQual. For each type of profile data, general guidelines on the menus and features in ProQual needed to perform data processing and quality assurance checks are described. Detailed information on the operation of ProQual is presented in the ProQual Manuals.[6, 7, 8]

The RSCs are not required to process profile data collected at WIM sites by inertial profilers, except to perform quality assurance checks if needed to make sure that data are error free. However, the RSCs are required to store the profile data at WIM sites according to the procedures described in section 5.6

5.2 INERTIAL PROFILER DATA

The following are the recommended procedures to be used in the office for processing and performing quality assurance checks on longitudinal profile data collected with the ICC inertial profilers:

1. Check the analysis Parameter Screen and Equipment Screen in ProQual. After starting ProQual, check if the settings in the Analysis Parameter Screen and Equipment Screen are set to values described in section 2.2.6.2.

   The following parameters in the Analysis Parameter Screen should be checked to see if they are set to the correct value: Running Average, Sample Length, Fault Threshold, Spike Threshold 1, Spike Threshold 2, Tolerance on Mean, Tolerance on Standard Deviation, Slope Variance Interval, Mays Coefficients, and RMSVA Base Length. (Note: The values for Sample Length, Fault Threshold, and RMSVA Base Length are not used in computations, but it is recommended that they be kept at the values indicated in section 2.2.6.2).

The Equipment Screen should be checked to see if the following parameters are set to the correct values: Manufacturer, Description, Serial #, Vertical Photocell Offset, and Horizontal Photocell Offset.

2. Compute the roughness indices. In ProQual, select the data set to be analyzed and click the "All" icon to compute all roughness indices (i.e., IRI, RMSVA, Slope Variance).

3. Review the header information and End of Run Comments. The header information and End of Run Comments for all profile runs can be reviewed by selecting the "Browse" option in the "Run Details" menu of ProQual. The following are the fields that need to be reviewed and they are presented in the order they appear when the "Browse' option is selected:

   a. *Time:* The time of profiling shown is obtained from the computer in the profiler during testing. Review the time to see if it is reasonable. If it is unreasonable, the time shown in the computer of the profiler should be checked for possible errors. If errors are detected, check with the operator to obtain the correct time when profile data were collected.

   b. *Sequence*: Check if the sequence identifier is correct. The value in this field is not uploaded to the LTPP PPDB. However, an incorrect value may affect the archival procedures used in the RSCs.

   c. *Software:* The software version that is shown should be 1.07, followed by the last five digits of the VIN number of the profiler vehicle (i.e., 1.0768231, 1.0768394, 1.0768395, or 1.0768396). Check if the last five digits of the software field match the VIN number of the profiler of the RSC. If the VIN number is not correct, that means the serial # was not correctly entered into ProQual (see section 2.2.6.2).

   d. *Filter:* The value in this field should be 100. If not, it means that the Filter Wavelength was set incorrectly when the data were collected. If a value other than 100 has been used to collect the data, discard the data and profile data will have to be recollected. Also, check the settings of the Filter Wavelength in the profiler software to ensure that it is set to a value of 100.

   e. *Crew:* Check if operator and driver initials have been entered correctly. The operator and driver should be identified by two characters each, the first letter of their first and last names. Operator and driver names should be separated by a forward slash and typed in capital letters (e.g., CK/RS). If profiling is done as a one person operation, the operator and driver name should be the same (e.g., CK/CK).

   f. *Road:* This field should show the route number where section is located (e.g., I-88). Check if the information is correct.

   g. *Lane:* This field refers to the lane that was profiled. Valid entries are INSIDE or OUTSIDE. Check if the entry in this field is correct.

h. *Direction:* This field refers to the travel direction when profiling the site. Valid entries for this field are NORTH, EAST, SOUTH, or WEST. Check if the travel direction is correct.

i. *Begin:* This is an entry made for the field Beginning Description in the profiler software. Check to see if the milepost has been entered in this field. If not, this field should show NONE.

j. *End:* This is an entry made for the field Ending Description in the profiler software. Check to see if this field indicates NONE or has the ending milepost.

k. *Surface:* This field shows the surface condition of the road. Valid entries are V. GOOD, GOOD, FAIR, and POOR. As this field is selected in the profiler software by toggling through these four possible values, an entry will always be present for this field. This is a subjective entry made in the field by the operator based on a set of guidelines described in step 22 of section 2.3.4.1. It is recommended that the value assigned to the section during the previous site visit be reviewed when checking this field. Otherwise, there could be variability in the value assigned to this field from one year to another (e.g., V. GOOD during latest visit, but value for previous visit was GOOD).

l. *Temperature:* This field shows air temperature at the time of profiling in degrees Celsius. Check if the value appears reasonable based on season or month of testing. If the temperatures appear to be questionable, check with the operator who collected the data.

m. *Clouds:* This field shows cloud condition at the time of profiling. Valid entries are CLEAR, P. CLOUDY (Partly Cloudy), or CLOUDY. As this field is selected in the profiler software by toggling through the three possible values, an entry will always be present for this field. However, there is no easy way to check if the entry is correct.

n. *Weather:* The value in this field corresponds to the field "Other Weather Conditions" that was entered in the ICC software. In the ICC software, the operator has the option of toggling through the following entries and selecting the appropriate one: CONDITIONS OK, STEADY CROSSWIND, WIND GUSTS, HOT AND HUMID, HAZY, and LOW SUN ANGLE. As this field is selected in the profiler software by toggling through the six possible values, an entry will always be present for this field. If there is a question about this entry, check with operator to verify the entry is correct. The information in this field should be used when evaluating profile data (see step 5).

o. *Start Method:* The start method for profile data collection is always PHOTOCELL. The code assigned to photocell is one. Verify that this field shows one. If a method other than Photocell has been used to collect the profile data, discard the profile data and profile data will have to be recollected.

p. *Stop Method:* The stop method for profile data collection is always DISTANCE. The code assigned to distance is three. Verify that this field shows three.

q. *Stop Distance:* The stop distance for GPS and SMP sections is 152.40 meters. Verify that the value is correct. For SPS projects, see if value appears reasonable. The stop distance shown for SPS projects is the length of the entire profile run.

r. *Wavelength Initialization:* For ICC profilers, this field should show a value of 2.

s. *Average Speed:* This field shows the average speed during profiling, which should normally be 80 km/h. However, higher values are also possible, as this manual indicates the operating speed may be increased to 88 km/h depending on traffic conditions. If a speed higher than 88 km/h is entered, the reason for the higher speed should be checked. If the speed is less than 80 km/h, the reason for the lower speed must be checked to verify it was due to the posted speed limit or prevailing traffic conditions.

t. *Note:* This field shows an entry made in the field by the operator at end of a profile run. The operator has the option of choosing one of the following entries from the drop down list in the ICC software: RUN OK, PAVEMENT SURFACE DAMP, TRAFFIC CONGESTION: SPEED VARIABLE, DIFFICULT TO MAINTAIN CONSTANT SPEED: UPGRADE, DIFFICULT TO MAINTAIN WHEEL PATH LOCATION, and LATE PHOTOCELL INITIATION. If none of these comments is appropriate, the operator has the option of typing in an entry. If the Run End Note is not one of the six ICC options, check if the Run End Note follows the guidelines described in section 2.2.7.8. The comment in this field will be useful when graphically comparing profile plots (step 5) and when evaluating IRI values of profiler runs (step 8).

u. *Operator Note:* This field shows comments made by the operator in the field after data have been reviewed through ProQual. Review comments and see if they follow the guidelines presented in section 2.2.7.8. Comments will be useful when graphically comparing profile plots (step 5) and when evaluating IRI values of profiler runs (step 8).

v. *Device Code:* The code shown in this field should be P.

w. *Manufacturer:* This field shows the profiler manufacturer and should reflect the value set in the Equipment screen of ProQual (see section 2.2.6.2). Check if the manufacturer is International Cybernetics.

x. *Model:* This field shows the profiler model and should reflect the value set in the Equipment screen of ProQual (see section 2.2.6.2). Check if the model is MDR4086L3.

y. *Model Code:* This field shows the model code assigned to the profiler and should reflect the value shown in the Equipment parameter screen of ProQual, which is 3.

z. *Sample Size:* This field shows the sample interval for profile data, which was assigned to "Sample" in the Analysis Parameter screen of ProQual (see section 2.2.6.2). Sample size should show a value of 150.

If there are errors in any of the headers that can be corrected, go to the "Identification and Conditions" menu under the "Run Details" tab and correct the header. If there are errors that cannot be corrected (e.g., not using the photocell to initiate data collection, using an incorrect filter) discard the data. Profile data will have to be recollected.

4. Check the profile data interval. Go to the "Profile Details" tab in ProQual and check if data are at 150 mm intervals and that data for 152.4 m are available (sections two and five in SPS-6 projects should have data for 304.8 m). Although the Analysis Parameters screen was checked to see if the running average was set to 150 mm, there is always the possibility that this value was not set to the correct value in the field. A review of the Location field in the "Profile Details" tab will verify that the Running Average was set to 150 mm.

5. Perform a graphical run-to-run comparison of profile data. The graphical run-to-run comparison of profile data involves making a visual comparison of the data obtained for the multiple runs. This comparison is performed separately for the left, right, and center paths. The "Graphic Profiles" option in ProQual is used to do the comparison. The profiles should be evaluated for repeatability. End of Run and Operator Notes entered by the operator in the field should be reviewed when the comparison between profiles is made. In addition, the Field Activity Report should also be reviewed to see if the operator has made any additional comments related to profiler runs in that report. If variations between the profile runs are noted, the runs showing the variability should be reviewed to see if any of the following conditions contributed to the variability: DMI shift, testing out of the wheel path, or variability that is not pavement related.

6. Evaluate spikes in the profile. The "Spikes" tab under "Data Sets" in ProQual shows the locations where spikes were detected in the profile. Review the Operator Notes to determine the cause(s) of the spikes. If spikes were noted, it is mandatory that the operator note if the spikes were pavement related. When performing the run-to-run profile comparison, evaluate if spikes occur at same station for different runs. The results of the previous distress survey can also be used as a tool to evaluate if pavement features caused the spikes. The visit-to-visit profile comparison described in the next step can also be used to check if spikes were noted in the previous visit.

If the cause(s) of the spikes is determined to be non pavement related, logically mark the locations where spikes are noted. This is done in the "Profile Details" tab in ProQual that shows the profile elevations; the spike is logically marked by changing entry in "Include" from "True" to "False." When a data point is logically marked, the data point is not used when computing profile indices.

7. Perform the graphical visit-to-visit comparison of the profile data. The visit-to-visit profile check involves making a visual comparison of profile data from the current visit with data from the previous visit. The "Graphic Profiles" option in ProQual is used for this comparison. Profile data for the previous visit is obtained from the LTPP PPDB. The

comparison is made only along the left and the right wheel paths, as center path data for the previous visit is not available in the LTPP PPDB.

Data obtained for multiple profile runs from the previous site visit should be evaluated and one representative profile run should be selected to perform the visit-to-visit comparison (it is permissible to select more than one run for the comparison). Profile data for the previous site visit should be overlaid with at least three good profile runs from the current data set, and the data for the two site visits should then be evaluated to determine if similar profile features are present in both data sets and to determine if profile shapes are similar. This comparison should be performed separately for each wheel path.

If there are differences in profile features and shapes between the two data sets, the cause(s) for the difference should be evaluated. When ICC profiler data are compared to data collected with K. J. Law T-6600 profilers, differences in long wavelengths may be seen. However, the profile features for both devices should be similar. When the comparison involves only ICC profiler data, both profile features as well as profile shapes should be similar. If a good match is not obtained, use data from two previous site visits and perform comparison. If no explanation for the differences in profiles is found, paper copies of the profiles should be submitted to appropriate RSC personnel for review.

When reviewing data for sections that were subsectioned (e.g., SPS sections), the visit to visit graphical profile comparison can be used to determine if subsectioning was performed correctly. If a horizontal offset of profile features is noted between visits, this may indicate a problem with subsectioning. If a horizontal shift in profile data is noted between visits for a section, check if it occurs for other sections in the SPS project. Based on feedback provided by the regions on typical profile shifts noted between visits, a shift of up to 1 m between visits is acceptable. If a subsectioning problem is suspected, reevaluate the subsectioning performed for the SPS project (or other cases where subsectioning was performed).

8. Review the profile indices. If a spike was logically marked, the "All" icon in the "Analysis" submenu of the "Data Sets" tab has to be selected again to recompute roughness indices. If no spikes were logically marked, it is not necessary to recompute the roughness indices. Print the Site Visit Report and Site Summary Report.

   Use a Site Visit Report to review the following: IRI Statistics (such as minimum IRI, maximum IRI, mean IRI, standard deviation of IRI, and IRI coefficient of variation), Run-to-Run Confidence Limits, and the IRI values obtained along left and right wheel path as well as the mean (both) IRI between runs. Use Site Summary Report to review the values computed for IRI, Spike Count, RMSVAs, Mays Output, and Slope Variance. Compare IRI values obtained from the current visit with those from previous visit. If difference in IRI value exceeds 10 percent for a wheel path (when mean IRI from all good runs are compared), check to see if cause for IRI change can be identified. If no explanation is found, paper copies of profiles including a graphical profile printout should be submitted to appropriate RSC personnel for review.

9. Assign a RCO Code and RCO Note:

    a. RCO Code: A RCO Code must be assigned to each profile run after quality assurance checks are performed on the data. Those checks include: (a) review operator comments, (b) compare IRI values and review IRI coefficient of variation for replicate profile runs collected during site visit, (c) compare profile data of replicate runs collected during site visit, (d) review spikes in profile data and review operator comments regarding spikes, (e) compare profile data with those collected during previous site visit(s), and (f) if required, review distress maps to investigate spikes in the data.

    Once these tasks have been completed, assign a RCO Code to each profile run using the guidelines presented in section 5.4. The RCO Code is assigned in the "Results and Status" tab of the "Run Details" sheet in ProQual.

    b. RCO Note: A RCO Note must be made for each profile run. The RCO Note is assigned in the "Results and Status" tab of the "Run Details" sheet in ProQual. A drop-down list is available in this field to select an appropriate comment. The person reviewing the data also has the option of typing in a comment in this field, or to select a comment from the drop-down list and then type in additional comments.

The following are reasons for making an entry in the RCO Note field:

    a. Indicate locations where spikes were logically marked.

    b. Indicate improper DMI calibration.

    c. Indicate if spikes are pavement related.

    d. Indicate cause(s) for variability in profiles.

The following comments are available in the drop-down list:

    a. PROFILE DATA OK, SPIKES ARE PAVEMENT RELATED,

    b. VARIABLE PROFILES,

    c. SPIKES IN ___ WHEELPATH REMOVED,

    d. POOR PROFILE MATCH: DMI DIFFERENCE, and

    e. POOR PROFILE OVERLAY: ROUGH PAVEMENT.

Any comments typed in this field must be in capital letters.

If there are no specific comments to make regarding a profile run, the comment "PROFILE DATA OK" must be selected from the drop-down list in the RCO Note field.

10. Select runs for upload to LTPP PPDB and create upload files. From all available profile runs, select five profile runs for upload. Thereafter, create RIMS upload files. Check ProQual Export Review Summary Report for errors and exceptions and if any are found resolve the issues and recreate RIMS upload files, as needed.

11. Submit RIMS files to the appropriate RSC personnel for review and upload to LTPP PPDB. If any problems are encountered during upload of RIMS data to LTPP PPDB, they should be resolved and the corrected data should be uploaded to LTPP PPDB.

12. Backup the data. The profile data files collected by the profiler (hereafter referred to as raw profile data) as well as all files generated by ProQual during processing of raw profile data should be backed up. For the ICC profiler, the raw profile data files that need to be backed up are the files with extensions of p, e, and v. All files generated by ProQual for each site should be backed up in conjunction with the raw profile data files. Use the file structure indicated in directive GO-41, Submission of Electronic Data for Customer Support and AIMS (or current version of that directive) to back up the data.

5.3 LONGITUDINAL DIPSTICK® DATA

The following are the recommended procedures to be used in the office for processing and performing quality assurance checks on longitudinal profile data collected with a Dipstick®:

1. Check if the Dipstick® passed pre and post measurement checks and if the data met the closure error. Check form DS-7 to verify that Dipstick® passed zero check and calibration check prior to and after data collection. Check form DS-1 to verify that closure error was within acceptable value.

2. Enter the header information. This section presents general procedures on navigating through the different ProQual menus and specifies the information that should be present in the header fields. Details on procedures for navigating between menus are presented in the ProQual Manuals.[6,7,8] To enter header information of a site into ProQual, select "Manual" from main menu, and then select the "Longitudinal" option. Thereafter, select the site from the left side of the screen (if the site has not been created in ProQual, create the site by selecting "System" in Main menu and then selecting the "Sites" option). Select the "Insert Data Set" icon (+ icon) and edit/enter information in the following fields in the Manual Data Set part of the screen:

   a. *Name:* The default entry shown in this field contains the LTPP Section ID, Current Date, and Current Time (for example, if the + icon was selected on 13 May 2003 at 1:36:10 PM for site 261000, the entry shown in this field will be, 261000 Manual Data Set: 13/May/2003 1:36:10 PM). Edit the date and time in this field to the show data collection date and the time at which data collection was started. This information is contained in form DS- 1.

   b. *Sample Interval:* This field shows a default value of 304.8 mm. The spacing between the two footpads of all Dipsticks® used in the LTPP program is 304.8 mm. No change is required to this field.

c. *Date:* Enter the date of data collection from sheet DS-1.

d. *Time:* Enter the time data collection started from sheet DS-1.

e. *Equipment:* Select the appropriate Dipstick® model number from a drop down list, such that the Model Number and Equipment Number corresponds to the Serial Number and Model Number shown in form DS-1. If the required Dipstick® Model Number and Serial Number is not available in the drop down list, then the appropriate Dipstick® information should be entered in the "Equipment" screen of ProQual.

Check if all entries are correct and save the data. After the data are saved, the Manual Header entry fields will appear on the screen and the information in following fields will have to be edited or entered: Road Name, Site Type, Visit, Run Length, Units, Lane, Direction, Crew, Clouds, Temperature, Weather, Surface Type, Surface Condition, Operator Comment, and Run End Comment. The entries for Road Name, Site Type, Visit, Lane, Direction, Crew, Clouds, Temperature, Weather, Surface Type, and Surface Condition are available in form DS-1. Check if entries meet the following criteria (described in section 3.3.5.2) and enter information into the appropriate field in ProQual:

a. *Road Name:* The highway or route designation in entered in this field. Enter information in capital letters (e.g., INTERSTATE 57, US 395, S.R. 31).

b. *Site Type:* The drop-down list gives the following options: SPS, GPS, SMP, CAL, WIM. Select appropriate site type. This information is not entered into the PPDB.

c. *Visit:* Select appropriate sequential visit identifier. (e.g., A for first visit to site, B for second visit, C for third visit, etc). Check if visit identifier is correct and enter value. This information is not entered into the PPDB.

d. *Run Length:* This field is used to enter the length of the test section in meters, which will usually be 152.4 m. Once the data set is saved, this value cannot be edited. Therefore, make sure that the correct value is entered as it is used to generate the data entry tables in the "Profiles" tab.

e. *Units:* This field shows a default value of mm. All Dipsticks® used in the LTPP program show readings in millimeters. Therefore, no change is required to the value shown in this field.

f. *Lane:* Use drop down list and enter lane, which can be either OUTSIDE or INSIDE. Check if lane is correct.

g. *Direction:* This is traffic direction of test section. Use drop down list and select NORTH, EAST, WEST, or SOUTH. Check if direction is correct.

h. *Crew:* Operator and recorder should be identified by two characters each, first letter of their first and last names. Operator and recorder names should be separated by a forward slash and typed in capital letters (e.g., CK/RS).

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i. *Clouds (Cloud Conditions):* Valid entries for this field are CLEAR, P. CLOUDY, or CLOUDY. Use drop-down list in ProQual to select appropriate entry.

j. *Temperature:* The average of the air temperatures obtained from the air temperature probe before and after longitudinal Dipstick® measurements is entered in this field. Check if temperature appears to be reasonable based on season/month when test was performed and, if reasonable, enter value. If not, check with the operator.

k. *Weather Comment:* ProQual contains the following predetermined comments: CONDITIONS OK, STEADY CROSSWIND, WIND GUSTS, HOT AND HUMID, HAZY, LOW SUN ANGLE. Select appropriate comment based on information contained in form DS-1 using the drop down list. If there is a weather related comment that is different from those available in the drop down list, type the comment in this field using capital letters.

l. *Surface Type:* Use drop-down list to select surface type; A-CC for asphalt surfaced pavements and P-CC for PCC surfaced pavements based on surface type entered in form DS-1. Check if the surface type is correct.

m. *Surface Condition:* Enter condition of pavement as either V. GOOD, GOOD, FAIR, or POOR. Use drop-down list to select entry that is noted in form DS-1. Since this is a subjective entry made in the field by the operator, it is recommended that the value assigned to the section during the previous site visit be reviewed when checking this field. Otherwise, there could be variability in the value assigned to this field from one year to another (e.g., V.GOOD during latest visit, but value for previous visit was GOOD).

n. *Operator Comment:* Enter operator comments in capital letters, if the operator made any comments.

o. *Run End Comment:* Enter Run End Comment in capital letters, if the operator made a comment.

Once all header entries have been entered and checked, save header information.

3. Enter the longitudinal Dipstick® data. Enter the Dipstick® survey readings recorded on forms DS-2 through DS-6 into the "Profiles" sheet in ProQual. The exact sign convention used in the data sheets should be followed when entering the data (i.e., a negative value in data sheet should be entered as a negative value into ProQual). Once data have been entered for the left and the right wheel paths, print the data by clicking on the Printer icon. Check Dipstick® data values along the left and right wheel paths in the printout with values in forms DS-2 through DS-6 to make sure all data have been entered correctly.

4. Sum the Dipstick® data and filter profile using the Surface Dynamics filter. After checking the data and making corrections as needed, click on the sum button to obtain elevation profile as well as the elevation profile that has been filtered with the Surface Dynamics upper wavelength cut off filter. This action will cause the four data columns

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right of the left profile reading column to be populated with data. (Note: The Surface Dynamics filter included with ProQual was used in the K.J. Law T-6600 profilers as the upper wavelength cut off filter). Thereafter, click on the Update Main Tables icon to update the main tables with the filtered profile data. (Note: ProQual provides the option of filtering the Dipstick® elevation profile with either the Surface Dynamics or ICC filter. Longitudinal Dipstick® data are collected on a regular basis at test sections in Alaska, Hawaii, and Puerto Rico. In order to provide consistency in data collected at these sites, the Surface Dynamics filter must be used to filter Dipstick® profiles).

5   Compute ride indices and review the data. The data set can now be treated as a profiler run that was obtained using an inertial profiler by selecting the "Profiles" menu from the main menu of ProQual, and then selecting the "Data" submenu. Select the data set to be analyzed and in the "Analysis" submenu of the "Data Sets" menu select the "All" icon to compute all roughness indices (i.e., IRI, RMSVA, Slope Variance). Review if spikes are present in the profile. If spikes are present, check to make sure that the spikes were not caused by errors during data entry. Print the Site Summary Report to review the values computed for IRI, Spike Count, RMSVAs, Mays Output, and Slope Variance. Plot profiles along the left and right wheel paths and review profile plots to see if they are reasonable.

6. Compare the data with data from a previous visit. Compare IRI values obtained along each wheel path with those obtained during previous site visit. If the difference is greater than 10 percent for a wheel path, investigate the reason for the difference. Graphically compare profiles along each wheel path with those generated from a previous site visit. If major differences are noted between the two data sets, and no explanation for differences is found, paper copies of the profiles should be submitted to appropriate RSC personnel for review.

7. Review the Operator Comment and Run End Comment. The Operator Comment as well as the Run End comment was entered into the header menu in step 2 (Enter Header Information). If needed, make changes to the Operator Comment or Run End Comment based on the review of profile data.

8. Assign a RCO Code and RCO Note

    RCO Code: A RCO Code must be assigned to the profile data after quality control checks have been performed on the data. Those checks include:

    a. Review operator comments.

    b. Compare IRI values along each wheel path with those obtained during previous site visit.

    c. Review spikes in profile data and review operator comments (if any) regarding spikes.

    d. Compare profile data with those collected during previous site visit(s).

e. Review distress maps to investigate spikes in data if required.

Once these tasks are completed, assign RCO Code to profile runs using guidelines presented in section 5.4. The RCO Code is assigned in the "Results and Status" tab of the "Run Details" sheet in ProQual.

RCO Note: A RCO Note must be made for each profile run. The RCO Note is assigned in the "Results and Status" tab of the "Run Details" sheet in ProQual. A drop down list is available in this field to select an appropriate comment. The operator also has the option of typing in a comment in this field, or to select a comment from the drop down list and then type in additional comments.

An entry in the RCO Note field should be made to indicate locations where spikes were logically marked and/or to indicate if spikes are pavement related.

The following comments are available in the drop down list:

a. PROFILE ATA OK.

b. SPIKES ARE PAVEMENT RELATED.

c. VARIABLE PROFILES.

d. SPIKE(S) IN ___ WHEELPATH REMOVED.

e. POOR PROFILE MATCH: DMI DIFFERENCE.

f. POOR PROFILE OVERLAY: ROUGH PAVEMENT.

Any comments typed in this field must be in capital letters. If there are no specific comments to make regarding a profile run, the comment "PROFILE DATA OK" must be selected from the drop down list in the RCO Note field.

9. Create LTPP PPDB upload files. Select the longitudinal Dipstick® profile file for upload and create a RIMS upload file. Check the ProQual Export Review Summary Report for errors and exceptions, and if any are found resolve issue(s) and recreate RIMS upload files, as needed.

10. Submit RIMS files to appropriate RSC personnel for review and upload. If any problems are encountered during upload of RIMS data to PPDB, resolve the problems and upload corrected data to PPDB.

11. Backup the data. Backup all files related to the site that were created by ProQual. Use the file structure indicated in directive GO-41, Submission of Electronic Data for Customer Support and AIMS (or current version of that directive) to back up the data. Store the field data sheets and ProQual generated reports in appropriate files.

5.4 ASSIGNMENT OF RCO CODE

A RCO Code must be assigned to the longitudinal profile data collected by the profiler as well as by the Dipstick® after quality control checks have been performed on the data. The assignment of a RCO code to profiler data is described in section 5.2 in step 9. The assignment of a RCO code to longitudinal Dipstick® data is described in section 5.3 in step 8.

The assignment of a RCO Code should be performed by a person knowledgeable in profile data analysis. This section provides guidance to the person who is performing the quality control checks in selecting the appropriate RCO Code to be assigned to each profile run. The following guidelines should be used to assign the RCO Code for a profile run:

1. RCO Code = 1.

    A RCO Code of one should be assigned to a profile run if there are no data problems. Such profile runs have the following characteristics:

    a. If there is variability between multiple profile runs, the operator comments explain that the cause of this variability is pavement related.

    b. If spikes are present in data, they occur because of pavement features and they are documented by the operator comments/notes to be pavement related.

    c. If profile data plots are in good agreement with those collected during previous site visits. This procedure provides a check on errors caused by incorrect subsectioning of SPS sites, incorrect labeling of sites, and incorrect start locations for profile data collection.

2. RCO Code = 2.

    A RCO Code of two should be assigned to a profile run if any of the following features are identified in the data:

    a. There is poor repeatability between the multiple profile runs, and operator comments do not indicate that this variability was caused by pavement features.

    It has been observed that sometimes profilers have poor repeatability on rough sections and on sections where the approach to the section is rough (e.g., patched core holes prior to section). On such sections, the data from multiple profiler runs are generally different from each other, with the operator having no comments regarding wheel path tracking problems. Although there are large differences in profile data, the IRI values from these runs are generally in good agreement with each other and may meet the ProQual IRI acceptance criteria. This occurs because differences in profile data are caused by long wavelengths that do not contribute to the IRI). Such profile runs should be assigned a RCO Code of two.

b. There are spikes in the profile.

   If there are spikes in the profile data, and the operator comments indicate that the spikes are not pavement related, such data points shall be logically marked and the profile run should be assigned a RCO Code of two.

   It has been reported that the white pavement markings at the beginning and end of a test section as well as 30 m crosses that are in the wheel path can cause spikes in the profile data. In such cases, the spikes will generally occur at the indicated locations for the replicate runs. If the operator indicates that these spikes are not explained by pavement features, such profile data points should be logically marked and the profile run assigned a RCO Code of two.

3. RCO Code = 3.

   A RCO Code of three should be assigned to a profile run if any of the following conditions are identified:

   a. There is a large IRI difference that cannot be explained when compared to other profile runs collected during the site visit.

   b. There are spikes in the profile data that are not explained by the operator comments.

   c. There are differences in the profile data when compared to other profile runs collected during the site visit, but the differences cannot be explained by the operator.

   d. The profiler runs collected during the site visit are repeatable, but they are different from those collected during previous site visits, and the differences are identified to be caused by conditions at the time of testing (e.g., damp pavement). It should be noted that data collection at LTPP test sections should be performed on dry pavements. There could be cases where data were collected on a damp surface due to existing circumstances.

5.5 TRANSVERSE DIPSTICK® DATA

The following are the recommended procedures to be used in the office for processing and performing quality assurance checks on transverse profile data collected with a Dipstick®:

1. Check if the Dipstick® passed pre and post measurement checks. Check form DS-7 to verify that the Dipstick® passed the zero check and calibration check prior to and after data collection.

2. Enter the header information. This section presents general procedures on navigating through the different ProQual menus and specifies the information that needs to be entered into the header fields. Details on procedures for navigating between menus are presented in the ProQual Manuals.[6,7,8] There are several header entries that are not

entered in the LTPP PPDB. However, these entries may be useful if the ProQual files are reviewed at a future date.

To enter header information for a site into ProQual, select "Manual" from main menu, and then select "Transverse" option. Thereafter, select the site from the left side of the screen (if the site has not been created in ProQual, create site by selecting "System" in Main menu and then selecting "Sites" option). Select the "Insert Data Set" icon (+ icon) and edit/enter information in the following fields in the Manual Data Set part of the screen:

a. *Name:* The default entry shown in this field contains the LTPP Section ID, Current Date, and Current Time (for example, if the + icon was selected on 13 May 2003 at 1:36:10 PM for site 261000 the entry shown in this field will be, 261000 Manual Data Set: 13/May/2003 1:36:10 PM). Edit the date and time in this field to show the data collection date and time at which data collection was started. This information is contained in form DS-8.

b. *Station Interval:* The default value shown in this field is 15.24 m. This is the station interval at which transverse data are collected at LTPP sections. No changes are needed to this field.

c. *Tests:* The number of readings taken for a transverse profile. Enter the number of readings by reviewing data on form DS-8.

d. *Date:* Enter the date of data collection from sheet DS-8.

e. *Time:* Enter the time data collection started from sheet DS-8.

f. *Equipment:* Select the appropriate Dipstick® model number from drop down list such that Model Number and Equipment # corresponds to the Serial Number and Model Number shown in form DS-8. If the required Dipstick® Model Number and Serial Number is not available in the drop down list, then the appropriate Dipstick® information should be entered in the equipment parameters screen of ProQual.

   Check if all entries are correct and save the data. After data are saved, the Manual Header entry fields will appear on the screen and the information in following fields have to be edited or entered: Road Name, Site Type, Visit, Run Length, Units, Lane, Direction, Crew, Clouds, Temperature, Weather, Surface Type, Surface Condition, Operator Comment, and Run End Comment. The entries for Road Name, Site Type, Visit, Lane, Direction, Crew, Clouds, Temperature, Weather, Surface Type and Surface Condition are available in form DS-8. Check if entries meet the following criteria (described in section 3.3.5.2) and enter information into appropriate field in ProQual.

g. *Road Name:* This is the highway or route designation. Enter information in capital letters (e.g., INTERSTATE 57, US 395, S.R. 31). This information is not entered into the LTPP PPDB.

h. *Site Type:* The drop down list gives the following options: SPS, GPS, SMP, CAL, and WIM. Select appropriate site type. This information is not entered into the LTPP PPDB.

i. *Visit:* Sequential visit identifier. (e.g., A for first visit to site, B for second visit, C for third visit, etc). Check if the visit identifier is correct and enter the value. This information is not entered into the LTPP PPDB.

j. *Units:* This field shows a default value of mm. All Dipsticks® used in the LTPP program show readings in millimeters. Therefore, no change is required to the value shown in this field.

k. *Lane:* Use drop down list to select lane, which can be either OUTSIDE or INSIDE. Check if lane is correct. This information is not entered into the LTPP PPDB.

l. *Direction:* This is traffic direction of test section. Use drop down list to select NORTH, EAST, WEST or SOUTH. Check if the direction is correct. This information is not entered into the LTPP PPDB.

m. *Crew:* The operator and recorder should be identified by two characters each; first letter of their first and last names. Operator and recorder names should be separated by a forward slash and typed in capital letters (e.g., CK/RS).

n. *Clouds (Cloud Conditions):* Valid entries for this field are CLEAR, P. CLOUDY, or CLOUDY. Use the drop down list in ProQual and enter the cloud conditions. This information is not entered into the LTPP PPDB.

o. *Temperature:* The pavement temperature in degrees Celsius obtained with an infrared device is entered in this field. Check if the temperature appears to be reasonable based on season/month when test was performed and enter the value. This information is not entered into the LTPP PPDB.

p. *Weather Comment:* ProQual contains the following predetermined comments: CONDITIONS OK, STEADY CROSSWIND, WIND GUSTS, HOT AND HUMID, HAZY, LOW SUN ANGLE. If comment indicated in form DS-8 corresponds to one of the predetermined comments, use the drop down list to select an appropriate entry. If the comment is different, type the comment noted in form DS-8 (use capital letters). This information is not entered into the LTPP PPDB.

q. *Surface Type:* Use the drop down list to select the surface type noted in form DS-8. Use A-CC for asphalt surfaced pavements and P-CC for PCC surfaced pavements. This information is not entered into the LTPP PPDB.

r. *Surface Condition:* Enter the condition of the pavement as either V.GOOD, GOOD, FAIR, or POOR. Use the drop down list to select entry that was made in form DS-8. Since this is a subjective entry made in the field by the operator, it is recommended that the value assigned to the section during the previous site visit

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be reviewed when checking this field. Otherwise, there could be variability in the value assigned to this field from one year to another (e.g., V.GOOD during latest visit, but value for previous visit was GOOD). This information is not entered into the LTPP PPDB.

There are three more header fields in the header menu: Operator Comment, Run End Comment, and RCO Comment. It is recommended that these three fields be completed after the transverse Dipstick® data has been entered and evaluated.

Once all header entries have been made and checked, save header information.

3. Enter the transverse Dipstick® data. The transverse Dipstick® data collected in the field and recorded on form DS-8 are entered into ProQual through the Profiles tab. The readings taken from Edge of Pavement to Center Line should be entered in the left column. The data for the return run (center of pavement to edge of pavement) should be entered in the right column. All measurements should be entered exactly as recorded on form DS-8, with negative values on form DS-8 entered into ProQual as negative values.

   All three boxes on top of the graph should be checked so that elevations are displayed for the following:

   a. Run from the edge of pavement to the centerline.

   b. Run from the centerline to the edge of the pavement.

   c. Sum of the two elevation measurements.

   Once data have been entered, review and see if the graphical "Sum" plot is a horizontal line. If the line is not horizontal and spikes are noted at some locations, the data at those locations may have been incorrectly entered. If so, check if data have been entered correctly.

   After data have been checked for accuracy, click on "Verify Profiles." Confirm that the closure error limit has been met. If not, recheck the data entry. If the data do not meet the closure limit, the data from that run should be submitted to the FHWA with a copy to the LTPP Technical Services Support Contractor.

   Enter data for the other transverse locations. Follow the procedures outlined above to check those data.

4. Use the graphic profile option to check the profiles. After the data for all transverse profile runs have been entered, use the "Graphic Profile" option to plot the profile data. When this option is selected, a graph showing the profile plots for all transverse locations is displayed. Check if the profiles reasonably match between the stations. If a plot for any specific station appears to be different from the rest of the profiles, check the data that were entered for that location.

5. Run a rut analysis. Click on the "Rut Analysis" icon to compute rut depths and then print a Rut Report using the "Rut Report" icon. Review rut depths computed along the left and right wheel paths at different transverse locations. If the rut depth at any location appears to be different from those for the other locations, check if the data have been entered correctly.

   If the RSC maintains a record of rut depths computed by ProQual for a previous site visit, compare the current rut depths with those from the previous visit. The comparison should be made at each transverse location for each wheel path. If there are large differences, investigate if correct data have been entered.

6. Enter an Operator Comment, a Run End Comment, and a RCO Comment. The Operator Comment, Run End Comment, or RCO Comment is not uploaded to the LTPP PPDB. Therefore, entries made to these fields are only useful if the ProQual data files are reviewed at a future date. If the operator has made comments in form DS-8 related to data collection, enter the comments in the Operator Comment field. If all comments cannot be entered into this field, enter remaining comments in the Run End Comment field. Also, enter a RCO Comment if needed to comment on the data.

7. Create PPDB upload files. Run "IMS Export" to create RIMS files. If problems are encountered, resolve the issue and recreate the RIMS upload files, as needed.

8. Submit RIMS files to the appropriate RSC personnel for review and upload. The RIMS files should be submitted to appropriate RSC personnel for review and then uploaded to the LTPP PPDB. Resolve any issues that may arise during upload.

9. Backup the data. Backup all files related to the site that were created by ProQual. Use the file structure indicated in directive GO-41, Submission of Electronic Data for Customer Support and AIMS (or current version of that directive) to back up the data. Store the field data sheets and ProQual generated reports in appropriate files.

5.6 STORING WIM DATA

Profile data collected at WIM sections should be stored at the RSC offices in external hard disk based media with a USB interface. RSCs should follow the naming convention specified in LTPP directive GO-41, Submission of Electronic Data for Customer Support and AIMS (or the current version of that directive) in the creation of the external drive. For the ICC profiler, the raw profile data files that need to be backed up are the files with extensions of p, e, and v. All files generated by ProQual for each site should be backed up in conjunction with the raw profile data files.

The storage of working files should be done in accordance with LTPP Directive GO-41, Submission of Electronic Data for Customer Support and AIMS (or current version of that directive).

In addition to the CD ROMs, the RSCs should maintain a file with the completed Profiling of WIM Sections: Data Summary Sheet (form PROF-7 in appendix C) for each occasion a WIM section has been profiled.

CHAPTER 6. INTER-REGIONAL PROFILER COMPARISON TESTS

6.1 INTRODUCTION

This chapter describes a plan for periodic comparison of the inertial profilers that are used in the LTPP program. This comparison is usually performed on an annual basis at a date and location determined by the FHWA. The FHWA will select a host RSC who will be responsible for coordination of logistical arrangements (hotel, maps, traffic control, meeting places, etc.), selection and marking of comparison test sections, and measurement of the longitudinal profile on those test sections using a Dipstick®. The annual profiler comparison will be rotated among the four RSCs, so that they are responsible for preparatory activities once every four years. After completion of preparatory activities, but within 14 days of the Dipstick® measurements, nonhost RSCs will travel to the test sites and, together with the host RSC perform profile measurements over a two to four day period with their respective profilers.

A report summarizing the results of the profiler comparison tests and associated data must be submitted by each RSC to the FHWA LTPP Office, with a copy to the LTPP TSSC within 21 days after completion of the tests. Interregional comparison and analyses of the profiler test data will be performed by the TSSC, who will produce and submit to the FHWA LTPP Office a report of the results within 45 days after receipt of the individual RSC reports.

6.2 PREPARATORY ACTIVITIES

The host RSC will be responsible for the following activities:

1. Dates for profiler comparison tests in coordination with the FHWA, TSSC, and other RSCs.

2. Site selection.

3. Logistical arrangements (reserve block of rooms at or near selected site, meal arrangements, traffic control arrangements, etc.).

4. Communication of final logistical arrangements to FHWA, TSSC, and other RSCs.

6.3 TEST SECTIONS

The host RSC will be responsible for selecting and marking the test sites that will be used for the profiler comparison. Five test sections for profile testing and one test section for DMI testing should be selected by the host RSC. The five test sections for profile testing should be selected based on the following guidelines:

1. Section One (AC-l): Smooth AC: AC pavement with a mean IRI < 1.6 m/km.

2. Section Two (AC-2): Rough AC: AC pavement with a mean IRI > 2.2 m/km.

3. Section Three (PCC-l): Smooth PCC: Jointed PCC pavement with a mean IRI < 1.6 m/km.

4. Section Four (PCC-2): Rough PCC: Jointed PCC pavement with a mean IRI > 2.2 m/km.

5. Section Five: Chip sealed section.

The test sections used for profile testing should meet the following criteria:

1. The AC pavement sections should not be a PCC section that has been overlaid with AC.

2. The test sections should have a marked outside lane edge stripe that can be used as an outside lane edge reference.

3. The test sections should 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.

4. The speed limit of the roadways containing the test sections should be at least 80 km/h.

5. Each test section should be 152.4-m in length, with the beginning and end marked.

6. The test sections should be located within a centralized locale with short travel distances between each test section to reduce travel time where possible.

7. The test sections do not have to be located on LTPP test sections. However, LTPP test sections can be used when convenient.

An accurately measured section, 300 m long, should be established as the DMI test section. A standard surveying tape should be used in conformance with standard surveying practice to accurately locate the end point relative to the start point. The DMI test section should be located on reasonably level pavement suitable for such testing (i.e., low traffic volume, adequate sight distances, operator safety, etc.).

6.4 DIPSTICK® MEASUREMENTS AT TEST SECTIONS

Dipstick® measurements along both wheel paths at all test sections should be obtained using the procedures outlined in Chapter three. The Dipstick® measurements should be performed within 14 days of the profiler comparison tests. On PCC test sections, the Dipstick® measurements should be performed after noon, at the same approximate time of day as expected for the collection of profiler data. If sufficient resources are not available for performing Dipstick® measurements at all test sections, with approval from the FHWA, the RSC should perform Dipstick® data collection only at the smooth AC test section

6.5 PROFILER COMPARISON TESTS

The following sequence should be followed in performing tests during the profiler comparison test:

1. Full calibration check of laser height sensors.

2. Accelerometer calibration and bounce test.

3. Static height sensor test.

4. DMI calibration data collection to check bias and precision of DMI.

5. Test section profiling.

6. DMI verification.

Details on each of these tests/checks are described in the following sections.

6.5.1 Full Calibration Check of Laser Sensors

A full calibration check of the laser height sensors should be performed following the procedures described in section 2.5.4 of this manual.

6.5.2 Bounce Test

The accelerometers should be calibrated prior to performing the bounce test following the procedures described in section 2.5.3 of this manual. Perform the bounce test using the procedures described in section 2.3.3.3. Record the IRI for the static test and the dynamic bounce test. Save the files created during the bounce test.

6.5.3 Static Height Sensor Test

This test is performed to determine the bias and precision of the laser height sensors. The following procedures should be followed for performing this test:

1. Measure the distance from the ground to the glass face of the laser sensor. Record the reading for each height sensor on the Static Height Sensor Measurements form that is included in appendix G.

2. Drive the vehicle such that all four tires will rest on the support blocks. The height of each support block should be 76 mm, as described in section 2.5.4.1.

3. Place a calibration base plate on the ground under each laser sensor. Place a calibration surface plate on top of each base plate. Let the computer take at least 500 readings.

4. Place a block on each base plate such that the 25 mm side of the block is vertical. Place a calibration surface plate on top of each block. Let the computer take at least 500

readings. Record the value shown under "Dif Ht" for each sensor on the data sheet (corresponding to cells Base Plate + 25 mm Block + Calibration Plate for Test 1). The value shown in "Dif Ht" is the height of the block that is measured by the data acquisition system in the profiler.

5. Repeat step 3. Place a block on each base plate such that the 50 mm side of the block is vertical. Place a calibration surface plate on top of each block. Let the computer take at least 500 readings. Record the value shown under Dif Ht for each sensor on the data sheet (corresponding to cells Base Plate + 50 mm Block + Calibration Plate for Test 1).

6. Repeat step 3. Place a block on each base plate such that the 75 mm side of the block is vertical. Place a calibration surface plate on top of each block. Let the computer take at least 500 readings. Record the value shown under "Dif Ht" for each sensor on the data sheet (corresponding to cells Base Plate + 75 mm Block + Calibration Plate).

7. Repeat step 3. Place two blocks on each base plate such that the two 50 mm sides are stacked on top of each other to give a total height of 100 mm. Place a calibration surface plate on top of each block. Let the computer take at least 500 readings. Record the value shown under "Dif Ht" for each sensor on the data sheet (corresponding to cells Base Plate + 100 mm Block + Calibration Plate).

8. Repeat steps 3 through 7 four more times and record readings on the data sheet.

9. Perform the following computations (Note: A spreadsheet can be used to perform these computations):

   a. Compute the average values obtained for tests one through five in the appropriate cell.

   b. Enter the actual block height in the appropriate cells.

   c. Subtract the average value computed previously from the actual block height and enter computed values in appropriate cells.

   d. Compute the standard deviation of block height measured by the data acquisition system for each block position (values shown under Height of Block for Tests one through five) for all sensors and record values on the form.

6.5.4 DMI Test

Calibrate the DMI following procedures described in section 2.5.2 of this manual. Then perform a profile run on the DMI section and record the distance shown under "Distance Old DCF" and the air temperature obtained from the temperature probe on the DMI Measurement form (see appendix G). Repeat this procedure five more times. The tire pressure may be checked and adjusted if necessary prior to performing each run. Compute the average and standard deviation of the six recorded distances.

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6.5.5 Profile Testing

Profile data collection at each test section should be performed following the procedures that are used when performing data collection at GPS sections as outlined in this manual. Testing should be performed at a speed of 80 km/h. The PCC test sections should be profiled after noon.

6.5.6 Verification of DMI

The purpose of this test is to evaluate the stability of the DMI over time. This test should be performed after all five test sections have been profiled. The DMI should not be calibrated before doing the verification testing. Warm up the tires using the procedures that were used when the tires were warmed up prior to calibrating the DMI. Perform a profile run on the DMI section and record the distance shown under "Distance Old DCF" and the air temperature obtained from the temperature probe on the DMI Verification form (see appendix G). Repeat this procedure five more times. The tire pressure may be checked and adjusted if necessary prior to performing each run. Compute the average and standard deviation of the six recorded distances.

6.6 REPORTS

6.6.1 Submission of Reports and Data by RSCs

Within 21 days after completion of the comparison testing, each RSC should submit a report and the data collected during the comparison test to the FHWA LTPP Office, with a copy to the TSSC. Section 6.6.2 presents the format for this report and section 6.6.3 describes the profile data that should be submitted.

6.6.2 Format of Report

The report should consist of the following items:

1. Static Height Sensor Measurements form (see appendix G).

2. DMI Measurement form (see appendix G).

3. DMI Verification form (see appendix G).

4. IRI Values Table: Compute the IRI of the five runs at each site that would have been selected for upload to the LTPP database using the current version of ProQual. Enter the IRI values into the IRI Values table that is included in appendix G. Compute average and standard deviation of IRI for each wheel path at each site.

5. Profile Plots: Use ProQual to overlay the five selected runs at each site. Create the following graphs separately for each site and cut and paste them into the report: (a) five overlaid runs for left wheel path, (b) five overlaid runs for the right wheel path, (c) five overlaid runs for the center path, (d) overlay two runs and show left and right profiles on same graph. Create these graphs for all five sites. Indicate test section, surface type, and date of testing with each set of graphs.

6. Bounce Test Results: Create a table and show IRI values for static test and dynamic bounce test for each test day of profiler.

7. Site Visit report generated by ProQual for each site in the report.

If any data anomalies are noted for the static height sensor measurements, DMI testing, IRI values at a test section, or repeatability of profile plots, discuss the possible causes for these anomalies.

The host RSC should include the following items in the report:

1. Provide a description of structural attributes (if known) and observed distresses for all test sections. Details should be given on those attributes of the test section which are suspected of influencing profile measurements, such as meandering cracks in the wheel paths, highly variable transverse profile, etc. Detailed measurements are not required and subjective based descriptions are satisfactory. Include a photograph(s) of test sections in the report.

2. Include a table showing the IRI values computed from Dipstick$^{®}$ measurements. Indicate date and time when Dipstick$^{®}$ measurements were performed.

6.6.3 Data Submission

Organize the data into a CD in a logical manner. The following data should be submitted in a CD:

1. Bounce test files for each day (p, e and v files from the ICC profiler and ERD files created from this data).

2. Data collected by the ICC profiler at the five test sites. These are the files with extension p, e, and v, and the ERD files created from those data files.

3. Files created by ProQual when data were processed.

4. Excel file with separate sheets in the file for each of the following items: Static Height Sensor Test Results, DMI Measurements, DMI Verification Results, and IRI values.

5. Data files containing the Dipstick$^{®}$ data, submitted by the host RSC.

6.6.4 Preparation of Report by TSSC

On receipt of the RSC reports and data, an interregional comparisons and analyses of the test results will be performed by the TSSC. A report summarizing the results of this effort should be submitted to the FHWA LTPP Office within 45 days after receipt of the individual RSC reports.

The report will document the results of the following analyses:

1. Evaluate the static accuracy of the profiler height sensors. The results from the static height sensor test will be evaluated to determine if the bias of each height sensor at each measurement position is within 0.25 mm, and if the precision of each height sensor at each measurement position is less than 0.125 mm.

2. Evaluate the results from the bounce test. The static and dynamic bounce test IRI values that were obtained for the profilers will be evaluated to determine if they meet the criteria specified in this manual.

3. Evaluate the accuracy of the DMI. The results obtained from the DMI test will be evaluated to determine if bias of the DMI is within 0.15 m (0.05 percent of the length of the section), and that the precision of the DMI is less than 0.075 m.

4. Compare the IRI values obtained by the profilers with those from the Dipstick® and compare the IRI values between the profilers. The IRI values will be evaluated to determine if:

   a. The precision of the IRI along a wheel path for a profiler is less 0.04 m/km.

   b. The difference in IRI for a wheel path between the Dipstick® IRI and average profiler IRI obtained from the five runs is less than 0.16 m/km.

5. Evaluate repeatability of each profiler along each wheel path at all sites by examining overlaid profile plots and by analyzing the point to point repeatability of each profiler.

6. Compare profile data obtained by the four profilers by preparing overlaid profile plots for each wheel path at each test section by selecting one representative profile run for each profiler at each test section.

APPENDIX A. PROFILER PROBLEM REPORT FORM

In an effort to provide for a more uniform way of reporting, handling, and tracking problems associated with the LTPP pavement profile monitoring activities, the FHWA LTPP team has designed a Profiler Problem Report (PROFPR) form that is included in next page for use by the regional contractors.

The PROFPR form provides several major benefits, including a standard format for submitting problems associated with the profiler monitoring activities, an easy means of tracking when a problem was submitted, who is responsible for resolving it, whether or not it has been resolved, and how and when it was resolved, and reduced probability of problems being forgotten or falling through the cracks.

A profiler problem report must be submitted whenever there are equipment problems in the profiler, problems with data collection or data processing software, problems with data collection guidelines, or other problems related to profiling activities or profile data. If a problem was encountered, and it was resolved, and the operator/coordinator feels that this information would be useful to the other RSCs, an informational problem report should be submitted. When submitting an informational problem report, indicate that the problem report is being submitted for informational purposes in the description part of the form.

The Profiler Problem Report form is self explanatory except for the PROFPR number. The number consists of two parts as follows:

A letter code representing the agency submitting the problem, F for FHWA LTPP Division, NA for North Atlantic RSC, NC for North Central RSC, S for Southern RSC, W for Western RSC, and TSSC for TSSC, and O for others.

A number code representing the PROFPR number for the submitting agency, in sequential fashion starting from one.

For example, F-07 represents the seventh problem reported by the FHWA LTPP Team; and NA-23 represents the 23rd problem reported by the North Atlantic RSC.

Completed PROFPR forms must be submitted to the FHWA LTPP Team, with copies to the TSSC and to the profiler coordinator at each RSC office. Forms may be faxed or transmitted electronically via e-mail message, but the latter option is much preferred. A complete set of the PROFPR submittals will be maintained by the FHWA LTPP Team and LTPP TSSC. A copy of the report should be submitted to the RSCs for their information and action, as appropriate.

LONG-TERM PAVEMENT PERFORMANCE (LTPP)
PROFILE PROBLEM REPORT (PROFPR)

Attention: _____

_____

_____

_____

_____

Type of Problem		Reported by: _____
Guidelines	_____	Agency: _____
Equipment	_____	
Software	_____	Date: _____
Name	_____	Urgent (Y/N) ____
Version	_____	
Other	_____	Page ___ of ___

Description:

THIS SECTION FOR USE BY FHWA AND TSSC	
Received by: _____	Date Received: _____
Referred to: _____	Approved by: _____
Date Referred: _____	Date Approved: _____

Resolution:

Notes:

APPENDIX B. PROFILE TROUBLE SHOOTING GUIDE

This appendix contains a catalog of problems commonly encountered by LTPP operators when collecting and reviewing profile data. Knowledge of these problems will help operators to collect more accurate and valid profile data for the LTPP program. These commonly encountered problems can be grouped into the following four categories:

1. Spikes in Profile due to Equipment Problems.
2. Miscalibrated DMI.
3. Early Start of Data Collection.
4. Different Profiles.

A brief description of each of these problems is presented in this appendix along with plots illustrating such conditions. To detect most of these problems, the profile data in question must be compared to those collected during the previous site visit (see section 2.2.8). This requires that profile data from the previous site visit be available. Furthermore, in order to perform an accurate and valid comparison, profile data from the previous site visit must be error free. Descriptions and references made later in this appendix to the profile data comparisons assume that data from the previous site visit are error free.

1. Spikes in Profile Due to Equipment Problems

Spikes can be introduced in the profile data as a result of equipment problems. These spikes can be identified by comparing multiple profile runs at a section. Accordingly, once a set of profile runs has been collected, the operator should compare the data from the repeat runs using the multi run plot option in ProQual (see reference 6). This comparison should be performed separately for the left, right, and center path profile data. Figure 94 illustrates the presence of a spike in the profile data. This figure shows five profile runs collected on the left wheel path. The profile data for run 4 indicates a spike that is not present in the other four runs. Profile data for run 4 has been offset in figure for clarity; in the ProQual multi run plot option, these repeat profile runs are color-coded (i.e., different color for each run). Since the spike only occurs in one run of the data set, it is possible that this spike may not have been caused by a pavement feature. When such a condition is encountered, the operator should determine if the spike is due to an equipment problem or if it is a pavement feature.
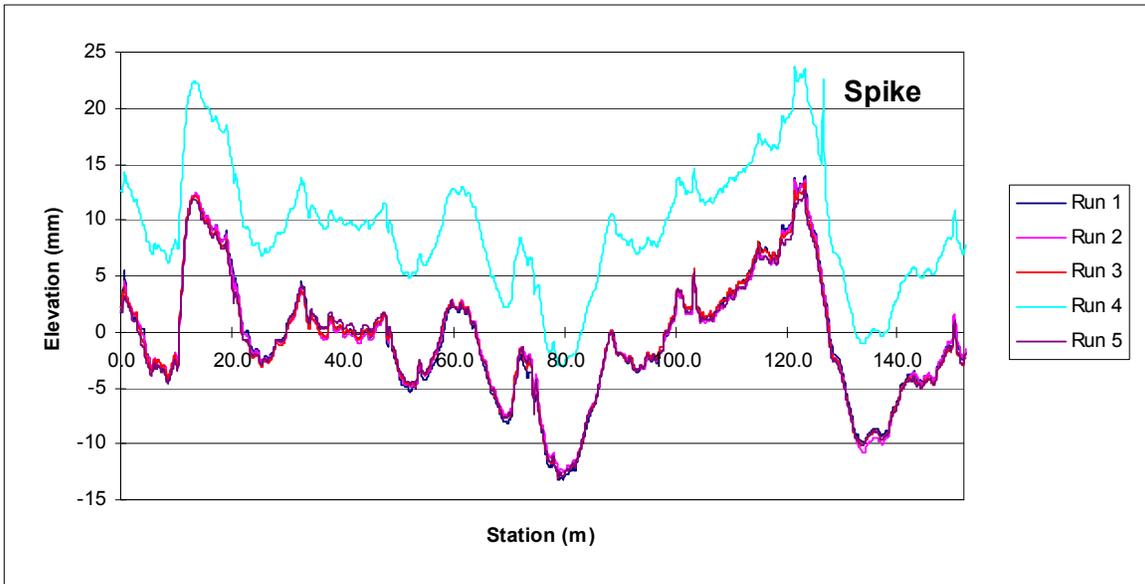
Figure 94. Graph. Spike in profile data (profile data for run 4 has been offset for clarity).

2. Miscalibrated DMI

A miscalibrated DMI cannot be detected by comparing the five repeat profile runs obtained during a site visit. However, when those runs are compared with the profile runs collected during the previous site visit, the profile (elevation versus distance) plot for the more recently collected data will appear squeezed or stretched in the x (distance) direction if the vehicle has a miscalibrated DMI. The comparison of the current and the previous profile data should be carried out using the multi visit plot option in ProQual (see reference 6). An example of profile data associated with a miscalibrated DMI is shown in figure 95; data for May 2, 1990, was collected using a miscalibrated DMI.
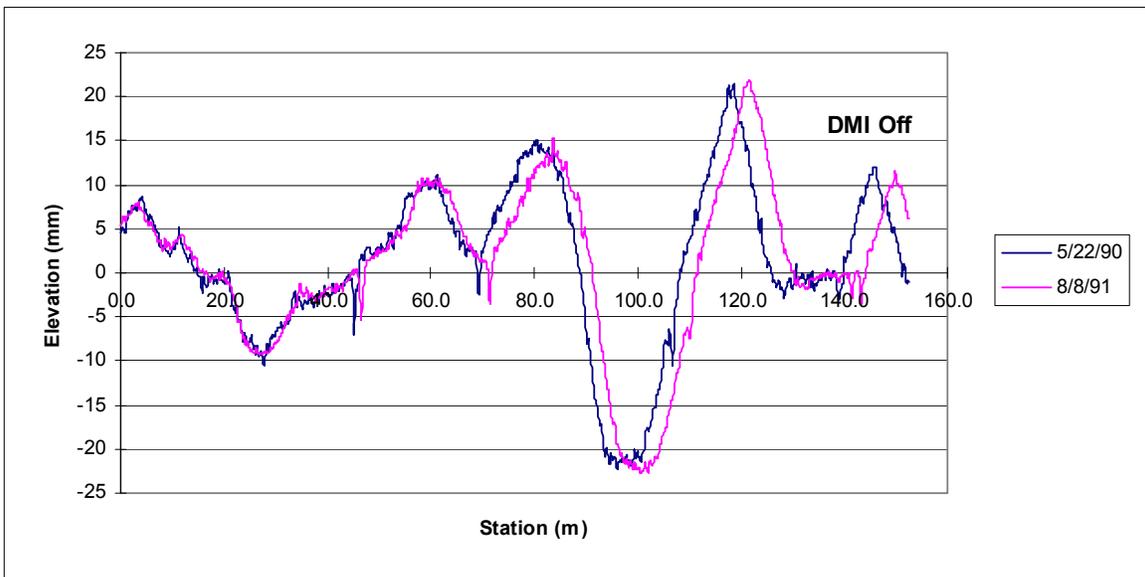
Figure 95. Graph. Data collected with a correctly calibrated and a miscalibrated DMI.

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When this problem is encountered, the operator should check tire pressure of vehicle to ensure it is at the values at which the DMI was calibrated. If the current tire pressure is different, the operator should adjust tire pressure so it matches tire pressure when the DMI was calibrated, and obtain a new set of measurements at the section. If the difference in the distance between the current data and previous data at the end of the section is less than or equal to 0.5 m for a GPS section, the current data set is considered to be acceptable. If the difference in the distance between the current data and the previous data is greater than 0.5 m, the operator should determine if the difference is occurring because the DMI is incorrect during the current visit or if it was incorrect during the previous visit. The following procedures can be used by the operator to make this determination:

1. The operator can determine if the DMI is calibrated correctly by running the section and then noting the distance between the event mark at the start of the section and end of the section that will be displayed in the green color MDR Run Screen. The event mark at the start of the section will generate a Reference Reset, and an event mark will be generated when the profiler passes the end of the section. If the length of the section obtained when the section is profiled using this procedure is within ±0.3 m of 152.4 m, the DMI can be assumed to be working properly. However, there may be cases where the actual length of the site is not 152.4 m. So if the distance obtained using the described procedure is outside the specified limit, it cannot be concluded that the DMI is working incorrectly. If such a case is encountered, the operator should follow the procedure described in the next step.

2. The operator can check on the accuracy of the DMI for the previous visit by calling the office and asking the office personnel to compare the previous year data with other data that is available for the site. Currently it is expected that all test sections would have at least two previous profile data sets. The purpose of this comparison is to determine if there is any error in DMI associated with the data from the previous visit. The office personnel should compare the relative position of the profile at the end of the section for previous visits to the section by the profiler, and convey that information to the operator. The office personnel together with the operator can then use the available information to judge the accuracy of the DMI for the current data. If all the available data indicates that the DMI for the previous visit is accurate, the indications are that the DMI in the profiler is out of calibration. The operator should proceed to another site, and compare the profile plots following the procedures described previously. If the data at that site also indicates the DMI is out of calibration, the DMI should be calibrated before further profile data are collected.

For SPS sites differences between runs can occur because of wheel path wander. This effect will usually be more pronounced in the sections that are located towards the end of the SPS section. When comparing profile data between two site visits at SPS sections, close attention should be paid to the first two sections in the SPS site. If the profile for the current data and the previous site visit data satisfies the criteria that were described previously at the first two sites, it can be concluded that the DMI is functioning correctly for the current visit. In such a case, a difference in distance of up to 1 m can be considered to be acceptable for the other sections in the SPS project.

3. Early Start of Data Collection

An early profile start can occur when the photocell triggers a reference reset prior to the start of the test section. It is possible for all repeat profile runs during a site visit to have the same starting location, with all runs having an early start. This problem can occur if there is a mark on the pavement that triggers data collection to start at the same location, but this location is before the beginning of the test section. When the current profile data are compared with those collected during the previous site visit, the early start problem can be easily identified by a clear shift in the two profile data sets. This profile comparison should be carried out using the multi visit plot option of ProQual (see reference 6). The early start problem is illustrated in figure 96, which shows the profile plot for a single run along the left wheel path conducted on three different dates—April 8, 1990; October 18, 1990; and August 10, 1994. The profile plot for the last two dates have similar start locations, but that for the earlier date (April 8, 1990) is shifted to the left because of an early start. If the early start problem is caused by a mark on the pavement that is located prior to the pavement section, the operator can use the horizontal photocell to initiate data collection.
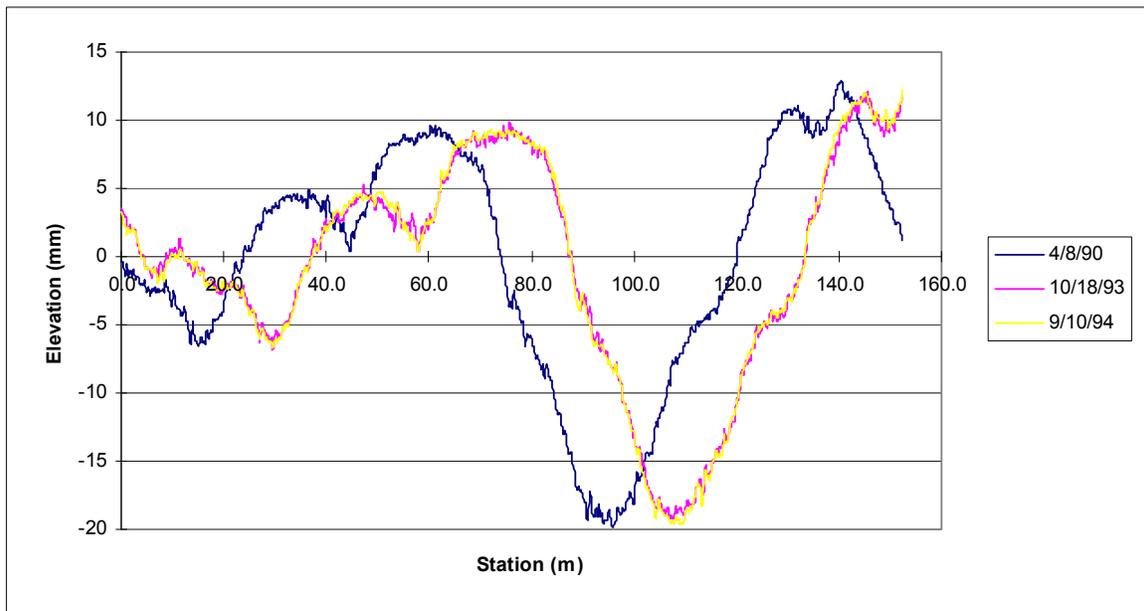
Figure 96. Graph. Example of early profile start.

The early start problem can also occur in one or more runs within a profile data set collected during a single site visit. This problem can be easily identified by comparing the repeat profiler runs using the multi run plot option in ProQual; one or more of runs will be shifted to left of the others if there is an early start. Although a plot illustrating the early start problem within a set of repeat runs is not included in this appendix, that plot will be very similar to that shown in figure 96. If an early start is detected in one or more profile runs, the operator should perform additional profile runs until a set of error free data (meeting the criteria described in section 2.2.8) is obtained. If the early start problem is caused by a mark on the pavement that is located prior to the pavement section, the operator can use the horizontal photocell to initiate data collection.

4. Different Profiles

The term "different profiles" is used to describe the occurrence of the following conditions: (a) when the operator compares repeat profile runs collected during a single site visit, no problems are observed in the data (i.e., error free) and (b) when the operator compares current data with that from previous site visit (also error free), the two sets of profiles appear to be different.

Such condition can be caused by rehabilitation or maintenance activities to the section between profiler site visits. It can also occur when the location of test section is incorrectly selected during one of the site visits.

Figure 97 illustrates the case where rehabilitation has been performed on a test section between site visits. This figure shows a plot of the left wheel path profile obtained on two separate site visits—September 10, 1991 and October 4, 1994. The two profiles shown in this plot are completely different. In this particular example, the profile differences were caused by an overlay that was placed on the section some time between the two site visits. When the location of the test section has been incorrectly selected during one of the site visits, differences in profile similar to those shown in figure 97 will be seen.
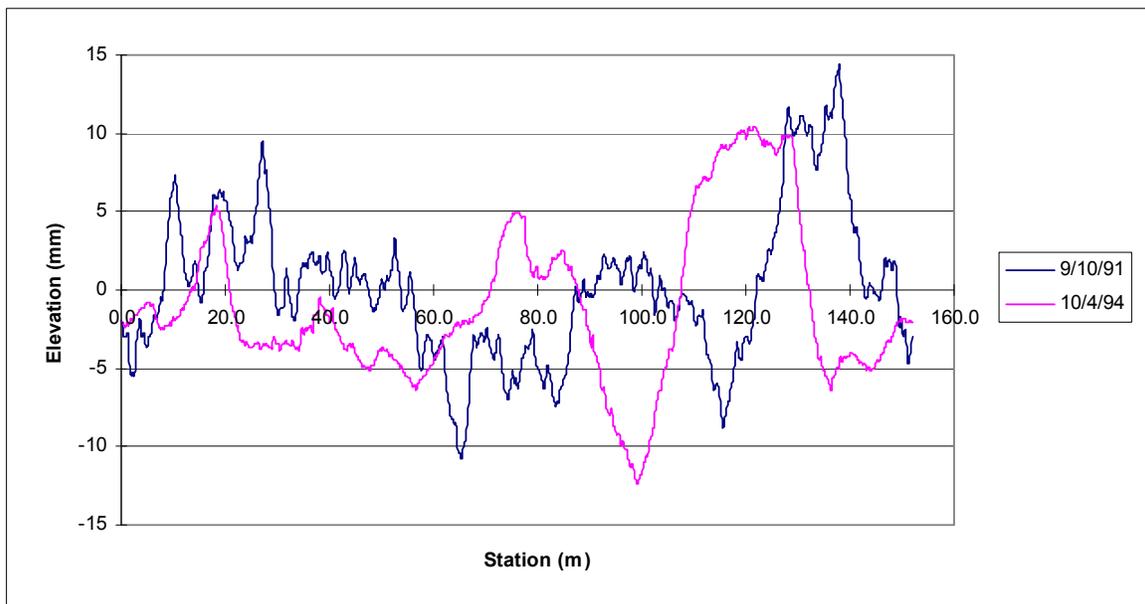
Figure 97. Graph. Differences in profile due to rehabilitation of section.

If a case such as that shown in figure 97 is encountered, the operator should first verify that the test section location is correct. If such a condition is encountered at a SPS section or at a GPS section that was profiled in conjunction with a SPS section, the operator should verify that the stationing used for subsectioning is correct. If evidence of rehabilitation is noted at the section, it should be entered as an Operator Comment and also noted in the form Status of Regions Test Sections.

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An example where maintenance has occurred at a test section between site visits is illustrated in figure 98. This figure shows a plot of the left wheel path profile obtained on two separate site visits—August 8, 1991, and August 5, 1992. This plot shows the profile at the beginning of the test section for the two site visits are different, indicating possible maintenance at the test section.

If a case such as that shown in figure 98 is encountered, the operator should look to see if there is evidence of maintenance activities, such as patching is present within the test section. If evidence of maintenance is found, the operator should indicate that maintenance has been performed on the test section in the Operator Comment Field (e.g., POSSIBLE MAINTENANCE IN SECTION) and also note it in the Status of Regions Test Sections form.
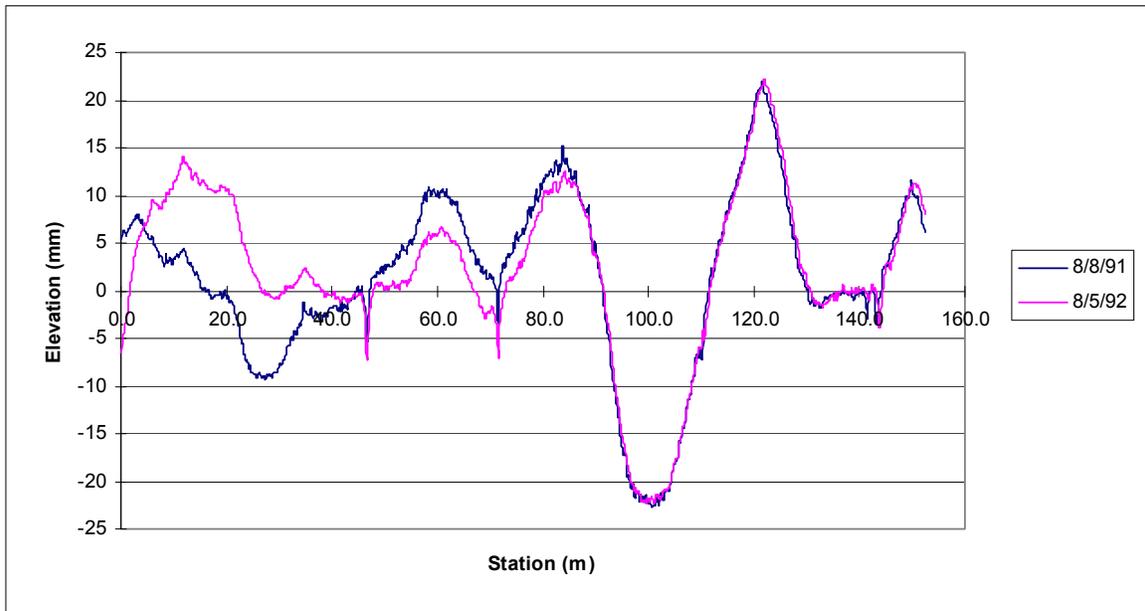
Figure 98. Graph. Differences in profile due to maintenance within section.

APPENDIX C. STANDARD FORMS FOR PROFILER OPERATIONS

DAILY CHECK LIST

ITEM
Under Hood
Fluids
Engine Oil
Brake
Windshield Washer Fluid
Radiator Coolant
Transmission
Exterior
Lights
Front
Rear
Emergency
Turning Signals
Strobe Bar
Flashing Signal Bar
Glass Cleaning
Windshield
Laser Sensor
Photocell
Underbody
Tires Properly Inflated
Fluid Leaks
Interior
Temperature Range

	LTPP Profiler Operations	Region	[___ ___]
	LTPP Profiler Field Activity Report	State Code	[___ ___]
	Form PROF-1	LTPP Section ID	[___ ___ ___ ___]

File Name: [___ ___ ___ ___ ___ ___ ___ ___]   **Surface:** [___ - ___ ___]   **LTPP Experiment Code:** [___ ___ ___ - ___]

Route/Highway Number: _____

Date: [___ ___ / ___ ___ ___ / ___ ___ ___ ___]   **Time Zone:** [___ ___ ___]   **Sheet Number:** _____

Laser Check Performed? _____ (Initial)   **Values From Check (mm):   Left** _____   **Center:** _____   **Right:** _____

Computer Time Set to Correct Local Time: _____ (Initial)   **Accelerometer Calibration Values Checked:** _____ (Initial)

Tire Pressure: Left: _____   Right: _____   Comments: _____

Bounce Test

	Left	Center	Right
Static			
Dynamic			
Difference			

	Time	Odometer
Start Travel	___ ___ : ___ ___	_____
Begin Test	___ ___ : ___ ___	_____
End Test	___ ___ : ___ ___	_____
End Travel	___ ___ : ___ ___	_____

Down Time: _____ (Hours / Minutes)   Reason(s): _____

_____

_____

Run Number	Average IRI
1	_____
2	_____
3	_____
4	_____
5	_____
6	_____
7	_____
8	_____
9	_____

10 % IRI Check After Testing

	Date	Left	Right	Average
Current Visit (R_{new}):	_____	_____	_____	_____
Prior Visit (R_{old}):	_____	_____	_____	_____
Percent Change [$100X(R_{new} - R_{old})/R_{old}$]:	_____	_____	_____	

Comment: _____

_____

_____

_____

_____

Additional Remarks Regarding Testing: _____

_____

_____

_____

_____

_____

Profile Crew: Driver: _____   Operator: _____

Others Present (List Names and Agencies): _____

_____

LTPP Profiler Operations
Status of Regions Test Section
Form PROF-2

LTPP ID Number	Experiment Type (e.g., GPS)	Date	Operator	Route	Direction	Mile Post	Current IRI			Paint Marks	Delineators	Signs	Comments (e.g., Any Rehab or Maintenance?)
							Left	Right	Avg				

LTPP Profiler Operations
Profiler Log
Form PROF-3

Date	Noted Problem	Action Taken and Date

LTPP Profiler Operations	Region	[___ ___]
LTPP Major Maintenance/Repair	Serial Number	[___ ___ ___ ___ ___]
Work Order	Odometer	[___ ___ ___ ___ ___ ___]
Form PROF-4	Scheduled	[YES / NO]

Problem Identification / Scheduled Maintenance

Equipment: _____

Description: _____

_____

_____

_____

Performed By: _____

Date: [__ __ / __ __ __ __ / __ __ __ __]

Start Time: [__ __ : __ __]

End Time: [__ __ : __ __]

Troubleshooting

Description: _____

_____

_____

_____

_____

Performed By: _____

Date: [__ __ / __ __ __ __ / __ __ __ __]

Start Time: [__ __ : __ __]

End Time: [__ __ : __ __]

Hours: _____

Reporting

Referred to: _____

_____

Actions (Return/Order Parts): _____

_____

_____

_____

Date: [__ __ / __ __ __ __ / __ __ __ __]

Time: [__ __ : __ __]

Date: [__ __ / __ __ __ __ / __ __ __ __]

Time: [__ __ : __ __]

Service

Description (Repairs Performed/Replacement Part Information): _____

_____

_____

_____

Agency Performing Maintenance: _____

_____

_____

Performed By: _____

Date: [__ __ / __ __ __ __ / __ __ __ __]

Start Time: [__ __ : __ __]

End Time: [__ __ : __ __]

Hours: _____

Total Cost: [$ __ __ __ __ __ . __ __]

Verification

Description (Check/Calibration): _____

_____

_____

_____

Performed By: _____

Date: [__ __ / __ __ __ __ / __ __ __ __]

Start Time: [__ __ : __ __]

End Time: [__ __ : __ __]

Hours: _____

Return to Service

Status: _____

Performed By: _____

Date: [__ __ / __ __ __ __ / __ __ __ __]

<table>
<tr><td colspan="2" rowspan="4">LTPP Profiler Operations
Calibration Form
(Laser Sensors Checked Simultaneously)
Form PROF-5</td><td>Region</td><td>[__ __]</td></tr>
<tr><td>Date</td><td>[__ __ / __ __ __ / __ __ __ __]</td></tr>
<tr><td>Time</td><td>[__ __ : __ __]</td></tr>
<tr><td>Serial Number</td><td>[__ __ __ __ __]</td></tr>
</table>

Operator(s): _____   Location: _____

Accelerometer Calibration

Calibration Factor	Accel #1	Accel #2	Accel #3
Prior			
New			

Bounce Test After Accelerometer Calibration

	Left	Center	Right
Static			
Dynamic			
Difference			

Laser Calibration Check

Block Position	Parameter	Row Number	Sensor Left #1	Sensor Right #2	Sensor Center #3
	Actual Height, Block A	(1)			
	Value Entered to Computer	(2)	25.00	25.00	25.00
25 mm	Adjustment Value (1) - (2)	(3)			
	Dif Blk from Computer	(4)			
	Adjusted Dif Blk (4) - (3)	(5)			
	Actual Height, Block A	(6)			
	Value Entered to Computer	(7)	50.00	50.00	50.00
50 mm	Adjustment Value (6) - (7)	(8)			
	Dif Blk from Computer	(9)			
	Adjusted Dif Blk (9) - (8)	(10)			
	Actual Height, Block A	(11)			
	Value Entered to Computer	(12)	75.00	75.00	75.00
75 mm	Adjustment Value (11) - (12)	(13)			
	Dif Blk from Computer	(14)			
	Adjusted Dif Blk (14) - (13)	(15)			
	Actual Height, Block A	(16)			
	Actual Height, Block B	(17)			
	Value Entered to Computer	(18)	100.00	100.00	100.00
100 mm	Adjustment Value (16) + (17) - (18)	(19)			
	Dif Blk from Computer	(20)			
	Adjusted Dif Blk (20) - (19)	(21)			

Air Temperature Probe Calibration Check

Verification Medium	ASTM Thermometer	Air Temperature Probe
Ambient Air		

Distance Measuring Instrument Calibration

Begin Time: [__ __ : __ __]   End Time: [__ __ : __ __]

Air Pressure	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
Left						
Right						

Prior Distance Calibration Factor: [__ __ __ __]   New Distance Calibration Factor: [__ __ __ __]

Comments: _____

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<table>
<tr><td rowspan="4">LTPP Profiler Operations
Calibration Form
(Laser Sensors Checked Individually)
Form PROF-6</td><td>Region</td><td>[__ __]</td></tr>
<tr><td>Date</td><td>[__ __ / __ __ __ / __ __ __ __]</td></tr>
<tr><td>Time</td><td>[__ __ : __ __]</td></tr>
<tr><td>Serial Number</td><td>[__ __ __ __ __]</td></tr>
</table>

Operator(s): _____   Location: _____

Accelerometer Calibration

Calibration Factor	Accel #1	Accel #2	Accel #3
Prior			
New			

Bounce Test After Accelerometer Calibration

	Left	Center	Right
Static			
Dynamic			
Difference			

Laser Calibration Check

Block Position	Parameter	Sensor Left #1	Sensor Right #2	Sensor Center #3
25 mm	Actual Height of Block			
	Dif Ht Value			
	Dif Blk Value			
50 mm	Actual Height of Block			
	Dif Ht Value			
	Dif Blk Value			
75 mm	Actual Height of Block			
	Dif Ht Value			
	Dif Blk Value			
100 mm	Actual Height Block 1			
	Actual Height Block 2			
	Dif Ht Value			
	Dif Blk Value			

Air Temperature Probe Calibration Check

Verification Medium	ASTM Thermometer	Air Temperature Probe
Ambient Air		

Distance Measuring Instrument Calibration

Begin Time: [__ __ : __ __]   End Time: [__ __ : __ __]

Air Pressure	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
Left						
Right						

Prior Distance Calibration Factor: [__ __ __ __]   New Distance Calibration Factor: [__ __ __ __]

Comments: _____
_____

	LTPP Profiler Operations
	Profiling of WIM Sections
	Data Summary Sheet
	Form PROF-7

State Code: _____ SHRP ID Assigned to WIM Location: _____

Date Tested: __ __ / __ __ __ / __ __ __ __   Pavement Type: _____

Operator/Driver: _____

Test Reason: Verification _____   Acceptance Testing _____   Annual Check _____

_____ m distance from Station _____ + _____ m of LTPP Section _____

Profiler Photocell Offsets: Vertical: _____mm   Horizontal: _____mm

Run Number	Location (Note 1)	Offset Reference and Distance (Note 2)	Time at Start of Run	File Name	Error Free?
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					

Note 1: Indicate location of run -- WP for wheel path, Left for left of wheel path, Right for right of wheel path

Note 2: For runs obtained left and right of wheel path, indicate the offset and reference for the offset (e.g., for runs left of the wheel path - 0.75 m left of wheel path; for runs right of wheel path - 0.5 m from right shoulder stripe).

Pavement condition at time of data collection that may have influenced profile measurements (e.g., crack sealant condition, joint sealant condition, distresses within section).

_____

_____

_____

Other information related to WIM site that may have influenced data collection (e.g., length of sensor array for multiple sensor configuration).

_____

_____

_____

<table>
<tr><td colspan="2">LTPP Profiler Operations
Accelerometer Test

Form PROF-8</td><td>Region   [___ ___]
Date   _ ___ / ___ ___ ___ / ___ ___ ___ ___]
Time   [___ ___ : ___ ___]
Serial Number   [___ ___ ___ ___ ___]</td></tr>
</table>

Operator(s): _____   Location: _____

Accelerometer Check

Parameter	Row Number	Accelerometer Calibration Factors (ACF)		
		Left #1	Right #2	Center #3
Pre-Test	(1)			
Switch at Position C - Offset I	(2)			
Switch at Position A (negative value) [valid range within -2552 and -2088]	(3)			
Switch at Position B (positive value) [valid range within 1908 and 2332]	(4)			
Switch at Position C - Offset 2	(5)			
Post-Test	(6)			
Calc 1: Difference in Offset Values, (Row 2 -Row 5) [±10]	(7)			
Calc 2: Offset 1 -1638, Row 2 - 1638	(8)			
Calc 3: Range Check for Pre-Test (Row 8 - Row 1) [±48]	(9)			
Calc 4: Range Check for Post-Check, (Row 8 - Row 6) [±48]	(10)			
Calc 5: Difference in Pre and Post Values, (Row 6 - Row 1[±24]	(11)			

Comments: _____

_____

_____

_____

_____

APPENDIX D. STANDARD FORMS FOR DIPSTICK® MEASUREMENTS

LTPP Dipstick Data Collection Form Longitudinal Profile Form DS-1 Measurement Information and Closure Computation	State Code [_ _] LTPP Section [_ _ _ _] Date (dd/mmm/yy) _ _ / _ _ _ / _ _

Dipstick Serial Number: [_ _ _ _ _]   Dipstick Model Number: <u>1500/2000/2200</u>

Dipstick Fitted with 32 mm footpads? __

Footpad Spacing (mm): [_ _ _ . _ _]   Operator: [_ _]   Recorder: [_ _]

Site Type: <u>GPS/SPS/WIM/Other</u>   Surface Type: [_ - _ _]   Pavement Condition: <u>V.GOOD/GOOD/FAIR/POOR</u>

Road Name:_____   Lane: <u>Inside/Outside</u>

Direction: <u>NORTH/EAST/SOUTH/WEST</u>   Cloud Conditions: <u>CLEAR/P. CLOUDY/CLOUDY</u>

Start Air Temperature: __°C   End Air Temperature: __°C   Average Air Temperature: __°C

Weather Comment:_____

Start Time (military): ___ ___ : ___ ___   Stop Time (military): ___ ___ : ___ ___

No	Elevation Sum	No	Elevation Sum	
O1		I1		
O2		I2		
O3		I3		**Traffic Control**
O4		I4		**Crew:**
O5		I5		
O6		I6		
O7		I7		
O8		I8		
O9		I9		
O10		I10		
O11		I11		
O12		I12		
O13		I13		**Other Personnel**
O14		I14		**At Site:**
O15		I15		
O16		I16		
O17		I17		
O18		I18		
O19		I19		
O20		I20		
Total O1 to O20	OA	Total I1 to I20	IA	
Transverse Sum T2	OB	Transverse Sum T1	IB	**Closure Error**
Total OA+OB	OC	Total IA + IB	IC	OC+IC

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State Code [__ __]
LTPP Section ID [__ __ __ __]
Date (dd/mmm/yy) [__ __ / __ __ __ / __ __]

Reading No.	Reading (mm)		Reading No.	Reading (mm)		Reading No.	Reading (mm)		Reading No.	Reading (mm.)	
	RWP ⇓	LWP ⇑		RWP ⇓	LWP ⇑		RWP ⇓	LWP ⇑		RWP ⇓	LWP ⇑
1			26			51			76		
2			27			52			77		
3			28			53			78		
4			29			54			79		
5			30			55			80		
6			31			56			81		
7			32			57			82		
8			33			58			83		
9			34			59			84		
10			35			60			85		
11			36			61			86		
12			37			62			87		
13			38			63			88		
14			39			64			89		
15			40			65			90		
16			41			66			91		
17			42			67			92		
18			43			68			93		
19			44			69			94		
20			45			70			95		
21			46			71			96		
22			47			72			97		
23			48			73			98		
24			49			74			99		
25			50			75			100		
Sum	O1	I1		O2	I2		O3	I3		O4	I4

Transverse Closure Measurements from Left Wheel Path to Right Wheel Path at Station 0+00

	Transverse Position							Sum
	LWP-1	1-2	2-3	3-4	4-5	5 - CC	CC - RWP	
Reading (mm)								T1

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LTPP Dipstick Data Collection Form Longitudinal Profile Form DS-3 Reading 101 to 200	State Code LTPP Section ID Date (dd/mmm/yy)	[__ __] [__ __ __ __] [__ __ / __ __ __ / __ __]

Reading No	Reading (mm)		Reading No	Reading (mm)		Reading No	Reading (mm)		Reading No	Reading (mm)	
	RWP ⇓	LWP ⇑		RWP ⇓	LWP ⇑		RWP ⇓	LWP ⇑		RWP ⇓	LWP ⇑
101			126			151			176		
102			127			152			177		
103			128			153			178		
104			129			154			179		
105			130			155			180		
106			131			156			181		
107			132			157			182		
108			133			158			183		
109			134			159			184		
110			135			160			185		
111			136			161			186		
112			137			162			187		
113			138			163			188		
114			139			164			189		
115			140			165			190		
116			141			166			191		
117			142			167			192		
118			143			168			193		
119			144			169			194		
120			145			170			195		
121			146			171			196		
122			147			172			197		
123			148			173			198		
124			149			174			199		
125			150			175			200		
Sum	O5	I5		O6	I6		O7	I7		O8	I8

Reading No.	Reading (mm)		Reading No.	Reading (mm)		Reading No.	Reading (mm)		Reading No.	Reading (mm)	
	RWP ⇓	LWP ⇑		RWP ⇓	LWP ⇑		RWP ⇓	LWP ⇑		RWP ⇓	LWP ⇑
201			226			251			276		
202			227			252			277		
203			228			253			278		
204			229			254			279		
205			230			255			280		
206			231			256			281		
207			232			257			282		
208			233			258			283		
209			234			259			284		
210			235			260			285		
211			236			261			286		
212			237			262			287		
213			238			263			288		
214			239			264			289		
215			240			265			290		
216			241			266			291		
217			242			267			292		
218			243			268			293		
219			244			269			294		
220			245			270			295		
221			246			271			296		
222			247			272			297		
223			248			273			298		
224			249			274			299		
225			250			275			300		
Sum	O9	I9		O10	I10		O11	I11		O12	I12

LTPP Dipstick Data Collection Form
Longitudinal Profile Form DS-4
Readings 201 to 300

State Code [__ __]
LTPP Section ID [__ __ __ __]
Date (dd/mmm/yy) [__ __ / __ __ __ / __ __]

	LTPP Dipstick Data Collection Form Longitudinal Profile Form DS-5 Readings 301 to 400		State Code LTPP Section ID Date (dd/mmm/yy)	[_ _] [_ _ _ _] [_ _ / _ _ _ _ / _ _]

Reading No.	Reading (mm)		Reading No	Reading (mm)		Reading No	Reading (mm)		Reading No.	Reading (mm)	
	RWP ⇓	LWP ⇑		RWP ⇓	LWP ⇑		RWP ⇓	LWP ⇑		RWP ⇓	LWP ⇑
301			326			351			376		
302			327			352			377		
303			328			353			378		
304			329			354			379		
305			330			355			380		
306			331			356			381		
307			332			357			382		
308			333			358			383		
309			334			359			384		
310			335			360			385		
311			336			361			386		
312			337			362			387		
313			338			363			388		
314			339			364			389		
315			340			365			390		
316			341			366			391		
317			342			367			392		
318			343			368			393		
319			344			369			394		
320			345			370			395		
321			346			371			396		
322			347			372			397		
323			348			373			398		
324			349			374			399		
325			350			375			400		
Sum	O13	I13		O14	I14		O15	I15		O16	I16

	LTPP Manual Dipstick Data Collection Form Longitudinal Profile Form DS-6 Station 401 to 500	State Code [__ __] LTPP Section ID [__ __ __ __] Date (dd/mmm/yy) [__ __ / __ __ __ / __ __]

Reading No	Reading (mm)		Reading No	Reading (mm)		Reading No	Reading (mm)		Reading No	Reading (mm)	
	RWP ⇓	LWP ⇑		RWP ⇓	LWP ⇑		RWP ⇓	LWP ⇑		RWP ⇓	LWP ⇑
401			426			451			476		
402			427			452			477		
403			428			453			478		
404			429			454			479		
405			430			455			480		
406			431			456			481		
407			432			457			482		
408			433			458			483		
409			434			459			484		
410			435			460			485		
411			436			461			486		
412			437			462			487		
413			438			463			488		
414			439			464			489		
415			440			465			490		
416			441			466			491		
417			442			467			492		
418			443			468			493		
419			444			469			494		
420			445			470			495		
421			446			471			496		
422			447			472			497		
423			448			473			498		
424			449			474			499		
425			450			475			500		
Sum	O17	I17		O18	I18		O19	I19		O20	I20

Transverse Closure Measurements from Right Wheel Path to Left Wheel Path at Station (152.40 m)

	Transverse Position							Sum
	RWP-1	1-2	2-3	3-4	4-5	5 - CC	CC -LWP	
Reading (mm)								T2

LTPP Dipstick Data Collection Form Longitudinal Profile Form DS-7 Pre/Post Measurement Zero and Calibration Checks	State Code [__ __] LTPP Section ID [__ __ __ __] Date (dd/mmm/yy) [__ __ / __ __ __ / __ __]

Operator: _____ Employer: _____

Dipstick Serial Number: _____Diameter of Dipstick Foot Pad: __ __ . __ __ mm

Pre Measurement Checks

Time (military): __ __ : __ __   **Automated Dipstick** - Zero Check Performed: _____

Zero Check - Manual Dipstick		Calibration Check	
Measurement	Reading (mm)	Measurement	Reading (mm)
First Reading		First Reading	
Second Reading after 180° Rotation		Second Reading on Calibration Block	
First + Second Reading	A	Second Reading - 3.2 - First Reading	B

Notes:
A. First + Second Reading must be less than ± 0.1. If not, adjust the start pin as suggested in the LTPP Profile Measurement Manual and repeat zero check.
B. Second Reading - 3.2 - First Reading must be less than ± 0.1. If not, notify the RSC office and contact Face Company for repair.

Post Measurement Checks

Time (military): __ __ : __ __

Zero Check		Calibration Check	
Measurement	Reading (mm)	Measurement	Reading (mm)
First Reading		First Reading	
Second Reading after 180° Rotation		Second Reading on Calibration Block	
First + Second Reading	A	Second Reading - 3.2 - First Reading	B

Notes:
A. First + Second Reading must be less than ± 0.1. If not, discard data as suspect, adjust the start pin as suggested in the LTPP Profile Measurement Manual, repeat zero check until it passes, perform calibration check and if it passes, resurvey section.
B. Second Reading - 3.2 - First Reading must be less than ± 0.1. If not, notify the RSC office and contact Face Company for repair.

Comments:_____

LTPP Dipstick® Data Collection Form
Transverse Profile
Form DS-8

Dipstick® Serial # [_____]

State Code [___ — ___]

Dipstick® Model # [_____]

LTPP Section ID [___ — ___]

Operator: [_____]　Recorder: [_____]　Site Type: [____]　Visit: [_____]

Date (dd/mmm/yy) [___ / ___ / ___]

Surface Type: [__ - __]　Condition: _____

Time [___ : ___]

Road Name: _____

Lane:　Outside / Inside　(Circle One)　Direction: [_____]

Clouds: _____

Temperature: [___ . ___]

Weather Comment: _____

Location	Dipstick® Readings																Sum	Closure
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
0.00																		
Difference																		
15.24																		
Difference																		
30.48																		
Difference																		
45.72																		
Difference																		
60.96																		
Difference																		
76.20																		
Difference																		
91.44																		
Difference																		
106.68																		
Difference																		
121.92																		
Difference																		
137.16																		
Difference																		
152.40																		
Difference																		

COMMENTS: _____

There is no Form DS-9

LTPP Dipstick Operations	Region	[___ ___]
LTPP Major Maintenance/Repair	Serial Number	[___ ___ ___ ___ ___]
Form DS-10	Scheduled	[YES / NO]

Problem Identification / Scheduled Maintenance

Equipment: _____

Description: _____

_____

_____

_____

Performed By: _____

Date: [__ __ / __ __ __ / __ __ __ __]

Start Time: [__ __ : __ __]

End Time: [__ __ : __ __]

Troubleshooting

Description: _____

_____

_____

_____

_____

Performed By: _____

Date: [__ __ / __ __ __ / __ __ __ __]

Start Time: [__ __ : __ __]

End Time: [__ __ : __ __]

Hours: _____

Reporting

Referred to: _____

_____

Actions (Return/Order Parts): _____

_____

_____

_____

Date: [__ __ / __ __ __ / __ __ __ __]

Time: [__ __ : __ __]

Date: [__ __ / __ __ __ / __ __ __ __]

Time: [__ __ : __ __]

Service

Description (Repairs Performed/Replacement Part Information): _____

_____

_____

_____

Agency Performing Maintenance: _____

_____

_____

Performed By: _____

Date: [__ __ / __ __ __ / __ __ __ __]

Start Time: [__ __ : __ __]

End Time: [__ __ : __ __]

Hours: _____

Total Cost: [$ __ __ __ __ __ . __ __]

Verification

Description (Check/Calibration): _____

_____

_____

_____

Performed By: _____

Date: [__ __ / __ __ __ / __ __ __ __]

Start Time: [__ __ : __ __]

End Time: [__ __ : __ __]

Hours: _____

Return to Service

Status: _____

Performed By: _____

Date: [__ __ / __ __ __ / __ __ __ __]

LTPP Dipstick Operations	Region	[__ __]
Air Temperature Probe Calibration Check	**Probe Serial Number**	[__ __ __ __]
	NIST Serial Number	[__ __ __ __ __]
	Date	[__ __ / __ __ __ / __ __ __ __]
Longitudinal Profile Form DS-11	**Scheduled**	[YES / NO]

Ambient Temperature Check - Trial # 1

Time	[__ __ : __ __]
Air Probe	[__ __ __ °C]
NIST Thermometer	[__ __ __ °C]
Is Air Probe within ± 2°C of NIST Thermometer?	[1] [YES / NO]

[1] If yes, Trial # 2 and Trial # 3 are not required.

Ambient Temperature Check - Trial # 2

Time	[__ __ : __ __]
Air Probe	[__ __ __ °C]
NIST Thermometer	[__ __ __ °C]
Is Air Probe within ± 2°C of NIST Thermometer?	[2] [YES / NO]

[2] If yes, Trial # 3 is not required.

Ambient Temperature Check - Trial # 3

Time	[__ __ : __ __]
Air Probe	[__ __ __ °C]
NIST Thermometer	[__ __ __ °C]
Is Air Probe within ± 2°C of NIST Thermometer?	[3] [YES / NO]

[3] If no, air probe is unacceptable.

Cold Temperature Check

Is Cold Temperature Check required?	[YES / NO]
Air Probe	[__ __ __ °C]
Is Air Probe Measurement 0 °C ± 2 °C	[4] [YES / NO]

[4] If no, air probe is unacceptable.

Performed by: _____   Employer: _____

APPENDIX E. PROCEDURE FOR DETERMINING DIPSTICK® FOOTPAD SPACING

BACKGROUND

Testing performed in the field has indicated that the spacing between the centerline of the footpads in various Dipsticks® that are used in the LTPP program is not exactly 304.8 mm. Therefore, each RSC is required to perform a field test annually to determine the footpad spacing of each Dipstick® in their possession. This appendix describes procedures for performing the field test and the procedure for computing the footpad spacing of the Dipstick® from that data.

TEST PLAN

This test should be performed on a smooth AC or PCC pavement that is free of distress. Use the following procedure to layout the section and perform the test.

1. Layout a 30.48 m long test section. Use a cloth tape that is in a good condition to layout the section. A longitudinal chalk line should be marked on the section. When marking the chalk line, extend the chalk line 0.3 m past the end on the test section. Two transverse chalk lines should be marked perpendicular to the longitudinal survey line at the start (0 m) and the end (30.48 m) of the section. Figure 99 shows the layout of the test section.
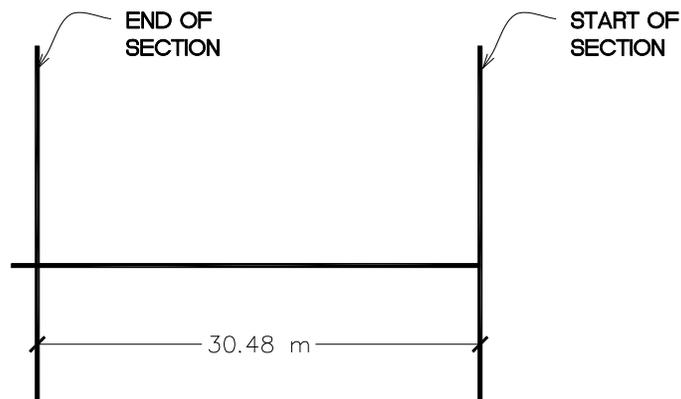
Figure 99. Illustration. Test section layout.

2. Measure the diameter (in mm) of each footpad in the Dipstick® using a caliper and record the values.

3. Place the back end of the back footpad of the Dipstick® in line with the transverse line marked at the beginning of the test section (see figure 100).
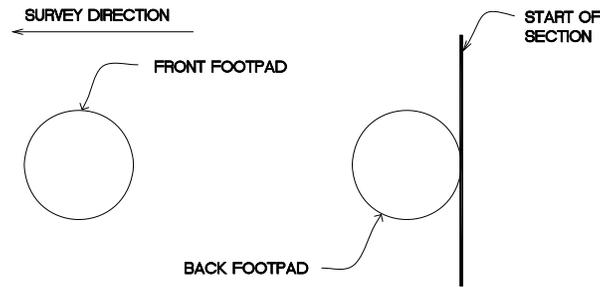
Figure 100. Illustration. Location of back footpad of Dipstick® at start of the section.

4. Walk the Dipstick® along the section following the procedures outlined in section 3.3.3 of this manual. After taking the 100th reading, measure the distance (in mm) from the back end of the front footpad of the Dipstick® to the transverse line that was marked at the end of the section. The following possible scenarios can occur:

    a. Back end of front footpad is past the transverse line at the end of the test section (see figure 101). The distance to be measured is the distance X indicated in figure 101. Measure this distance (in mm).
    b. Back end of the front footpad is before the transverse line at the end of the section (see figure 102). The distance to be measured is the distance X indicated in figure 102. Measure this distance (in mm).
    c. Back end of the front footpad is exactly on the transverse line at the end of the section, in which case the offset X is zero.
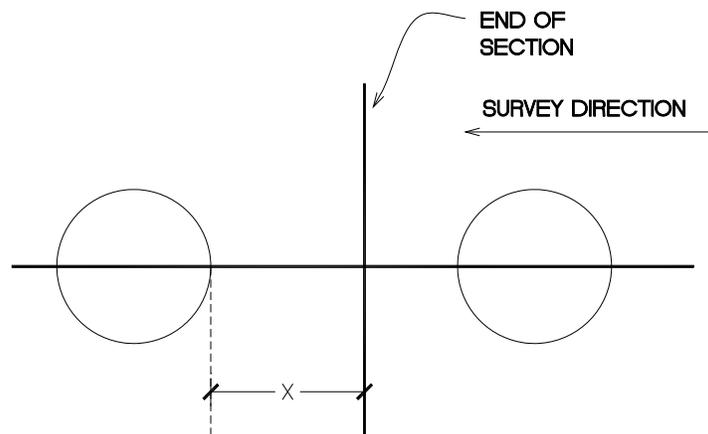
Figure 101. Illustration. Back end of front footpad is past the end of the test section when last reading is obtained.

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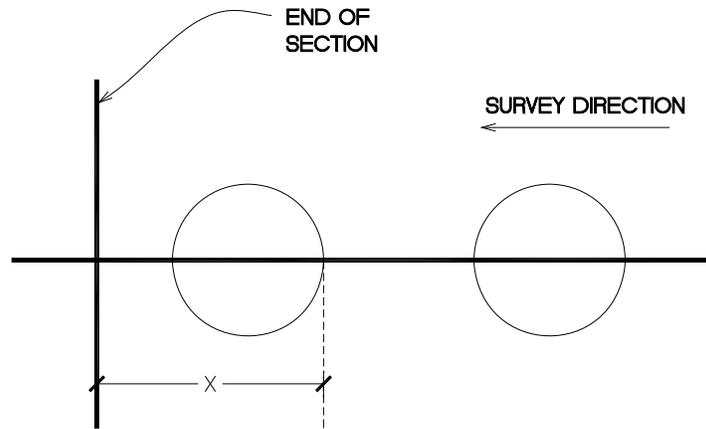
Figure 102. Illustration. Back end of the front footpad is before the end of the test section when last reading is obtained.

5. Repeat steps 3 and 4 two additional times.

COMPUTATION OF DIPSTICK® FOOTPAD SPACING

1. Compute the footpad spacing for the Dipstick® for each run using the following procedure:

    If back edge of front footpad was past the end of the section when the last reading was obtained (case shown in figure 101), use the following formula to compute footpad spacing:

    $$\text{Footpad spacing (mm)} = (30480 + X) / 100 \tag{3}$$

    Where:

    X is in mm.

If back edge of front footpad was before the end of the test section when the last reading was obtained (case shown in figure 102), use the following formula to compute footpad spacing:

$$\text{Footpad spacing (mm)} = (30480 - X)/100 \qquad\qquad (4)$$

Where:

X is in mm.

If the back edge of the front footpad is exactly in line with the end of the section, the footpad spacing is 304.8 mm.

Compute the average footpad spacing for each Dipstick® by averaging the values obtained for the three runs (to two decimal places).

2. Maintain a log in the RSC office that indicate the following information: date when testing was performed, Dipstick® model number, diameter of the Dipstick® footpads, results from the field tests, computed footpad spacing for each run and the average footpad spacing. The suggested format of the log is shown in the following table (date of testing should be included in the log).

Table 3. Suggested format of RSC office log.

Dipstick Model	Serial Number	Diameter of Footpad (mm)		Test Number	Offset at End of Section[1] (mm)	Footpad Spacing (mm)	Average Footpad Spacing (mm)
		Front	Back				
				1			
				2			
				3			
				1			
				2			
				3			
				1			
				2			
				3			
Note 1: Offset is positive if back end of front footpad is past end of section at last reading, offset is negative if back end of front footpad is before end of the section when last reading is obtained							

3. Write the average Dipstick® footpad spacing and date when testing was performed on a sheet of paper and securely tape it to the inside of the Dipstick® carrying case.

APPENDIX F. DATA COLLECTION FORM FOR ROD AND LEVEL PROFILE MEASUREMENTS

LTPP Code   [_ _]
LTPP Section   [_ _ _ _]
Date (dd/mmm/yy)   _ _ / _ _ _ / _ _

Reading Number	I.S.	B.S.	F.S.	Reading Number	I.S.	B.S.	F.S.	Reading Number	I.S.	B.S.	F.S.
Stn 0+00				34				68			
1				35				69			
2				36				70			
3				37				71			
4				38				72			
5				39				73			
6				40				74			
7				41				75			
8				42				76			
9				43				77			
10				44				78			
11				45				79			
12				46				80			
13				47				81			
14				48				82			
15				49				83			
16				50				84			
17				51				85			
18				52				86			
19				53				87			
20				54				88			
21				55				89			
22				56				90			
23				57				91			
24				58				92			
25				59				93			
26				60				94			
27				61				95			
28				62				96			
29				63				97			
30				64				98			
31				65				99			
32				66				100			
33				67							

B.S. = Back Sight, F.S. = Foresight

Comments:

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LTPP Rod and Level Data Collection Form
Longitudinal Profile Measurements
Form RL-2

LTPP Code	[_ _]
LTPP Section	[_ _ _ _]
Date (dd/mmm/yy)	_ _ / _ _ _ / _ _

Reading Number	I.S.	B.S.	F.S.	Reading Number	I.S.	B.S.	F.S.	Reading Number	I.S.	B.S.	F.S.
101				135				169			
102				136				170			
103				137				171			
104				138				172			
105				139				173			
106				140				174			
107				141				175			
108				142				176			
109				143				177			
110				144				178			
111				145				179			
112				146				180			
113				147				181			
114				148				182			
115				149				183			
116				150				184			
117				151				185			
118				152				186			
119				153				187			
120				154				188			
121				155				189			
122				156				190			
123				157				191			
124				158				192			
125				159				193			
126				160				194			
127				161				195			
128				162				196			
129				163				197			
130				164				198			
131				165				199			
132				166				200			
133				167							
134				168							

B.S. = Back Sight, F.S. = Foresight

Comments:

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LTPP Rod and Level Data Collection Form
Longitudinal Profile Measurements
Form RL-3

LTPP Code	[_ _]
LTPP Section	[_ _ _ _]
Date (dd/mmm/yy)	_ _ / _ _ _ _ / _ _

Reading Number	I.S.	B.S.	F.S.	Reading Number	I.S.	B.S.	F.S.	Reading Number	I.S.	B.S.	F.S.
201				235				269			
202				236				270			
203				237				271			
204				238				272			
205				239				273			
206				240				274			
207				241				275			
208				242				276			
209				243				277			
210				244				278			
211				245				279			
212				246				280			
213				247				281			
214				248				282			
215				249				283			
216				250				284			
217				251				285			
218				252				286			
219				253				287			
220				254				288			
221				255				289			
222				256				290			
223				257				291			
224				258				292			
225				259				293			
226				260				294			
227				261				295			
228				262				296			
229				263				297			
230				264				298			
231				265				299			
232				266				300			
233				267							
234				268							

B.S. = Back Sight, F.S. = Foresight

Comments:

| LTPP Rod and Level Data Collection Form |
| Longitudinal Profile Measurements |
| Form RL-4 |

LTPP Code [_ _]
LTPP Section [_ _ _ _]
Date (dd/mmm/yy) _ _ / _ _ _ _ / _ _

Reading Number	I.S.	B.S.	F.S.	Reading Number	I.S.	B.S.	F.S.	Reading Number	I.S.	B.S.	F.S.
301				335				369			
302				336				370			
303				337				371			
304				338				372			
305				339				373			
306				340				374			
307				341				375			
308				342				376			
309				343				377			
310				344				378			
311				345				379			
312				346				380			
313				347				381			
314				348				382			
315				349				383			
316				350				384			
317				351				385			
318				352				386			
319				353				387			
320				354				388			
321				355				389			
322				356				390			
323				357				391			
324				358				392			
325				359				393			
326				360				394			
327				361				395			
328				362				396			
329				363				397			
330				364				398			
331				365				399			
332				366				400			
333				367							
334				368							

B.S. = Back Sight, F.S. = Foresight

Comments:

LTPP Code   [_ _]
LTPP Section   [_ _ _ _]
Date (dd/mmm/yy)   _ _ / _ _ _ / _ _

Reading Number	I.S.	B.S.	F.S.	Reading Number	I.S.	B.S.	F.S.	Reading Number	I.S.	B.S.	F.S.
401				437				473			
402				438				474			
403				439				475			
404				440				476			
405				441				477			
406				442				478			
407				443				479			
408				444				480			
409				445				481			
410				446				482			
411				447				483			
412				448				484			
413				449				485			
414				450				486			
415				451				487			
416				452				488			
417				453				489			
418				454				490			
419				455				491			
420				456				492			
421				457				493			
422				458				494			
423				459				495			
424				460				496			
425				461				497			
426				462				498			
427				463				499			
428				464				500			
429				465				501			
430				466				502			
431				467				503			
432				468				504			
433				469				505			
434				470				506			
435				471				507			
436				472				508			

B.S. = Back Sight, F.S. = Foresight

Comments:

APPENDIX G. FORMS FOR INTER-REGIONAL PROFILER COMPARISON TESTS

STATIC HEIGHT SENSOR MEASUREMENTS

RSC: _____

Date: _____

Distance from Ground to Sensor Glass (mm):   Left: _____ Center _____ Right _____

Left Sensor

Position	Values Shown on Monitor for Dif Ht (Note 1)					Avg. of Heights (mm)	Actual Block Height (Note 2) (mm)	Actual Minus Average (mm)	Std Dev. of Heights (mm) (Note 3)
	Test 1	Test 2	Test 3	Test 4	Test 5				
Base Plate + 25 mm Block + Calibration Plate									
Base Plate + 50 mm Block + Calibration Plate									
Base Plate + 75 mm Block + Calibration Plate									
Base Plate + 100 mm Block + Calibration Plate									

Center Sensor

Position	Values Shown on Monitor for Dif Ht (Note 1)					Avg. of Heights (mm)	Actual Block Height (Note 2) (mm)	Actual Minus Average (mm)	Standard Dev. of Heights (mm) (Note 3)
	Test 1	Test 2	Test 3	Test 4	Test 5				
Base Plate + 25 mm Block + Calibration Plate									
Base Plate + 50 mm Block + Calibration									

Position									
Plate									
Base Plate + 75 mm Block + Calibration Plate									
Base Plate + 100 mm Block + Calibration Plate									

Right Sensor

Position	Values Shown on Monitor for Dif Ht (Note 1)					Avg. of Heights (mm)	Actual Block Height (Note 2) (mm)	Actual Minus Average (mm)	Standard Dev. of Heights (mm) (Note 3)
	Test 1	Test 2	Test 3	Test 4	Test 5				
Base Plate + 25 mm Block + Calibration Plate									
Base Plate + 50 mm Block + Calibration Plate									
Base Plate + 75 mm Block + Calibration Plate									
Base Plate + 100 mm Block + Calibration Plate									

Note 1: Do Test 1 for each block position. Then repeat procedure for other tests. Let computer take 500 readings before recording value.

Note 2: Record actual height of block stamped on block in this column

Note 3: Calculate standard deviation using the STDEV function in Excel

DMI MEASUREMENTS FORM

RSC: _____

Date: _____

Left Rear Tire Pressure Prior to Test (psi):   _____

Right Rear Tire Pressure Prior to Test (psi):   _____

Left Rear Tire Pressure After Last Run (psi):   _____

Right Rear Tire Pressure After Last Run (psi): _____

Note: Calibrate DMI before performing DMI Measurements.

Run Number	Air Temp. (°C)	Distance (m) See Note 1
1		
2		
3		
4		
5		
6		
Average		
Std Dev		

Note 1: Record values shown for "Distance old DCF"
Note 2: Use the STDEV function in Excel to calculate Std. Deviation

DMI VERIFICATION FORM

RSC: _____

Date: _____

Left Rear Tire Pressure Prior to Test (psi): _____
Right Rear Tire Pressure Prior to Test (psi): _____
Left Rear Tire Pressure After Last Run (psi): _____
Right Rear Tire Pressure After Last Run (psi):_____

Note: Do Not Calibrate DMI Before Performing Measurements.

Run Number	Air Temp. (°C)	Distance (m) See Note 1
1		
2		
3		
4		
5		
6		
Average		
Std Dev		

Note 1: Record values shown for "Distance old DCF"
Note 2: Use the STDEV function in Excel to calculate Std. Deviation

IRI VALUES

Left Wheel Path

Site Number	Site Description	Left Wheel Path IRI (m/km)					Average IRI (m/km)	Standard Deviation (m/km) (Note 1)
		Run Number						
		1	2	3	4	5		
1	Smooth AC							
2	Rough AC							
3	Smooth PCC							
4	Rough PCC							
5	Chip Seal							

Right Wheel Path

Site Number	Site Description	Right Wheel Path IRI (m/km)					Average IRI (m/km)	Standard Deviation (m/km) (Note 1)
		Run Number						
		1	2	3	4	5		
1	Smooth AC							
2	Rough AC							
3	Smooth PCC							
4	Rough PCC							
5	Chip Seal							

Note 1: Use the STDEV function in Excel to calculate Std. Deviation

`

ACKNOWLEDGMENTS

Many of the operating procedures described in this manual for the ICC profiler were obtained from the ICC Profiler User Manuals. Much of the information relating to the operation of the Face Company Dipstick® was obtained from the Instruction Manual for the Dipstick®.

The following registered trademarks are used in this document:

Dipstick® is a trademark of Face Company.
Iomega™ and Zip™ are registered trademarks of Iomega Corporation.
Windows XP, Windows 98, and MS DOS are registered trademarks of Microsoft®.

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HRDI-13/11-08(1M)E