LTPP Manual for Profile Measurements and Processing

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16. Abstract This manual describes operational procedures for collecting longitudinal pavement profiles and macrotexture data for the Long-Term Pavement Performance (LTPP) Program using the Ames Engineering profile/texture device. It also contains procedures for measuring pavement longitudinal and transverse profiles using the Face Company Dipstick®, and procedures for measuring the pavement longitudinal profile using the rod and level. Procedures for calibration of equipment, performing calibration checks on the equipment, data collection, record keeping, and maintenance of equipment for each of these devices are also described in this manual. In addition, the manual describes procedures to be followed in the office when processing profile data that were collected in the field as well as guidelines for performing inter-regional comparison tests among the LTPP Ames Engineering profile/texture devices.			
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FOREWORD

The Long-Term Pavement Performance (LTPP) program is a study of pavement performance at in-service pavement sections in the United States and Canada. The primary goal of the LTPP program is to answer how and why pavements perform as they do. The specific objectives of the LTPP program are to:

- Evaluate existing design methods.
- Develop improved design methods and strategies for the rehabilitation of existing pavements.
- Develop improved design equations for new and reconstructed pavements.
- Determine the effects of loading, environment, material properties and variability, construction quality, and maintenance levels on pavement distress and performance.
- Determine the effects of specific design features on pavement performance.
- Establish a national long-term pavement performance database.

Towards accomplishing the program goal and objectives, LTPP is collecting data on in-service pavements. 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.

The collection of longitudinal profile data at each test section is a major task of LTPP. The left and right wheel path profile data for five repeat runs on a test section for each test date are stored in the LTPP PPDB. In addition, the International Roughness Index (IRI), Root Mean Square Vertical Acceleration (RMSVA), and Slope Variance (SV) that are computed from the profile data are also stored in the LTPP PPDB. A new data element that is being collected with the Ames Engineering devices is macrotexture data along the wheel paths.

This manual describes operational procedures to be followed when measuring longitudinal pavement profiles for the LTPP program using the Ames Engineering profile/texture device, Face Company Dipstick®, and the rod and level. The primary device currently used to obtain longitudinal pavement profile measurements for LTPP is the Ames Engineering profiling/texture device. However, when a profiler is not available, the Dipstick® is used to collect profile data. Also, a rod and level can be used to measure pavement profile if a profiler or a Dipstick® is not available. Procedures for collecting macrotexture data using the Ames Engineering profile/texture device and procedures for measuring pavement transverse profiles using the Face Company Dipstick® are also contained in this manual. In addition, the manual describes procedures to be followed in the office when processing profile data that were collected in the field as well as guidelines for performing inter-regional comparison tests among the four LTPP profilers.

The Ames Engineering profile/texture devices started collecting data for the LTPP program in April 2013. This manual is an update of the November 2008 LTPP Manual for Profile Measurements and Processing, which reflects the operational procedures associated with the Ames Engineering device.

Four K.J. Law DNC 690 profilers collected data for the LTPP program from June 1989 until November 1996. The Manual for Profile Measurement: Operational Field Guidelines (Publication SHRP-P-378) contains the procedures that were used for collecting data with these profilers as well as with the Face Company Dipstick® and the rod and level.

Four K.J. Law T-6600 profilers collected data for the LTPP program from December 1996 to August 2002. The document LTPP Operational Procedures for K.J. Law T-6000 Profilometer – Legacy Document contains the procedures that were used for collecting profile data with these profilers as well as with the Face Company Dipstick® and the rod and level.

Four International Cybernetics Corporation (ICC) MDR 4086L3 profilers collected data for the LTPP program from September 2002 to March 2013. The document Long-Term Pavement Performance Program Manual for Profile Measurements and Processing (Publication No. FHWA-HRT-08-056) contains the procedures that were used for collecting profile data with these profilers as well as with the Face Company Dipstick® and the rod and level.

ACKNOWLEDGMENTS

Many of the operating procedures described in this manual for the Ames Engineering profiling/texture device were obtained from documents provided by the manufacturer. 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.
Windows is a registered trademark of Microsoft.

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ACRONYMS

AC	Asphalt Concrete
AIMS	Ancillary Information Management System
ARD	Ames Raw Data
CCD	Charged Couple Device
CSV	Comma Separated File
DAU	Data Acquisition Unit
DLL	Dynamic Link Library
DMI	Distance Measuring Instrument
ERD	Engineering Research Division
FHWA	Federal Highway Administration
GPS	General Pavement Studies
GPSR	Global Positioning System Receiver
ICC	International Cybernetics Corporation
IRI	International Roughness Index
JPEG	Joint Photographic Expert Group
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LTPP	Long Term Pavement Performance
MPD	Mean Profile Depth
NIST	National Institute of Standards and Technology
PROFPR	Profile/Texture Problem Report
PSM	Profile System Monitor
PCC	Portland Cement Concrete
PPDB	Pavement Performance Database
PSD	Power Spectral Density
QC	Quality Control
RSC	Regional Support Contractor
SHRP	Strategic Highway Research Program
SMP	Seasonal Monitoring Program
SPS	Specific Pavement Studies
SV	Slope Variance
TSSC	Technical Support Services Contractor
UMTRI	University of Michigan Transportation Research Institute
USB	Universal Serial Bus
VIN	Vehicle Identification Number
WAAS	Wide Area Augmentation System
WIM	Weigh-in-Motion

CHAPTER 1. INTRODUCTION

1.1 OVERVIEW OF THE LTPP PROGRAM

The Long-Term Pavement Performance (LTPP) program is a research program that investigates in-service pavement performance. Started in 1987 as part of the first Strategic Highway Research Program (SHRP), the LTPP program has been managed by the Federal Highway Administration (FHWA) since 1992. The primary goal of the LTPP program is to answer how and why pavements perform as they do. In order to accomplish this goal, LTPP collects pavement performance data using standard data collection procedures and protocols on a variety of pavement types. This information is stored in a database that can be used by pavement engineers and researchers worldwide to advance the science of pavement engineering.

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.

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 International Roughness Index (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 on 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 June 1989 until November 1996, profile data at test sections were collected using a model DNC 690 inertial profiler manufactured by K. J. Law Engineers, Inc. In December 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 International Cybernetics Corporation (ICC) MDR 4086L3 inertial profiler. In April 2013, each RSC replaced their ICC profiler with an Ames Engineering Model 8300 inertial profiler. In addition to profile data collection equipment, this device is equipped with texture lasers to collect macrotexture data along the wheel paths, a sensor to measure pavement surface temperature, a sensor to measure ambient temperature, a Global Positioning System Receiver (GPSR) to obtain position information, and a right-of-way camera mounted inside the cabin of the vehicle to obtain images. Previous equipment used to collect profile data for the LTPP program did not have the capability to collect these data elements except for the ambient temperature. The operation and maintenance of the profiler and storage of collected data are the responsibility of each RSC.

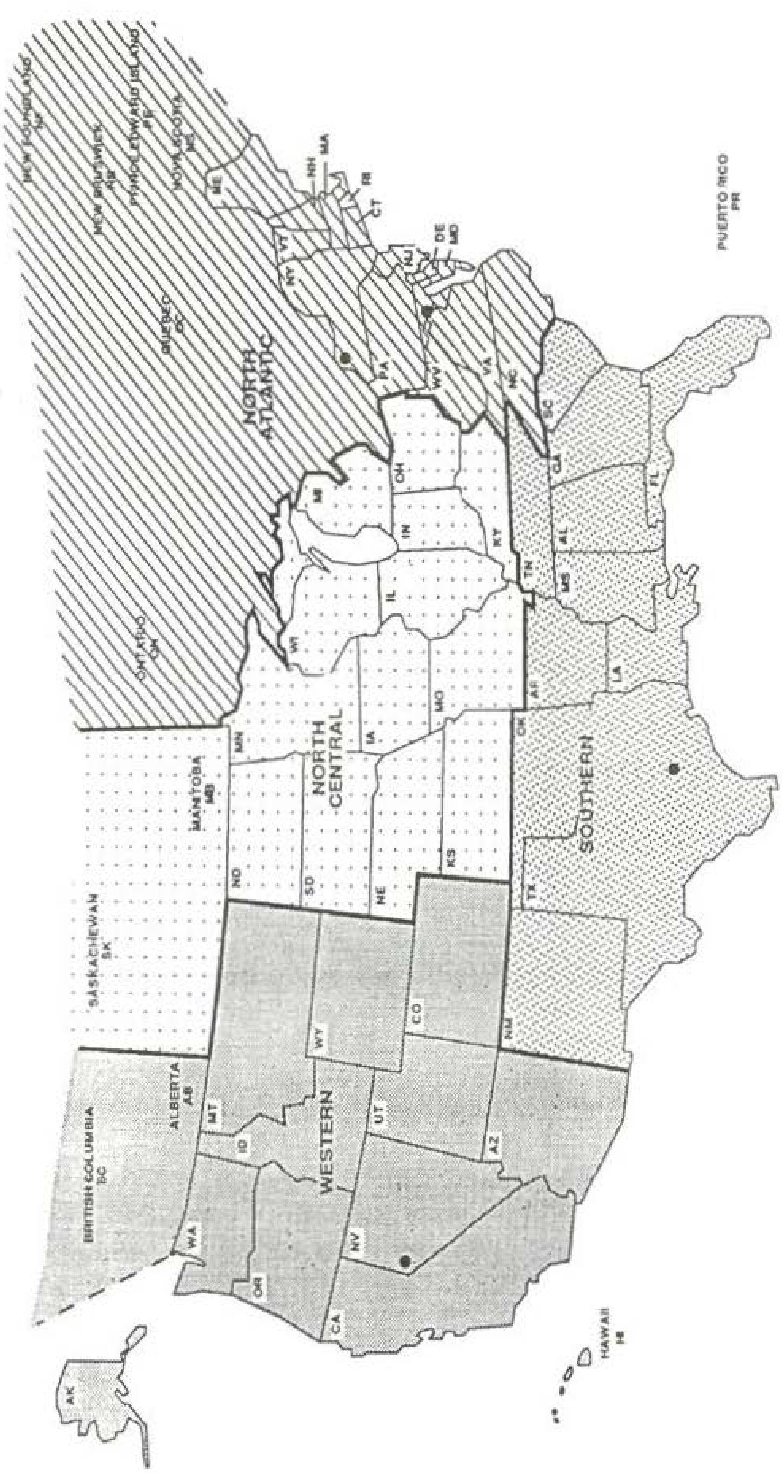


Figure 1. LTPP regions.

Table 1 shows the Ames Engineering identification number, the license plate number, and the Vehicle Identification Number (VIN) of the device assigned to each RSC.

Table 1. Ames Engineering device assigned to each RSC.

Region	Ames Identification Number	Plate Number	Vehicle VIN Number
North Atlantic	830112	45147	1FMNE1BW2CDA91456
North Central	830412	45148	1FMNE1BW4CDA91457
Southern	830212	45149	1FMNE1BW4CDA86601
Western	830312	45150	1FMNE1BW6CDA86602

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 to obtain transverse profile data. The North Atlantic, North Central, and Western RSC's 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 Dipstick® or the profiler. 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 Ames Engineering device, Face Company Dipstick®, and the rod and level. Procedures for calibration of equipment, data collection, record keeping, and maintenance of equipment for each of the devices are also described in this manual. In addition, the manual describes procedures to be followed in the office when processing profile data collected in the field as well as guidelines for performing inter-regional comparison tests among the four Ames Engineering devices.

This document addresses those aspects of profile measurements and macrotexture measurements that are unique to the LTPP program. Other references included in the References section of this manual should be consulted for general information about the equipment.

CHAPTER 2. PROFILE AND MACROTEXTURE MEASUREMENTS USING AMES ENGINEERING DEVICE

2.1 INTRODUCTION

The Ames Engineering Model 8300 profile/texture device uses a Ford E150 XLT Wagon as the host vehicle[(1)]. This device is equipped with specialized instruments to measure and record road profile data and surface macrotexture data. The device contains three laser height sensors with an accelerometer located above each height sensor to collect data to compute the longitudinal profile. These laser height sensors are hereafter referred to as profile height sensors. The device is also equipped with two additional laser sensors to collect surface macrotexture data. These laser height sensors are hereafter referred to as texture height sensors. The profile and texture height sensors are mounted on a sensor bar that is installed on the front of the vehicle. One profile height sensor is located at the center of the vehicle, while the other two profile height sensors are located along each wheel path. A texture height sensor is located behind each profile height sensor that collects data along a wheel path such that profile data and macrotexture data are collected along the same path. The longitudinal distance measuring instrument (DMI) is mounted on the rear left wheel of the vehicle, and measures the distance traveled by the vehicle. A laptop computer is mounted on a stand between the driver and the passenger seats in the device. This laptop computer is used to control all data collection activities. All data collected by the device in a single run are saved in one file and is stored in this laptop computer.

Profile height sensors measure the distance from the sensor to the road while the accelerometers measure vertical acceleration. Signals from the profile height sensors, accelerometers, and DMI are saved onto a file in the laptop computer. These signals are also used to compute the profile of the pavement along the path traversed by each profile height sensor in real time. The data recorded by the profile height sensors, accelerometers, and DMI can be post-processed to obtain the longitudinal profile along the path that was traversed by each sensor at 25 mm intervals.

The two texture height sensors collect macrotexture data along each wheel path. The data collected by these two height sensors are recorded in the same data file where the profile data are stored. These data can be post-processed to obtain macrotexture data at 0.5 mm intervals.

The Ames Engineering device is equipped with two photocells that are mounted on the sensor bar. One photocell is mounted vertically to sense reflections from pre-placed marks on the road surface. The other photocell is mounted horizontally on the passenger side of the vehicle so it can sense reflective markings on a cone placed on the side of the road. The operator can select one of these photocells during a data collection run to trigger data collection at a specified location. The device is also equipped with a GPSR and sensors to measure the ambient temperature and the pavement surface temperature. In addition, the device has a camera mounted inside the cabin of the vehicle that takes pictures of the roadway as viewed from inside of the vehicle.

The host vehicle is equipped with both a heater and an air conditioner to provide a uniform temperature for the electronic equipment inside the vehicle. This device can measure road profiles at speeds ranging from 10 to 112 km/h. The test speed normally used to collect profile data at LTPP sections is 80 km/h.

2.2 OVERVIEW OF THE COMPONENTS IN THE PROFILE/TEXTURE DEVICE

This section presents an overview of the various components included in the Ames Engineering profile/texture device. Most of the information presented in this section was obtained from the documents provided by Ames Engineering during the training session and user manual (see references 2 through 5). These documents should be consulted for additional details about the components.

2.2.1 Sensor Bar

A sensor bar is mounted on the front of the vehicle and houses the three profile height sensors, the accelerometers located on top of each profile height sensor, the two texture height sensors and the associated controllers, the interface box for processing macrotexture data, the vertical and horizontal photocells, and the data acquisition unit (DAU). The sensor bar is 1.825 m long and 0.37 m wide.

The sensor bar has a cover that is fixed to the bar by four retention knobs. The cover can be opened by removing the four knobs and lightly pulling on each side. The cover is fitted with a tilt sensor that sets off the vehicle alarm if the cover is opened when the vehicle alarm is on. The sensor bar has an approximate ground clearance of 268 mm. Figure 2 shows a view of the sensor bar. Figure 3 shows a view of the sensor bar with the cover open. A brief description of the various components that are located inside the sensor bar is presented later in this chapter.

Figure 2. Sensor bar mounted on the front of the vehicle.

Figure 3. Sensor bar with the cover open.

2.2.2 Profile Height Sensors and Accelerometers

Three LMI-Selcom laser sensors that collect elevation data to compute the longitudinal profile are located inside the sensor bar (see figure 4). One sensor is located at the center of the vehicle and the other two sensors are located on either side from the center of the vehicle at a distance of 838 mm. The profile height sensors are designated as SLS5000 200/300-RO. The 200 in the designation indicates the sensor has a 200 mm measurement range, the 300 indicates the sensor has a stand-off height of 300 mm, and the term RO indicates the sensor is optimized for road applications. The closest distance the sensor can see from the sensor glass is 200 mm, and the furthest distance the sensor can see from the glass is 400 mm. The stand-off height of 300 mm is the center point of the sensor's range and should be approximately at the ground surface. The profile height sensors are rated as 16 kHz lasers.

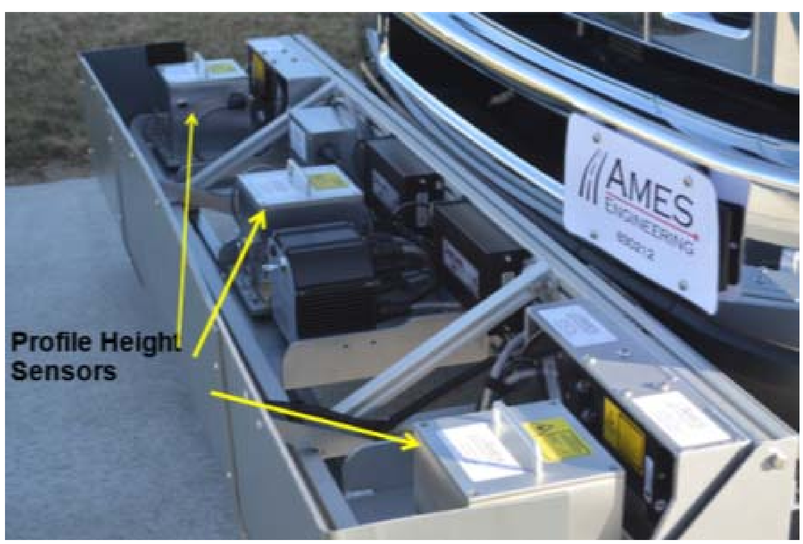


Figure 4. Profile height sensors.

The SLS sensor contains a light source and a detector integrated with optics and electronics. The laser light source illuminates a spot on the pavement surface, and the reflected light from the spot is detected by the detector that uses the signal to calculate the height. The emitted light can damage the eye if directly exposed, or if the laser light is reflected by a mirror or any mirror like surface directly into the eye. The three profile height sensors are designated as ODS1 (left wheel path), ODS 2 (right wheel path) and ODS3 (center sensor). Each height sensor is housed inside a customized box manufactured by Ames Engineering. This box can be removed from the sensor bar by releasing the two latches in each box. The profile height sensors are identified by a label on the top of the box. To ensure data are collected along the proper path, the labels should be in normal reading orientation when standing in front of the van.

An accelerometer is located on top of each profile height sensor to measure accelerations. The accelerometers are manufactured by Colibrys and can measure accelerations between ±5g. The accelerometer is also inside the customized box. Circuit boards manufactured by Ames Engineering located within each sensor box process the data collected by the height sensor and the accelerometer and combine these data elements with the DMI data to compute the profile in real time. It should be noted that the profile data are not computed in the device's laptop computer; computation of the profile data is performed by the circuit boards that are inside each sensor box.

2.2.3 Texture Height Sensors and Control Units

The device is equipped with two LMI-Selcom Optocator sensors that collect macrotexture data (see figure 5). These sensors are mounted directly behind the left and right profile height sensors such that the profile data and the macrotexture data are collected along the same path. The texture height sensors are designated as Optocator 2008-180/390. The 180 in the designation indicates these sensors have a measurement range of 180 mm, and the 390 indicates the sensors have a stand-off height of 390 mm. The closest distance the sensor can see from the glass is 300 mm, and the furthest distance the sensor can see from the glass is 480 mm. The stand-off height of 390 mm is the center point of the sensor's range and is approximately at the ground surface. The texture height sensors are referred to as ODS4 (left wheel path sensor) and ODS5 (right wheel path sensor).

The Optocator sensor consists of two major parts, the Optocator head (sensor head) and the probe processing unit, which is referred to as the controller in this document. The Optocator head contains the laser light source that emits laser light to the road surface, the light receiver that detects the reflected light from the laser spot on the road surface, and a preamplifier. The controller contains the signal processing part of the Optocator. The output from each controller is fed into the interface box that is located inside the sensor bar on the passenger side of the vehicle. A cable from the interface box transmits the macrotexture data collected by both height sensors to the DAU. The texture height sensors are rated at 62.5 kHz and all of the data obtained by these sensors at this frequency are stored in the same data file where the profile data are stored.

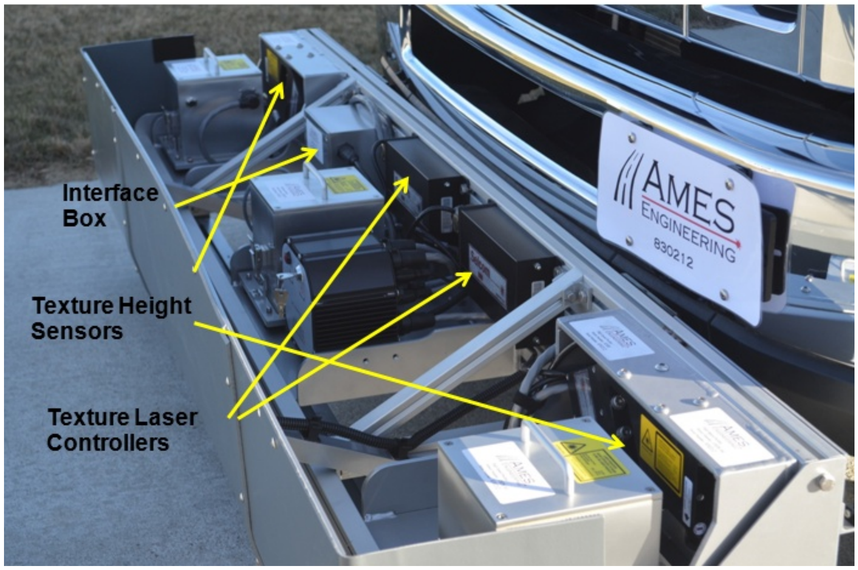


Figure 5. Equipment associated with macrotexture data collection.

2.2.4 Data Acquisition Unit

The data acquisition unit (DAU) is mounted next to the center profile height sensor (see figure 6). Figure 7 shows the ports on the DAU. As seen in figure 7, the power connection, DMI, and GPSR have designated ports. The power connection provides power from the auxiliary battery and is used to provide power to the profile and texture height sensors, accelerometers, DMI, the two photocells, and the GPSR. The data collected by each profile height sensor, the accelerometer associated with that sensor, and the computed profile is input into a port in the DAU. The macrotexture data from both texture height sensors are input from the interface box into the DAU through one cable. One port in the DAU is not used. Except for the power input, GPS, and DMI that have designated ports, data from other components described above can be connected to any port in the DAU.

It should be noted that Ames Engineering computer cards in each sensor box are independently processing the data, and the final data are transferred through an Ethernet protocol to the DAU that contains an Ethernet switch. From there the data are sent to the router located on the equipment rack, and from there the data are transferred to the laptop computer for permanent storage.

The front of the DAU has a power on/off switch and a keyway (see figure 8). The power to all components associated with data collection in the device is turned on by using the power switch (see section 2.2.15). Once this switched is turned on, the power button in the DAU can be used to turn-off power to the components. Pressing this switch again will turn the power on. The power switch on the DAU may be used to cut-off power when inspecting or servicing parts located inside the sensor bar.

The key can be used to cut-off power to the profile and texture laser height sensors. The key should always be inserted and set to the "On" position for data collection. The key can only be removed in the "Off" position. The key should only be removed when a need arises to cut-off power to the profile and texture height sensors.

Figure 6. Data acquisition unit.

Figure 7. Ports in the DAU.

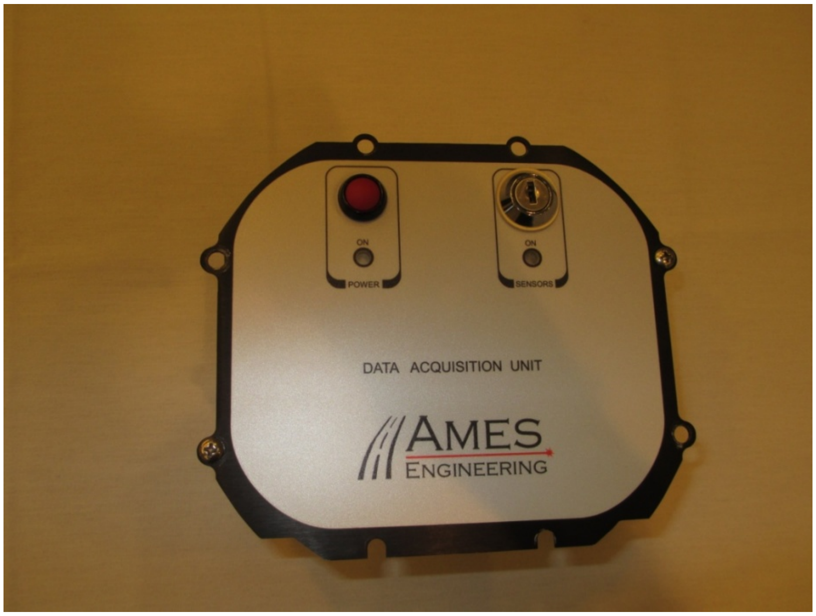


Figure 8. Front view of the DAU.

2.2.5 Photocells

There are two photocells mounted on the sensor bar, a downward facing photocell referred to as the vertical photocell (see figure 9) and a sideways facing photocell referred to as the horizontal photocell (see figure 10).

Both of these photocells are manufactured by Pepperl+Fuchs. The vertical photocell is mounted approximately at the center of the sensor bar. The horizontal photocell is mounted at the edge of the sensor bar on the passenger side. A cable connects the vertical photocell to the center sensor box and the horizontal photocell to the right wheel path sensor box. The vertical photocell can trigger off HVAC tape. The horizontal photocell triggers off reflective tape that is placed on a cone. Two cones with the reflective tape were provided with each device. Figure 11 shows a photograph of a cone. Manufacturers' literature indicates the horizontal photocell has a 15 m range. The reflective tape on the cone is manufactured by Reflexlite. Ames Engineering has recommended this reflective tape be used on the cone for optimum performance of the horizontal photocell.

2.2.6 Distance Measurement Instrument

An Encoder Products DMI encoder that transmits 500 pulses per revolution is installed on the rear left wheel of the van (see figure 12). This DMI is a quadrature output signal device, and a microcontroller installed in the DAU is able to analyze the signal utilizing single edge detection and increase the resolution to 2,000 pulses per revolution. The DMI encoder mounts directly over four of the lug studs on the wheel. Four nuts are used to hold the encoder in place. The encoder can be taken off the wheel by taking out the four nuts. A harness runs from the encoder to an input that is connected to the fender (see figure 13). The output from the encoder is transmitted through a cable to the DAU located on the sensor bar. When the encoder is disassembled, a dust cap is provided to protect the connector (see figure 14).

Figure 9. Vertical photocell.

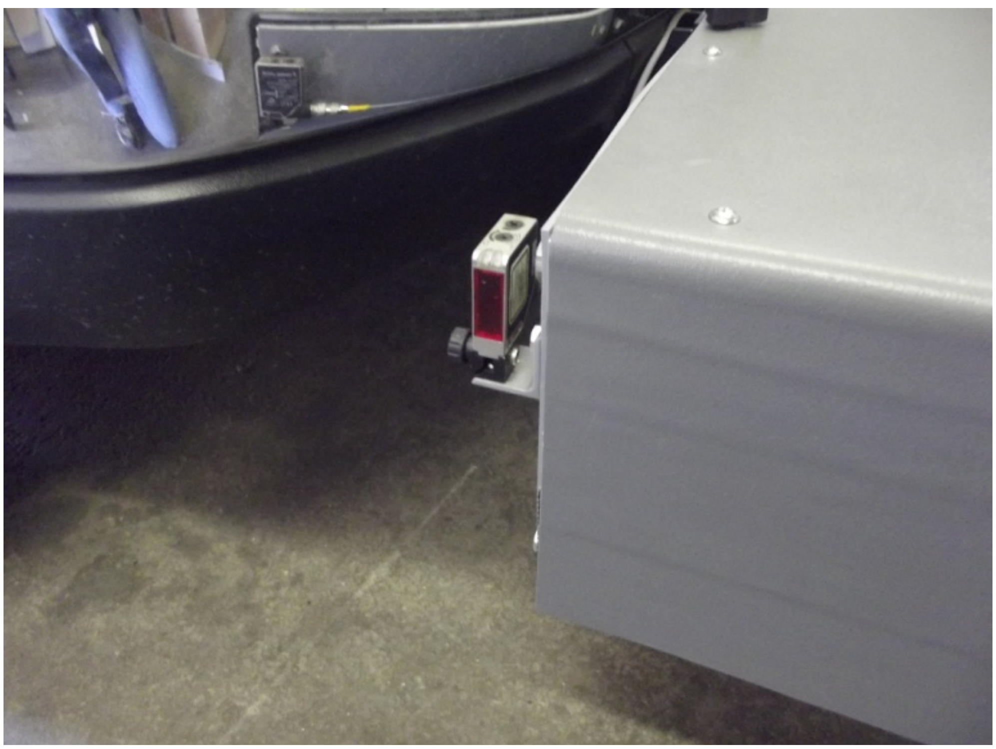


Figure 10. Horizontal photocell.

Figure 11. Cone with reflective tape.

Figure 12. DMI encoder.

Figure 13. DMI input connection.

Figure 14. Cap to protect input when DMI is disassembled.

If the short cable that connects the encoder to the fender is damaged, and a backup short cable is not available, it is possible to bypass this short cable by cutting some wire ties and extending the extra cable that is coiled up forward of the wheel well, and carefully routing it to the encoder directly. Care should be taken to not rout the cable too close to the tire in the process.

2.2.7 Global Positioning System Receiver

A Garmin 18X-5 Hz GPSR is installed on the vehicle within the light bar (see figure 15). The GPSR includes the capability of Wide Area Augmentation System (WAAS) differential GPS. Manufacturers' literature indicates the accuracy of the GPSR under standard positioning service to be within 15 m and with WAAS correction to be within 3 m. The earth datum in the GPSR is programmable and has been set to WGS 84. The output from the GPSR is fed into to the DAU located in the sensor bar. Signals are then transmitted from the DAU to the router located in the equipment rack and then to the laptop computer for storage. As the GPSR is rated at 5 Hz, which means five readings are obtained every second. All of this data are stored in same data file where the profile and macrotexture data are stored.

Figure 15. Location of the GPS receiver.

2.2.8 Ambient Temperature Sensor

An ambient temperature sensor manufactured by Sensirion (model number SHT 15) is located within a protective shield that is mounted on the rear driver's side of the vehicle (see figure 16). This sensor has two ambient temperature probes that independently obtain the ambient temperature. Three wires from the sensor are connected to an interface board that is located inside the rear left tail light. The rear left tail light must be removed to access this sensor's interface board. The output from the sensor interface board is fed by a cable into the Profile Sensor Monitor (PSM) that is located within the equipment rack inside the vehicle. An Ethernet cable carries the data from the PSM to the router, and the data are then transferred from the router to the laptop computer through an Ethernet cable for storage. The ambient temperature sensor is rated at 1 Hz, which means ambient temperature data are obtained at one second intervals. All of the obtained data are stored in the same data file where the profile and the macrotexture data are stored.

2.2.9 Pavement Surface Temperature Sensor

A non-contact Raytek infrared temperature sensor (model Number MID10LT-CB8) to measure the pavement surface temperature is mounted to the bottom of the vehicle on the driver's side at the rear of the vehicle. The temperature sensor is mounted within a PVC structure for protection from road debris and other contaminants. A protection window has been installed below the lens of the sensor to protect the lens from damage. There is a possibility for this protection window to crack if it has been installed too tightly. The protection window should be inspected at regular intervals to check for cracks. A sensor to measure a reference ambient temperature is also located in the pavement surface temperature sensor module. A spring loaded protective cover is provided to protect the sensor when it is not being used. The protective cover is rotated by 90° when temperature measurements are needed. Figure 17 and 18 respectively show the protective cover in place and the protective cover rotated by 90° to obtain pavement surface temperature measurements.

Figure 16. Protective shield housing the ambient temperature sensor.

Figure 17. Protective cover covering the pavement surface temperature sensor.

Figure 18. Protective cover open to permit pavement surface temperature measurements.

A cable carries the outputs from the pavement surface temperature sensor to the Raytek controller that is located on the equipment rack inside the vehicle. The output from the Raytek controller is fed into the PSM, which is also located inside the equipment rack. An Ethernet cable carries the data from the PSM to the router, and the data are then transferred from the router through an Ethernet cable to the laptop computer for storage. The pavement surface temperature sensor obtains data at a frequency of 40 Hz, which means 40 samples are obtained every second. All of these data are stored in the same data file where the profile and the macrotexture data are stored.

2.2.10 Light Bar, Directional Warning Light, and Strobe Lights

The vehicle is equipped with a Light Emitting Diode (LED) light bar mounted on the front of the vehicle (see figure 19), a directional warning light bar mounted on the rear of the vehicle (see figure 20), and LED strobe lights mounted inside the headlights and the taillights of the vehicle.

The front light bar is 1.6 m in length and is manufactured by Whelen. The rear directional warning light is 1.15 m long, has eight lamps, and is manufactured by Whelen. The strobe lights mounted inside the headlights and the taillights are also manufactured by Whelen.

The standard Ford uplifter switches mounted on the dashboard labeled AUX 1 through AUX 4 are used to control the lighting system (see figure 21).

The safety lighting controlled by each switch are:

- AUX 1: Provides power to the light bar.
- AUX 2: Provides power to the directional warning light.
- AUX 3: Controls the front strobe lights.
- AUX 4: Controls the rear strobe lights.

Figure 19. Light bar on front of the vehicle.

Figure 20. Directional warning light on the rear of the vehicle.

Figure 21. Uplifter switches used to control the safety lighting.

The end of the switch illuminates amber when turned on. These switches have a green backlight when the vehicle lights are turned on.

The controller for the directional warning light is mounted on the right side of the driver's seat at the base of the seat. The controller has a Low/Off/High position switch and a rotary switch to control the flash pattern (see figure 22). The "Low" position should be used for night time operations while the "High" position should be used for daytime operations.

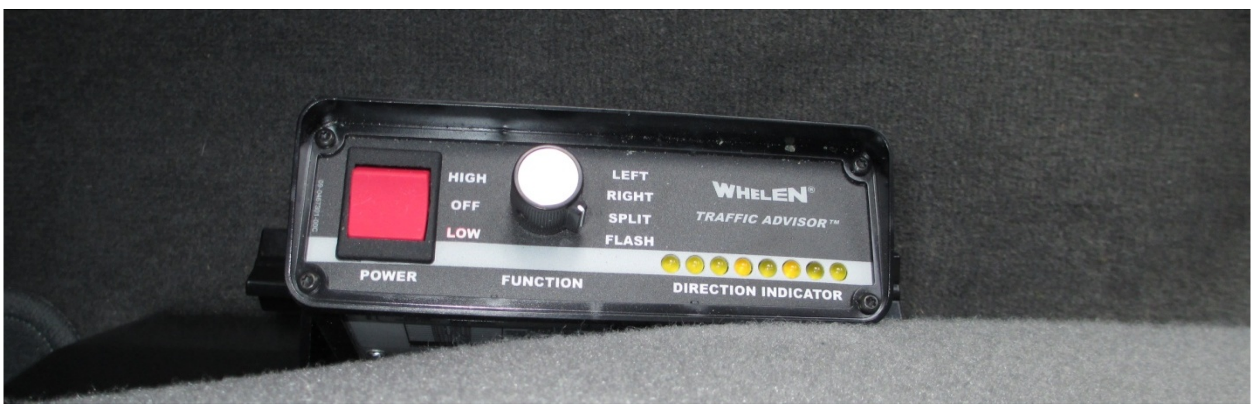


Figure 22. Control switch for directional warning light.

The rotary switch has four positions, which are:

- Left: The lights flash from right to left.
- Right: The lights flash from left to right.
- Split: The lights starts from center and go towards both left and right side.
- Flash: The lights flash on continuously.

The flash patterns of the strobe lights can be changed by pressing the red button that is inside the engine compartment (see figure 23) while the strobe lights are turned on. Two persons are needed to set a flash pattern. One person must turn on the strobe lights while the other presses and holds the red button for two seconds.

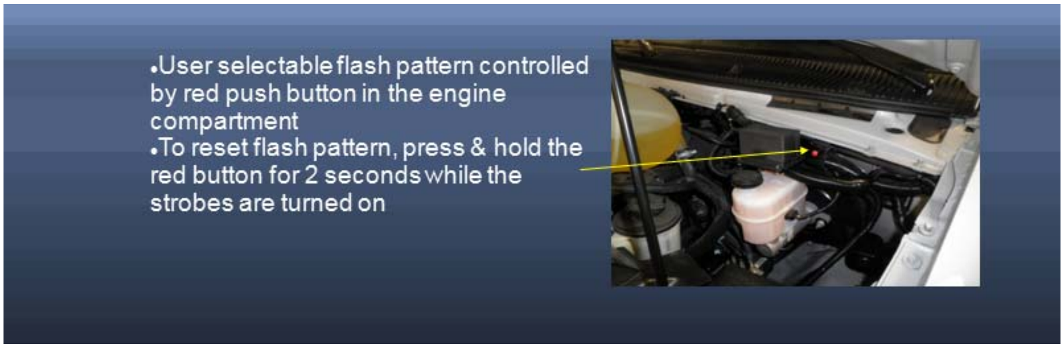


Figure 23. Control button to change strobe pattern.

The strobe lighting system contains a turn signal interrupt module. This module disables the strobe lights when a turn signal is activated, and enables the strobe lights five seconds after the turn signal is disabled.

Figure 24 shows the top view of the fuse and relay junction box that is associated with the safety lighting systems on the vehicle.

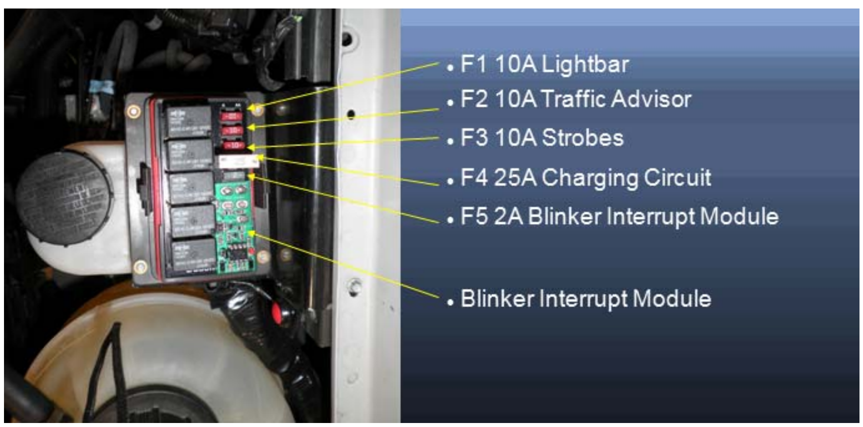


Figure 24. Fuse and relay junction box of the safety lighting system.

2.2.11 Equipment Rack

An equipment rack is located behind the driver's seat in the van. The following components/equipment are housed on or inside the equipment rack:

- Shore power port.
- Auxiliary battery.
- Auxiliary battery charger.
- Auxiliary battery status monitor.

- Inverter.
- Laser printer.
- Buzzer.
- PSM module.
- Network Router.
- Circuit breakers.

Figure 25 shows a front view of the equipment rack, while figure 26 shows a view of the bottom of the equipment rack with the front cover off.

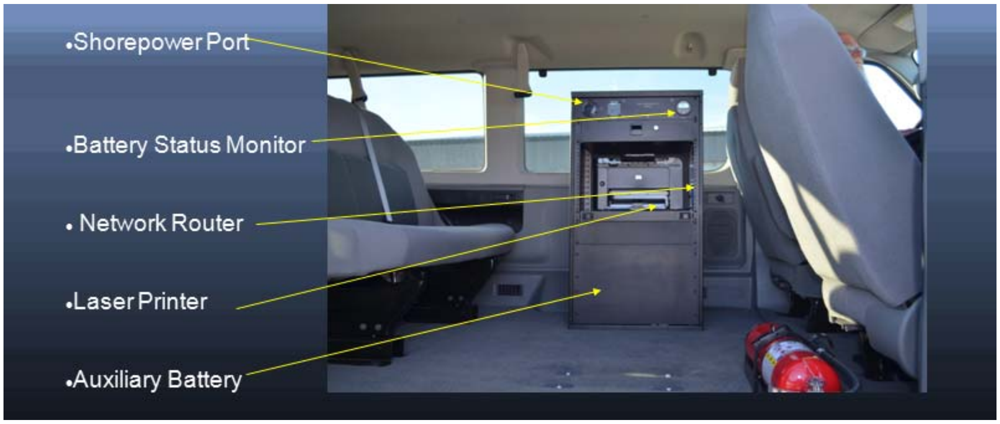


Figure 25. Front view of the equipment rack.

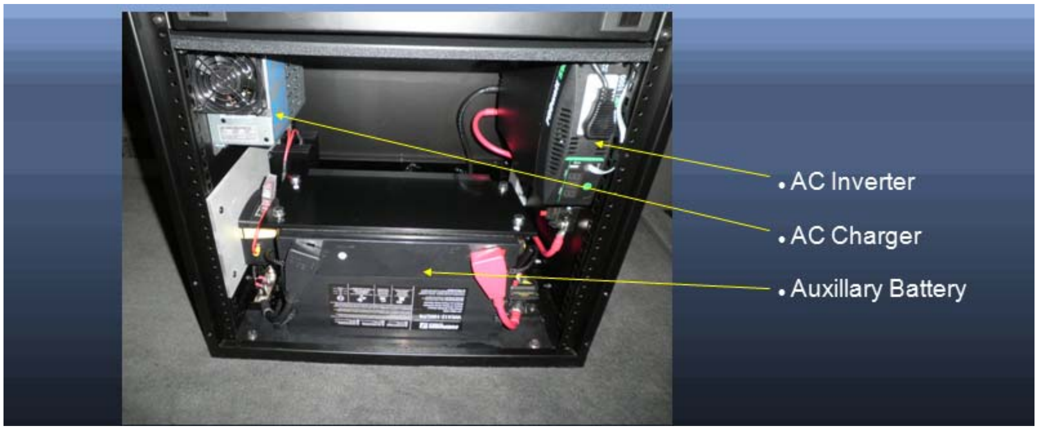


Figure 26. View of the bottom of the equipment rack with the front cover off.

Shore power Port: The top of the rack has a port for plugging in power from an outside source.

Auxiliary Battery: A 100 ampere, 12 V battery is located at the bottom of the rack. This battery is manufactured by Werker, is located within a battery guard, and is sealed and does not require maintenance. The battery supplies power to the DAU, all sensors mounted in the sensor bar, the ambient and surface temperature sensors, the GPS, the display box mounted on the dashboard, the laptop computer, and the laser printer. When the vehicle is running, the alternator in the vehicle is used to charge and maintain the voltage of this battery; a maximum of 30 amperes will be drawn from the alternator to charge the battery. The battery has a low voltage disconnect at 11.8 V, and will shut off power when this voltage is reached.

Auxiliary Battery Charger: The battery charger charges the auxiliary battery when connected to shore power. The charger supplies 15 amperes of current for charging the auxiliary battery. The charger will first charge the auxiliary battery, and when the auxiliary battery voltage rises above 13.6 V, the automatic relay will combine the two batteries, which will allow the vehicle battery to be charged as well. The relay disconnects the auxiliary battery from the vehicle battery when the voltage falls below 12.75 V.

Auxiliary Battery Status Monitor: The auxiliary battery status monitor on the equipment rack shows the voltage of the auxiliary battery.

Inverter: A PROWatt sine wave inverter manufactured by Xantrex is located in the equipment rack and provides power to the laser printer and a power strip. The power strip can be used for charging any equipment. This inverter is rated at 1000 W. The inverter is turned on by a push button at the top of the rack.

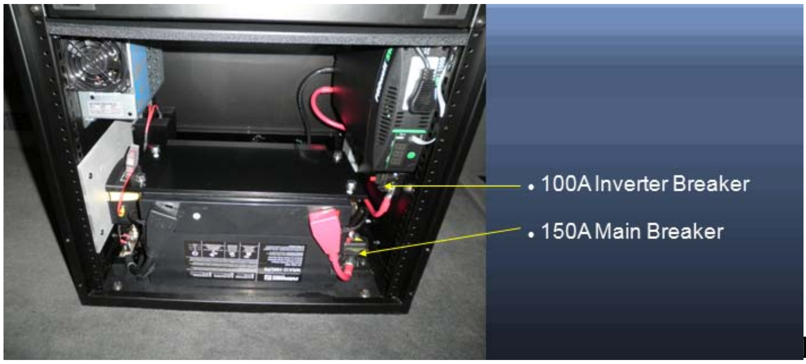
Laser Printer: A Hewlett Packard Model P 1606 laserjet printer is located inside the equipment rack.

Buzzer: A buzzer is located inside the equipment rack. The buzzer will emit five rapid beeps when the photocell detects the reflective mark at the start of the section. When profiling SPS sections, the buzzer will emit a single short chirp when reflective marks located at the start of the subsequent sections are encountered. The buzzer will emit five rapid beeps at the end of the section when the "Distance" option is used to terminate data collection, and thereafter will emit a long beep after 152.4 m of profile data has been collected after the end of the section.

PSM Module: A single cable that contains an Ethernet cable and a RS485 cable, connected to one port in the DAU, transmits the data collected by all sensors located in the sensor bar, the GPSR, and the DMI to the PSM. The Ethernet cable is then carried through and connected to an input port in the router that is located on the equipment rack. The output from the ambient temperature sensor and the Raytek controller that provides the output from the surface temperature sensor is fed into the PSM module. An Ethernet cable connects the PSM module to an input port in the router and transmits the ambient temperature and pavement surface temperature data from the PSM module to the router.

Network Router: One input port in the router receives the ambient and pavement surface temperature data from the PSM module through an Ethernet cable. Another input port in the router receives an Ethernet cable from the DAU that transmits the profile height sensor data, accelerometer data, profile computed from data collected by each profile height sensor, the macrotexture data, DMI data, GPS data, and photocell signals. A single Ethernet cable connects the output port of the router to the laptop computer dock, and carries all of the data collected by various sensors in the device from the router to the laptop computer dock, and thereafter to the laptop computer for storage.

Circuit Breakers: There are two circuit breakers located at the bottom of the rack (see figure 27). The 100 ampere breaker mounted on the side of the rack disconnects power to the inverter. The 150 ampere breaker located next to the battery disconnects the battery from everything.



E

Figure 27. Circuit breakers on the equipment rack.

2.2.12 Display Unit on Dashboard

A display unit mounted on the top of the dashboard on the left side shows distance, speed, pavement surface temperature, reference temperature from the pavement surface temperature probe, ambient temperature, voltage, and current draw (see figure 28).

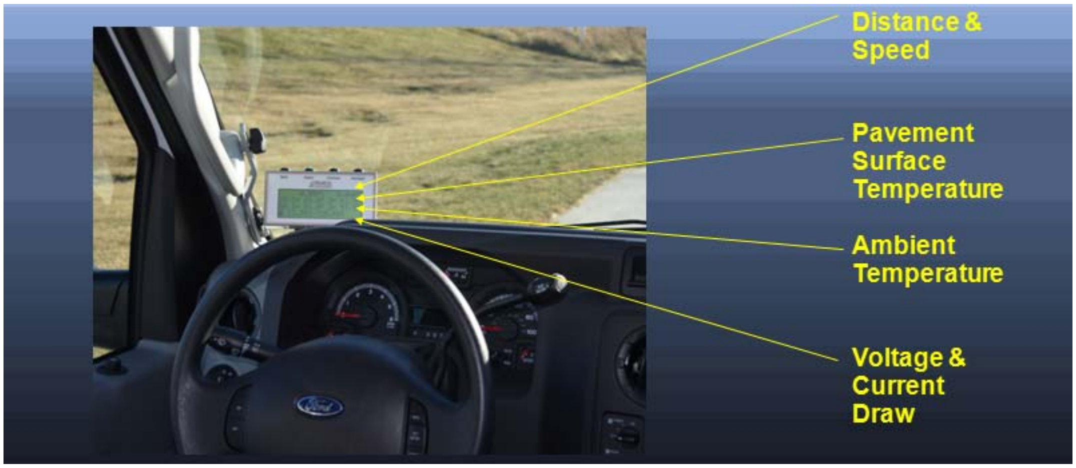


Figure 28. Display unit mounted on the dashboard.

The display unit is connected to the PSM, and obtains the displayed items through the PSM. There are four buttons on top of the display unit that are labeled as Mark, Select, Contrast, and Backlight (see figure 29).

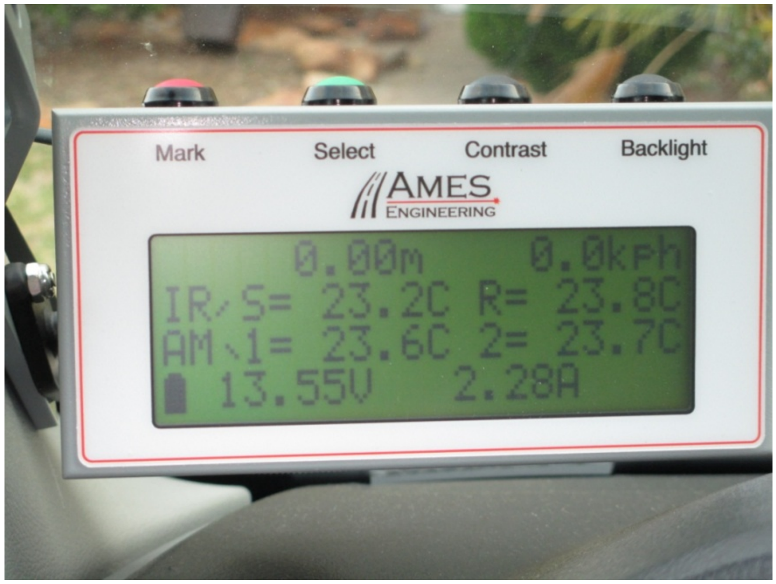


Figure 29. Display unit showing four data items.

Mark: When the Ames Engineering software is in the Horizontal Test mode, pressing this button will show the distance travelled. The vehicle can be stopped at any point and this button can be pressed again to re-zero the distance.

Contrast: This button controls the contrast of the display.

Backlight: This button controls the background light of the display.

Select: Pressing this button cycles through the amount of data that is shown on the display. The display can show a maximum of four data lines (see figure 29). The first row shows the travelled distance and the speed, the second row shows the temperatures measured by the pavement surface temperature sensor with S being the pavement surface temperature and R being the reference temperature. The third row shows the ambient temperature measured by the two probes in the ambient temperature sensor. The fourth row shows the voltage and current draw of the auxiliary battery.

Pressing the select button again will show only the first and the fourth rows (see figure 30). Pressing the button again will display all rows except for the third row (see figure 31). Continually pressing the Select button will cycle through the three display modes described above except that the display units will change from SI units to US Customary units (see figure 32).

2.2.13 Computer and Docking Station

A Ram Tough-Dock laptop computer docking station has been installed between the driver and passenger seats (see figure 33). The laptop computer provided in the device to record the collected data is a Panasonic Toughbook CF-52.

Figure 30. Display unit showing first and fourth rows.

Figure 31. Display unit showing all rows except for third row.

Figure 32. Display unit showing four rows (US customary units).

Figure 33. Laptop computer docking station with laptop computer.

The laptop computer has a Microsoft Windows 64 bit operating system, 8 GB of random access memory, a 500 Gb solid state hard drive, and 390 mm anti-glare display. A handle under the dock must be used to fully engage the laptop computer. The laptop computer can be locked onto the dock using the rotary key switch located on the front. The laptop computer dock has a secondary power switch located on the side.

2.2.14 Vehicle Security System

The van is equipped with a Clifford security system. The control box for the security system is mounted to the firewall near the brake pedal. A LCD remote with a pager is provided. The pager can be set to tone and a vibration mode or a vibration only mode. The security system includes a tilt sensor located on the sensor bar that will set off the alarm if the sensor bar cover is opened when the alarm is on.

2.2.15 Master Power Switch

The master power switch that provides power to all sensors in the device is located on the dashboard (see figure 34). Turning this switch on provides power from the auxiliary battery to the DAU, all sensors mounted in the sensor bar, the ambient and surface temperature sensors, the GPS, the display unit mounted on the dashboard, the PSM, laptop computer, laser printer, and the power strip. However, the inverter must be "On" in order to provide power to the laser printer and the power strip.

Figure 34. Master power switch.

2.2.16 Fire Extinguishers

There are two 4.5 kg ABC rated fire extinguishers inside the vehicle. One fire extinguisher is mounted behind the passenger seat, while the other is at the rear of the vehicle (see figure 35).

Figure 35. Fire extinguishers in the vehicle.

2.2.17 Calibration Block Kit

Ames Engineering provided a calibration block kit with each profiler. The following items are included in the calibration block kit

- Three 25 mm blocks.
- Three 50 mm blocks.
- Three 75 mm blocks.
- Three 100 mm blocks.
- Three base plates.
- Three targets.
- A digital level.

The blocks and targets are in one case, while the base plates and the digital level are in a separate case (see figure 36).

Figure 36. Calibration block kit.

The calibration blocks are steel blocks with a rustproof black oxide coating. The target is a tungsten carbide plate that has been sand blasted. The target plate has a shiny side and dull (matte) side and measurements should always be obtained on the dull side. The base plate is made out of aluminum. The calibration blocks have a block label engraved on the side. Table 2 shows the exact dimensions of the blocks. One set of blocks is included in each device. The blocks assigned to each device are shown in table 2.

Table 2. Dimensions of calibration blocks.

Ames Serial No,	Block Label	Block Height (mm)	Block Label	Block Height (mm)	Block Label	Block Height (mm)	Block Label	Block Height (mm)
830112	A-1	25.00422	A-13	50.00445	A-25	75.00381	A-37	100.00356
	A-2	25.00432	A-14	50.00406	A-26	75.00343	A-38	100.00279
	A-3	25.00381	A-15	50.00419	A-27	75.00381	A-39	100.00305
830212	A-4	25.00366	A-16	50.00381	A-28	75.00381	A-40	100.00381
	A-5	25.00427	A-17	50.00432	A-29	75.00406	A-41	100.00381
	A-6	25.00469	A-18	50.00445	A-30	75.00406	A-42	100.00076
830312	A-7	25.00396	A-19	50.00394	A-31	75.00356	A-43	100.00254
	A-8	25.00305	A-20	50.00279	A-32	75.00457	A-44	100.00432
	A-9	25.00348	A-21	50.00432	A-33	75.00356	A-45	100.00406
830412	A-10	25.00445	A-22	50.00457	A-34	75.0033	A-46	100.00152
	A-11	25.00394	A-23	50.00457	A-35	75.00305	A-47	100.00432
	A-12	25.00457	A-24	50.00356	A-36	75.00406	A-48	100.00406

2.2.18 Texture Reference Test Device

Ames Engineering provided a texture reference test device to verify the accuracy of the texture laser height sensors. Figure 37 shows a photograph of this device. It consists of a hard disk that has been machined accurately to provide four steps alternating between 0.5 and 1 mm in height. This device is connected to the DMI port in the DAU by first disconnecting the DMI connection from the encoder to simulate travel distance and is powered from a photocell outlet in the laser box. The device is placed below a texture height sensor with the laser dot centered on the target indicated on this device. This disk is rotated at 7,200 rpm, which produces 120 rotations per second. This simulates data collection at 86.4 km/h. One rotation of the disk covers 200 mm of distance. The mean profile depth (MPD) value is computed from the collected data and displayed on the screen of the laptop computer. Ames Engineering has indicated the theoretical MPD computed from the step heights on the disk is 0.75 mm.

2.2.19 Toolbox

Ames Engineering provided a toolbox with each profiler (see figure 38). Figure 39 shows the contents of the toolbox.

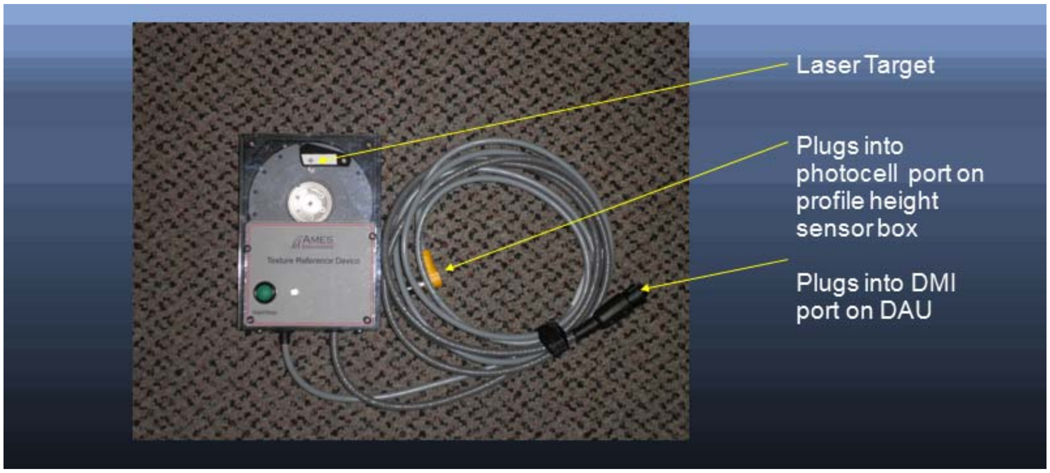


Figure 37. Texture reference test device.

Figure 38. Toolbox provided with each device.

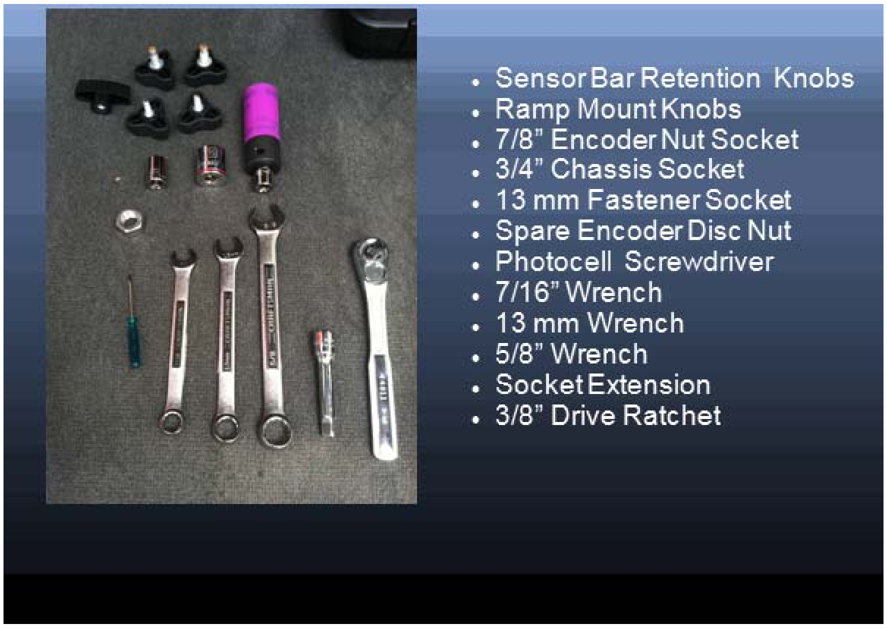


Figure 39. Contents of the toolbox.

2.2.20 Calibration Ramps

Four ramps that are used to elevate the vehicle when conducting the full calibration check of the profile and texture height sensors is provided with each device. Figure 40 shows a photograph of a ramp. There are two steps in the ramp, with each step being 38 mm in height. The ramps must be secured after completing the full calibration check using the securing mechanism provided at the back of the bench seat in the vehicle (see figure 41). The securing mechanism consists of two vertical rods, and the ramps are inserted into these rods through the two holes in each ramp, and then tightened with a nut. A felt cloth is placed between the ramps to prevent them from sticking together.

Figure 40. Ramp used to elevate vehicle.

Figure 41. Mechanism for securing the ramps.

2.2.21 Camera

The device is equipped with an Ames right-of-way camera system that contains a Sony Charge Coupled Device (CCD) camera. This camera is mounted inside the vehicle on the metal mount that is attached to the windshield that supports the rear view mirror (see figure 42). The camera takes images of the roadway as viewed from inside of the vehicle. A cable from the camera is connected to a Universal Serial Bus (USB) port in the laptop computer. Figure 43 shows an example of an image obtained by this camera. The date, time, GPS information, and distance from start of the section are embedded into the bottom of the image as shown in figure 43. The location of the data file is embedded on the top of the image. The camera will take the first image when the photocell detects the reflective tape that is placed on the pavement if using the vertical photocell or the reflective tape on the cone if using the horizontal photocell. Because of the system delay, the first image is obtained about 4 to 5 m from the reflective tape. The images taken are stored in the Joint Photographic Expert Group (JPEG) format.

Figure 42. Right-of-way camera.

Figure 43. Example of an image obtained by the camera.

2.3 FEATURES OF THE DEVICE

2.3.1 Data Saved by the Device

All data collected by the device in a single run are saved in one file which is referred to as an Ames Raw Data (ARD) file that has a file extension of ARD. These files are hereafter referred to as ARD files. The following data items are contained in an ARD file: profile data, profile height sensor data, texture height sensor data, accelerometer data, DMI data, ambient temperature sensor data, pavement surface temperature data, GPS data, event data from photocells, event keys entered by the user, and diagnostic information. The profile data saved in the ARD file has an upper wavelength filter applied on the data. However, the applied upper wavelength cut-off filter is greater than 100 m. A 100 m upper wavelength filter is applied when the collected profile data is viewed in the Ames Engineering Viewer software or when the data is exported to ProQual.

2.3.2 Exporting Data to ProQual

The ProQual software is used in the LTPP program to process and perform quality control checks on the collected profile data in the field, while the Sidekick program is used in the field to perform quality control checks on the ambient temperature data, pavement surface temperature data, MPD data, and the data collected by the GPSR. The ProQual software is used in the office to create data files that are uploaded to the LTPP Pavement Performance Database (PPDB). The data saved in Ames Engineering data file are transferred into ProQual and Sidekick through a Dynamic Link Library (DLL).

2.3.3 First Data Point in a Section

Historically, in the LTPP program, the first profile data point assigned to a section has been at a distance of 114 mm from the leave edge of the start stripe located at the beginning of the section (i.e., Distance = 0 for profile data is located 114 mm from the leave edge of the start stripe at a section). Data collected by Ames Engineering devices also conform to this criterion.

The vertical photocell in the device triggers when the photocell detects the approach end of a reflective tape placed on the pavement. The horizontal photocell in the device triggers when the photocell detects the approach end of the reflective tape that is mounted on the cone that is placed on the shoulder. The width of the reflective tape that is used to trigger data collection is an input parameter in the header screen that must be filled before starting data collection. The distance of 114 mm that was mentioned previously is a parameter that is assigned in a setup screen in the Ames Engineering software. The Ames Engineering software uses these 114 mm in the setup screen and the width of the tape input in the header screen in order to assign the first profile and macrotexture data point at a section to be at a distance of 114 mm from the leave edge of the reflective tape at the beginning of the section.

2.3.4 Pre- and Post-Run Data

Height sensor, accelerometer, DMI, and profile data for a distance of 152.4 m before the start of the section and after the end of the section are stored in the ARD file. This pre- and post-run distance is a value that is specified in a setup screen in the Ames Engineering software. Proper application of the 100 m upper wavelength cut-off filter to the profile data requires 152.4 m of data before the start of the section and 152.4 m of data after the end of the section.

Macrotexture data for a distance of 30 m before start of the section and after end of the section are also stored in the ARD file. The pre- and post-run macrotexture data distance is set in an Ames Engineering software initialization file.

2.3.5 Event Keys

The operator can press any letter key in the bottom row of the keyboard (i.e., keys Z though M) during data collection to include an event mark in the data file. Event keys are not used for normal LTPP data collection. However, these keys could be useful if these devices are used for non-LTPP data collection. For example, the following are some examples when event keys can be used:

- Mark start and end of a bridge.
- Mark start and end of a Weigh-in-Motion (WIM) scale located on the pavement.
- Mark location where the surface type of the pavement changes.

2.4 COMPUTER AND SOFTWARE SETTINGS

2.4.1 Computer Settings

1. The laptop computer contains a wireless adapter. The wireless adapter can interfere with data collection as the adapter is always looking for wireless connections. Therefore, the wireless adapter should be disabled. Figure 44 shows the Microsoft Windows menu where the status of the wireless adapter can be checked.

Figure 44. Wireless adapter setting in the computer.

2. The power management in the laptop computer should be set to the settings shown in figure 45 to avoid the display from dimming, turning off, or putting the laptop computer to sleep, which all can affect data collection.

Figure 45. Power management settings in the laptop computer.

2.4.2 Ames Engineering Software Settings

The Ames Engineering software is used to collect, process, and save profile and macrotexture data. The settings in the Ames Engineering software were set at appropriate values when the FHWA took delivery of the devices. 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 re-installed, if a newer version of the software is installed, or if problems are encountered with the software.

The setup menu in the software has the following six tabs to enter or select setup parameters:

- Report.
- Analysis.
- Profiler.
- Sensors.
- Camera.
- Raytek.

Only the items in the Profiler, Sensors, Camera, and Raytek menus have an impact on the data collected for the LTPP program. There is one setting in the Report menu that has an impact on the MPD values computed by the Ames Engineering software and during the texture reference device test; the other settings have no impact on data collected or processed for the LTPP program. The following steps take the operator through the different settings that need to be checked and/or updated.

1. Follow procedures described in section 2.8.1 to boot-up the laptop computer and launch the Ames Engineering software. The Ames Engineering start-up screen (see figure 46) should now be displayed on the laptop computer screen.

2. Press F1 key or select "Setup". The Report Options screen shown in figure 47 will be displayed. The setting for "Spike Removal" has an impact on MPD values that are computed through the Ames Engineering software and during the texture reference device test. All other settings in this screen have no impact on data collected or processed for the LTPP program. When the "Spike Removal" field is enabled, spikes in texture data will be removed using an algorithm that was developed by Ames Engineering before computing the MPD value for data collected during the texture reference device test and also when computing MPD values through the Viewer menu in the Ames Engineering software. LTPP has decided not to use the "Spike Removal" option for MPD computations. Therefore, the "Spike Removal Field" should not be checked.

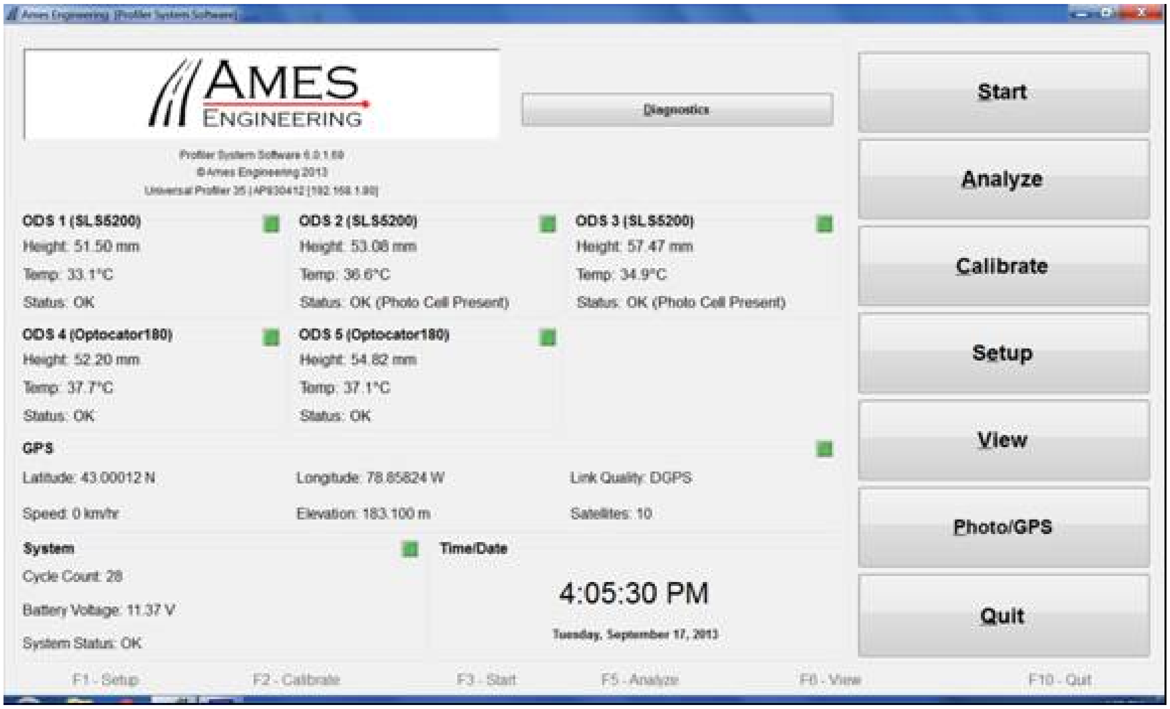


Figure 46. Ames Engineering start-up screen

3. Select “Profiler” tab. The Profiler Setup screen shown in figure 48 will be displayed. This screen should show the following settings:

   - Identification: As shown in figure 48, all fields under “Identification” which are Operator Name, Company Name, Certification #, and Certification date should be blank.

   - Collections Options: As shown in figure 48, “Show End of Run Note” should be checked. “Create ADF file” and “Single Block Extensive” should not be checked.

   - Profiler Settings: The entries under “Profiler Settings” are protected by a password. The password is ames60, and any entry under “Profiler Settings” can be changed by the operator after entering the password. The Serial # field should have the serial number assigned to the device. See table 1 for the serial number of the device assigned to each RSC. All other entries under “Profiler Settings” should exactly match the values shown in figure 48 except for the Product Key. The Product Key will show the unique number that was provided for the camera for each device.

4. Select “Sensors” tab. The Sensor Setup screen shown in figure 49 will be displayed. The items that are checked and the values shown on the laptop computer screen should exactly match parameters shown in figure 49. If any differences are noted change settings to match what is shown in figure 49 and then select the “Save” button must to save the changes.

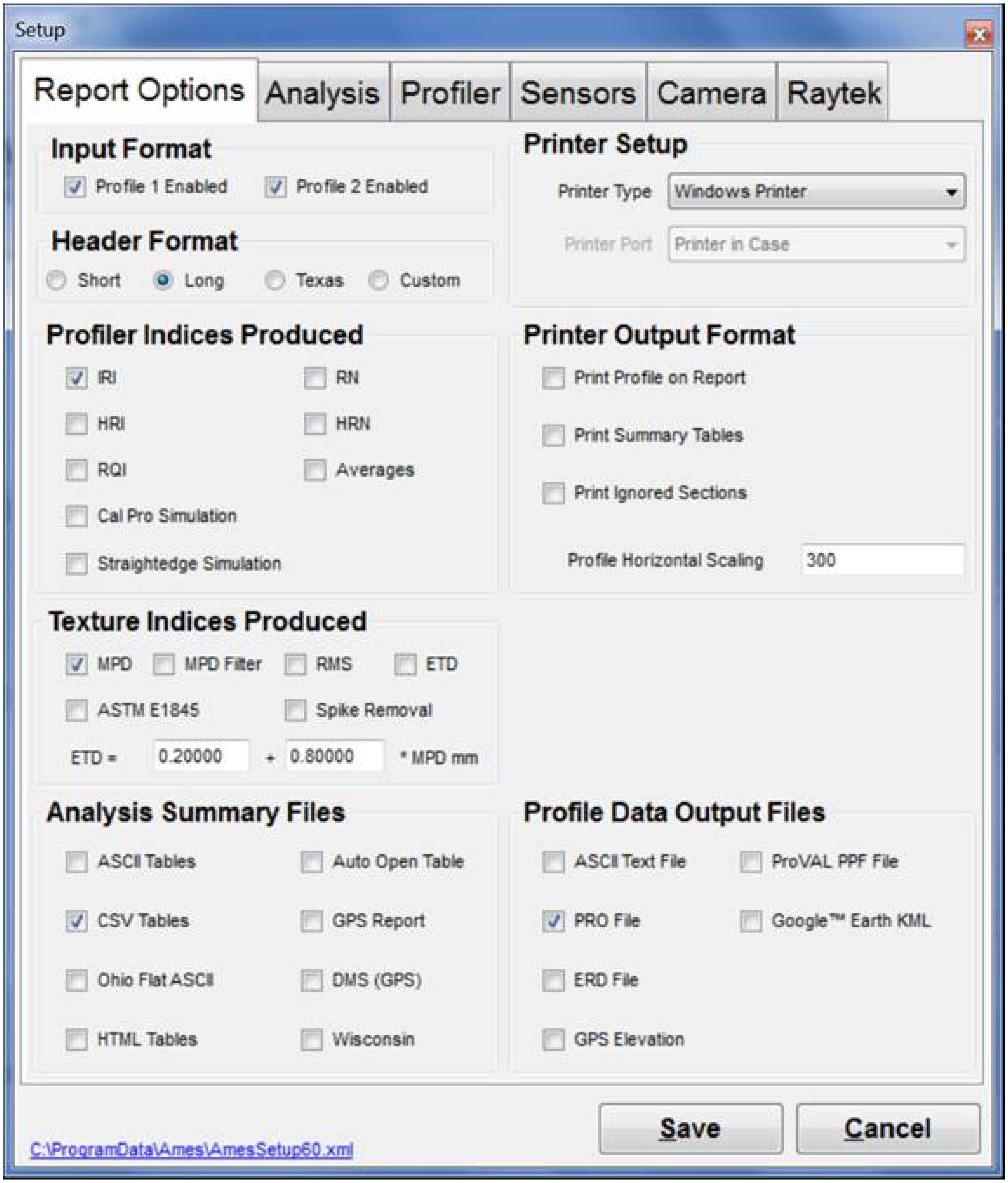


Figure 47. Report options screen.

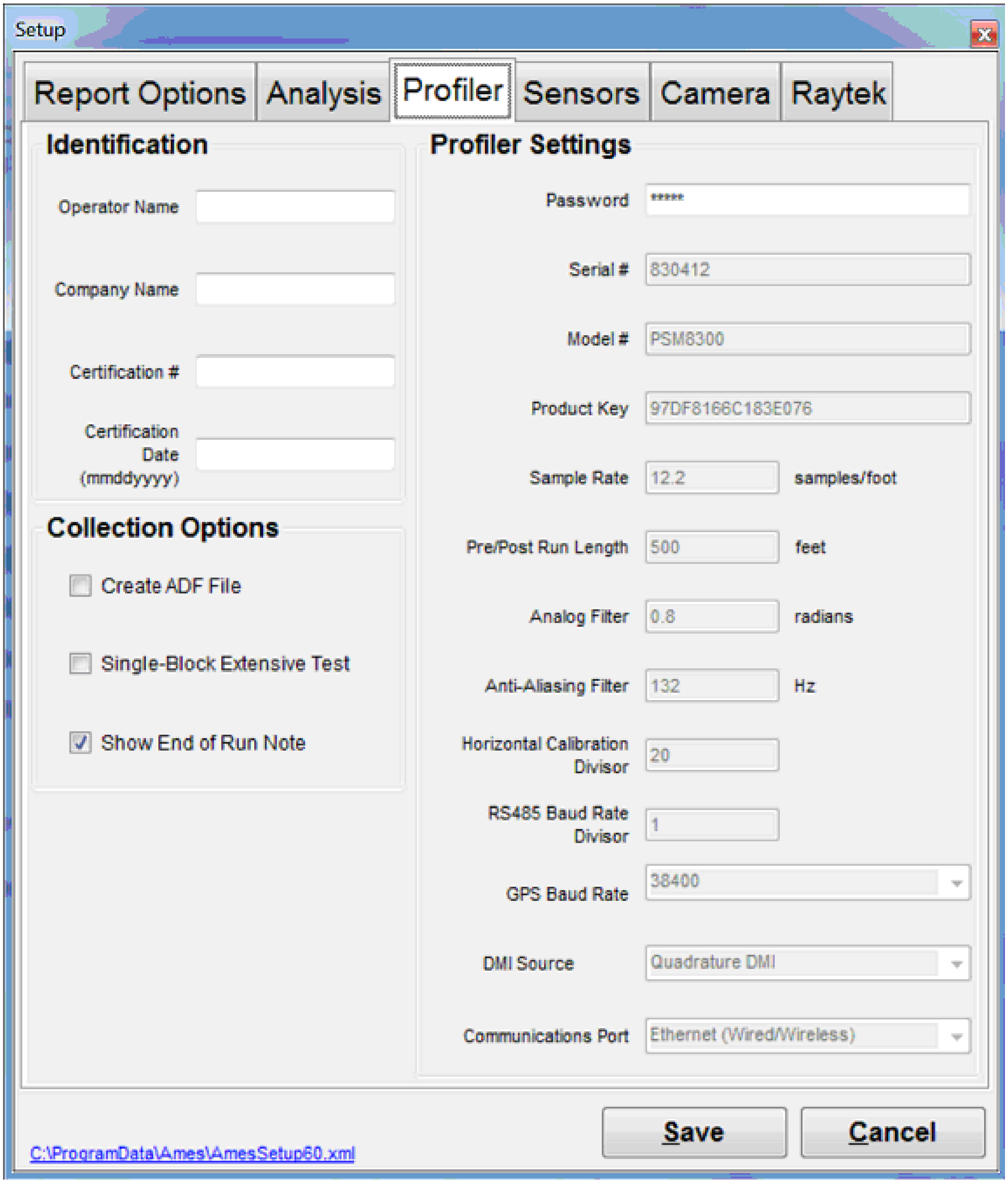


Figure 48. Profiler setup screen.

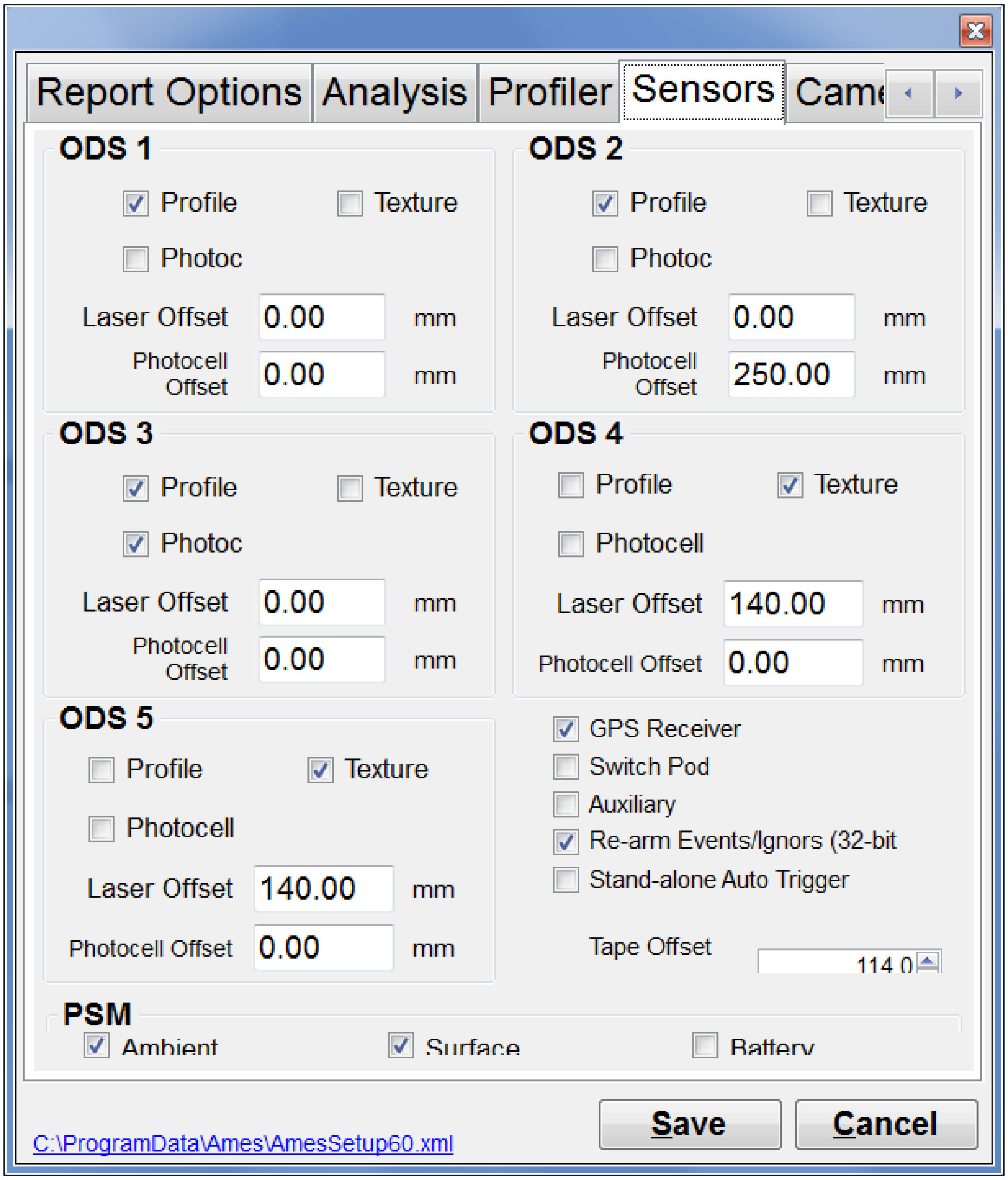


Figure 49. Sensors setup screen.

The following is a brief explanation of the items shown on this screen:

- The checkmark for "Profile" under ODS1, ODS2, and ODS 3 indicates these sensors are enabled for profile data collection. Note: ODS1 is the left wheel path profile sensor, ODS 2 is the right wheel path profile sensor, and ODS3 is the center profile sensor.

- The checkmark for "Texture" under ODS4 and ODS5 indicates these sensors are enabled for macrotexture data collection. Note: ODS4 is the left wheel path texture sensor and ODS 5 is the right wheel path texture sensor.

- The vertical photocell is connected to ODS3. Hence, photocell is checked for ODS3. The vertical photocell is in line with all three profile height sensors (i.e., ODS1, ODS2, and ODS3). Hence, the photocell offset for ODS3 is zero.

- The horizontal photocell is connected to ODS2. Hence, photocell is checked for ODS2. The horizontal photocell is located 250 mm behind the profile height sensors. The photocell offset value of 250 mm is entered under ODS2 to account for this difference.

- The texture laser height sensors (ODS4 and ODS5) are located 140 mm behind the profile height sensors. In order to ensure the post-processed texture data for the section starts exactly at the same location where profile data collection started, the Laser Offset value is set to 140 mm.

- The tape offset is set to 114 mm in order for the first data point that appears in the post-processed data file to be 114 mm from the leave edge of the reflective tape that is either placed on the pavement or located on the cone that is placed on the side of the road.

- Check marks for Ambient, Surface, and GPS Receiver respectively make the ambient temperature sensor, pavement surface temperature sensor, and GPSR active.

- The check mark for Re-arm Event/Ignors makes the photocell look for a reflective tape mark after the photocell triggers off the mark at the start of the section. This function is used when SPS section are profiled, where the photocell looks for the reflective tape that is placed at the start of the SPS sections after the photocell is triggered by the reflective tape that is located at the start of the first section.

5. Select "Camera" tab to view the settings that are used for the right-of-way camera. Figure 50 shows an example of the displayed screen. When the camera is first installed, the product key for the camera that is provided by Ames Engineering has to be entered into the Product Key field that is under Profiler Settings in the Profiler Setup screen (see step 3).

   In the Camera Setup screen, the "Photo" mode must be enabled with 25.00 selected in the meters per photo field. The selected value indicates that images will be obtained by the camera at 25 m intervals.

   The following is a brief explanation of the other items shown on this screen:

   - Camera Configuration: This field is automatically filled, and shows DFx 41AU02.

   - Width and height: These fields are automatically filled with a width of 1,280 and a height of 960. These are image pixel sizes and indicate the highest resolution that is possible with the camera, which is 1,280 x 960. These values must not be changed.

   The Camera Preview window at the bottom of the setup screen shows the view from the camera. The software requires the settings to be saved before exiting the screen.

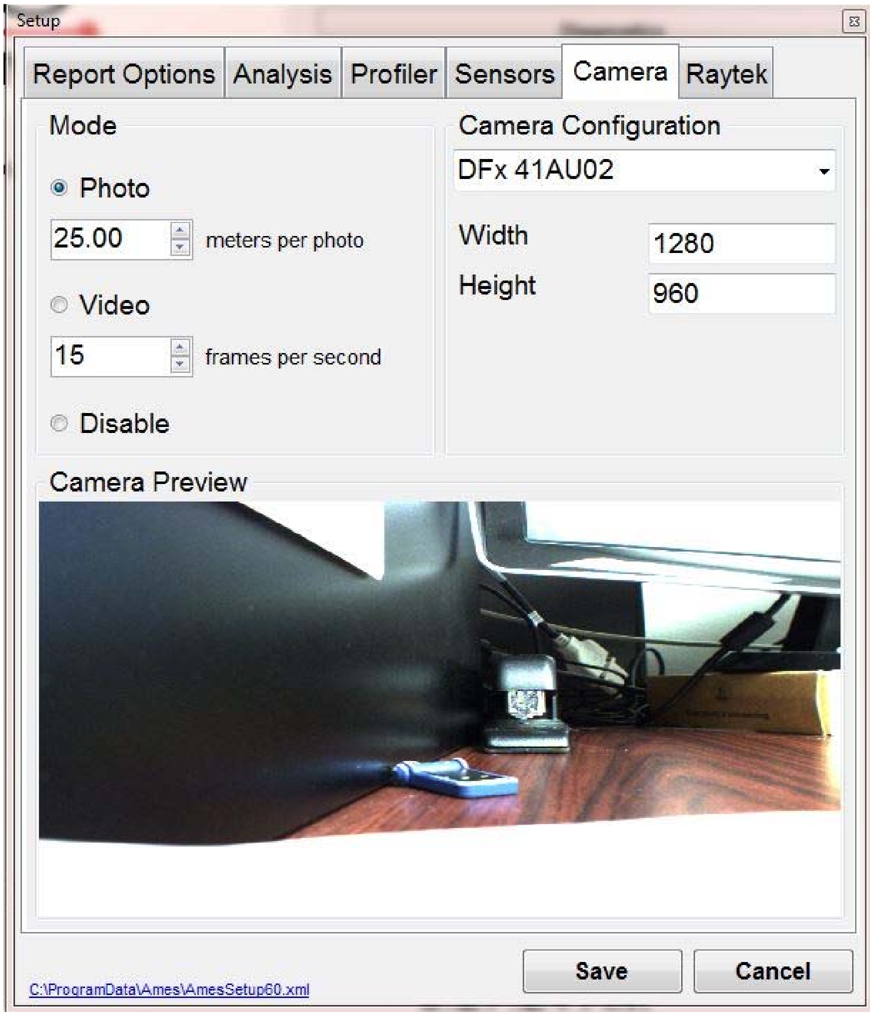


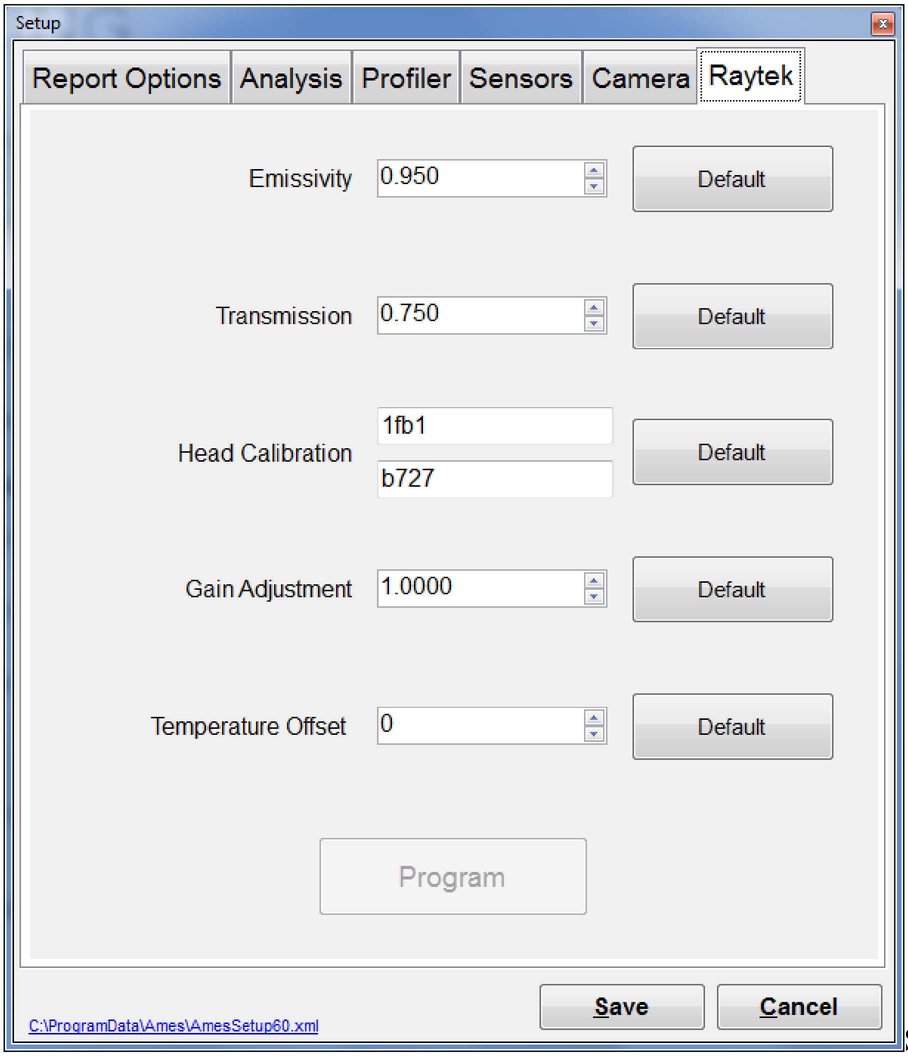
Figure 50. Camera setup screen.

6. Select "Raytek" tab to view the settings for the surface temperature sensor that measures the pavement surface temperature. When this tab is selected, the software accesses the Raytek Controller board and displays the current settings that are stored in the controller board. Figure 51 shows an example of the displayed screen.

The following values should be seen in this setup:

- Emissivity: The value should be 0.95.

- Transmission: The value should be 0.75 with the protective window present on the sensor and 1.0 when the sensor does not have the protective window. In the normal operating mode, the protective cover is present in front of the lens. There have been reports that the protective sensor has had cracks. If the protective cover is cracked, the sensor can be used with the protective cover off, with the transmission value set to 1.0.



Select

Figure 51. Raytek options screen.

- Head Calibration: The head calibration values specific to each device were entered into this field by Ames Engineering prior to the delivery of the device. When the sensors are purchased as a complete set (controller and sensor head), they come pre-programmed with the head calibration that matches the head that was shipped with that controller. If the two items are replaced together, the head calibration value should already match. These values must be updated manually if the Raytek temperature sensor is replaced, but not the controller. These values are usually attached to a label on the sensor head cable and must be entered manually. Ames Engineering must be contacted to get their input on how the values for the head calibration should be entered in this screen if the temperature sensor, controller, or both are replaced.

- Gain Adjustment: This value should be set to 1.0. The gain adjustment is used to add a linear gain adjustment to the values that are transmitted by the sensor controller.

- Temperature Offset: The value should be set to 0. This field is used to add or subtract an offset bias in the temperature measurements. The range for the offset is -200 to 200, with a change of 3°C for a 100 change in offset. Hence, the maximum adjustment is ±6 °C.

Note: If any value on this set-up screen is changed, such as changing the value for Transmission if collecting data without the protective cover, the "Save" button must be selected to save the entered parameters.

2.4.3 Ames Engineering Viewer Settings

The Ames Engineering Data Viewer is accessed by pressing the F6 key or selecting "View" in the start-up screen (see figure 46). Figure 52 shows the main menu of the Data Viewer. The data viewer can be used to perform following functions:

- Plot profile and macrotexture data.
- Calculate IRI values.
- Calculate MPD values.
- Generate data files containing profile or macrotexture data conforming to the University of Michigan Transportation Research Institute (UMTRI) Engineering Research Division (ERD) file format, referred to as ERD format.
- Generate data files containing profile or macrotexture data conforming to the data format for pavement profile specified in ASTM standard E 2560, referred to as ppf files.

The ERD files generated through the Viewer only contain the data collected within the test section. The file does not contain pre- or post-section data.

For the LTPP program purposes, profile data are generated at 25 mm intervals, while the macrotexture data are generated at 0.5 mm intervals. In order to generate ERD or PPF files having this data recording interval, certain parameters have to be set in the "Preferences Menu" of the Viewer that is located under the "Options" menu. The upper wavelength cut-off filter that is applied to the profile data also has to be specified in the "Preferences" menu. In order to correctly calculate MPD values, certain parameters also have to be set in the "Preferences" menu.

The following steps describe how to set the parameters referred to above:

1. From the main menu of the data viewer (see figure 52), select Options and then select preferences (see figure 53).

2. The General menu will now be displayed. The General menu should show the settings shown in figure 54.

3. Select "Profile Processing" and the Profile Processing menu shown in figure 55 will be displayed. The Profile Processing menu should show the settings and values shown in figure 55.

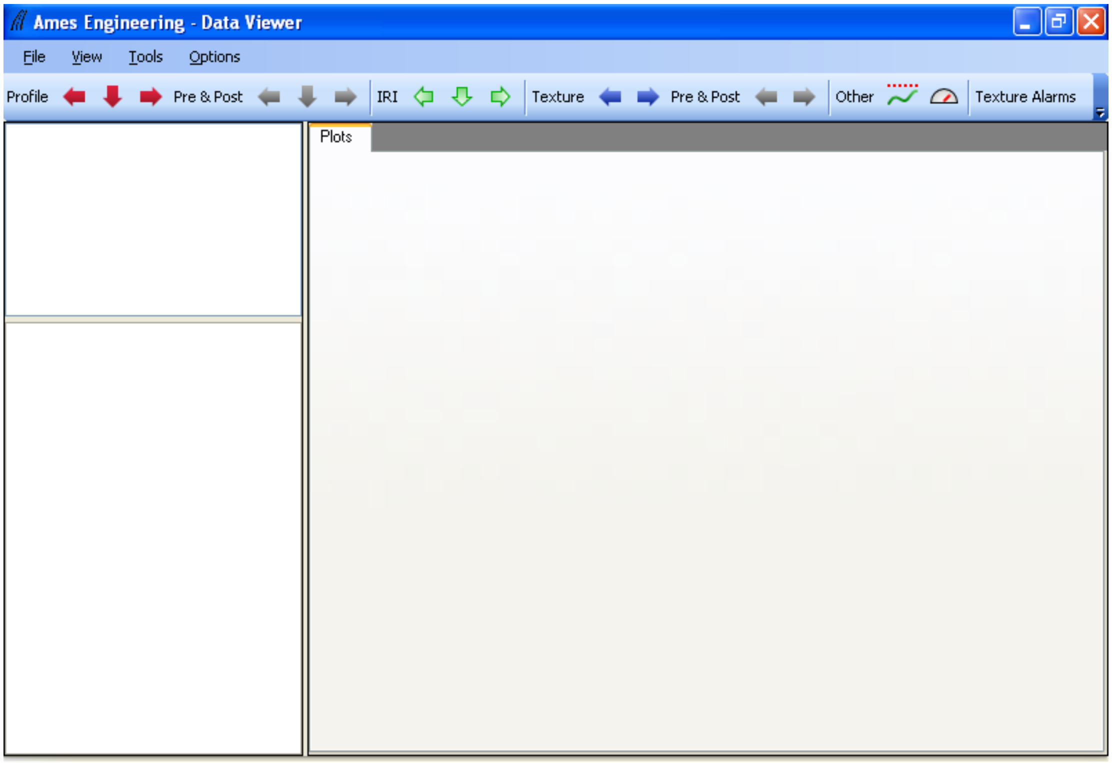


Figure 52. Main menu of data viewer.

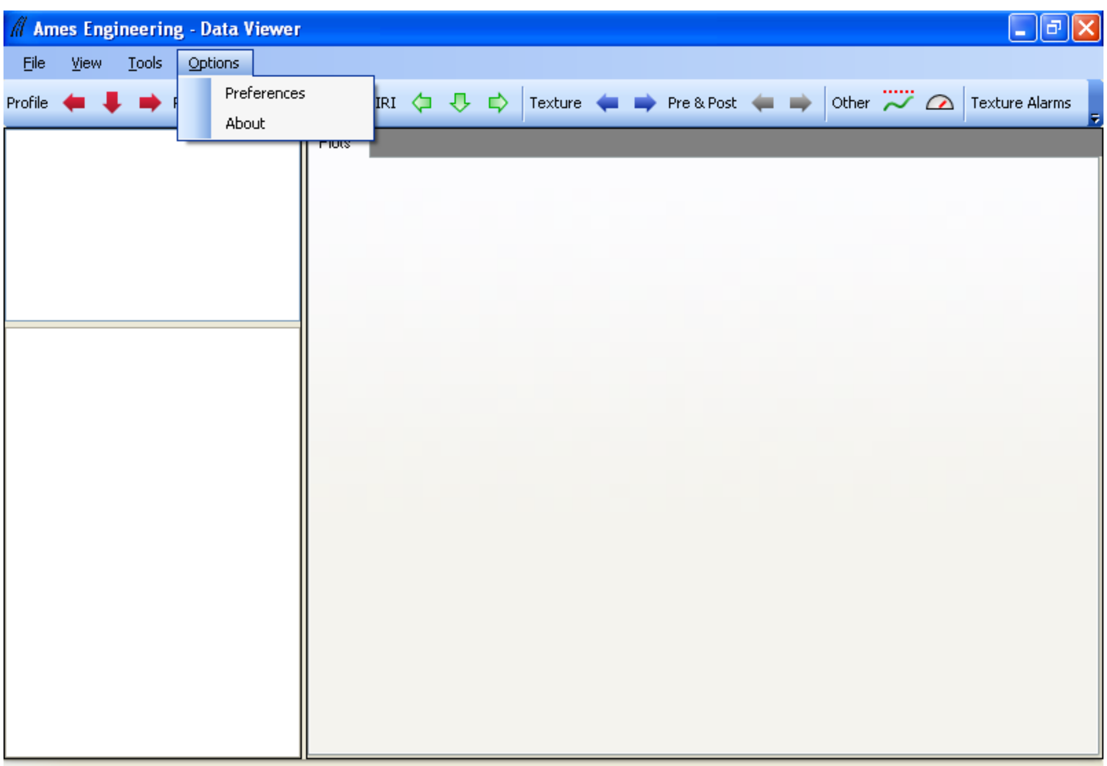


Figure 53. Selecting Preferences menus.

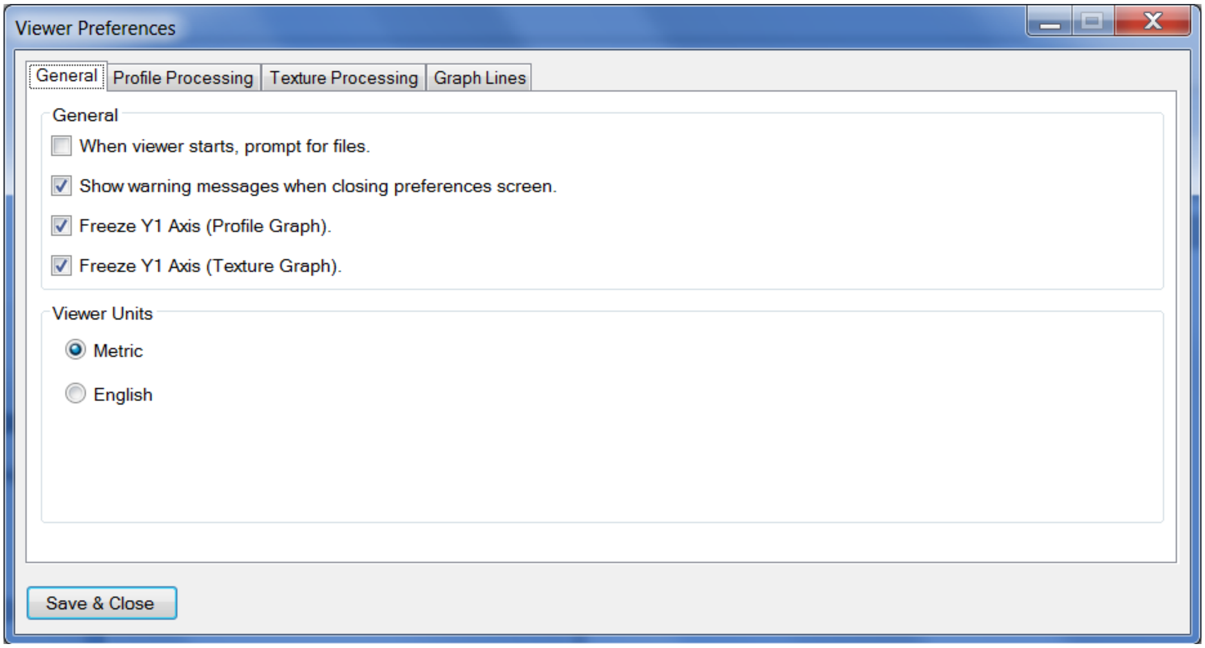


Figure 54. General menu.

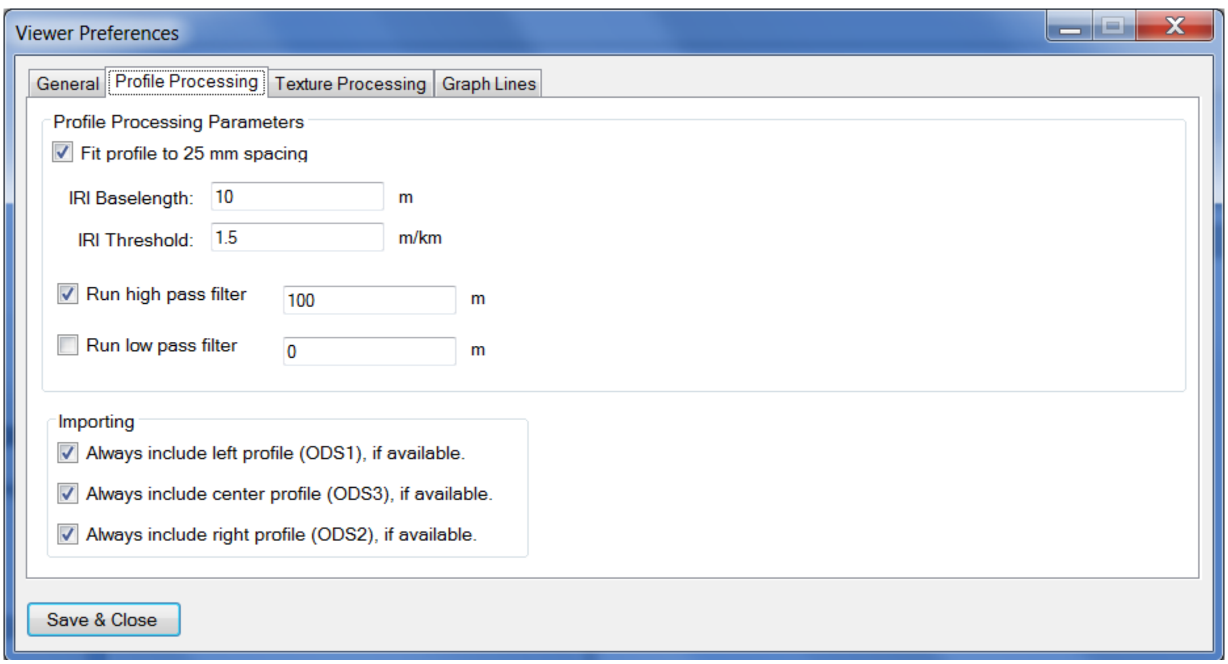


Figure 55. Profile processing menu.

4. Select “Texture Processing” and the Texture Processing menu shown in figure 56 will be displayed. The Texture Processing menu should show the settings and values shown in figure 56.

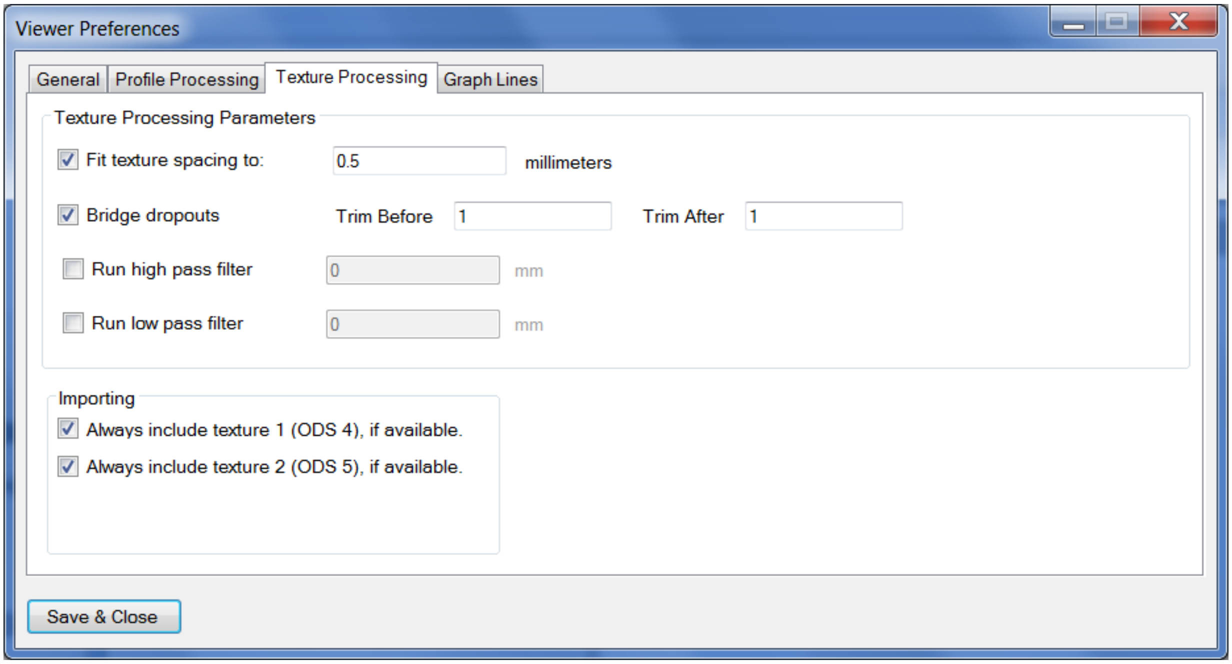


Figure 56. Texture processing menu.

5. If any changes were made because the displayed screens in the software were different from the ones shown in the manual, select “Save and Close” button to save the changes.

6. The MPD is computed from the Mean Profile Depth Analysis menu. Select “Tools” from the main menu of the data viewer (see figure 57) and then select Mean Profile Depth Analysis to get to this menu.

7. In the Mean Profile Depth Analysis menu, “Apply 2.5 mm low pass filter” option located on the left side of the menu must be checked when computing the MPD (see figure 58). Texture Track 1 and Texture Track 2 correspond to ODS4 (left wheel path texture data) and ODS5 (right wheel path texture data), respectively.

Note: In the “Report Options Menu” (see step 2 in section 2.4.2), the “Spike Removal” field was not checked. Hence, the spikes in the texture data are not removed before the MPD values are computed. If the user wants to compute MPD with spikes removed from the data, check the “Spike Removal” field in the “Report Options” menu, save the changes, and then compute the MPD values. After computations are completed, go back to the “Report Options Menu”, and remove check mark for the “Spike Removal” field, and save the changes.

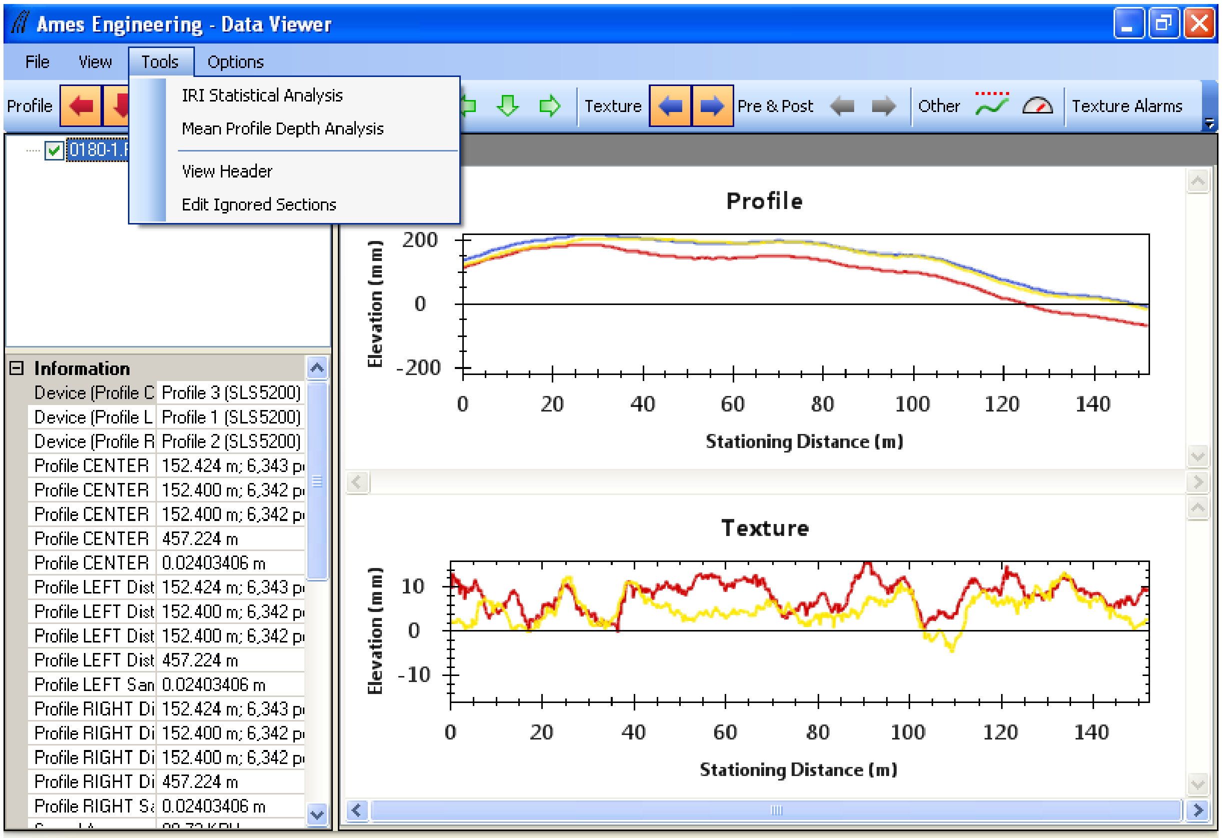


Figure 57. Accessing the Mean Profile Depth Analysis menu.

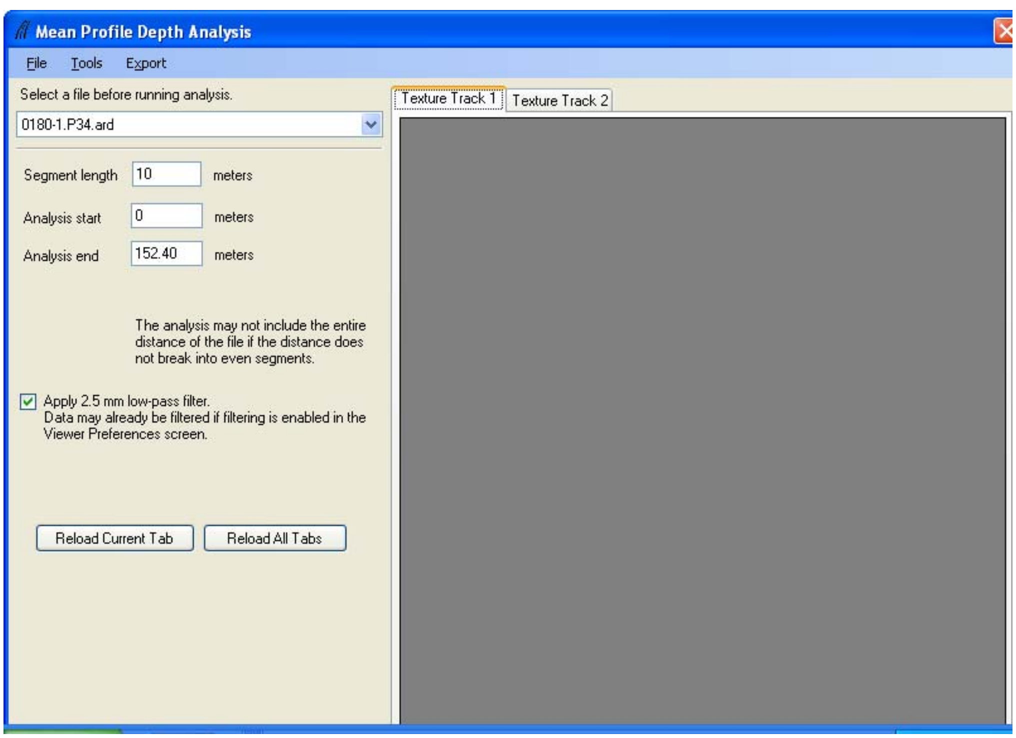


Figure 58. Mean Profile Depth analysis menu.

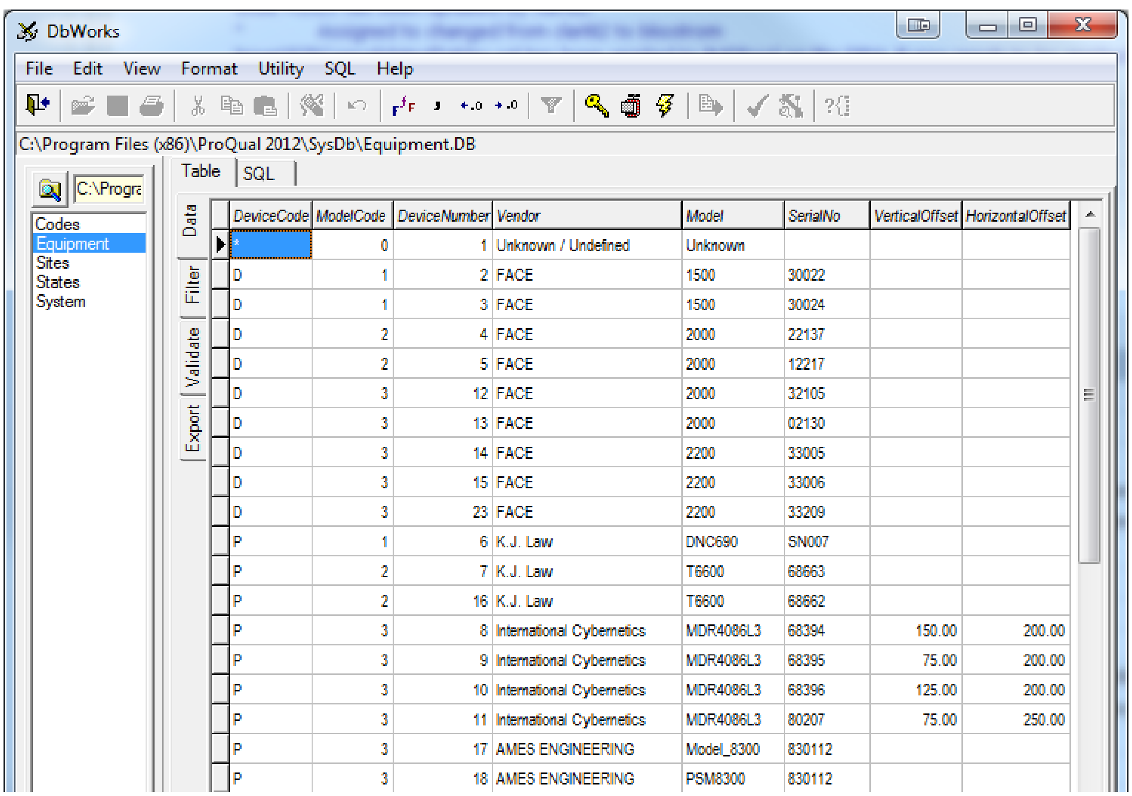
2.4.4 ProQual Software Settings

Installation procedure and descriptions of the ProQual software are provided in references 6 through 8. After ProQual is installed in the laptop computer, there are several parameters that have to be entered (or set) and others that have to be checked. Also, the Ames Engineering device has to be added as a device into ProQual. Use following procedure to add the Ames Engineering device to the file equipment.db:

1. Use Dbworks[(8)] to open the equipment.db file.

2. Add the following items related to the Ames Engineering device to the equipment.db file (see figure 59).

   Device Code: P
   Model Code: 3.
   Device Number: Sequential number indicating number of equipment in the file.
   Vendor: AMES ENGINEERING
   Model: PSM8300
   Serial Number: Select appropriate Ames Identification Number from table 1 (should be 830112, 830212, 830312, or 830412)
   Vertical Offset: Should be blank.
   Horizontal Offset: Should be blank.



DeviceCode	ModelCode	DeviceNumber	Vendor	Model	SerialNo	VerticalOffset	HorizontalOffset
*	0	1	Unknown / Undefined	Unknown			
D	1	2	FACE	1500	30022		
D	1	3	FACE	1500	30024		
D	2	4	FACE	2000	22137		
D	2	5	FACE	2000	12217		
D	3	12	FACE	2000	32105		
D	3	13	FACE	2000	02130		
D	3	14	FACE	2200	33005		
D	3	15	FACE	2200	33006		
D	3	23	FACE	2200	33209		
P	1	6	K.J. Law	DNC690	SN007		
P	2	7	K.J. Law	T6600	68663		
P	2	16	K.J. Law	T6600	68662		
P	3	8	International Cybernetics	MDR4086L3	68394	150.00	200.00
P	3	9	International Cybernetics	MDR4086L3	68395	75.00	200.00
P	3	10	International Cybernetics	MDR4086L3	68396	125.00	200.00
P	3	11	International Cybernetics	MDR4086L3	80207	75.00	250.00
P	3	17	AMES ENGINEERING	Model_8300	830112		
P	3	18	AMES ENGINEERING	PSM8300	830112		

Figure 59. Adding Ames Engineering device information to the ProQual equipment file.

Use following procedure as a check on the items that were entered into the equipment.db file:

1. Start ProQual, and then select System to bring up the System Menu shown in figure 60.

2. Select "Equipment" and the laptop screen will display a screen similar to that shown in figure 61.

3. Verify that the entries for Manufacturer, Model, Device Code, Model Code and Serial #: are correct. The Serial # should show the Ames Engineering identification number of the device used by the RSC. Under "Photocell Offsets" the entries for "Vertical" and "Horizontal" should both be blank.

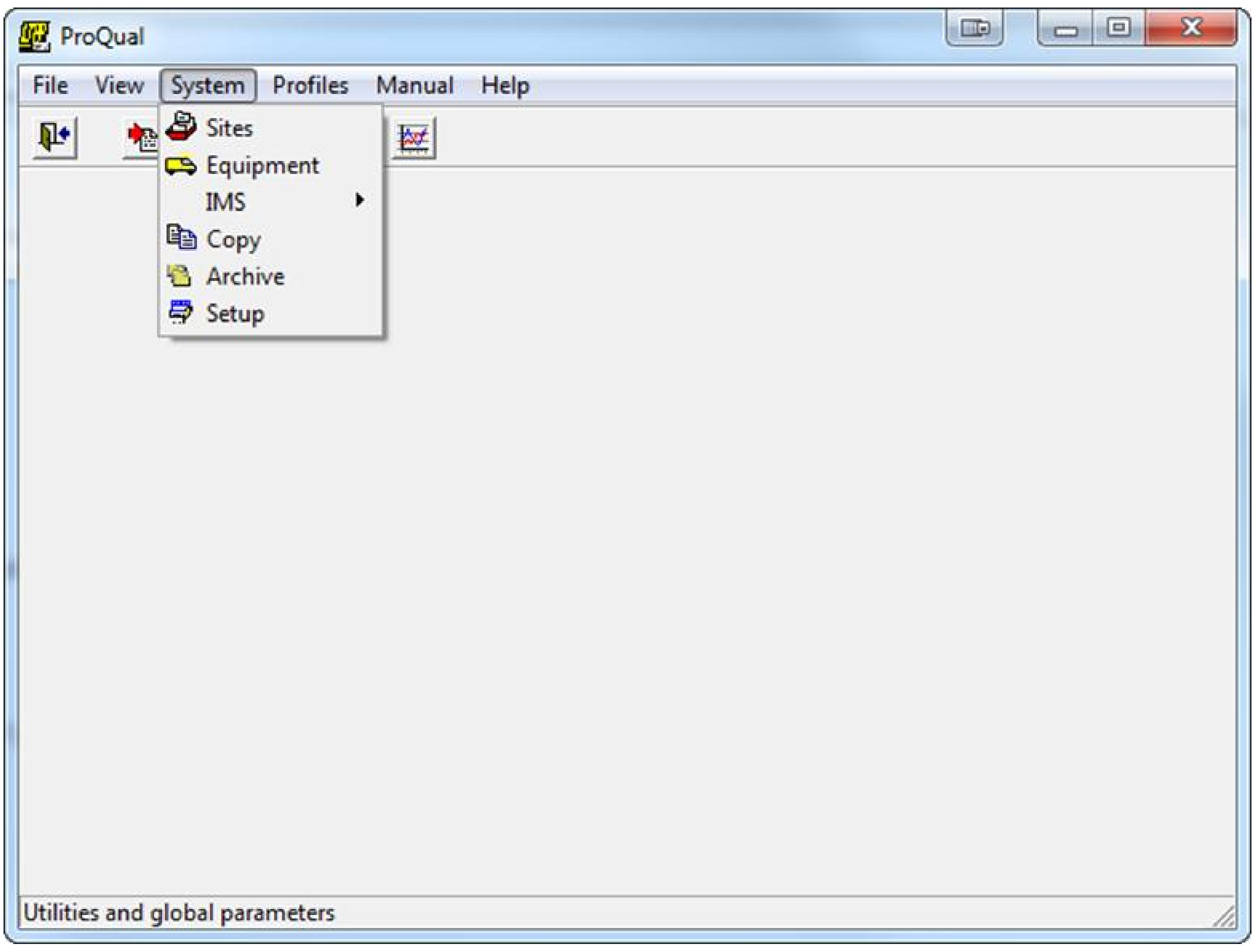


Figure 60. ProQual system menu.

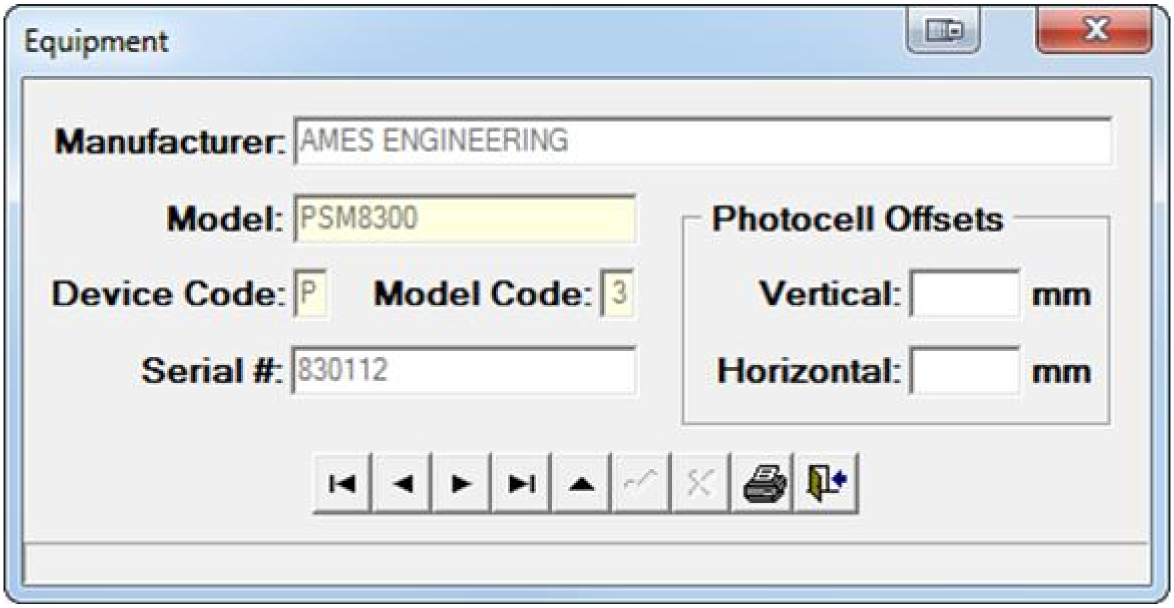


Figure 61. Equipment screen in ProQual.

Check that the Analysis Parameters have been set to the correct values by using the following procedure:

1. In Systems menu (see figure 60), select Setup. The Analysis Parameters screen shown in figure 62 will be displayed.

   The value for each parameter should exactly match the value shown in figure 62. These values are set to the correct value when ProQual is installed. It is possible to edit these values using first button at the bottom of screen. However, operator should never edit the values shown on this screen.

   The following parameters shown in figure 62 are not currently used in 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.

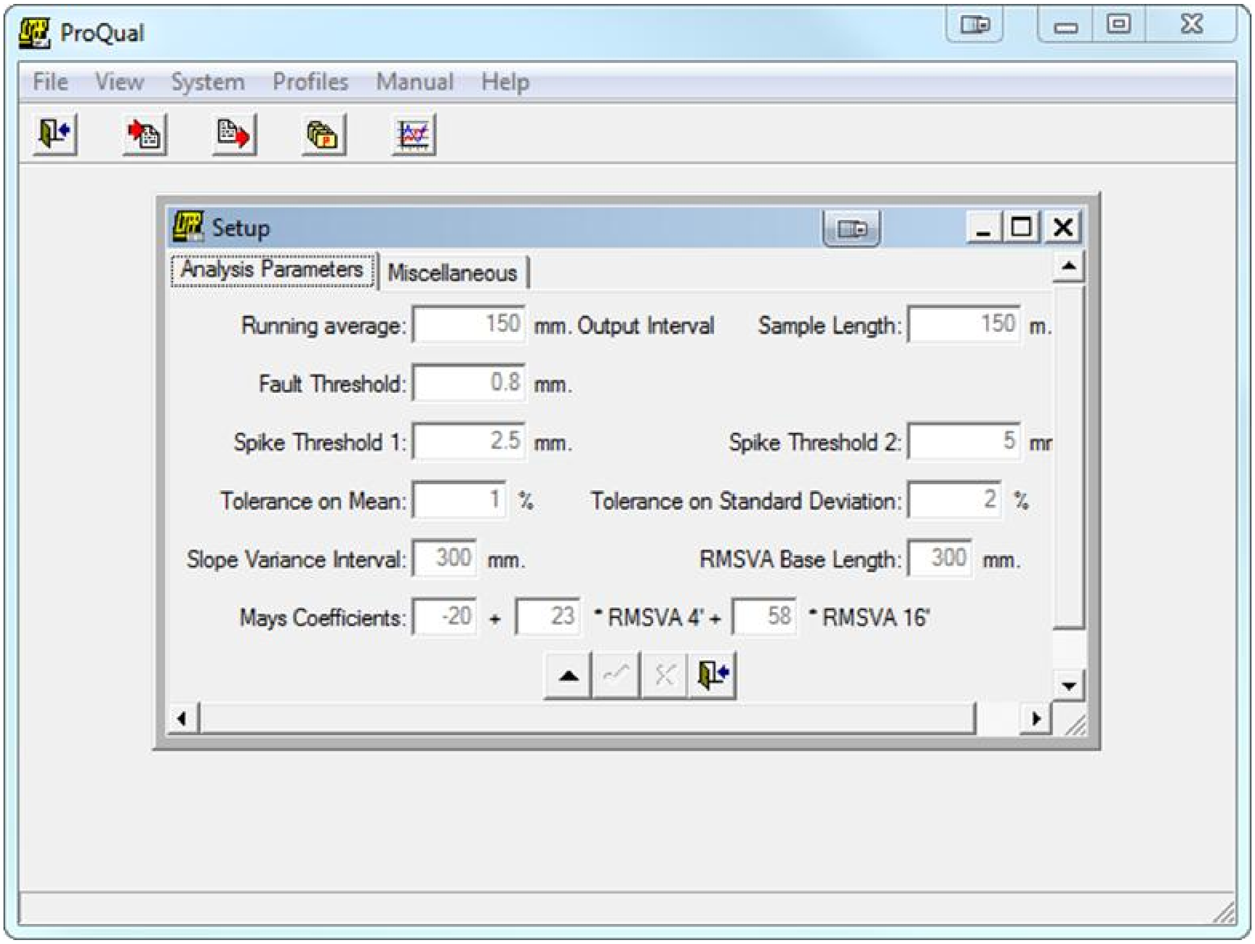


Figure 62. Analysis parameter screen in ProQual.

2.5 EQUIPMENT SPECIFIC OPERATIONAL GUIDELINES

2.5.1 Profile and Texture Laser Height Sensors

The device is equipped with three LMI-Selcom laser profile height sensors and two LMI-Selcom laser texture height sensors. According to LMI-Selcom literature, the laser light emitted from these sensors damage the eye if directly exposed, or if the laser light is reflected by a mirror or any mirror like surface directly into the eye. Hence, reflection of the laser beam from a surface such as a polished base plate, a gauge block, or a watch could damage the eyesight. Operators should take adequate precautions to avoid the laser light directly from the laser sensor or from a reflected surface come in contact with the eye. Always make sure that power to the laser sensors are turned-off when inspecting the sensor glass, cleaning the sensor, when performing maintenance on the sensors, and performing the accelerometer calibration check. The power switch located on the dashboard (see figure 34) will turn power off to the profile and texture laser height sensors as well as other components in the device. If only the power to the profile and texture height sensors needs to be turned off, as during the accelerometer calibration check, use the key in the DAU to turn power off (see section 2.2.4).

According to the manufacturer's literature, the ambient operating temperature range of the profile and texture lasers is from 0 to 50 °C. LMI-Selcom has indicated to Ames Engineering that a laser sensor will automatically shut-off when the internal temperature of the sensor is less than 0 °C or higher than 70°C. LMI-Selcom has also indicated that the internal temperature of the sensor is typically about 10 °C higher than the ambient temperature. The profile height sensors in the device are housed inside a box manufactured by Ames Engineering; the temperature inside this box will be typically higher than the ambient temperature. Sensors to monitor the temperature inside each sensor box that houses the profile height sensors is included in the Ames Engineering circuit boards located inside each box. The temperature inside the interface box that processes macrotexture data (see figure 5) is also monitored by a temperature sensor located on a circuit board. The Ames Engineering software start-up screen (see figure 46) shows the internal temperature of the sensor boxes under ODS1 (left wheel path), ODS2 (right wheel path), and ODS3 (center sensor). The temperature shown for ODS4 (left texture laser) and ODS5 (right texture laser) is the temperature inside the interface box, and both of these temperatures should show the same value. The displayed temperatures are measured at one second intervals.

Based on their testing, Ames Engineering has recommended an operating temperature range of 0 to 60 °C for the profile and texture lasers based on the temperature measured inside the sensor boxes for the profile height sensors and temperature measured inside the interface box for the texture height sensors. If the temperature for a sensor falls below 0 °C, the letters on the main screen that shows "Temp" will turn blue. If the temperature for a sensor is above 60 °C, the letters on the main screen that shows "Temp" will turn red. A warning message will be displayed on the screen if a monitored temperature goes outside the recommended range. Ames Engineering software will not shut-off either the profile of the texture height sensors. However, circuitry inside the laser sensor will automatically shut-off a profile or a texture height sensor when the internal temperature of the sensor is less than 0 °C or higher than 70°C.

If profile or texture laser height sensor shuts-off due to high ambient temperature, the testing may have to be scheduled for early morning or after-sunset hours.

2.5.2 Cleaning Sensor Glass

The sensor glass of the profile height sensors should be cleaned after performing the accelerometer calibration check that is specified to be performed at a maximum interval of 30 days (see section 2.12.4). During the accelerometer calibration check, power to the profile height sensors is turned off, and the sensors are turned upside down such that the sensor glass is at the top. After performing the accelerometer calibration check, inspect sensor glass for any damage.

Clean sensor glass using compressed air. If the sensor glass appears to be clean, no further cleaning is needed. If excessive dirt is noted, water applied through a sprayer may be needed to clean the glass. Once done, wipe sensor glass with a damp lens-cleaning cloth or a lint free cloth. Extreme care should be used when cleaning the sensor glass to prevent scratching the glass.

Wipe glass once in a single motion. Do not rub glass with the cloth. If the glass does not appear to be clean after a single swipe, repeat the procedure. Do not use paper towels to clean the sensor glass as these can scratch the sensor glass

When power is turned-off to the profile height sensors for performing the accelerometer calibration test, power is also turned-off to the texture height sensors. After inspecting and cleaning the profile height sensors follow a similar procedure to inspect and clean the sensor glass of the texture height sensors. In the texture height sensors, the laser light emitting unit and the detection unit are separate, and the sensor glass in both units must be inspected and cleaned.

During the daily profile and texture height sensor checks, it is only necessary to inspect the sensor glass for damage unless dirt is visible on the sensor glass. If dirt is noticed, follow the procedure described above to clean the sensor glass. However, it is not necessary to unlatch and turn the profile height sensor upside down to clean the sensor glass. Clean glass either through the sensor cover or open sensor bar and clean sensor glass.

2.5.3 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. The sensor bars were set to a level position when the devices were delivered. However, equipment and material that were added to the back of the vans by the RSC's may have caused the sensor bar to go out of level. Accordingly, the levelness of the sensor bar should be checked periodically when the van is parked on a level surface. If the bar is not leveled, Ames Engineering should be contacted to obtain their guidance on the procedure to level the sensor bar. There are bolts on the two mounting plates that can be loosened to allow the entire beam assembly to be pivoted front to back, and therefore be brought back to a level position.

The center profile height sensor should be at the center of the vehicle. The laser dot on the pavement surface for the left and right profile height sensors should 838 mm from the laser dot on the pavement surface from the center sensor. The laser dot on the pavement surface from the texture height sensors located along the wheel paths should be directly behind the laser dot from the profile height sensors that are located along the wheel paths. The distance between the two laser dots on the pavement surface from the texture height sensors should be 1,676 mm apart.

2.5.4 Photocell

There are two photocells mounted on the sensor bar, a downward facing photocell referred to as the vertical photocell and a sideways facing photocell referred to as the horizontal photocell. The vertical photocell is mounted approximately at the center of the sensor bar. The horizontal photocell is mounted at the end of the sensor bar on the passenger side. The vertical photocell triggers off reflective tape placed on the pavement, while the horizontal photocell triggers off reflective tape that is fixed to a cone placed on the side of the road.

The vertical as well as the horizontal photocells have a Light/Dark switch, and this switch must be set to the “Dark” position. The vertical photocell has a sensitivity adjustment knob. The profile operator needs to adjust the sensitivity setting if the photocell does not trigger.

2.5.5 Tire Pressure

The tire pressure should be checked before driving the vehicle in the morning to see if it is at the vehicle manufacturers recommended values that are listed on the door panel, which are 380 kPa (55 psi) for the front tires and 550 kPa (80 psi) for the rear tires. The listed tire pressures are cold tire pressure values.

The tires should be sufficiently warmed-up before testing. If the vehicle has traveled about 8 km (5 miles) 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 of the tires will cause a slight increase in tire pressure compared to cold tire pressure.

The DMI is affected by the tire pressure of the rear tire on the driver’s side. The operator should have a copy of the Distance Calibration Report that was printed when the DMI in the device was last calibrated. This report will indicate the tire pressure of the rear tires during calibration. The tire pressure of both 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.

2.5.6 Sensor Covers

A protective cover protects the profile and texture height sensors in the device from debris. Figure 63 shows a view of a protective cover. The protective covers located along the wheel paths protect both the profile and texture height sensors. The protective cover is held in place by two retention knobs. The protective covers must be closed when device is not collecting data. The protective covers must be opened when performing sensor checks, performing bounce test, and collecting profile data. The protective cover is opened by loosening the knobs and sliding the cover off and then retightening the two knobs.

2.5.7 Distance Measuring Instrument

The device is equipped with an encoder that is attached to the rear wheel on the driver’s side (see section 2.2.6). It is recommended the encoder be dismantled from the wheel when travelling long distances without any testing being performed. As a general rule, dismantle the encoder from the wheel on days the device is travelling without testing being performed. After the encoder is dismantled from the wheel, place the cap on the connector to protect it from dust and other contaminants (see figure 14).

Figure 63. Protective cover that protects the laser sensors.

2.5.8 Interior Temperature of Vehicle

The vehicle is equipped with a heater and an air conditioner to maintain interior temperatures within the vehicle at a temperature that is comfortable to the operator. On cold days when the van has been parked outside, it can take a considerable amount of time to warm-up interior of the vehicle. The laser printer manual indicates the operating temperature range of the printer to be between 15 and 32.5 °C, with the recommended operating temperature range being between 18 and 25 °C. The laptop computer specifications do not indicate an operating temperature range. However, a report on the web by Southwest Research Institute indicates the computer was able to function at a low temperature of 0 °C and a high temperature of 60 °C. The Ames Engineering electronics within the van should operate satisfactorily even at temperatures below 0 °C.

2.5.9 Equipment for Calibration Check of Profile and Texture Height Sensors

The profile and texture height sensors have been calibrated in the factory and operators cannot calibrate these sensors. A calibration check on these sensors is performed before collecting data (see section 2.9.2.2). In the calibration check, profile and texture height sensors are checked to see if they can accurately measure the height within a specified tolerance by using a 25 mm block. However, this procedure only checks the accuracy of the height sensor over a 25-mm distance within its measuring range. A more comprehensive check of profile and texture height sensors is specified to be performed at a maximum interval of 30 days, which will check the accuracy of the height sensors over a 100-mm measuring range. This check is referred to as the full calibration check of height sensors to distinguish it from the calibration check of height sensors that is performed before collecting data.

The following items are needed to perform the calibration checks of the profile and texture height sensors:

1. Calibration base plates.
2. Calibration targets.
3. Calibration blocks.
4. Digital level.

2.5.9.1 Calibration Base Plates

Three base plates are provided with each device. The base plates have three feet for support, and these can be used to level the plate. The bottom view of the calibration base plate is shown in figure 64, while figure 65 shows the top view of the plate. A square mark that corresponds to the dimensions of the calibration blocks has been drawn in the middle of the base plate. This ensures the calibration blocks are placed exactly at the same location when performing the calibration check.

Figure 64. Bottom view of the base plate.

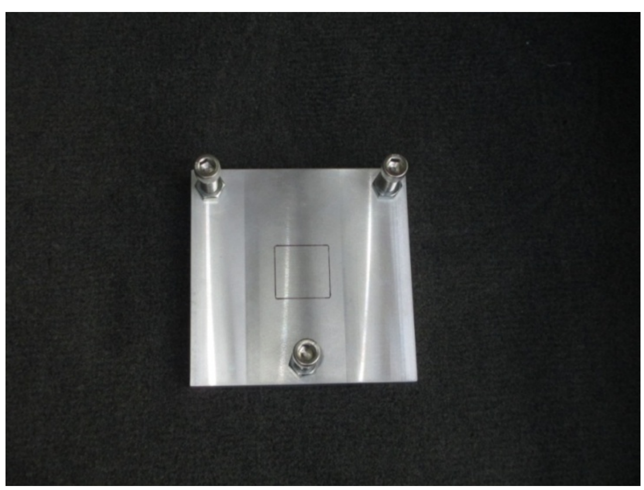


Figure 65. Top view of the base plate.

2.5.9.2 Calibration Targets

Three target plates are provided with each device. Measurements are always obtained by the height sensors on these targets. After placing a calibration block on the base plate, the calibration target is placed on top of the block and readings with the height sensor are obtained on the target. The target has a shiny side and a dull (matte) side and measurements should always be obtained on the dull side. Figure 66 shows a photograph of a target placed on top of the base plate.

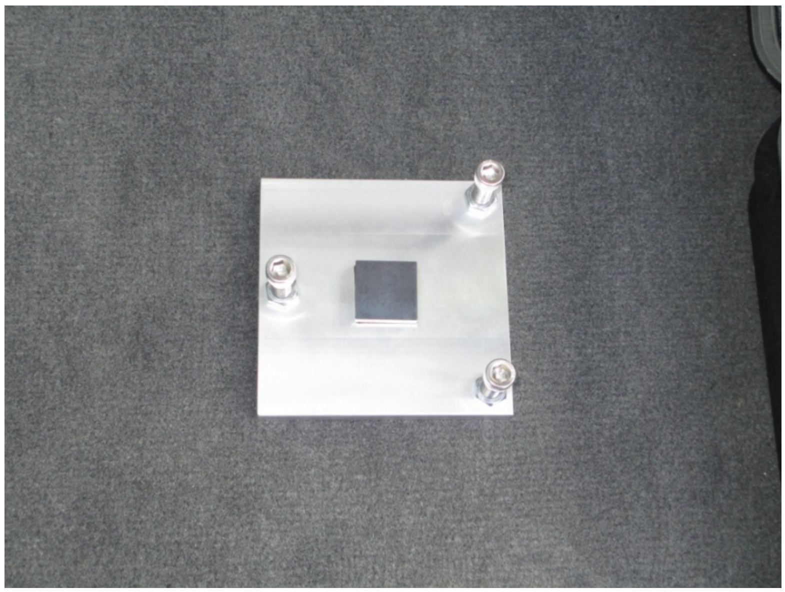


Figure 66. Calibration target placed on the base plate.

2.5.9.3 Calibration Blocks

Three sets of blocks having nominal heights of 25, 50, 75, and 100 mm are provided with each device. The block number is engraved on the side of the block. The exact height of the blocks was shown in table 2. The exact height of the blocks to four decimal places must be entered into the Ames Engineering software. This step needs to be done only once as the entered data are saved. However, this step may have to be repeated if the software is reinstalled or updated. Always check and ensure the proper block height values are present in the settings following any changes, updates, or reinstallation of the software.

Use following procedure to enter the exact block heights into the software:

1. Boot-up the laptop computer and start the Ames Engineering software as described in section 2.8.1.

2. Press F2 key or select "Calibrate" to bring-up the calibration menu (see figure 67).

3. Press F4 key or select "Extensive Vertical Test" and the Extensive Test menu (see figure 68) will be displayed on the laptop computer screen.

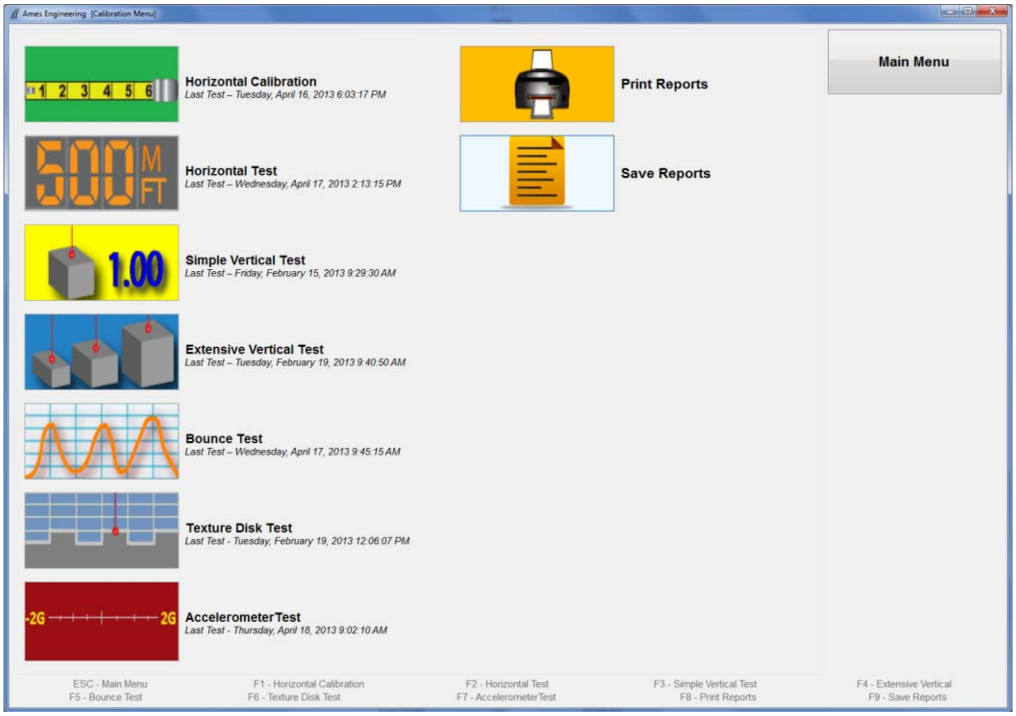


Figure 67. Calibration menu.

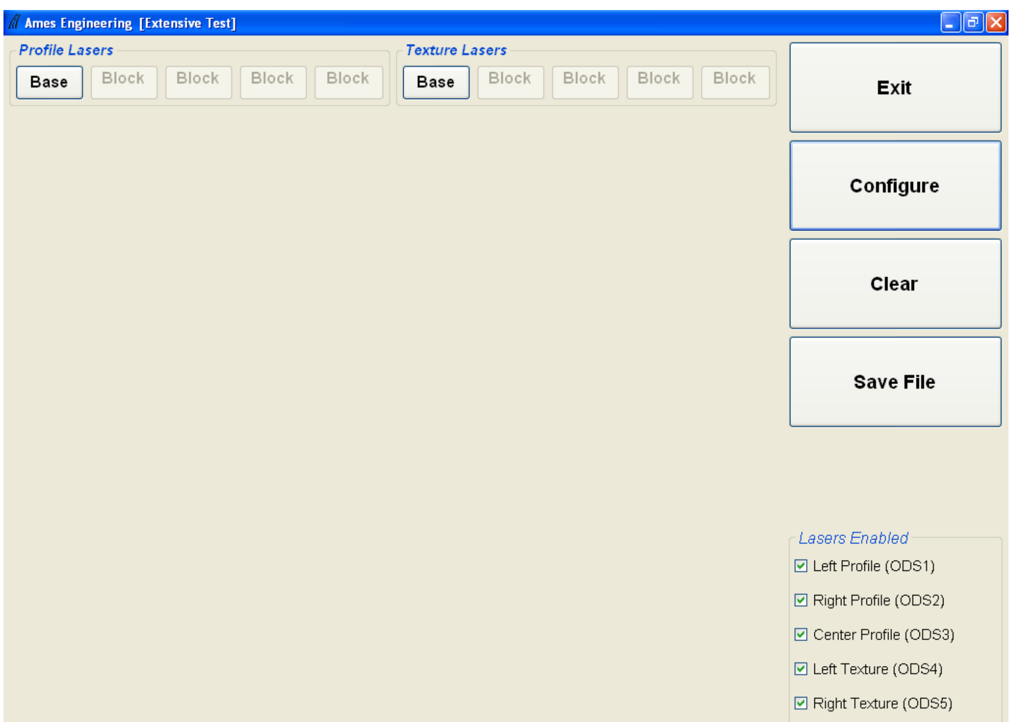


Figure 68. Extensive test menu.

4. Select configure and the menu to enter the block heights will be displayed (see figure 69).

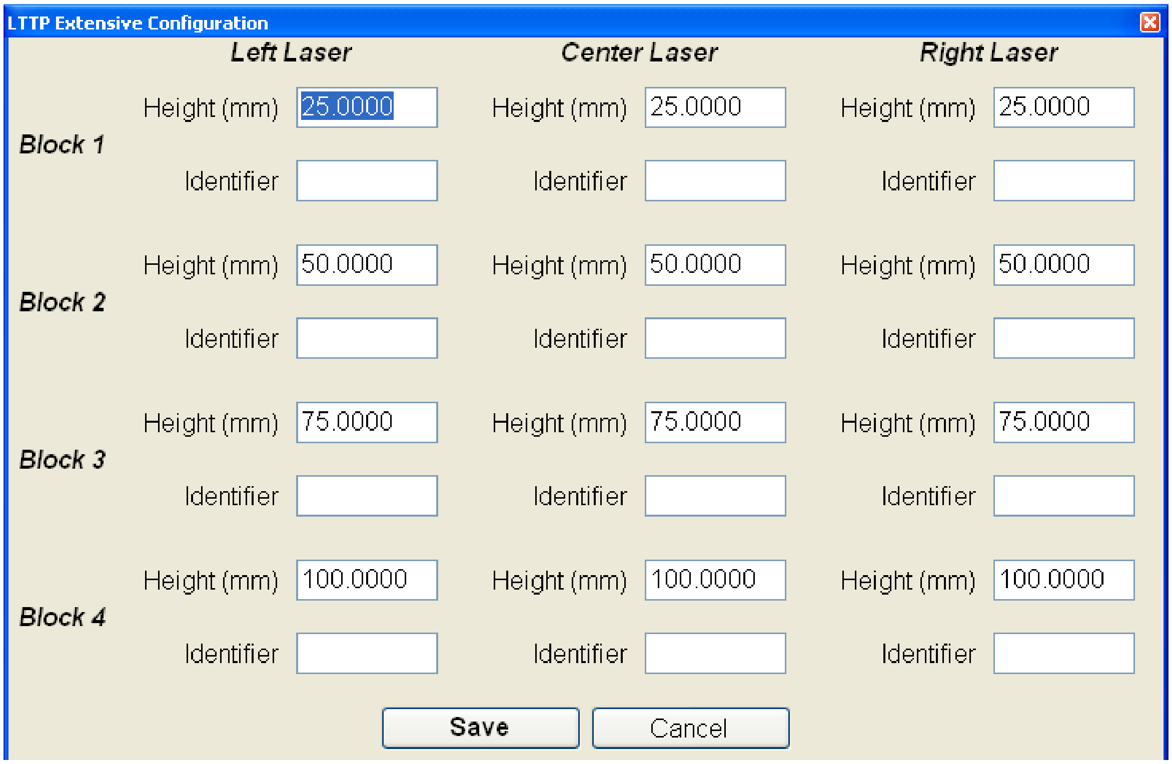


Figure 69.Menu for entering actual block heights.

5. Enter the block identifier that is engraved on the side of the block and the exact height of the block shown in table 2 into this menu. Figure 70 shows an example of this screen with the block identifiers and block heights entered. Press “Save” to save the entered values. The operator should note the block identifier associated with each height sensor so that the correct block will be placed below each sensor when performing the calibration check

2.5.9.4 Digital Level

A digital level is provided with each device (see figure 71) to level the base plate when performing the calibration check of the height sensors.

2.5.10 Auxiliary Battery

When the device has been parked, not connected to shore power, and not used for a couple of days, a Lo-Battery alarm may be displayed on the auxiliary battery status monitor LCD display. This will be displayed when the main power switch is in the “On” or “Off” position.

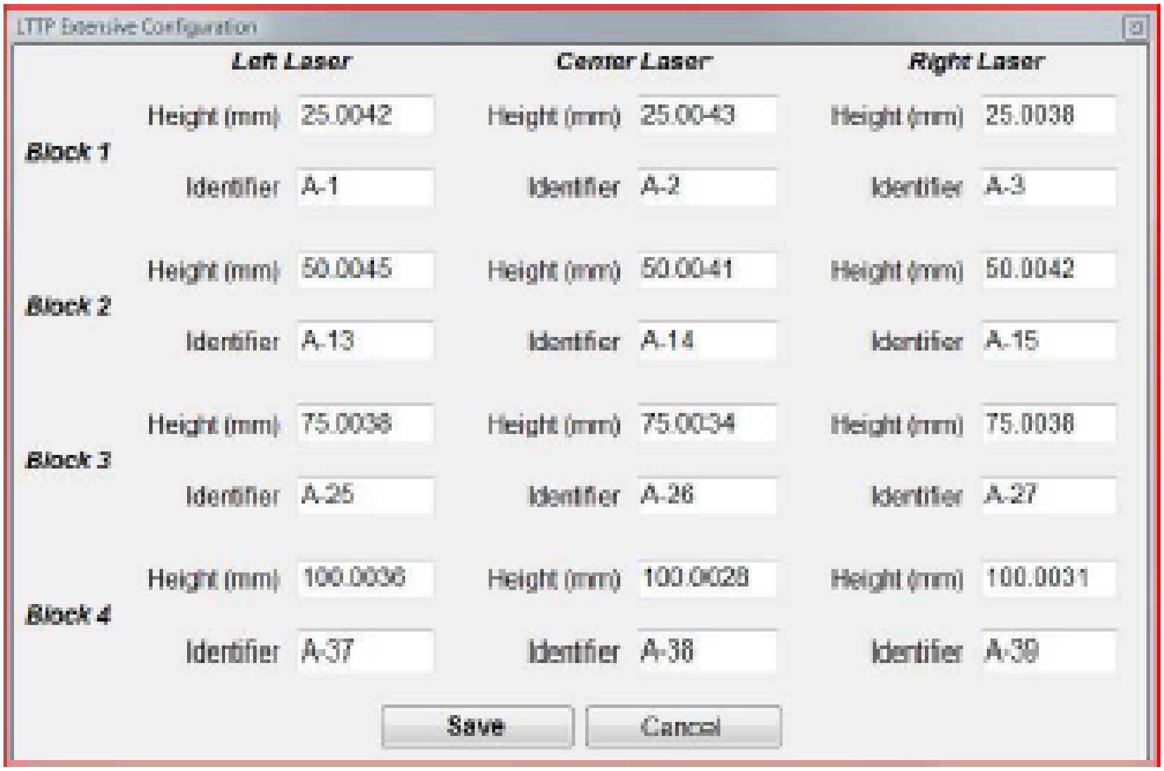


Figure 70. Menu with actual block heights entered.

Figure 71. Digital level.

When the engine of the van is off, shore power is not connected, and the main power switch has been turned off, there is still about a 0.05 ampere draw on the auxiliary battery because of the battery status monitor and other electronics that protect and charge the battery. The battery status monitor keeps track of this current flow. However, the battery status monitor can only resolve 0.1 amperes, and hence it overestimates the current draw out of the battery by twice the actual draw. This causes the Lo-Battery alarm to appear even though the battery has not reached the Lo-Battery stage.

This Lo-Battery alarm will not clear until operator manually synchronizes the display. However, the auxiliary battery must be fully charged before this synchronization is performed. This message does not necessarily mean the auxiliary battery does not have sufficient capacity to operate the equipment. The display unit on the dashboard will display the actual current voltage of the auxiliary battery. It is possible to collect data if power to all components is provided when the main power switch is turned on with the battery status monitor indicating Lo-Battery. To get rid of the Lo-Battery warning message, connect device to shore power, and after charging the auxiliary battery overnight press on the two arrow keys on the battery status monitor simultaneously for 3 seconds. Then a flashing "FULL" message will appear on the display indicating it is now synchronized at full capacity, and the Lo-Battery message will clear.

To avoid getting the Lo-Battery warning, connect the device to shore power when the device will be parked and not used for a couple of days. The shore power connector powers a smart battery charger that will charge the auxiliary battery and then drop down to a trickle charge when the battery is fully charged. The vehicle battery will also be charged to full capacity after the auxiliary battery is fully charged. When connected to shore power, the battery monitor will detect a small amount of charging current rather than a small amount of current draw from the auxiliary battery, and therefore the battery status monitor will indicate the auxiliary battery is fully charged. However, it is not be possible to follow this procedure unless the device is parked in a garage.

A recommended procedure if shore power cannot be connected continuously is to inspect the battery status monitor before the device goes on a trip to collect data. If the Lo-Battery status indicates "on" in the battery status display, connect device to shore power and wait until battery is fully charged by checking the display unit on dashboard, and then press on the two arrow keys on the battery status monitor simultaneously for 3 seconds. Usually the auxiliary battery will be fully charged in about 8 hours after connecting to shore power.

Ames Engineering should be contacted if the operator has any questions about the procedure to follow when the Lo-Battery alarm is displayed on the auxiliary battery status monitor LCD display.

2.5.11 Camera

Obtain images at all LTPP sections when collecting profile/texture data. This includes GPS, SPS and WIM sites.

For security purposes, the RSC may elect to remove the camera from the mounting bracket when the vehicle is parked outside. After removing the camera, it can be kept inside the vehicle at an appropriate location.

When the camera is mounted, it must be aimed properly such that consistent images are obtained every time it is used. After mounting camera, connect the camera to a USB port in the laptop computer, and then boot-up the laptop computer and start the Ames Engineering software as described in section 2.8.1. Thereafter, press F1 key or select "Setup" to get into the setup menu and then select the "Camera" tab to go to the Camera setup menu (See step 5 of section 2.4.2). Use the Camera Preview to properly aim the camera. The hood of the vehicle and the guide posts on either side of the vehicle can be used as reference marks to aim the camera consistently.

The images that are obtained during a data collection run are stored in a subdirectory that is created under the directory where the ARD file is stored. For example, if the ARD file is called 361111GD.P01.ARD, and the ARD file is stored in a directory called C:\Profiles, a subdirectory called C:\Profiles\361111GD.P01Images will be created to store the images associated with that run. The operator cannot change the location where the images are stored. The images are obtained at 25 m intervals, with the first image obtained at the start of the section, which is 0 m. However, because of the system delay, the first image is obtained about 4 to 5 m from the reflective tape. The other images have a delay of about 3 m. The file name of the first image obtained for this example will be 361111GD.P01_00000A.jpg, where A indicates distance in meters from the start of the section and is usually 4 or 5. The file name of the second image obtained for this example will be 361111GD.P01_0000BB.jpg, where BB indicates distance in meters from the start of the section and is usually around 28. The file name of the last image obtained for this example at a GPS section will be 361111GD.P01_000CCC.jpg, where CCC indicates distance in meters from the start of the section and is usually around 152.

The operator can use one of the following options regarding collection of images.

Option 1: Elect to have the camera "on" and obtain images for all repeat runs performed at the section. Thereafter, after data collection is completed and data have been reviewed, review the images (e.g., using Windows explorer) and select one set of acceptable images for the section and delete unwanted images.

Option 2: Review the obtained images (e.g., using Windows explorer). If the obtained images are not satisfactory obtain images for next run(s) until a set of satisfactory images have been obtained. If the obtained images are satisfactory, close the camera window, so that images will not be obtained during subsequent runs at the section. Once the camera is closed it is disabled. In order to enable the camera again, go to the camera setup menu (see step 5 of section 2.4.2, and check camera).

2.6 LTPP OPERATIONAL GUIDELINES

2.6.1 General LTPP Procedures

Accidents**:** In the event of an accident, operator shall inform the RSC as soon as possible after the mishap. Details of 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.

Maintenance of Records: Operator is responsible for preparing and forwarding the forms and records to the RSC associated with calibration or calibration checks (see section 2.12) and maintenance (see section 2.13).

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

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

2.6.2 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), and WIM sites.

2.6.3 Major Repairs to Profile System Components

2.6.3.1 General Procedures

Form PROF-4, LTPP Major Maintenance/Repair Activity Report, which is included in appendix B, must be completed whenever repairs are performed on any component in the device that is associated with data collection such as profile height sensors, accelerometers, DMI, texture height sensors or controllers, ambient and pavement temperature sensors, GPSR, and DAU. This report must also be prepared if any of the referenced components is replaced due to a malfunction.

The following guidelines should be followed regarding performing checks and calibrations after a repair:

- DMI should be calibrated whenever repairs are performed on the DMI or if the DMI is replaced.

- An accelerometer calibration check should be performed whenever repairs are performed on the accelerometer or any circuit board associated with the accelerometer, or if the accelerometer is replaced.

- A full calibration check must be performed when repairs are performed on a profile height sensor or a texture height sensor or any circuit board associated with these sensors. A full calibration check should also be performed if a profile height sensor or a texture height sensor is replaced.

- A bounce test must be performed after a profile height sensor or an accelerometer is repaired or replaced, or when circuit boards associated with these components are repaired or replaced.

- The texture reference device should be used to check the proper functioning of the texture height sensor when a texture height sensor is replaced, or any repairs or replacements are made to any component associated with macrotexture data collection.

2.6.3.2 Profile Height Sensor

After replacing a profile height sensor, data collected by the device 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 device. 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 their judgment in selecting an appropriate site to perform this comparison taking into account the current location of the device and availability of a suitable site close to the location of the device.

2. Collect profile data at the selected site and obtain an acceptable set of runs as described in section 2.9.3.

3. Compare the profile data as well as the IRI values with the previously collected data for the 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 from ProQual.

4. If evaluation indicates the collected data is comparable with the previously collected data, the profile system components are considered to be functioning correctly. If discrepancies are noted, the comparison should be performed at another section. If discrepancies are still noted, Ames Engineering should be contacted to resolve the problem.

If a malfunction is detected in a profile height sensor located along a wheel path, it may be replaced by the center profile height sensor to continue data collection. Ames Engineering should be consulted how this can be accomplished. 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. 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 2.12.5) should be performed on the replacement sensor. Thereafter, the accelerometer check (see section 2.12.4) and a bounce test (see section 2.9.2.4) should be performed. Procedures that were described previously (i.e., profiling at a previously profiled section) should be followed to ensure that the repaired/replaced sensor is functioning correctly.

2.6.3.3 Texture Height Sensor

After replacing a texture height sensor, data collected by the device should be checked using the following procedure to ensure that accurate data are being collected.

1. Select an asphalt concrete (AC) surfaced test section where macrotexture data has been collected recently and is close to the current location of the device. Preferably the site should not have visible pavement distress. The RSC should use their judgment in selecting an appropriate site to perform this comparison taking into account the current location of the device and availability of a suitable site close to the location of the device.

2. Profile the selected site and obtain an acceptable set of runs.

3. Compute the MPD values for the data collected with the left and right texture height sensors.

4. Compare the MPD value computed from data collected with the replacement sensor with the MPD values that were obtained previously. The current MPD value should be within 10 percent of the previous MPD value. Also, the percentage difference in MPD for the sensor that was replaced should be close to the percentage difference that was obtained for the sensor that was not replaced. (To compute the percentage difference, deduct the current MPD from the previous MPD and divide this value by the previous MPD and then express the computed value as a percentage.) If discrepancies are noted, the comparison should be performed at another section. If discrepancies are still noted, Ames Engineering should be contacted to resolve the problem.

2.6.4 Data from Previous Site Visit

After collecting profile data at a site, profiler 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 2.9.4. The profile data comparison between the visits is made using the Graphic Profiles feature in ProQual. Before collecting data at a site, operator must ensure that the data files that are required to do this comparison for the previous site visit are available. Operator should also have the IRI values for the site from the previous visit.

2.6.5 Software, Computer System, and Manuals

Operator should maintain a copy of the Ames Engineering software, ProQual software, and Sidekick software in the vehicle in case software problems occur in the software installed in the laptop computer. If the Ames Engineering or ProQual software program is re-installed, operator should go through the setup menus described in section 2.4 of this manual to make sure that appropriate parameters have been set to the correct values. Procedures for installing the ProQual software are described in the ProQual manual.(9) Procedures for installing the Sidekick software are described in the Sidekick manual.(12)

Apart from ProQual, Sidekick, and Microsoft Office, other software should not be loaded onto the laptop computer, unless specifically approved in writing by FHWA.

Do not add hardware (extra drives or other device) to the laptop computer system before contacting Ames Engineering through FHWA to determine if they will interfere with Ames Engineering data collection and processing programs. Interference of programs due to additional devices may not be readily apparent.

Profiler data files should be organized into subdirectories in the hard drive as outlined in LTPP directive GO-48, AIMS Electronic Data Format, Submission, Standards, and Dates, or current version of that directive.

2.7 FIELD OPERATION GUIDELINES

2.7.1 Turnarounds

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

2.7.2 Light Bar, Directional Warning Light, and Strobe Lights

Device is equipped with a light bar in front, a directional warning light mounted on the rear of the van, and strobe lights located within the headlamps and the tail lights. The light bar, directional warning light and strobe lights should be turned-on during testing or when parked on the shoulder of a roadway.

2.7.3 File Naming Convention for GPS and SPS Sites

The file naming convention to be used in specifying name of data file when collecting data at GPS and SPS sections is described in this section. File naming conventions for collecting data at WIM sites are described in section 2.11. 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 state in which site is located (e.g., 27 for Minnesota).

2. Characters three to six: Four-digit site number. For GPS sites this is the four-digit LTPP identification number (e.g., 1023). For SPS sites, the third character should be 0, 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; G for GPS, S for SPS, 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 site is being profiled for second time use letter B, use C for the third time, H for eighth time and so on. If a site is being profiled for the first time (it has not been profiled 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/is profiled by the RSC, whether with the DNC690, T-6600, ICC or Ames device. 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 GPS site, change character seven to H, and assign site visit identifier to be A. For subsequent profile visits, maintain character seven as H and change sequential visit identifier to be B, C, D, etc.
   (c) If the site is a SPS site, change character seven to T, and assign site visit identifier to be A. For subsequent profile visits, maintain character seven as T and change sequential visit identifier to be B, C, D, etc.

   The following are examples of valid data file names:

   1. 171002GD: GPS section 1002 in Illinois (state code = 17), profiled for the fourth time.
   2. 260200SB: SPS-2 site in Michigan (state code = 26), profiled for the second time.
   3. 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 file name should be replaced by a character for each group. For example, consider 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.

2.7.4 Operating Speed

A constant vehicle speed of 80 km/h should be maintained during a data collection run. 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 speed limit at site is less than 80 km/h, site should be profiled at 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 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. Change in throttle pressure or use of brakes to correct vehicle speed should be applied slowly and smoothly.

2.7.5 Event Initiation

During profile data collection, the data collection program uses an event mark to record the start of the section. Event marks are generated by the photocell. The vertical photocell detects the white paint stripe or reflective tape at the beginning of test section and sends a signal to record that event in the data file. This information is used to generate the data corresponding to the test section. In those instances where existing paint mark on pavement is not able to trigger vertical photocell, the horizontal photocell should be used. The cone with a reflective marker provided with the 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.

2.7.6 Loading and Saving Files

Saving files to the hard disk or flash drive 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 hard disk.

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/texture data. Profile/texture 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, 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, data collection should be suspended until pavement is completely dry.

Electromagnetic radiation from radar or radio transmitters may affect data recorded by the device. If this occurs, 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.

2.7.8 End of Run Comments

The software allows operator to enter comments at the end of each data collection run, and those comments are hereafter referred to as end of run comments. These comments can be edited if required in ProQual when the data files are imported into ProQual. 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 PPDB. Examples are provided in this section separately for end of run comments and operator comments with suggested format for the comment.

End of run comments entered for a group of sections profiled in one run (e.g., SPS site) are put into each individual file that is sub-sectioned 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 sub-sectioned from that profile run. Therefore, operator should ensure 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:

1. Good Profile Run: Comment used to indicate that profile run was good and that no problems were encountered. Example comment: RUN OK.

2. Environment Related Comments: Profile testing should not be performed when environmental conditions are such that they can affect quality of the data. If operator believes there is a possibility that environmental conditions may have affected quality of the data, a comment should be entered. Example comment: HEAVY WINDS.

3. Speed Related Comments: The following are examples where a comment related to speed of testing should be entered:

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

End of run comment is made at end of the run before saving the data. Ames Engineering software offers five end of run comments that user can select at the end of a run. Operator can only select one of the comments. If none of these comments are applicable, user can type any desired comment. The five end of run comments that are available in the Ames Engineering software are:

- RUN OK.
- PAVEMENT SURFACE DAMP.
- TRAFFIC CONGESTION SPEED VARIABLE.
- DIFFICULT TO MAINTAIN CONSTANT SPEED: GRADE.
- DIFFICULT TO MAINTAIN WHEEL PATH LOCATION.

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.

2.7.9 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 surfaced 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 PCC surfaced 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) 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 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. Operator should specifically make a note if "overband" type crack filling has been performed on the section. (Overband type crack filling is typically about 100 mm wide and is placed over the crack.)
   Example comment: RECENT MAINTENANCE IN SECTION, PATCHES.

3. Wheel Path Tracking Related Comments: A comment should be entered if 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 section has a potential impact in obtaining repeatable profile runs. Such conditions include:

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

   (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 before test section because of pavement condition. Example comment: CORE HOLES ON WHEEL PATH BEFORE SECTION

6. Spike Related Comments: After ProQual has processed data, the operator should look for presence of spikes in the data. If spikes are present, enter comment indicating whether or not 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:

- 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.

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 indicating 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 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 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 form PROF-1, LTPP Profiler Field Activity Report, which is included in appendix B under the field Additional Remarks Regarding Testing. (Note: If a factor has been entered as an operator comment into ProQual, it should not be repeated in the Field Activity Report).

2.8 POWER UP AND SHUTTING DOWN EQUIPMENT

2.8.1 Power Up Procedure

Use following procedure to power up the equipment:

1. Attach the laptop computer to the laptop computer dock.

2. Turn on the master power switch located on the dashboard (see figure 34). The switch will show an amber color at the bottom. Note: The master power switch can be turned on either before starting the vehicle or after starting the vehicle.

3. Turn on laptop computer. Look at the time shown on the task bar. If the time is different at the current location, use the Date/Time menu in Windows accessible through the control panel to set the correct time.

4. Start the Ames Engineering software, and the start-up screen shown in figure 72 will appear on the screen

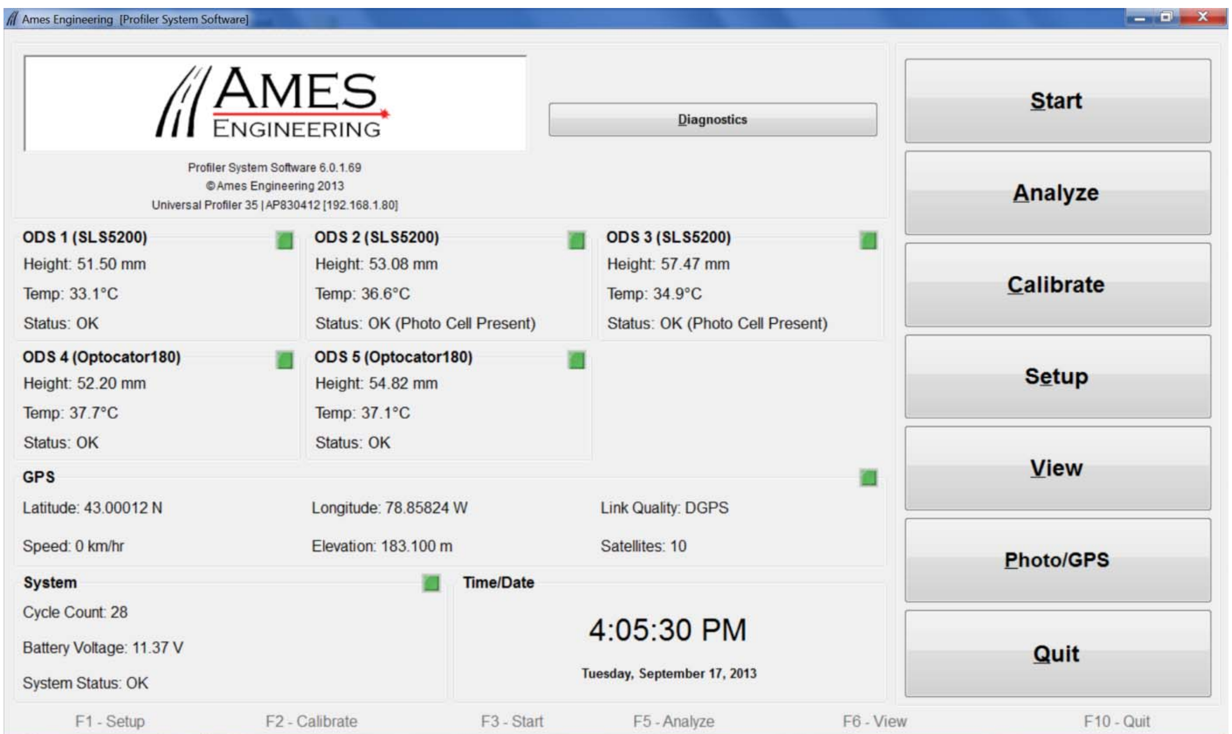


Figure 72. Ames Engineering software start-up screen.

5. Check the date and time on start-up screen to make sure they are correct.

The start-up screen will show the status of the following sensors through a status LED:

- ODS1, Left wheel path profile height sensor.
- ODS2, Right wheel path profile height sensor.
- ODS3, Center profile height sensor.
- ODS4, Left wheel path texture height sensor.
- ODS5, Right wheel path texture height sensor.
- Photocells.
- GPSR.
- System.

The status LED appears to the right of the sensor and will be green if the sensor is functioning properly and ready to collect data. The sensor covers must be open in order for ODS1, ODS2, ODS3, ODS4, and ODS5 to show a green LED. The LED will be yellow if the sensor is not properly viewing the road surface, for example if the sensor covers have not been opened. The LED will be red if the sensor is not communicating with the DAU or the laptop computer.

The start-up screen displays the following information for the profile height sensors (ODS1, ODS2, and ODS3):

- Height: Indicates the height measured by the sensor. The height should be close to zero (generally within ±15 mm of zero) if the vehicle is parked on a level surface.

- Temperature: This is the temperature inside the box in which the profile height sensor is housed.

- Status: The status will indicate OK if the sensor is ready to take measurements. The status will indicate "Auto Start Present" if a photocell is connected to that sensor. Note: If the message "Auto Start Present" does not appear for ODS3 sensor, it means the vertical photocell was not detected. This can happen if the pavement surface below the photocell is reflective (e.g. on a concrete surface). If this occurs, and data collection is to be performed on a portland cement concrete (PCC) surface, exit software, turn down sensitivity of photocell, turn main power switch off and then turn it on again, and then start-up software again and check if "Auto Start Present" appears next to "Status" for ODS3. If data collection is to be performed on an AC surface, exit software, move profiler to an AC surface, and then start-up software again and check if "Auto Start Present" appears next to Status for ODS3.

The start-up screen displays the following information for the texture height sensors (ODS3 and ODS4):

- Height: Indicates the height measured by the sensor. The height should be close to zero (generally within ±15 mm of zero) if the vehicle is parked on a level surface.

- Temperature: This is the temperature inside the interface box located in the sensor bar that processes macrotexture data.

- Status: The status will indicate OK if the sensor is ready to take measurements.

The start-up screen displays the following information for the GPSR:

- Latitude.
- Longitude.
- Link Quality: Will indicated DGPS if a WAAS correction is made to the data.
- Speed: Speed of vehicle in km/hr.
- Elevation.
- Satellites: Number of satellites that are being used by the GPSR.

The start-up screen displays the following information about the system:

- Cycle count.
- Battery voltage: Voltage of the auxiliary battery,
- Time: Time set in the laptop computer.
- Date: Date set in the laptop computer.
- System Status: Indicate OK if the system components are working satisfactorily.

The following menus can be accessed by pressing a function key or selecting the button located on the right side of the screen:

- Start (F3). Starts data collection.
- Analyze (F5): To analyze the collected data. This menu is not used for LTPP data collection.
- Calibrate (F2): To calibrate or perform calibration checks on components.
- Setup (F1): To enter parameters associated with data collection.
- View (F6): To view the collected data and perform analysis on the collected data.
- Quit (F10): To exit program.

The Photo/GPS menu is not used for LTPP data collection activities.

2.8.2 Shutting Down Procedure

Use the following procedure to shut down the system.

1. Go to the Ames Engineering start-up screen (see figure 72). Exit the software by pressing F10 key or select "Quit" and then shutdown laptop computer. If you plan to use the laptop computer, you can keep the laptop computer on and proceed to step 2 to turn power off to all components. The laptop computer will then be powered by the laptop computer battery.

2. Turn the master power switch located on the dashboard to off position (see figure 34). Note: Never turn the master power switch off when the Ames Software is within a menu. Always exit Ames Engineering software before setting the master power switch to the "Off" position,

3. If shutting down when being powered by shore power, unplug the shore power input. .

2.9 DATA COLLECTION

2.9.1 General Background

Procedures to be followed each day before and during data collection with respect to daily checks of vehicle and equipment, start-up procedures, software set-up for data collection, and using software for data collection are described in the following sections. The procedures to be followed when testing GPS sections are detailed in section 2.9. Because some of the procedures for testing SPS and WIM sections are different than those for GPS sections, section 2.10 describes the procedures for SPS sections that differ from those for GPS sections, while section 2.11 describes the procedures for WIM sections that differ from those for GPS sections.

2.9.2 Daily Checks on Vehicle and Equipment

2.9.2.1 Introduction

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

In order to maintain the laptop computer and various associated equipment, care must be taken to either cool or warm equipment to the operating temperature described in section 2.5.8 before turning on the master power switch. After turning on the master power switch wait for about 15 minutes for the equipment to warm-up before performing daily checks.

The following equipment checks should be performed daily before collecting data:

1. Calibration check on profile height sensors.
2. Calibration check on texture height sensors.
3. Bounce test.
4. Visual check of the pavement surface temperature sensor.

Complete form PROF-1, LTPP Profiler Field Activity Report, which is included in appendix B after performing the daily checks.

2.9.2.2 Calibration Check of Profile Height Sensors

The exact heights of the calibration blocks should have been entered into the software following the procedures described in section 2.5.9. The entered values are saved, and once entered these values need not be checked every time a calibration check is performed. However, the operator must check to make sure the entered block heights are correct if the software is re-installed or updated.

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

Do not enter, bounce or bump vehicle, or lean on vehicle when this check is performed. Operator should adjust the laptop computer so that the screen can be seen from outside the vehicle. The calibration check is performed simultaneously on all three sensors. The following procedure should be followed for performing this test.

1. Park van on a level surface.

2. Before powering up system open the sensors covers and inspect the glass face of sensor. There is no need to clean sensor glass if the glass does not appear to be dirty. If glass appears to be dirty, clean glass face using the procedures described in section 2.5.2.

3. Power up the system, start laptop computer, and start Ames Engineering software using the procedure described in section 2.8.1. Press F2 key or select "Calibrate" to enter the Calibration Menu shown in figure 73.

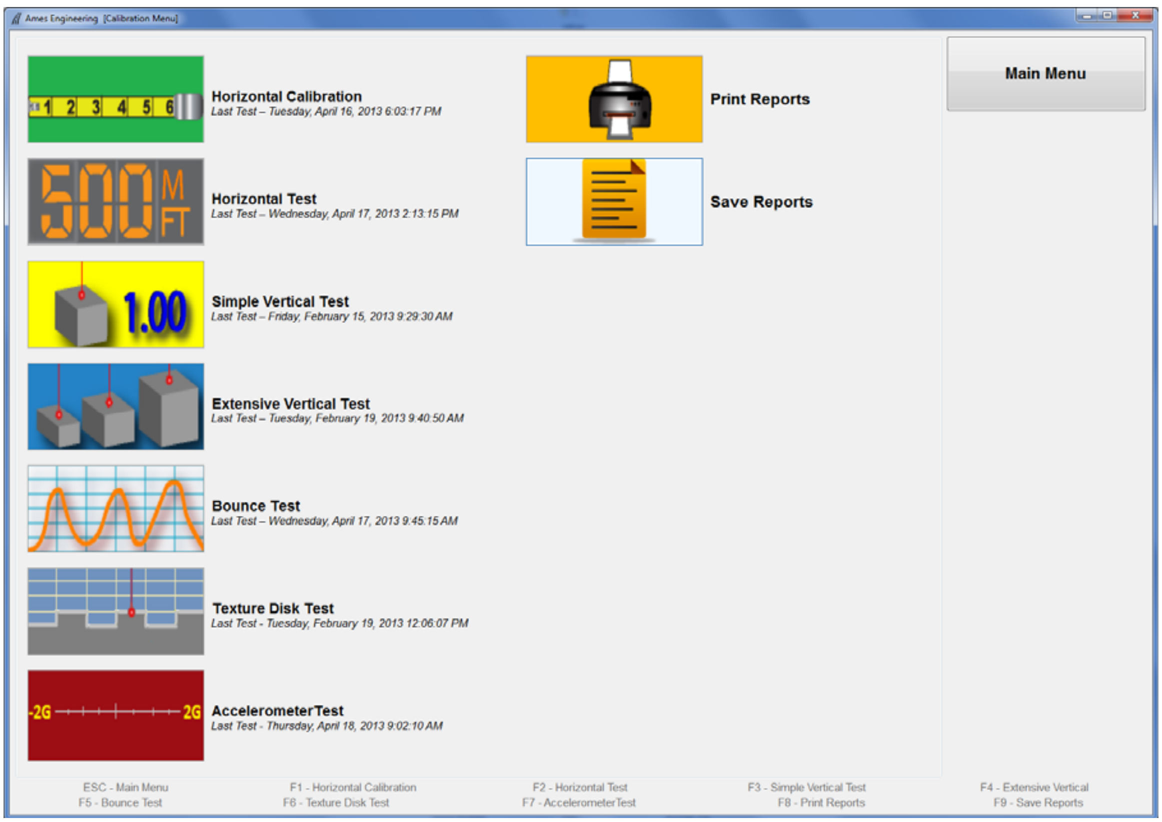


Figure 73. Calibration menu.

4. In the Calibration Menu, press F4 key or select "Extensive Vertical Test" and the Extensive Test menu shown in figure 74 will be displayed. All sensors shown on bottom right of the screen should have a check mark.

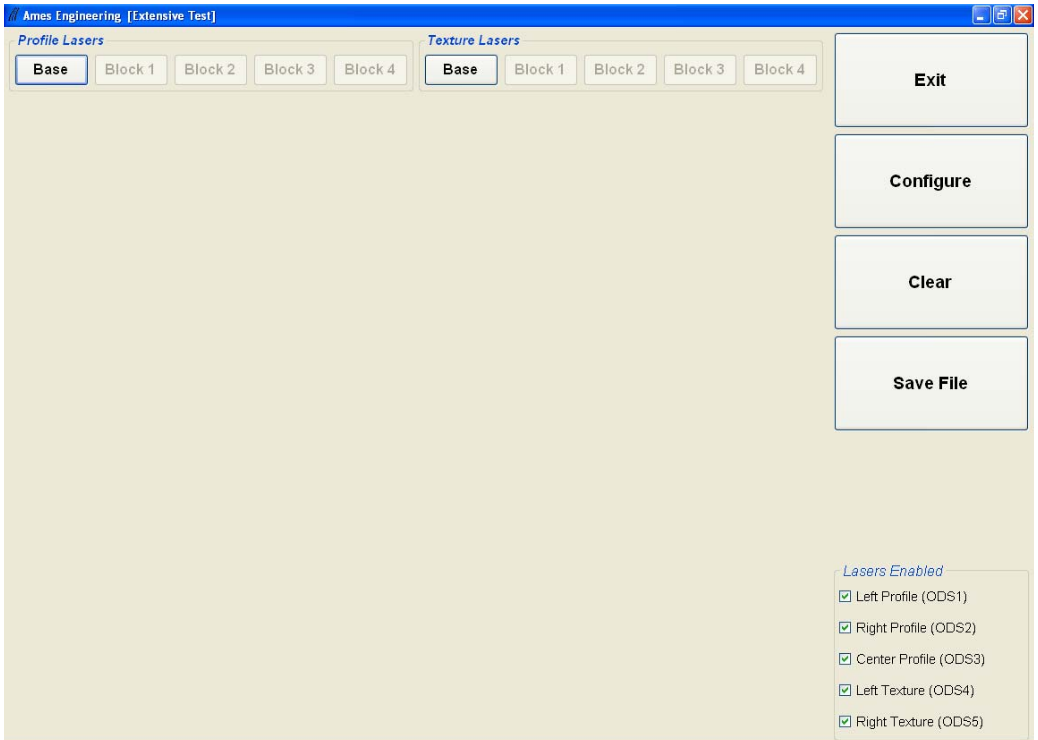


Figure 74. Extensive test menu.

5. Clean the top of the calibration base plates as needed, and place a calibration base plate on the ground under each profile height sensor such that two screws on the base plate are parallel to the sensor bar and the red laser dot from the height sensor on each plate is centered on the plate (see figure 75). Place level parallel to the two screws that are parallel to the sensor bar and level base plate using these two screws and the digital level as a guide. Then place level perpendicular to the two screws that are parallel to the sensor bar and use other screw to level plate. The base is considered to be level when the reading on the digital level is less than or equal to 0.05° when placed parallel and perpendicular to the two screws that are parallel to the sensor bar.

6. Place a calibration target plate with the dull side facing up on top of each calibration base plate within the square marked on the base plate and place the 25 mm block behind the target plate to provide stability to base plate (see figure 76).

7. In the software, under "Profile Lasers" select "Base" to take a measurement on top of target plate that is placed on each base place. Six sets of measurements are taken on the target plate. Figure 77 shows an example screen capture after the measurements are obtained.

8. Remove calibration target plate from calibration base plate, place the 25 mm block associated with the sensor on top of base plate within the square marked on the base plate such that the block identifier faces the operator. Place calibration target plate on top of the block (see figure 78) with dull side facing up. Repeat procedure for the other two sensors. Thereafter in the software, under "Profile Lasers" select "Block 1" to take measurements on top of target

plate. Six sets of measurements are taken on the target plate. Figure 79 shows an example screen capture after the measurements are obtained.

Figure 75. Laser dot centered on base plate.

Figure 76. Readings being taken on target plate placed on base plate.

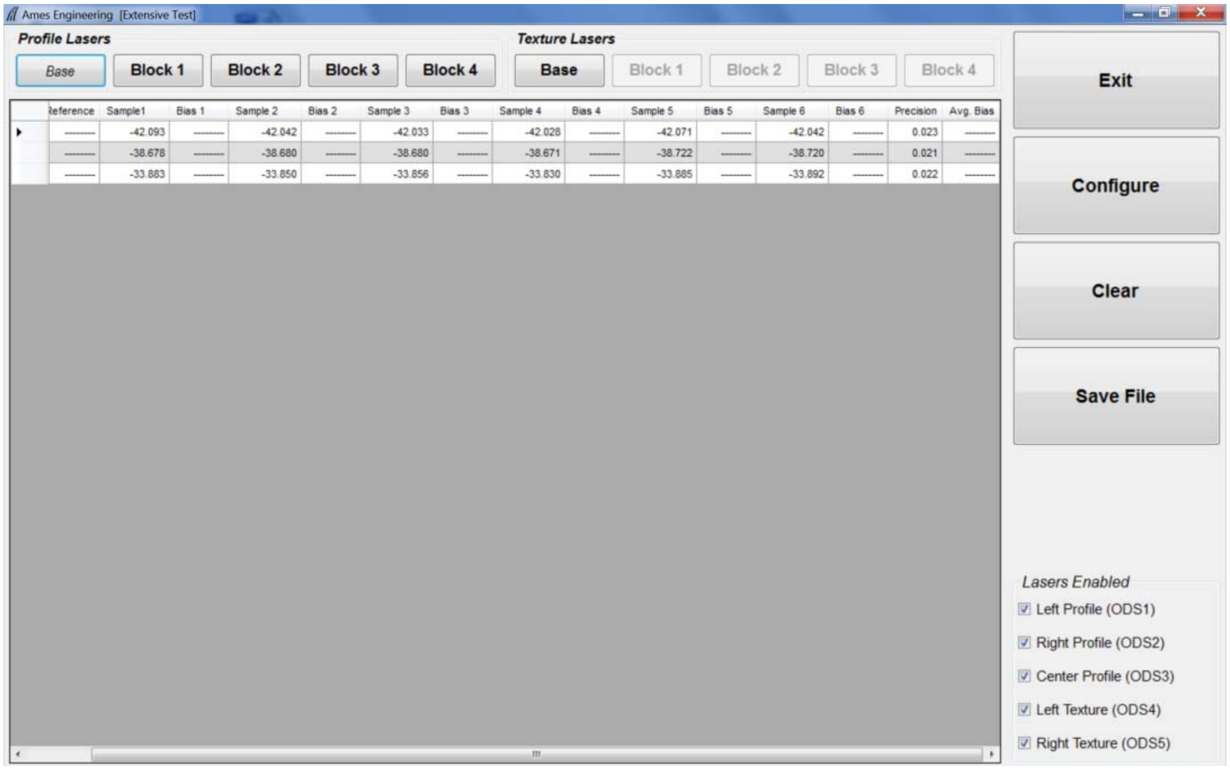


Figure 77. Display after obtaining measurements on target placed on base plate.

Figure 78. Readings being taken on 25 mm blocks.

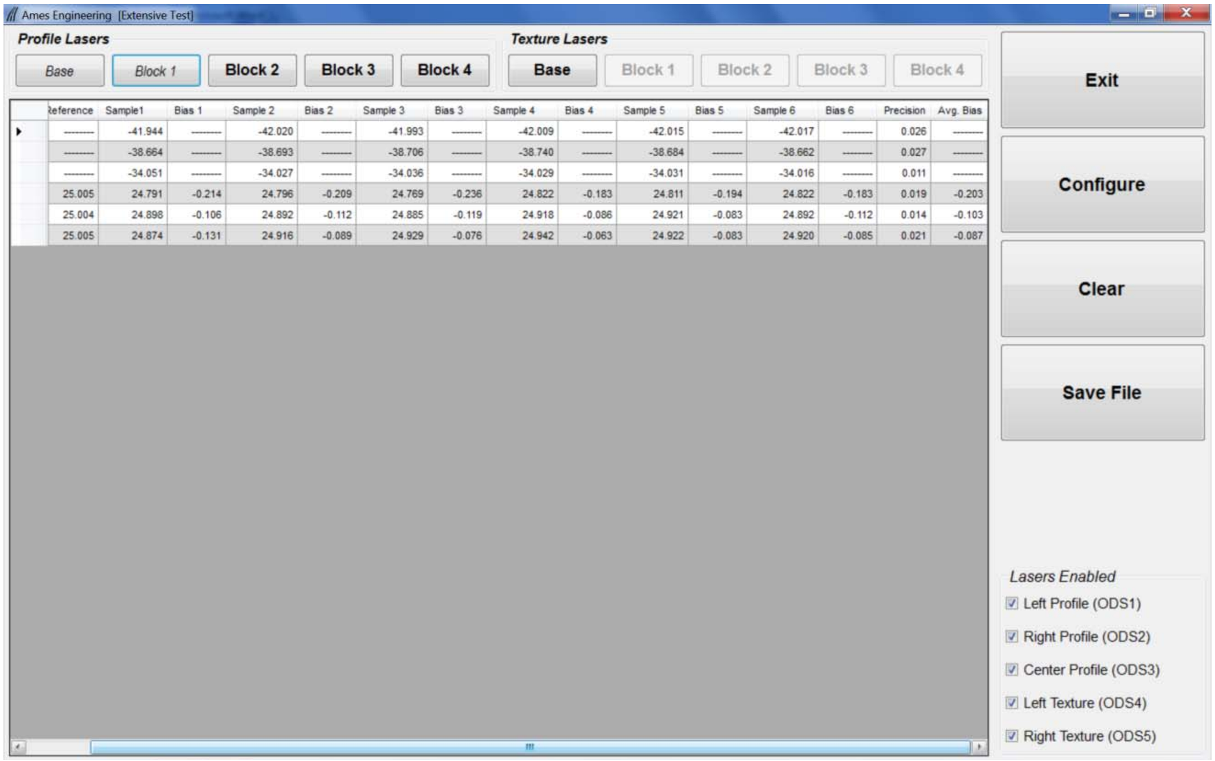


Figure 79. Display after obtaining measurements on target placed on base plate.

9. Check the average bias value. The average bias value for each sensor must be within ± 0.25 mm. If bias values for all three sensors meet the specified criterion, select "Save" to save the results from the calibration check. Repeat test if average bias is outside this value. If the bias is still outside the specified tolerance contact the RSC and decide on a suitable course of action.

2.9.2.3 Calibration Check of Texture Height Sensors

The calibration check on the texture height sensors should be performed immediately after the calibration check of the profile height sensors has been performed. Use following procedure to perform this check:

1. Place a calibration base plate on the ground under each texture height sensor such that two screws on the base plate are parallel to the sensor bar and the red laser dot on each plate is centered within the plate (see figure 75). Level the base plate following the procedure described in step 5 of previous section.

2. Place a calibration target plate with dull side facing up on top of each calibration base plate within the square marked on the base plate and place the 25 mm block behind the target plate to provide stability to base plate (see figure 76).

3. In the software, under “Texture Lasers” select “Base” to take a measurement on top of target plate that is placed on each base place. Six sets of measurements are taken on each target plate.

4. Remove calibration target plate from calibration base plate, place the 25 mm block associated with the sensor on top of base plate within the square marked on the base plate such that the block identifier faces the operator. Place calibration target plate with dull side facing up on top of the block (see figure 78). Repeat procedure for the other sensor. Thereafter in the software, under “Texture Lasers” select “Block 1” to take measurements on top of target plate. Six sets of measurements are taken on the target plate by each sensor.

5. Check the average bias value. The average bias value for each sensor must be within ± 0.25 mm. If bias values for both sensors meet the specified criterion, select “Save” to save the results from the calibration check. Repeat test if average bias is outside this value. If the bias is still outside the specified tolerance contact the RSC and decide on a suitable course of action.

2.9.2.4 Bounce Test

The bounce test is performed to verify that profile height sensors and accelerometers in the profiler are functioning properly. This test must be performed immediately after the calibration checks on profile and texture height sensors have been performed. Vehicle engine may be on or off when performing this test.

The bounce test consists of two separate portions, a static test and a dynamic test. No movement is induced on the vehicle during the static portion of the test, while the vehicle is bounced while stationary during the dynamic portion of the test. The simulation speed used for the bounce test is 80 km/h, which means the profiler will collect data as if it was moving at 80 km/h. Profile data are recorded for the entire duration of the bounce test. The power to the equipment should have been provided at least for 15 minutes for the equipment to warm-up before performing this test.

The following procedures should be followed to perform the bounce test:

1. Park vehicle on a level surface. If the master power switch has been turned on, laptop computer turned on and the Ames Engineering software started-up, go to step 2. Otherwise, power up equipment and start Ames Engineering software using the procedure described in section 2.8.1.

2. In main menu of Ames Engineering software (see figure 72) press F2 key or select “Calibrate” to go into the calibration menu (see figure 73).

3. In the calibration menu press F5 key or select “Bounce Test” icon to enter the bounce test menu. The bounce test screen shown in figure 80 will appear on the laptop computer screen. Under “Setup” that appears at the bottom right corner in this menu, check marks should be present in front of ODS1, ODS2, and ODS3. The “Distance” field should show a value of 1066.8 m. The distance of 1066.8 m means data will be collected over seven 152.4 m long

sections during the bounce test. A beep will be heard at the start of the test, and thereafter at the end of each 152.4 m long segment for the duration of the test. The IRI of each 152.4 m segment will be displayed on the top of the graph corresponding to each sensor during this test.

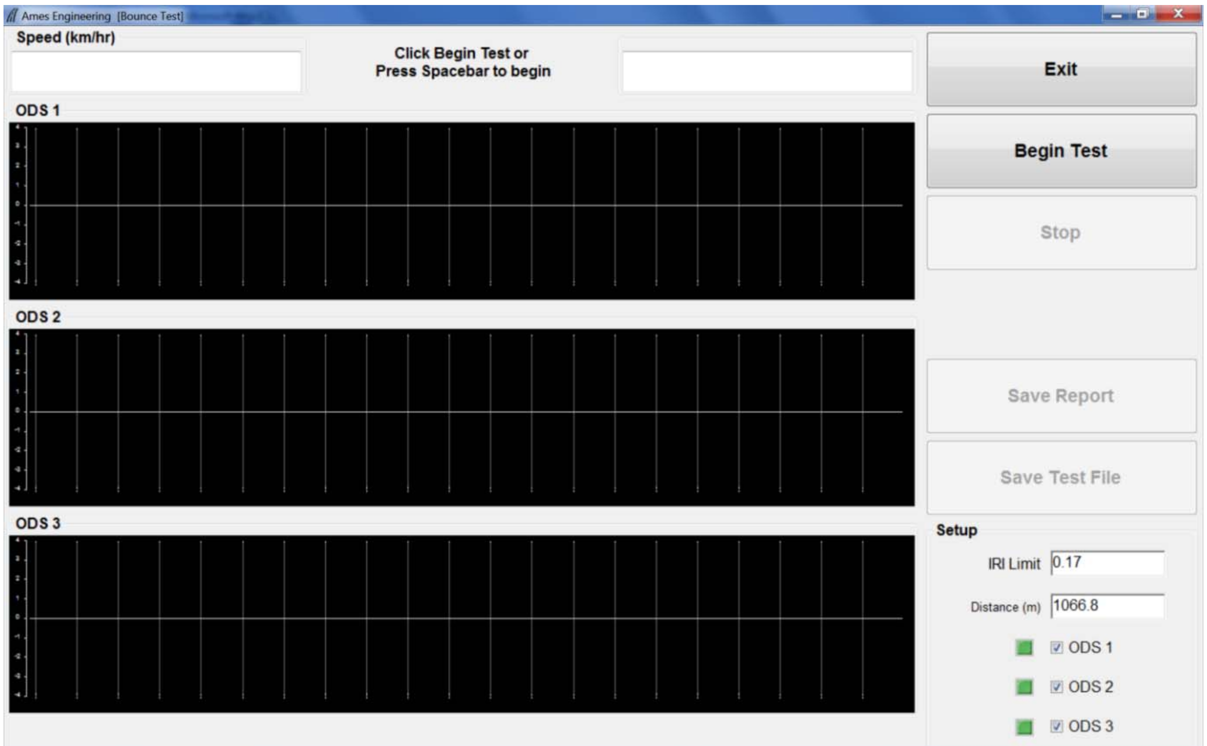


Figure 80. Bounce test start-up screen.

4. Place a base plate under each profile height sensor such that the red laser dot appears at the center of the square that is marked on the base plate. Level the plate using the digital level as described in step 5 of section 2.9.2.2. Place calibration target with dull side facing up on the square marked on the base plate.

5. Select "Begin Test" in software (see figure 80) to start the test. The system will begin collecting pre run data during the filter warm-up process as shown in figure 81. Thereafter, the system will emit a beep to indicate the start of the bounce test. Do not induce any movement on the vehicle as data for the static portion of the bounce test is collected during this period. Wait until two more beeps are heard indicating that data have been collected over two 152.4 m long segments (Segments 1 and 2).

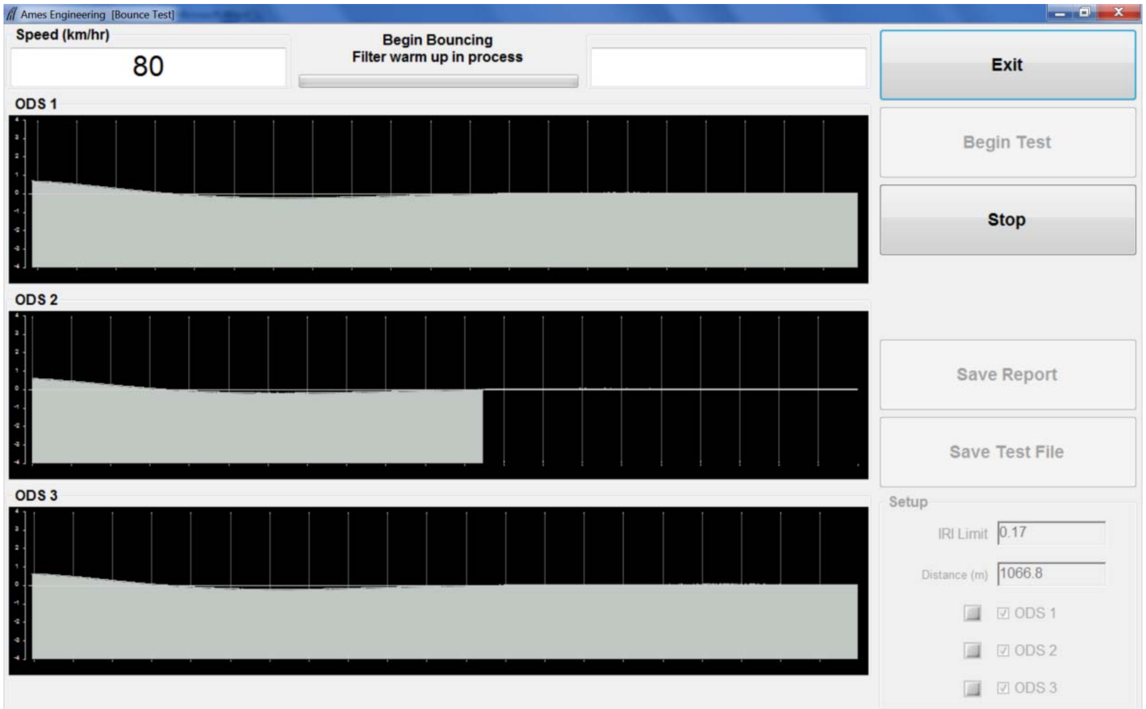


Figure 81. Filter warm-up in progress during bounce test.

6. Immediately after the third beep, the operator should get onto the rear bumper and start bouncing the vehicle such that a pitching motion is induced on the vehicle. This motion should pitch 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). The bouncing motion should continue until two more beeps are heard. Stop the bouncing motion thereafter. As the operator started bouncing the vehicle after the third beep, for the third 152.4 m long segment (Segment 3) that is from 304.8 to 457.2 m, the bouncing motion occurred only within a portion of this segment. For the fourth 152.4 m long segment (Segment 4) from 457.2 m to 609.6 m a bouncing motion was induced on the vehicle for the entire segment length. As the operator stopped the bouncing motion after the fifth beep, for the fifth 152.4 m long segment (Segment 5) that is from 609.6 to 762 m, the bouncing motion occurred only within a portion of this segment.

   The system will automatically stop the bounce test after three more beeps are heard (i.e., the total simulated distance of 1066.8 m is reached). The screen will display the message "Filter cool down in process" (see figure 82), and thereafter will display the screen shown in figure 83 where the IRI value of each 152.4 m segment is displayed on the top of the graph for each sensor.

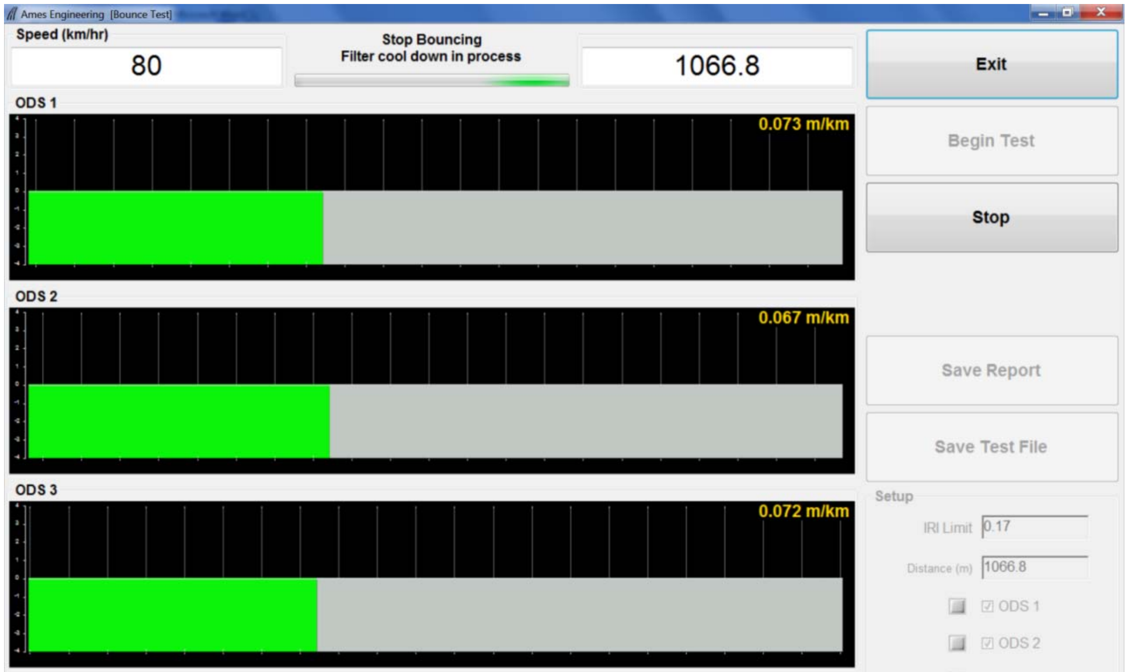


Figure 82. Filter cool-down process after bounce test is terminated.

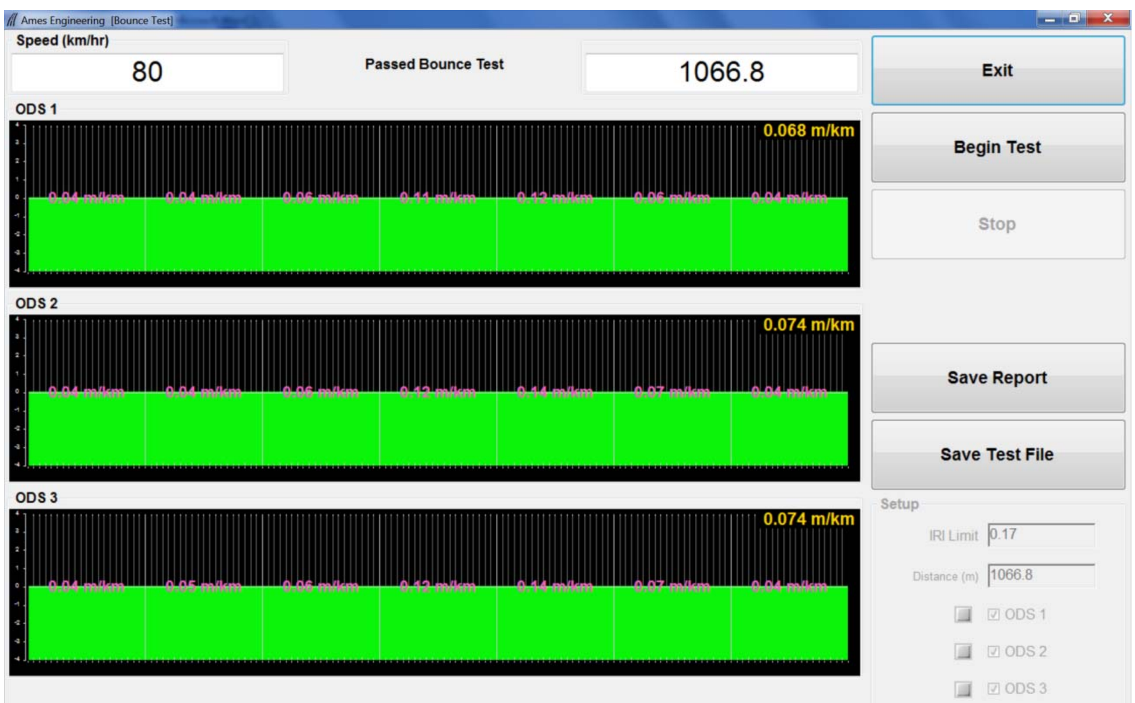


Figure 83. Display after completion of the bounce test.

7. Use the IRI of Segment 2 (i.e., from 152.4 to 304.8 m) to obtain the IRI corresponding to the initial static portion of the bounce test. Use the IRI of Segment 4 (i.e., from 457.2 to 609.6 m) to evaluate the IRI of the dynamic portion of the bounce test. Use the IRI of Segment 7 (i.e.,

from 914.4 to 1066.8 m) to obtain the IRI corresponding to the final static portion of the bounce test.

The IRI corresponding to Segment 2 (i.e., from 152.4 to 304.8 m) for all three sensors must be less than or equal 0.08 m/km. Also for each sensor the difference between IRI for segment 7 (i.e., from 914.4 m 1066.8 m) and IRI for segment 1 ((i.e., from 152.4 to 304.8 m) must be within ± 0.01 m/km. A sensor is considered to have passed the static portion of the bounce test if both criteria are met.

8. For each sensor (left, center and right), compute difference in IRI between the dynamic portion of the bounce and initial static portion of bounce test (i.e., deduct IRI obtained for Segment 2 from IRI obtained for Segment 4). If difference in IRI is less than or equal to 0.10 m/km, the sensor is considered to have passed the dynamic portion of the bounce test.

9. If all three sensors meet the criterion indicated in steps 7 and 8, go to step 10. If a sensor fails to pass the criterion indicated in step 7, step 8, or both steps, repeat the test. If one or both bounce test criterion indicated in steps 8 and 9 is not satisfied after repeating test several times, see the subsection "Failure of Bounce Test Criterion" in the end of this section.

Note: The passing of the bounce test must be based on meeting the requirements indicated in steps 8 and 9 and not on the message displayed by the software indicating "Passed Bounce Test" (see top of figure 83) The software computes the IRI for the entire duration of the bounce test (over a distance of 1066.8 m) and then compares this IRI with the IRI that is present in the IRI Limit field, and displays "Passed Bounce Test" if the obtained IRI for entire run is less than the value in the IRI Limit field.

10. Press "Save Report" to save the IRI values from the bounce test. The report will indicate the IRI for each 152.4 m segment for all three sensors. The file name will have a date and time stamp.

11. Press "Save Test Filet" to save the data collected during the bounce test. The file name will have a date and time stamp.

Failure of Bounce Test Criterion: If the IRI during the initial static portion of the bounce test is greater than 0.08 m/km for a sensor, or if the difference in IRI for segment 7 and segment 1 is not within ± 0.01 m/km, or if difference in IRI between dynamic portion of bounce test and initial static portion of bounce test exceeds 0.10 m/km for a sensor, operator should contact RSC to decide on a course of action. If an error in the equipment is found and fixed, operator should re-evaluate 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 the problem was in the center sensor, profile plots for data obtained during the previous day should be compared with profile plots for data obtained from the last visit. If data problems are suspected, such sections should be re-profiled after equipment repairs.

2.9.2.5 Pavement Temperature Sensor

Open the protective cover of the temperature sensor (see figure 17), and visually look at the housing of the sensor to see if any damage is noted. Also check the protection widow at the bottom of sensor for cracks.

2.9.3 Data Collection

2.9.3.1 Attaching Camera

Mount the camera, connect cable from camera to a USB port in laptop computer, and power-up the system using the procedures described in section 2.8.1. Properly aim the camera using the procedures described in section 2.5.11

2.9.3.2 Entering Header Information

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

1. In the Ames Engineering software start-up screen (see figure 72) press F3 key or select "Start" button. The message "Make sure the door of the surface sensor is open before beginning collection" will be displayed. Make sure the protective cover covering the pavement surface temperature sensor is open and sensor covers for the profile/texture height sensors are open and select "OK" button and the Header Menu to enter file name to save data and other header information will be displayed (see figure 84).

2. The following items on the right side of the menu should have check marks:

   - ODS1: Profile should be checked.
   - ODS2: Profile should be checked. If using the horizontal photocell to initiate data collection, Autotrigger should be checked.
   - ODS3: Profile should be checked. If using the vertical photocell to initiate data collection, Autotrigger should be checked.
   - ODS4: Texture should be checked.
   - ODS5: Texture should be checked.
   - PSM: Ambient, Surface, and GPS should be checked.

   A check mark indicates the sensor is enabled for data collection. Sensors that are available for use will show a dark green light status indicator, and sensors that have been enabled will show a bright green status light.

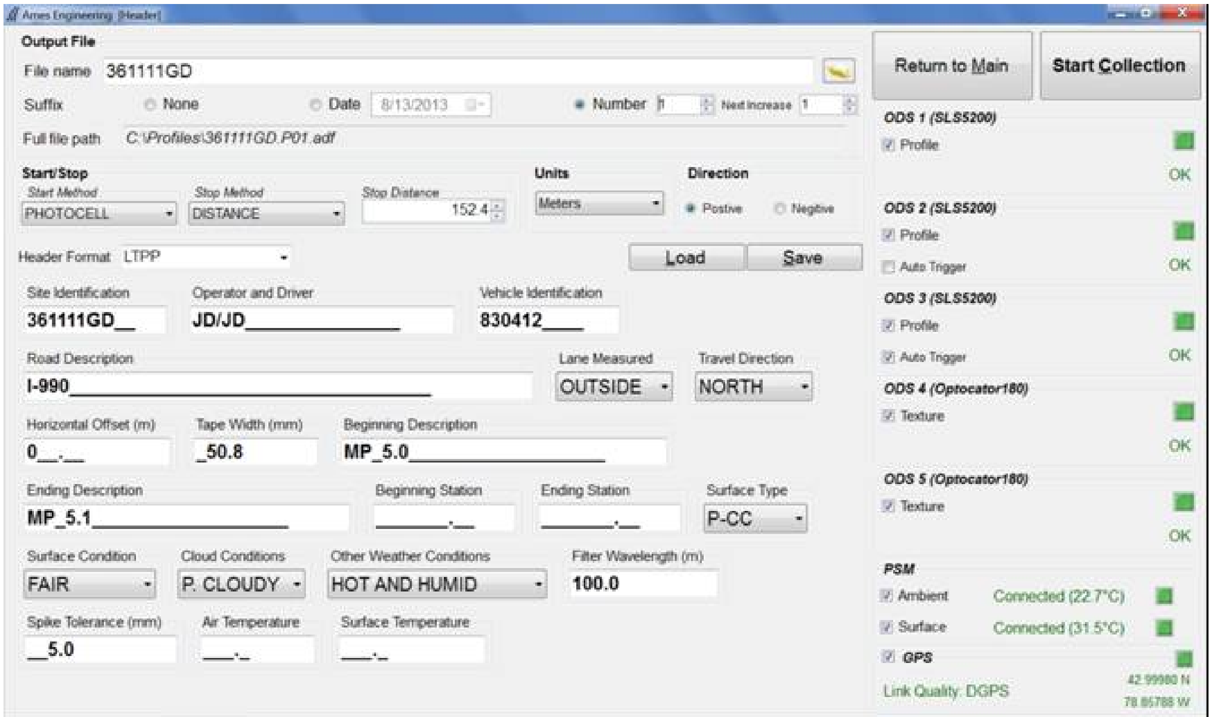


Figure 84. Header menu.

A sensor that is not available for use will show a dark red light. If the status indicator is red that means the DAU or the laptop computer is not getting the data collected by that sensor. If the status indicator is orange, that means there is a problem with that sensor reading data, such as the protective window has not been opened from a laser sensor. If a sensor is enabled and is having an error it will be blinking red. Operator must investigate and resolve problem(s) with a sensor.

The software will not allow the operator to continue data collection if any of the enabled sensors do not have a green status with the exception of the GPS sensor. Due to possible gaps in satellite coverage, it is possible to collect data without the GPS receiving data. The device will start collecting GPS data in the middle of the run if the link is established later.

3. If a header file has already been created for the site during a previous site visit, the previously created header file can be loaded. This will save some time in entering the header data. To load a previously created header file, select “Load” and then browse to select and load the appropriate header file. Some fields in the loaded header information will have to be changed to reflect current data collection. The fields that need to be changed or updated are: File Name, Operator/Driver, Surface Condition, and Other Weather Conditions. However, it is a good practice to check all header fields to make sure they are correct.

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

4. Select browse button next to “File name” and select the directory to store the data. If necessary make a new directory.

5. In the field “File Name” enter the file name to record the data. The default file name that is shown in this field is the file name from the last data run. Use file naming conventions for GPS and SPS sites indicated in section 2.7.3 to determine and enter an appropriate filename. If the site is a WIM site decide on an appropriate file name using the guidelines indicated in section 2.11

6. The parameters/settings for the fields under suffix should be set as follows:
   None: Should not be checked.
   Date: Should not be checked.
   Number: Should be checked and set to 1.
   Next Increase: Should be set to 1.

7. Start Method: The start method for data collection should always be Photocell. From drop-down menu select PHTOCELL. The other option available in this field is PENDANT. If PENDANT is selected, data collection is initiated manually by pressing F3 key in the keyboard. Start method PENDANT is not used for normal LTPP data collection.

8. Stop Method: Stop Method should always be DISTANCE. From drop-down menu select DISTANCE. The other options available in this field are PHOTOCELL and PENDANT. The PHOTOCELL option is sued when data collection is terminated using the Photocell, while PENDANT option is used when data collection is terminated manually. If PENDANT option is used, data collection is terminated manually by pressing the F4 key in the keyboard. Stop methods PHOTOCELL or PENDANT are not used for normal LTPP data collection.

9. When “Distance” is selected as the Stop Method, a field called “Distance” appears to the right of “Stop Method”. The distance over which data must be collected (in meters), starting from the start of the section, must be entered into this field. For GPS sites the distance is always 152.4, while for WIM sites the distance is always 305. For a SPS site determine the value of distance using the procedure described in section 2.10.2, and enter the value in this field.

10. Units should be set to Meters.

11. Direction: “Positive” should be checked.

12. Header Format: Header format should show LTPP.

13 Site Identification. Type the site identification in this field (e.g., 451024). Follow procedure described in steps 1 and 2 of section 2.7.3 to obtain the appropriate six-digit code for the Site ID. For WIM sites follow the procedure specified in section 2.11.

14. Operator/Driver: Operator and driver should be identified by a two digit character for each, which should be first letter of their first and last name. Operator and driver names should be

separated by a backslash and typed in capital letters (e.g., CK/RS). If profiler is used as a one person operation, operator and driver name would be the same (e.g., CK/CK).

15. Vehicle ID: The Ames Engineering vehicle identification number assigned to the device should be entered in this field (see table 1). Once this parameter has been set to the correct value, it does not need to be changed when the header screen is brought up subsequently.

16. Road Description: Type route number where section is located (e.g., I-88). All letters should be capital.

17. Lane Measured: The valid entries for the field are INSIDE or OUTSIDE. Outside lane is the lane adjacent to shoulder at right edge of road. Select appropriate lane from the drop-down menu. For nearly all LTPP sections, lane measured is OUTSIDE.

18. Travel Direction: Select appropriate lane direction (NORTH, EAST, SOUTH, or WEST) by using the drop-down menu.

19 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 specified value when the header screen is brought up subsequently.

20. Tape Width: Enter the width of the reflective tape that is placed on the pavement in millimeters if data collection is initiated using the vertical photocell. Enter the width of the reflective tape that is on the cone in millimeters if data collection is initiated using the horizontal photocell.

21. 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.

22. Ending Description: This field should indicate NONE.

23. Beginning Station: This field should be blank.

24 Ending Station: This field should be blank.

25. Surface Type: Valid entries for road surface type are A-CC for AC surfaced pavements and P-CC for PCC surfaced pavements. Use drop-down menu to select an appropriate entry.

26. Surface Condition: Describes surface condition of pavement; valid entries are V. GOOD (Very Good), GOOD, FAIR or POOR. Select an appropriate entry by using the drop-down box. Severity levels that are described correspond to the definitions given in the LTPP Distress Identification Manual [(10).]
    (a) V. GOOD: Pavement does not show any distress.
    (b) GOOD: Pavement exhibits few visible signs of surface deterioration. AC surfaced pavements may show low severity cracks, and PCC surfaced pavements may show low severity cracks and spalling.

(c) 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.
(d) POOR: Pavements in this category have deteriorated to such an extent that they affect the speed of free-flow traffic. Typical distress on AC 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 surfaced pavements can include the following distresses in a medium to high severity: spalling, transverse and longitudinal cracking, faulting and patching.

27. 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. Select an appropriate entry using the drop-down menu.

28. Other Weather Conditions: Valid entries for this field are CONDITIONS OK, STEADY CROSSWIND, WIND GUSTS, HOT AND HUMID, HAZY, LOW SUN ANGLE. Select an appropriate entry using the drop-down menu.

29. Filter wavelength: 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.

30. Spike Tolerance: Enter 5.0 in this field.

31. Air Temperature: The Air Temperature field is used to manually enter an ambient temperature reading if the ambient temperature sensor is not enabled because it is not functioning correctly.

32. Surface Temperature: The Surface Temperature field is used to manually enter a pavement surface temperature if the pavement surface temperature sensor is not enabled because it is not functioning correctly.

33. After all header information has been entered, check to make sure that all fields are correct and select "Save" button to save the entered header information.

2.9.3.3 Collecting Data

After header information has been entered and equipment has warmed-up sufficiently (allow 15 minutes after turning main power switch on for equipment to warm-up), device is ready to collect data. The following procedures should be followed to get an acceptable set of runs at GPS and SPS sites. Some of the procedures for profiling WIM sites are different from the procedures presented in this section. See section 2.11 for procedures for profiling WIM sections.

1. While in the Header Menu, press F1 key or select "Start Data Collection". A screen showing the vehicle speed, distance, and data collection status in real time for the three selected profile or texture sensors will be displayed. Tabs on this screen can be used to display either

profile data (ODS1, ODS2, and ODS3) or texture data (ODS4 and ODS5) for the left and right sensors. The data for the sensors is displayed in real time as a white shaded trace. A pop-up window will appear on top of the display showing the camera preview.

2. Attain a constant test speed of 80 km/h at least 200 m before beginning of test section and align vehicle along wheel paths. As described in section 2.7.4, a speed different from 80 km/h may be used depending on site conditions. The profile data collected for a distance of 152.4 m before the start of the section and texture data collected for a distance of 30 m before the start of the section will be saved in the data file. If sufficient pre-run data is not available before the section due to a short available lead-in distance, the software will fill the missing data with a ramp to the first point.

3. About 40 m before start of the section (after passing lead-in stripe of the section), press F5 key or select “Enable Autotrigger”. The photocell is now armed and will be looking for reflective mark on pavement surface or cone with reflective marking depending on photocell that was selected to begin data collection.

4. When photocell detects the reflective tape, five rapid beeps will be heard and the profile/texture plot on the screen will become a solid green color to indicate that data are now being collected and recorded (see figure 85). The distance measurement value will increase as the profiler moves forward. Note: The camera window showing the camera preview will appear as a window in this screen. An orange frame will appear around the preview window when an image is obtained.

Figure 85. Screen after initiating data collection.

. If vertical photocell is not triggered by the reflective tape, clean photocell and repeat run and see if the photocell triggers. If the vertical photocell still fails to trigger, operator should adjust sensitivity control for photocell and see if photocell will trigger. If this is not successful, operator should use horizontal photocell. Follow procedure described in step 2 of section 2.9.3.2 to select horizontal photocell to initiate data collection.

When profiling SPS sections, the buzzer will emit a short chirp whenever a white reflective mark is detected at the beginning of the test section.

5. The buzzer will emit five rapid beeps at the end of the section after data have been collected for the specified distance. The buzzer will then emit long beep after 152.4 m of post-run data has been collected after the end of the section. Thereafter, the End of Run window will appear on the screen (see figure 86).

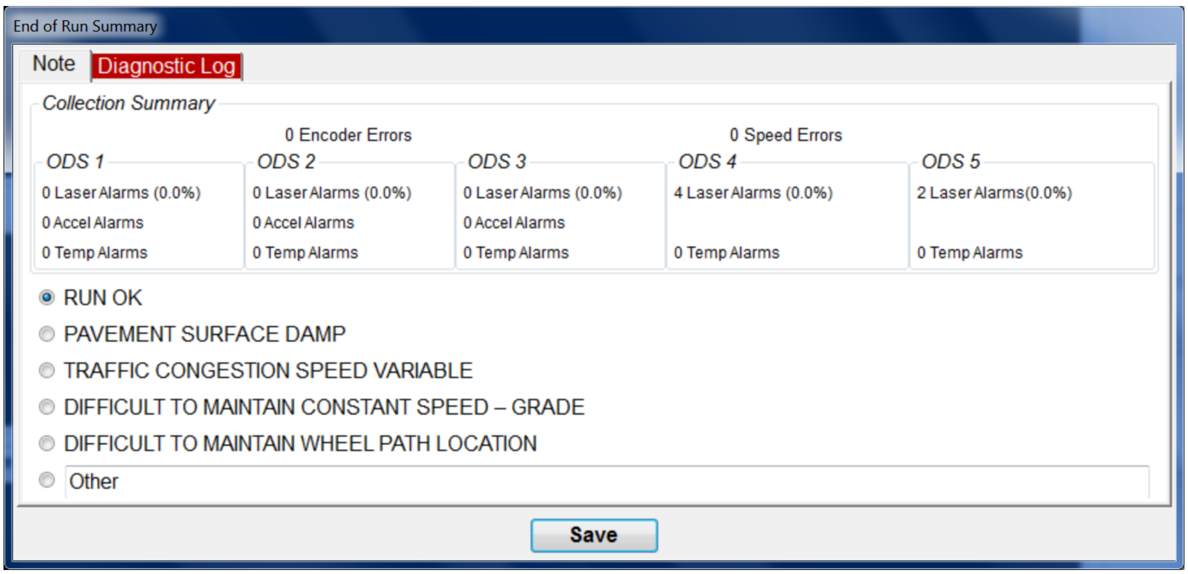


Figure 86. End of run window.

6. Bring vehicle to a stop at a suitable location to evaluate alarms and error messages if any, enter end of run comment, and save data to hard disk.

   The following information is displayed in the End of Run window for ODS1 (left profile sensor), ODS2 (right profile sensors), and ODS3 (center profile sensors):

   - Laser alarms (number and percentage).
   - Accelerometer alarms (number).
   - Temperature alarms (number)

   The following information is displayed in the End of Run Menu for ODS4 (left texture sensor) and ODS5 (right texture sensor):

   - Laser alarms (number and percentage).
   - Temperature alarms (number).

   This screen will also display errors associated with encoder and speed.

If error messages are present in the diagnostic log, then the Diagnostic tab on the window will be red (see figure 87). Selecting this tab will display all error messages sent by any sensor in the device.

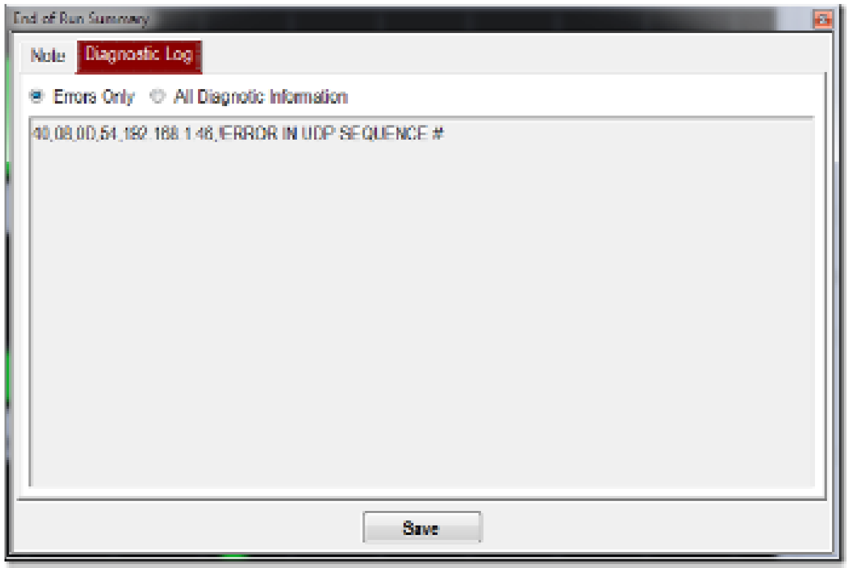


Figure 87. Diagnostic log.

Evaluate the laser alarms, accelerometer alarms, temperature alarms and the information in the diagnostic tab according to the procedures presented in section 2.9.3.4 and 2.9.3.5.

7. Evaluate the six end of run comments that are displayed, which are:

- RUN OK.
- PAVEMENT SURFACE DAMP.
- TRAFFIC CONGESTION: SPEED VARIABLE.
- DIFFICULT TO MAINTAIN CONSTANT SPEED: GRADE.
- DIFFICULT TO MAINTAIN WHEEL PATH LOCATION.
- Other

8. Use guidelines presented in section 2.7.8 to select an appropriate end of run comment. End of run comment should only be based on conditions during the profile run. If one of the displayed comments is appropriate for the profile run, select appropriate comment and select "Save" button. If none of the displayed comments are appropriate for the data collection run and operator wants to type a different comment, select "Other" and type an end of run comment using capital letters and select "Save" button

9. After the file is saved, laptop computer screen will show the Header screen, with the last digit of file name incremented by one.

   Review obtained images if the operator has elected to follow option 2 for obtaining images as described in section 2.5.11.

10. Collect five more runs at the test section using steps 2 through 9 described above. Before starting a data collection run look at the right side of the header screen to make sure that all sensors are enabled and all sensors are showing the green status indicator.

11. After collecting five error free runs, follow procedures described in section 2.9.4 to use ProQual to evaluate collected profile data. Also perform quality control checks on the data collected by the ambient temperature sensor, pavement surface temperature sensor, and the GPSR using the Sidekick software according to the procedures described in section 2.9.5.

12. If five runs are acceptable go to step 14. If not, obtain additional runs as described in section 2.9.4, and review these runs using ProQual. Complete form PROF-1, LTPP Profiler Field Activity Report, which is included in appendix B after reviewing data.

13. Backup Data: Use Windows Explorer to backup data to a flash drive. Ames Engineering data are saved in a file with extension ARD, and this file needs to be backed up. All files generated by ProQual when the profile data were processed should also be backed up.

14. Operator should verify that the form PROF-2, Status of Regions Test Section, which is included in appendix B is filled before leaving test site.

2.9.3.4 Evaluating Error Messages

Errors Associated with Profiling Sensors

The following information is displayed in the End of Run window for ODS1 (left profile sensor), ODS2 (right profile sensors), and ODS3 (center profile sensors):

- Laser alarms (number and percentage).
- Accelerometer alarms (number).
- Temperature alarms (number).

<u>Laser Alarms:</u> Laser alarms indicate number of data points that have invalid height sensor readings. An invalid height sensor reading occurs when the detector in the height sensor fails to detect the laser point on the pavement surface. For profile data, several measurements obtained by the height sensor are used to compute a profile data point at 25 mm intervals. The profile data point is tagged as having a laser alarm if one or more height sensor readings that are used to compute the profile data point have an error. When computing the profile at a point, an invalid height sensor reading is replaced by the previous reading. Laser alarms should normally be less than 1 percent for a profile height sensor.

<u>Accelerometer Alarms:</u> Accelerometer alarms indicate the number of readings where an accelerometer reading was not properly received. An accelerometer alarm occurs when the acceleration measured by the accelerometer goes outside the ± 5g range that can be measured by the accelerometer or if the zero measurements of the accelerometer are not within the normal range. An accelerometer alarm will cause the laptop computer to beep. A warning message will

also appear on the screen. Accelerometer alarms should not occur normally. There is a possibility for accelerometer alarms to occur on an extremely rough pavement that will cause the accelerometers to go outside the ± 5g range. However, such occurrences should be very rare. If an accelerometer alarm occurs, and the pavement is very rough, collect data at a lower speed to see if accelerometer alarms still happen. If this is the case, there may be a problem with the accelerometer.

Temperature Alarms: Temperature alarms indicate the number of readings where the temperature inside the laser box is outside the limits recommended by Ames Engineering. As indicated in section 2.5.1, Ames Engineering software monitors the temperature inside each individual sensor box that houses a profile height sensor. Go to the start-up screen of Ames Engineering software and see if the displayed temperatures are close to the upper or lower limit of the temperatures indicated by Ames Engineering (see section 2.5.1). If displayed temperatures are at or outside the recommended temperature range, data collection may have to be postponed to a suitable time when the temperature is satisfactory for data collection.

Errors Associated with Texture Sensors

The following information is displayed in the End of Run Menu for ODS4 (left texture sensor) and ODS5 (right texture sensor):

- Laser alarms (number and percentage).
- Temperature alarms (number).

Laser Alarms: The macrotexture data are sampled at 62.5 KHz frequency. The number of laser alarms for a texture height sensor indicates the number of individual readings in the section that had invalid data. An invalid height sensor reading occurs when the detector in the height sensor fails to detect the laser point on the pavement surface. The raw data file that is saved will have all locations with invalid data tagged as having invalid data.

When the collected data are used to compute the MPD values using the Ames Engineering software or when the data is exported through the DLL to be used in ProQual, the invalid data points are replaced. The following procedure is used to replace the invalid data points:

1. The invalid data point (point n), the point before the invalid data point (point n-1), and the point after the invalid data point (n+1) are all replaced. This procedure was adopted as there is a possibility that the points adjacent to an invalid data point could also be erroneous.

2. A linear interpolation is performed between the data value at n-2 and n+2 to select data values to use for points n-1, n, and n+1.

3. The replaced data values are used to create a macrotexture profile that do not have invalid data points, and this profile is used to compute MPD and also exported through a DLL to ProQual.

Sometimes a series of invalid readings can appear in a row. An interpolation technique is used in such a case to replace all invalid data points. Interpolation is performed between the second reading before the first invalid data point and the second reading after the last invalid data point to fill in the invalid data points.

Laser alarms should normally be less than 5 percent for a texture sensor.

Temperature Alarms: Temperature alarms indicate the number of readings where the temperature within the interface box for texture sensors is outside the limits recommended by Ames Engineering. As indicated in section 2.5.1, Ames Engineering software monitors the temperature inside the interface box that processes macrotexture data. Go to the start-up screen of Ames Engineering software and see if the displayed temperatures are close to the upper or lower limit of the temperatures indicated by Ames Engineering (see section 2.5.1). If displayed temperatures are at or outside the recommended temperature range, data collection may have to be postponed to a suitable time when the temperature is satisfactory for data collection.

Encoder Errors

An encoder error is detected if the pulses from the encoder are coming in at a rate that is faster than the fastest speed that has been allowed for the device, which is about 160 km/h.

Speed Errors

A speed error is an error detected by the DAU indicating that synchronization signals are not being sent out properly to the sensors and the system is getting behind because the DMI signal is indicating another sample is required before the last synchronization signal was sent out. An encoder error could cause a speed error to occur, but other problems on the RS485 serial bus could cause a speed error as well. For example if the sensor cable that contains both Ethernet and RS485 signals has the RS485 connections shorted out intermittently would cause a speed error.

2.9.3.5 Evaluating Diagnostic Messages

If error messages are present in the diagnostic log, then the Diagnostic tab on the End of Run window will be red. Selecting this tab will display all error messages sent by any sensor in the (see figure 87).

The error messages consist of a comma delimited string that each sensor sends during data collection when an error condition is encountered. There error messages are stored in the ARD file. Examples of diagnostic messages are shown below:

01,01,0A,1,192.168.1.136,>Local IP address:192.168.1.136
01,01,0A,2,192.168.1.136,>Ethernet interface initialized
01,01,0A,10,192.168.1.136,!ERROR IN UDP PACKET CRC

Each error message field starts with a '>' for informational messages and a '!' for error messages. Each field in the definition is separated by a comma. Informational messages will include sensor calibration and settings information from each sensor and other start-up messages at the start of each run. The format for this string is

- Device address (see table 3).
- Device type.
- Device attributes.
- Seconds since boot.
- IP address.
- Log string.

Table 3. Device addresses.

Device Address	Module
0x01	ODS #1 Sensor
0x02	ODS #2 Sensor
0x03	PSM Modulus
0x10	ODS #3 Sensor
0x20	ODS #4 Sensor
0x40	ODS #5 Sensor

Some error messages are problems that have been corrected, like a UDP Ethernet packets that were resent and will have no effect on the data. A message indicating a Trigger Sequence Error means that the trigger message sent on the serial 485 bus did not get to the intended sensor because there was a skip in the trigger sequence numbers. This is not a correctable error because the sample was never taken. When this happens, that single sample will be bridged with the last good sample to fill in the space where this sample should have been taken. This could happen because of noise on the RS485 communication lines. A sample or two like this is not likely to have any effect on the results generated by these files, but if 10 or more are included in a run it is probably an indication that there is a problem with the cabling to that sensor, or a communications driver in the sensor is damaged. In case of such an event, contact Ames Engineering to discuss the diagnostic messages.

2.9.4 Evaluating Collected Profile Data

2.9.4.1. Evaluating Acceptability of Runs

Once the operator is confident that a minimum of five error free runs has been obtained, the ProQual program is used to evaluate acceptability of profile runs based on LTPP criteria. Procedures for running ProQual are described in the ProQual manuals [6, 7, 8]. ProQual uses collected profile data to compute IRI values for the left and right wheel paths, as well as 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:

1. IRI of three runs is within 1% of mean IRI of the five selected runs.

2. Standard deviation of IRI of the five selected runs is within 2% 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 2.9.4.2 should be followed.

If ProQual indicates that five runs are acceptable, but spikes are present in the data, operator should determine if spikes are pavement related or the result of equipment or operator error. 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. Operator should select the "Graphic Profiles" tab in ProQual to do this comparison. If there are spikes believed to be caused by operator or equipment error, operator should correct cause of the anomalies and make additional runs until five runs free of equipment or operator errors are obtained.

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, operator should compare the current profile data with those obtained during previous site visit. Operator should also be familiar with the trouble-shooting guide included in appendix C. 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 indicated in section 2.6.4, operator must have profile data for site from previous site visit. 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 the ProQual software. This comparison should be performed separately for the left and right wheel paths. 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 previous site visit.

When Ames Engineering data are compared to data collected with ICC profilers, differences in profile plots will be seen (see appendix D). However, sharp upward and downward features in both profiles that are indicative of short wavelength features should occur at the same location. When the comparison involves only Ames Engineering 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 visit. If there are still discrepancies between profiles from the current visit and previous visit, operator should verify that these differences are not caused by equipment problems or due to incorrect sub-sectioning of SPS test sections. Operator should also explore if differences are due to pavement maintenance activities on the test section.

After profile comparison is completed, an IRI comparison of current versus previous site visit data should be performed using procedures described in section 2.9.4.3. If IRI from profiler runs meet LTPP criteria (as seen in the ProQual output) and operator finds no other indication of errors, no further testing is needed at the site.

2.9.4.2 Non-Acceptance of Runs by ProQual

Profiler 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, 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, rapid acceleration or deceleration of vehicle could have affected collected data.

2. Review spike report generated by ProQual to determine if spikes are 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. Operator should also examine profile plots for discrepancies and features that cannot be explained by observed pavement features. ProQual provides user 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 previous site visit. This comparison can be performed by selecting the "Graphic Profiles" tab and selecting the desired data sets in the ProQual software. 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 the ProQual software. If data from last two runs are consistent with those from first five runs in terms of variability and presence of pavement-related anomalies, no further runs are required. If data from last two runs differ from those for first five runs, operator should re-evaluate 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 2.9.4.3.

2.9.4.3 Comparison of IRI with Previous Values

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 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. 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, 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.

2.9.4.4 Graphical Outputs

Although not mandatory, the RSC may request the operator to 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 2.14.1). The graphical plot can be obtained using the ProQual program. 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.

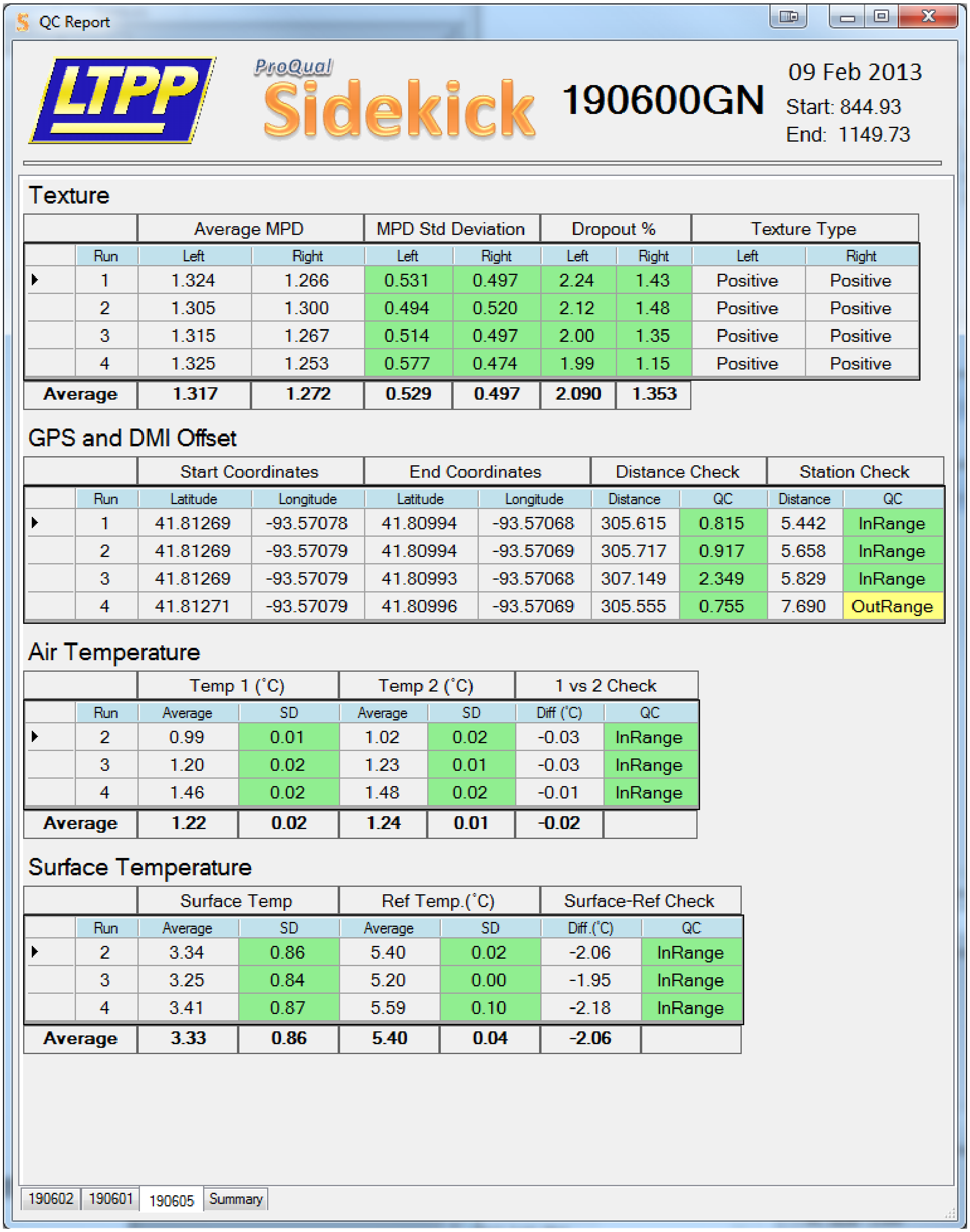
2.9.5 Quality Control Checks Using ProQual Sidekick

ProQual Sidekick is a software that is used in the field to review and analyze the following data elements collected by the device:

- Macrotexture.
- GPS coordinates and DMI offset.
- Ambient temperature.
- Pavement surface temperature.

The procedures for installing and using Sidekick is described in the Sidekick user guide.[9] Sidekick produces a quality control (QC) report for each section. For SPS projects, a QC report is produced for each section after sub-sectioning the data. Figure 88 shows an example of a QC report produced by Sidekick. Following is a brief description of the items indicated in the QC report for the above mentioned data elements:

Macrotexture: The following items are displayed for each data collection run for the left and the right sensor: average MPD, standard deviation of MPD, percentage of dropouts, and texture type (either positive or negative).



QC Report

LTPP ProQual Sidekick 190600GN

09 Feb 2013
Start: 844.93
End: 1149.73

Texture

	Average MPD		MPD Std Deviation		Dropout %		Texture Type	
Run	Left	Right	Left	Right	Left	Right	Left	Right
1	1.324	1.266	0.531	0.497	2.24	1.43	Positive	Positive
2	1.305	1.300	0.494	0.520	2.12	1.48	Positive	Positive
3	1.315	1.267	0.514	0.497	2.00	1.35	Positive	Positive
4	1.325	1.253	0.577	0.474	1.99	1.15	Positive	Positive
Average	**1.317**	**1.272**	**0.529**	**0.497**	**2.090**	**1.353**		

GPS and DMI Offset

	Start Coordinates		End Coordinates		Distance Check		Station Check	
Run	Latitude	Longitude	Latitude	Longitude	Distance	QC	Distance	QC
1	41.81269	-93.57078	41.80994	-93.57068	305.615	0.815	5.442	InRange
2	41.81269	-93.57079	41.80994	-93.57069	305.717	0.917	5.658	InRange
3	41.81269	-93.57079	41.80993	-93.57068	307.149	2.349	5.829	InRange
4	41.81271	-93.57079	41.80996	-93.57069	305.555	0.755	7.690	OutRange

Air Temperature

	Temp 1 (˚C)		Temp 2 (˚C)		1 vs 2 Check	
Run	Average	SD	Average	SD	Diff (˚C)	QC
2	0.99	0.01	1.02	0.02	-0.03	InRange
3	1.20	0.02	1.23	0.01	-0.03	InRange
4	1.46	0.02	1.48	0.02	-0.01	InRange
Average	**1.22**	**0.02**	**1.24**	**0.01**	**-0.02**	

Surface Temperature

	Surface Temp		Ref Temp.(˚C)		Surface-Ref Check	
Run	Average	SD	Average	SD	Diff.(˚C)	QC
2	3.34	0.86	5.40	0.02	-2.06	InRange
3	3.25	0.84	5.20	0.00	-1.95	InRange
4	3.41	0.87	5.59	0.10	-2.18	InRange
Average	**3.33**	**0.86**	**5.40**	**0.04**	**-2.06**	

190602 190601 190605 Summary

Figure 88. Example of a QC report produced by Sidekick.

GPS coordinates: The estimated GPS coordinates at the start of the section and end of the section for each data collection run are displayed. The GPSR obtains measurements at a frequency of 5 Hz. A GPSR reading is not obtained exactly at start and end of the section. The GPS coordinates obtained at a location immediately before the start of the section and immediately after start of the section is used with section initiation data to estimate the GPS coordinate at the start of the section. A similar procedure is used to estimate the GPS coordinate at the end of the section. The GPS coordinates at the start and end of the section are used to determine the length of the section. Thereafter, the estimated GPS coordinates at the start of the section is compared with the GPS coordinates for start of the section that are in the PPDB database by computing the distance between the two sets of GPS coordinates.

Ambient Temperature: The ambient temperature sensor is rated at 1 Hz, which means a reading is obtained every second. At a speed of 80 km/h, seven temperature readings are obtained over a 152.4 m distance. The average ambient temperature and standard deviation of ambient temperature computed from these readings for the two temperature probes for each run are shown in the QC report. The difference in average temperatures obtained for the two probes for each run is also shown.

Pavement Surface Temperature: The pavement surface temperature sensor is rated at 41 Hz, which means 41 readings are obtained by this sensor per second. At a speed of 80 km/h, this sensor obtains about 278 readings over a 152.4 m distance. The average pavement surface temperature, standard deviation of pavement surface temperature, average reference temperature, and standard deviation of reference temperature computed from the readings obtained by the pavement surface temperature senor for each run are shown in the QC report. The difference between the average pavement surface temperature and the average reference temperature for each run is also shown in the QC table.

Evaluation of the QC report: The various data elements shown in the QC report are color coded. Items that are satisfactory are shown highlighted in green, while items that may be problematic are highlighted in red. Sidekick uses pre-programmed values for the computed parameters to determine if they are satisfactory (i.e., green) or if the data elements may be problematic (i.e., red).

Following are the data elements that are highlighted:

- Texture: Standard deviation of MPD and percentage of dropouts.

- GPS: The distance between start and end of section based on estimated GPS coordinates at start and end of the section, which is referred to as the distance check. The distance between the GPS values at start of section estimated from GPSR and GPS values at start of section that are in the PPDB, referred to as the Station check.

- Ambient Temperature: Standard deviation of temperature for each probe and the difference in average temperature between the probes.

- Pavement Surface Temperature: Standard deviation of pavement surface temperature and the difference between the average pavement surface temperature and the average reference temperature.

Parameters that are highlighted in red should be evaluated to determine if there is a potential problem with the sensor that collected the data element in question. If problems are found, correct issue, and obtain new set of data.

Complete the Sidekick checklist form that is included in appendix B when evaluating the QC report.

2.9.6 Data Backup

Data collected at a site by the device, the image files, and the files generated by ProQual and Sidekick when these data were processed (site files) should be backed up to a flash drive before leaving the site. All raw data collected by device during one run at a site is stored in a file with file extension ARD. ProQual data that should be backed up are the site files that were created when the ARD files were processed. The data generated by Sidekick are stored in a Microsoft SQL database file that has the file extension mdf.

A recommended procedure to follow during backup of data for a site is to create separate directories in the flash drive for each site.

When a SPS site is processed, separate subdirectories are created for each of the sub-sectioned sites. The ProQual and Sidekick files created for each of these sections as well as the raw profile data collected at the SPS site (i.e., ARD files) should be backed up. The operator should maintain a log to document files that are contained in each flash drive.

At end of each day, an additional backup copy of all data collected on that day should be made. Therefore, at end of each test day, there should be two backup copies that contain the data that were collected on that day. One of these backups should be kept in the device (device copy) while the other copy (RSC copy) should be forwarded to RSC. Until RSC copy is forwarded, device copy must be removed from the vehicle whenever testing is not in progress. No collected data should be deleted from the hard drive of the laptop computer until the RSC has informed the operator that RSC copy has been received and processed by RSC. The flash drive can be recycled once the RSC informs the operator that data have been received, processed and backed up.

Profiler data files should be organized into subdirectories in the hard drive, as outlined in LTPP directive GO-48, AIMS Electronic Data Format, Submission, Standards, and Dates, or current version of that directive.

2.10 PROFILING SPS SECTIONS

2.10.1 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 data collection run at a SPS site, profile and macrotexture data are collected for entire site, which includes test sections as well as transition areas.

2.10.2 Length of Test Section

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. Operator may elect to break the SPS project into two segments for profiling depending on location of 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, operator may elect to profile the SPS project as two groups of sections.

2.10.3 Operating Speed

Guidelines regarding operating speed described in section 2.7.4 should be followed when testing SPS test sections. When SPS test sections are tested, 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 2.7.4) before next section is tested. If there is traffic in front of the device, the device speed can be initially decreased in the transition section to give more leeway with the vehicle in front. Thereafter, device must be brought up to a constant speed of 80 km/h or appropriate speed depending on site conditions before entering next test section.

2.10.4 Number of Runs

The procedure outlined in section 2.9.4.1 should be followed in order to obtain an acceptable set of runs at a SPS project. The ProQual program 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 sub-sectioning individual test sections from a profile run made at a SPS section is described in the ProQual manual[6]. Operator should study IRI computed for each run and plot data from repeat runs to ensure that repeatable data are obtained between runs.

2.10.5 Header Information

The procedures outlined in section 2.9.3.2 for entering header information should also be followed for SPS test sections. However, Stop Distance that is entered in step 9 for a SPS project is different than that entered when collecting data at GPS sections.

Operator should refer to site layout plans and obtain length of SPS project that will encompass all test sections. To guard against discrepancies between layout plans and as-built sections, 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 9 of section 2.9.3.2.

If operator is not certain about the length to be entered, perform a trial run to determine the length of the SPS project. Set Stop method to Pendant and terminate data collection once the end of the last test section is passed for the trial run. Use the distance noted from the trial run to obtain the length of the SPS project to be entered in the Stop Distance field in the header.

2.10.6 Hardcopy of Profile

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, plot should be attached to the Profiler Field Activity Report. The graphical plot can be obtained using 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.

2.10.7 Data Backup

Data collected at SPS projects should be backed up using the procedures described in section 2.9.6.

2.11 PROFILING WIM SECTIONS

2.11.1 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 before 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 Ames device. 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 exists 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.

2.11.2 Weigh-In-Motion (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 89. 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 89. 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 before 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.

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. 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 present at the WIM section, 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 before the second visit to the site.

2.11.3 Profile Measurements

2.11.3.1 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.

NOT TO SCALE

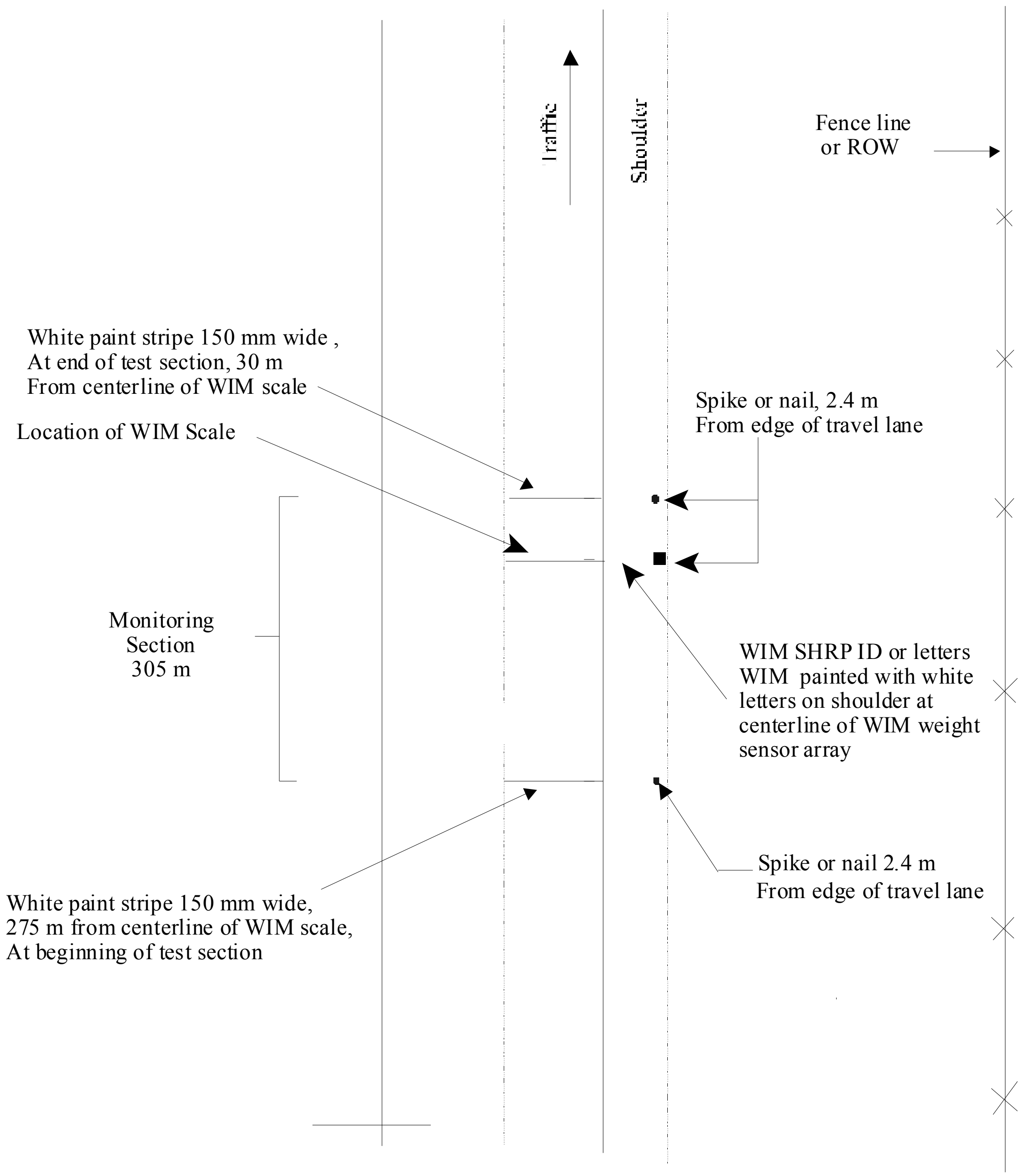


Figure 89. Layout of WIM Site.

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 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; 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.

2.11.3.2 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:

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 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.

After the sequential visit identifier code has been assigned as Z, change character seven to X, and assign site visit identifier to be A. For subsequent profile visits, maintain character seven as X and change sequential visit identifier to B, C, D, etc.

2.11.3.3 Data Collection Procedure

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

1. Daily checks should be performed on the equipment (i.e., laser sensor check, accelerometer calibration check, bounce test).
2. Highway agency procedures relating to safety issues should be strictly followed (i.e., light bar, directional warning light, strobe lights, use of turnarounds, etc.).
3. 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 speed limit at the site is less than 80 km/h, the site should be profiled at 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.
4. Photocell should always be used to initiate data collection at beginning of test section.
5. When entering header information into the software, the section number assigned to the WIM should be entered as the Site ID.
6. "Stop Distance" in software should be specified as 305 m.

On completion of the above steps, the below procedure should be followed to obtain an acceptable set of profile runs at WIM sections. 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.

1. Operator should 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. After completing data collection, review the profile runs that were collected along each path. Evaluate the profiles for equipment related spikes following the procedures described in section 2.9.4. 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 form PROF-7, Profiling of WIM Sites: Data Summary Sheet, which is included in appendix B to maintain a log of the runs.
7. Backup the data before leaving the site following procedures described in section 2.9.6.

2.12 CALIBRATION/CALIBRATION CHECKS

2.12.1 General Background

The only component in the device that can be calibrated is the DMI. However, there are several components in the device on which calibration checks must be performed to ensure the components are collecting accurate data. Table 4 shows the components in the device on which calibrations/calibration checks must be performed, as well as the maximum interval between calibration/calibration checks. This table also shows the section in the Profile Manual that describes the calibration/calibration check.

Table 4. Components requiring calibration/calibration checks.

Component	Test	Maximum Interval Between Tests	Section in Manual
DMI	Calibrate	30 Days (Note 1)	2.12.3
Accelerometer	Calibration check	30 days (Note 2)	2.12.4
Profile height sensors	Full calibration check	30 days (Note 3)	2.12.5
Texture height sensor	Full calibration check	30 days (Note 4)	2.12.5
Texture height sensor	Dynamic check	30 Days (Note 4)	2.12.6
Bounce test		Whenever full calibration check of profile height sensors are performed in addition to daily check	2.12.7
Ambient Temperature probe	Calibration check	30 Days (Note 5)	2.12.8
Pavement surface temperature probe	Calibration check	30 Days (Note 5)	2.12.9
GPS receiver	Calibration check	30 Days (Note 5)	2.12.10
Photocells	Initiation Check	365 Days (Note 5)	2.12.11
Note 1: DMI must be calibrated whenever problems are suspected, tires are replaced, suspension repairs are performed, wheels are rotated or aligned, repairs are performed on the encoder, or if the encoder is replaced. Note 2: This test must be performed whenever problems are suspected, when repairs are performed on any cards associated with the accelerometer, or when an accelerometer is repaired or replaced. Note 3 This test must be performed whenever problems are suspected, when repairs are performed on any cards associated with the profile height sensor, or when a profile height sensor is replaced. Note 4 This test must be performed whenever problems are suspected, when repairs are performed on any cards associated with the texture height sensor, or when a texture height sensor is replaced. Note 5: This test must be performed whenever problems are suspected with the sensor, and when repairs are performed on any components or cards associated with the sensor			

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

2.12.2 Calibration Menu

The calibration menu is accessed from the Ames Engineering software start-up screen (see figure 72) by pressing the F2 key or by selecting the “Calibration” button. The Calibration Menu shown in figure 90 will then be displayed on the laptop computer screen. All of the calibration/calibration checks shown in table 4 except for the checks on the ambient temperature sensor, pavement surface temperature sensor, GPSR, and photocell are performed by selecting the appropriate test from this menu.

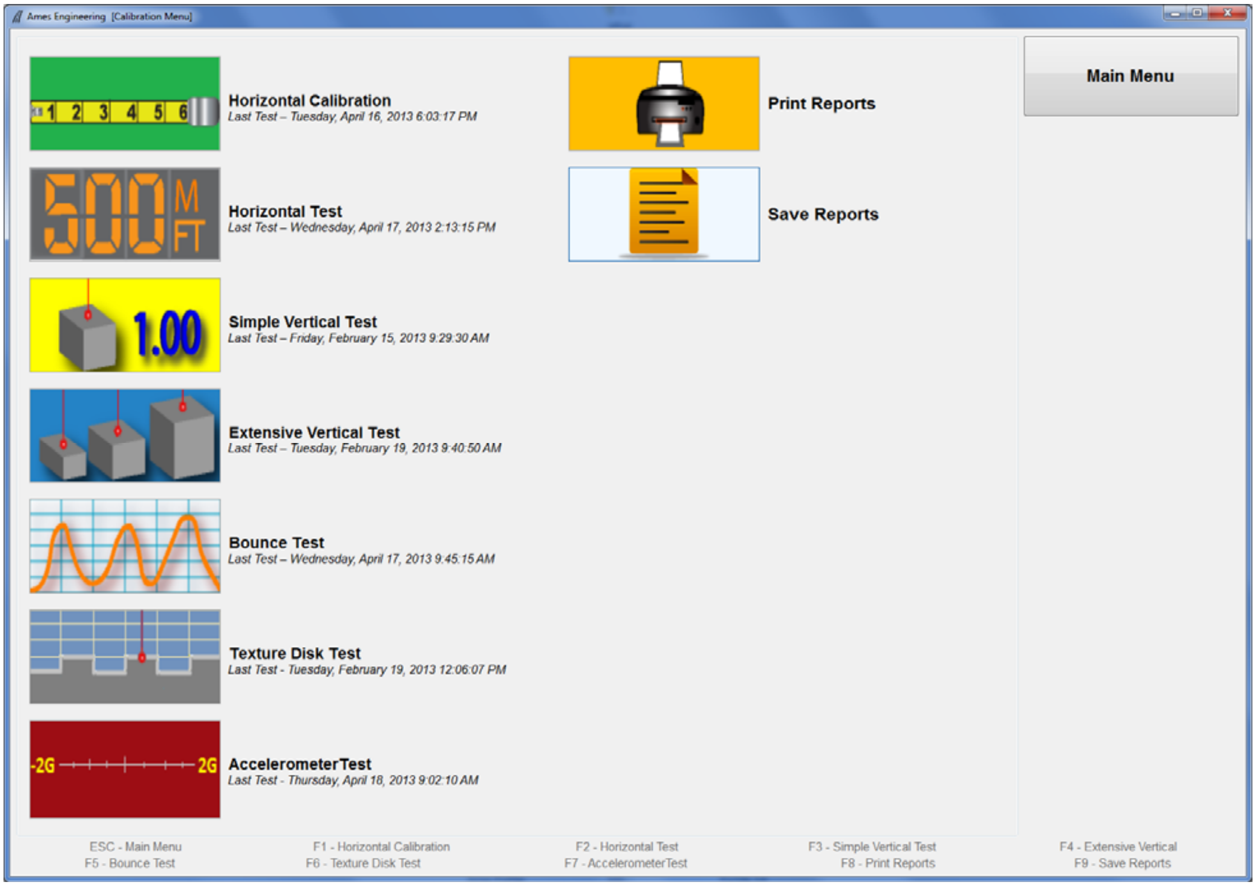


Figure 90. Calibration menu.

2.12.3 Calibration of Distance Measuring Instrument (DMI)

The DMI is calibrated by driving vehicle over a known distance to count the number of pulses from the DMI to calculate a Horizontal Calibration Factor. An accurately measured section of 300 m should be used to calibrate the DMI. This section must be located on a straight portion of roadway that is reasonably level and has a low traffic volume. Speed limit at site should be at least 80 km/h. This section should be in an area where vehicle can be driven at a constant speed without interruptions. Section should be measured with a standard surveying tape using standard surveying procedures. Reflective tape that will trigger the vertical 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 device traverses the test section.

The calibration factor that is computed will depend on the tire pressure of the rear left tire, as the encoder is attached to the rear left wheel. The operator should check and maintain tire pressure of all tires at the value recommended by the vehicle manufacturer (see section 2.5.5), and not just that of the rear left tire.

Before driving the vehicle in the morning, the operator should check the tire pressure (cold) to ensure that the tire pressure of the front tires are at 380 kPa (55 psi) for the front tires and 550 kPa (80 psi) for the rear tires, which are the manufacturers recommended tire pressures. Adjust the tire pressure if needed.

Operator should drive the vehicle for about 6 to 8 km (4 to 5 miles) at highway speeds before calibrating the DMI 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.

Before calibrating the DMI, do a "Horizontal Test" using the "Horizontal Test" option in the Ames Engineering software (see figure 91) to obtain the distance the DMI is measuring at the section with the current calibration factor. This test will provide information about the stability of the DMI over time. Perform the Horizontal Test using the following procedure:

1. Adjust tire pressure of all tires so they match the tire pressure at the time the DMI was calibrated last.

2. In the calibration menu (see figure 90), press F2 key or select "Horizontal Test" icon, and the screen shown in figure 91 will be displayed. This screen shows the current calibration factor of the DMI.

3 Under Auto Start Sensor select "Attached to ODS3" to select the vertical photocell as the active photocell.

4 Under Direction, "+(Pos)" should be selected to indicate distance will be increasing.

5. Bring vehicle up to a speed of 80 km/h about 150 m before start of the section and select "Begin Test" button. Then press space bar on keyboard to arm the photocell.

6. As device crosses the start of the section, a beep will be heard when photocell is triggered by the reflective tape that is located at the start of the section. The Distance field will be reset to zero.

7. As the device approaches the end of the section press space bar on keyboard to activate the photocell. As device crosses the end of the section, a beep will be heard when photocell is detected by the reflective tape located at the end of the section. The Distance field will display the measured distance.

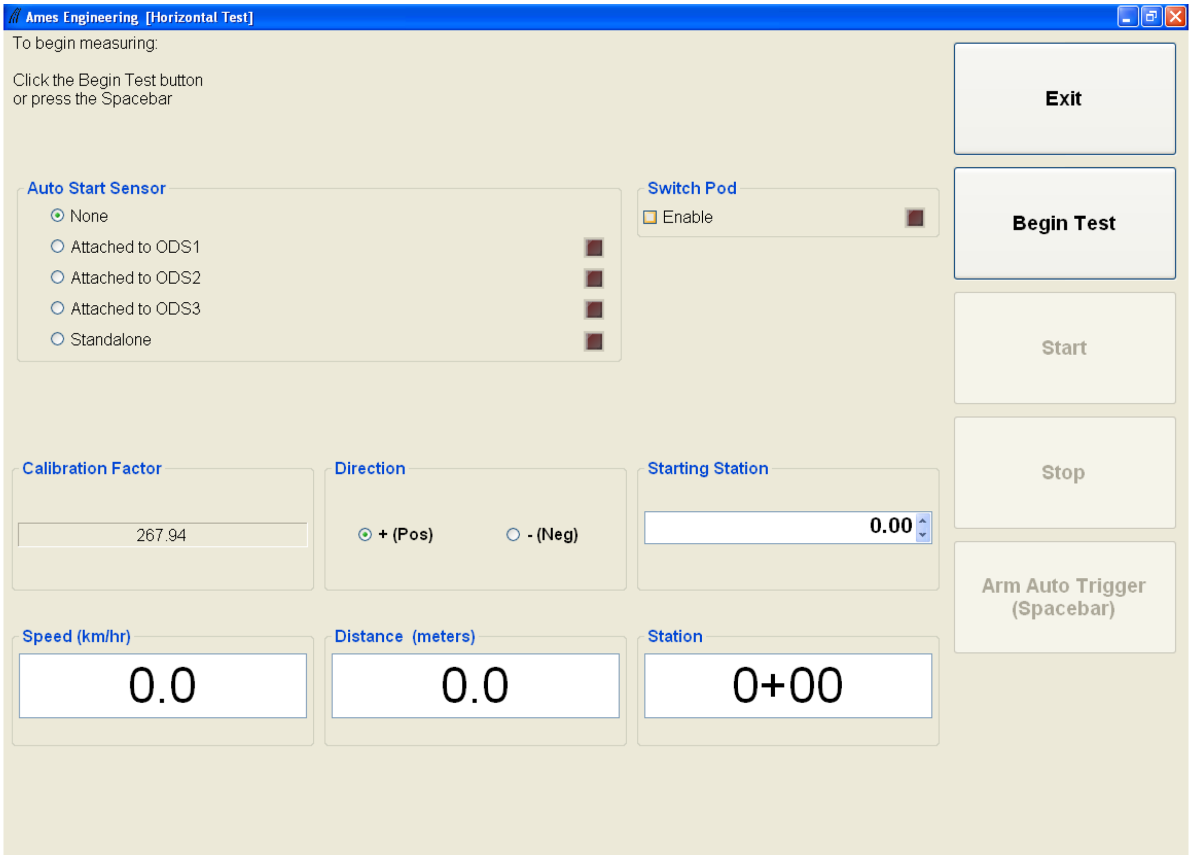


Figure 91. Horizontal test screen.

Note: If the photocell fails to trigger at the start or at the end of the section, the Stop button can be used to terminate the test. Clean photocell and repeat the run and see if the photocell triggers. If photocell still fails to trigger, operator should adjust the sensitivity control for photocell and repeat the test. If this is not successful, operator should use horizontal photocell. To use horizontal photocell, place two cones on side of road at beginning and end of section such that leave edge of the reflective mark on each cone is aligned with the leave edge of the mark that is on the pavement surface. Under "Autostart Sensor" (see figure 91) select "Attached to ODS2" to select the horizontal photocell and perform test using procedure described in steps 5 and 6.

8. Note the distance displayed in the "Distance" field. This is the distance that was measured by the DMI between the reflective tapes at the start and the end of the section based on the current calibration factor. This value can be used to evaluate the stability of the DMI over time.

After performing the Horizontal Test, use the following procedure to calibrate the DMI:

1. Adjust tire pressure such that the tire pressure of the front tires are between 380 and 415 kPa (55 and 60 psi) and the tire pressure of the rear tires are between 550 and 585 kPa (80 and 85 psi. Note tire pressure.

2. In the calibration menu (see figure 90), press F1 or select the icon "Horizontal Calibration" and the Horizontal Calibration Screen shown in figure 92 will be displayed on the laptop computer screen. This screen shows the calibration factor for the DMI that was saved the last time the DMI was calibrated.

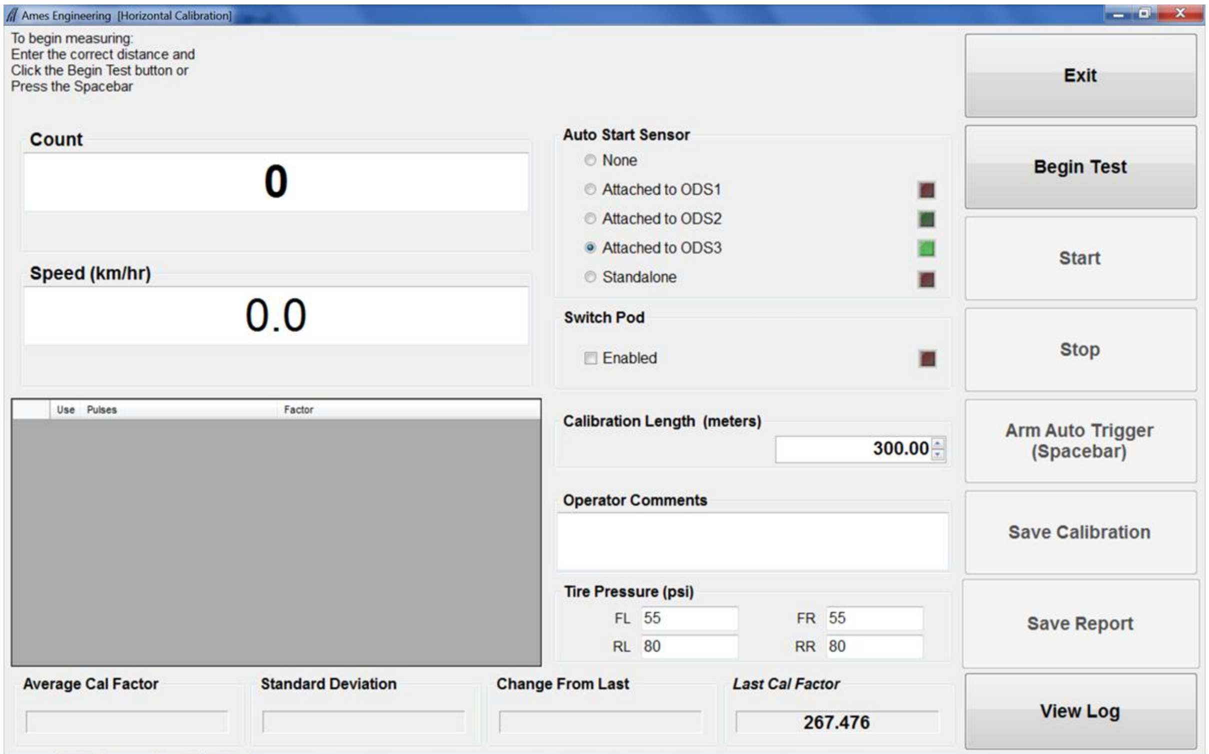


Figure 92. Horizontal calibration screen.

3 Under Auto Start Sensor select "Attached to ODS3" to select the vertical photocell as the active photocell.

4. In the Calibration Length field enter 300, which is the length of the calibration section in meters. Enter the tire pressures in psi in the Tire Pressure section of this screen, where FL is front left tire, FR is front right tire, RL is rear left tire and RR is rear right tire. In the "Operator Comment" field enter the distance that was noted in step 8 of the Horizontal Test.

5. Bring vehicle up to a speed of 80 km/h about 150 m before start of the section and press "Begin Test" button and then press space bar to arm photocell. As device crosses the start of the section, a beep will be heard when photocell is triggered by the reflective tape that is located at the start of the section.

6. As the device approaches the end of the section press space bar to arm the photocell. As device crosses the end of the section, a beep will be heard when photocell detects the reflective tape located at the end of the section. Figure 93 shows an example of the DMI calibration screen after performing one run. The Pulses and Factor field on the screen will be

populated. The pulses field indicates the pulses counted by the encoder over the calibration section and the factor indicates the calibration factor that was computed.

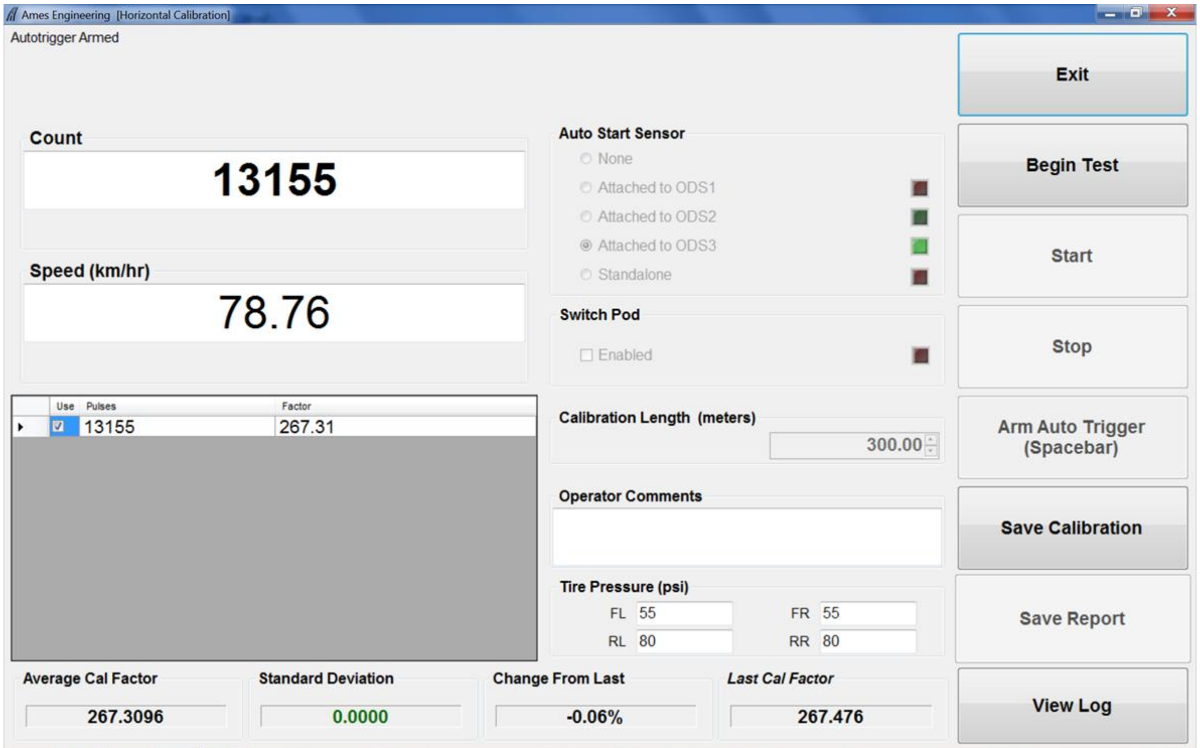


Figure 93. DMI calibration screen after performing one run.

Note: If the photocell fails to trigger at the start or at the end of the section the Stop button can be used to terminate the test. Clean photocell and repeat the run and see if the photocell triggers. If photocell still fails to trigger, operator should adjust the sensitivity control for photocell and repeat the test. If this is not successful, operator should use horizontal photocell. To use horizontal photocell, place two cones on side of road at beginning and end of section such that leave edge of the reflective mark on each cone is aligned with the leave edge of the mark that is on the pavement surface. Under "Autostart Sensor" (see figure 92) select "Attached to ODS2" to select the horizontal photocell and perform test using procedure described in steps 5 and 6.

7. Repeat the calibration procedure (steps 5 and 6) five more times so that six calibration runs are obtained. At start of each run adjust tire pressure to value noted in step 1. After six calibration runs have been obtained, select the six runs such that a check mark appears to the left of the run. An average calibration factor that is the average of the calibration factor obtained for each run will be displayed on the screen. Figure 94 shows an example of screen at this stage. The screen will also display the standard deviation of the calibration factor as well as the percentage change in the calibration factor from the last value. If the standard deviation of the calibration factor that is displayed on the screen is less than or equal to 0.07, sufficient DMI calibration runs have been obtained.

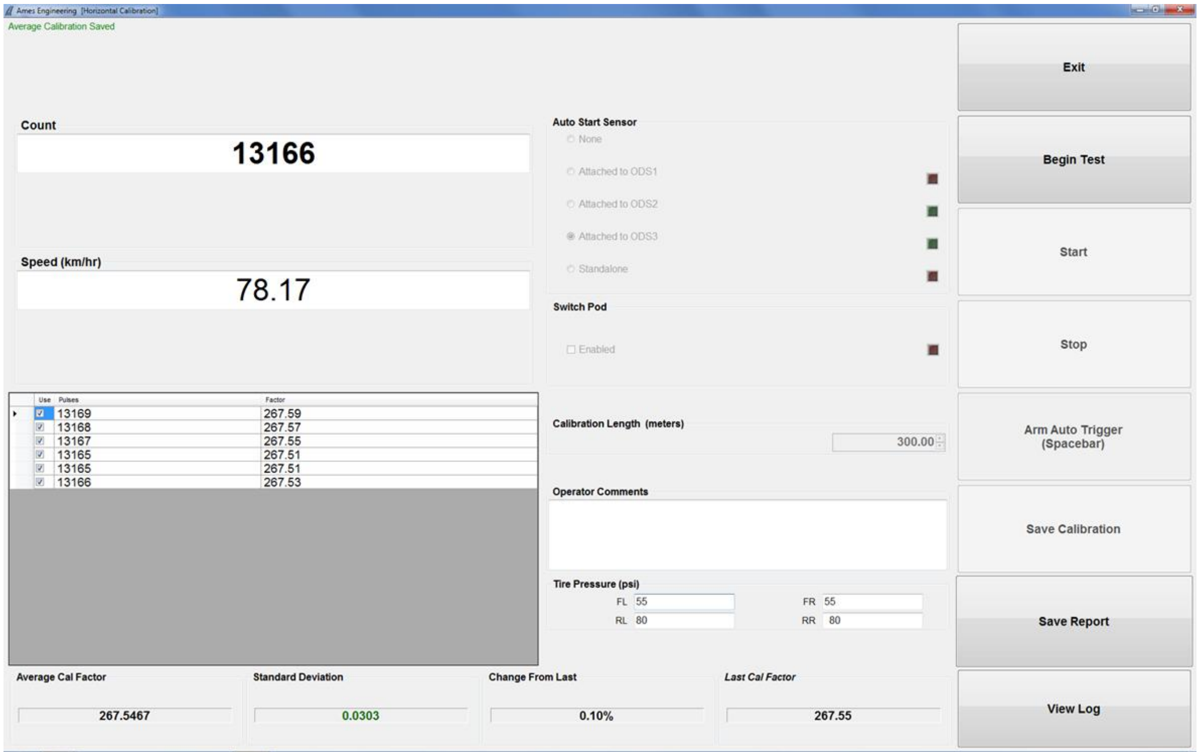


Figure 94. DMI calibration screen after obtaining six runs.

8. If the standard deviation of the calibration factor is greater than 0.07, obtain additional runs. Then select the runs that are to be used for computing the calibration factor. Figure 95 shows an example of where seven calibration runs were obtained, with six of the seven runs selected for computing the calibration factor.

9. If percent change in calibration factor from the previous value is not within ±1 percent repeat test.

Note: If tires in the van are changed, there is a possibility that the percent change may not fall within ±1 percent of the previous value. If this is the case, repeat test and if percent change is still not within ±1 percent of the previous value and the obtained values are similar to previous test that failed, select “Save Calibration” to save the computed calibration factor, and then select “Save Report” to save the DMI calibration report that will have details about the current calibration. Go to step 11.

10. If standard deviation of the calibration factor computed from the selected runs is less than 0.07 and the percent change in calibration factor is within ±1 percent select “Save Calibration” to save the computed calibration factor, and then select “Save Report” to save the DMI calibration report that will have details about the current calibration.

11. The new calibration factor will be used from this point forward until this procedure is repeated again in the future. Fill form PROF-5, Laser Sensor, Accelerometer, DMI

Calibration/Calibration Check Form, which is included in appendix B. Press Exit to exit the Horizontal Calibration menu.

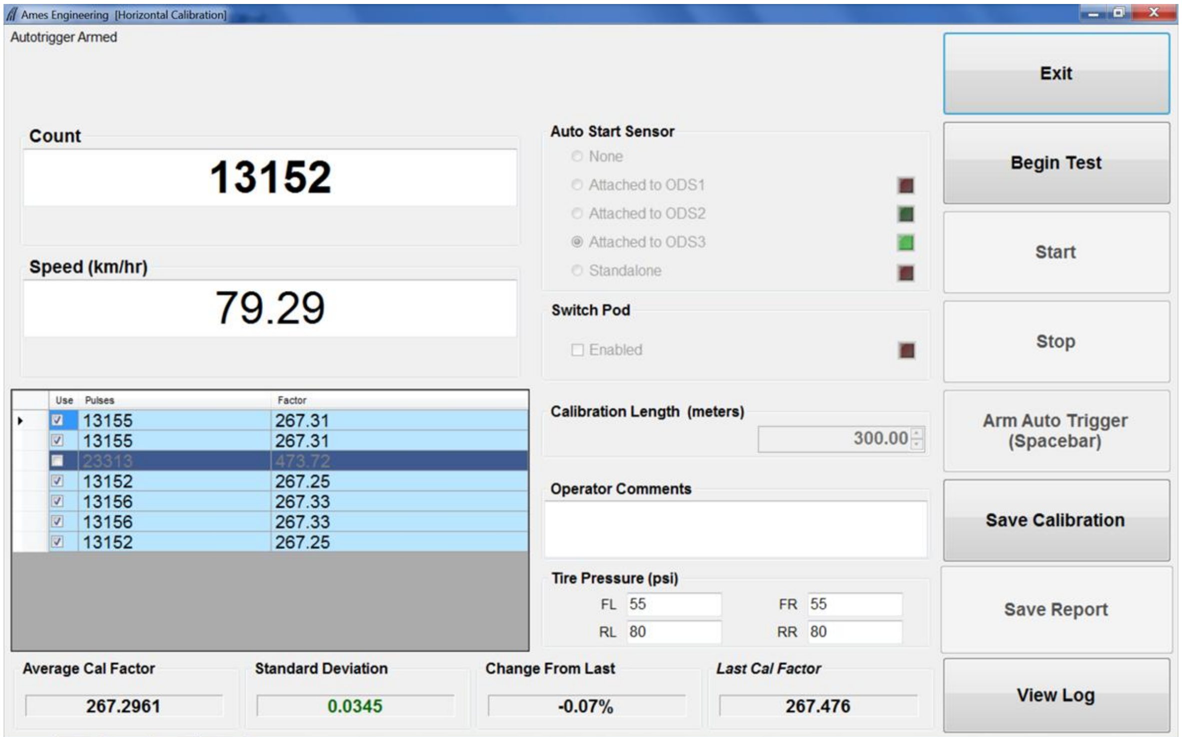


Figure 95. DMI calibration screen showing seven runs with six selected.

2.12.4 Calibration Check of Accelerometers

The calibration check of accelerometers checks the scaling of the accelerometers using the acceleration of the earth's gravity by flipping the accelerometers over to measure a change in acceleration of 2g.

The accelerometer calibration check should be performed while the vehicle is parked on a level surface with the engine off. Location where calibration check is performed should be free of any vibrations and operator should be outside of vehicle when performing this check. Operator should adjust the docking station such that the screen of the laptop computer can be seen from outside vehicle and the keyboard is easily accessible. Do not enter vehicle, bounce or bump vehicle, or lean on vehicle during calibration check.

The following procedure should be followed to perform this check:

1. Open cover of sensor bar. Turn key to "Off" position in DAU to shut-off power to laser sensors and remove key (see section 2.2.4). The red laser dot should not be displayed on the ground. Unlatch all three laser boxes containing the profile height sensors from the mounting latches.

2. In the Calibration Menu (see figure 90) press F7 key or select “Accelerometer Test” icon. The laser sensor warning shown in figure 96 is displayed.

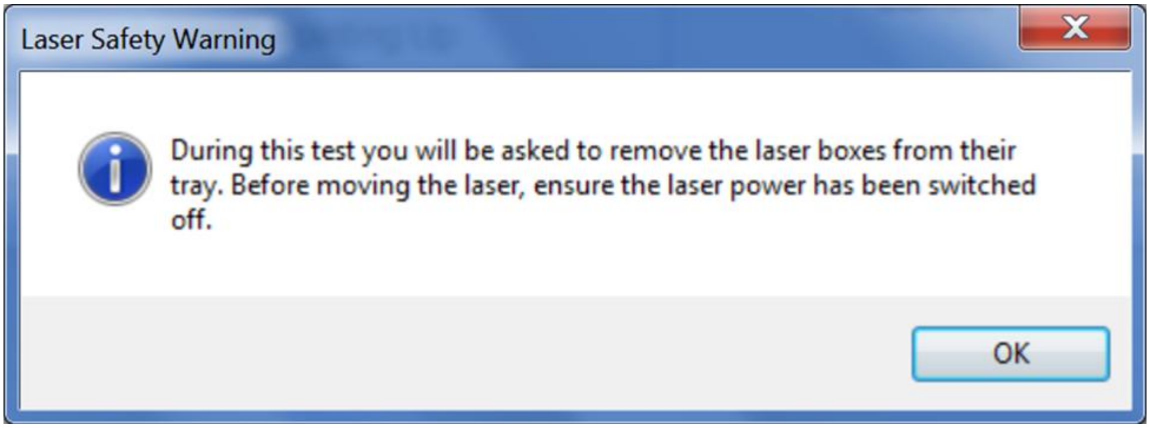


Figure 96. Laser sensor warning during the accelerometer calibration check.

3. Press OK on the Laser Safety Warning message and the Accelerometer Test menu shown in figure 97 will be displayed.

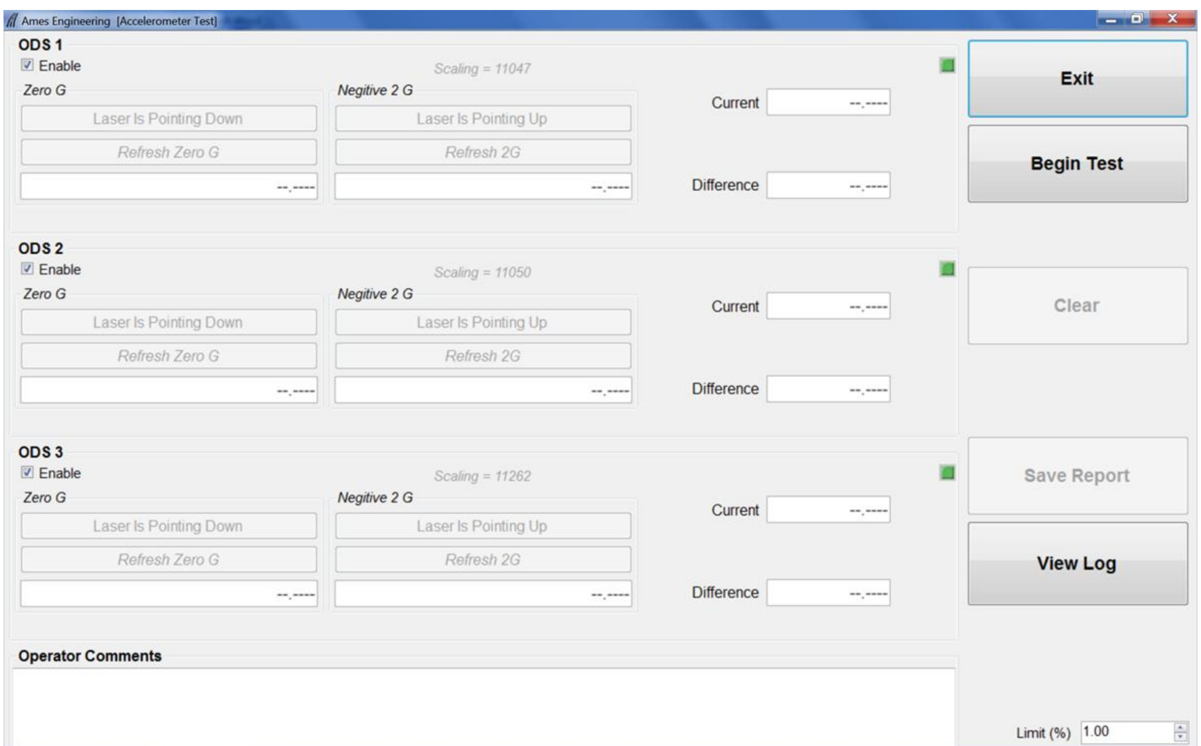


Figure 97. Accelerometer test menu.

4. Press Begin Test button. The system will start displaying the current measurements in g's from the accelerometers as shown in figure 98.

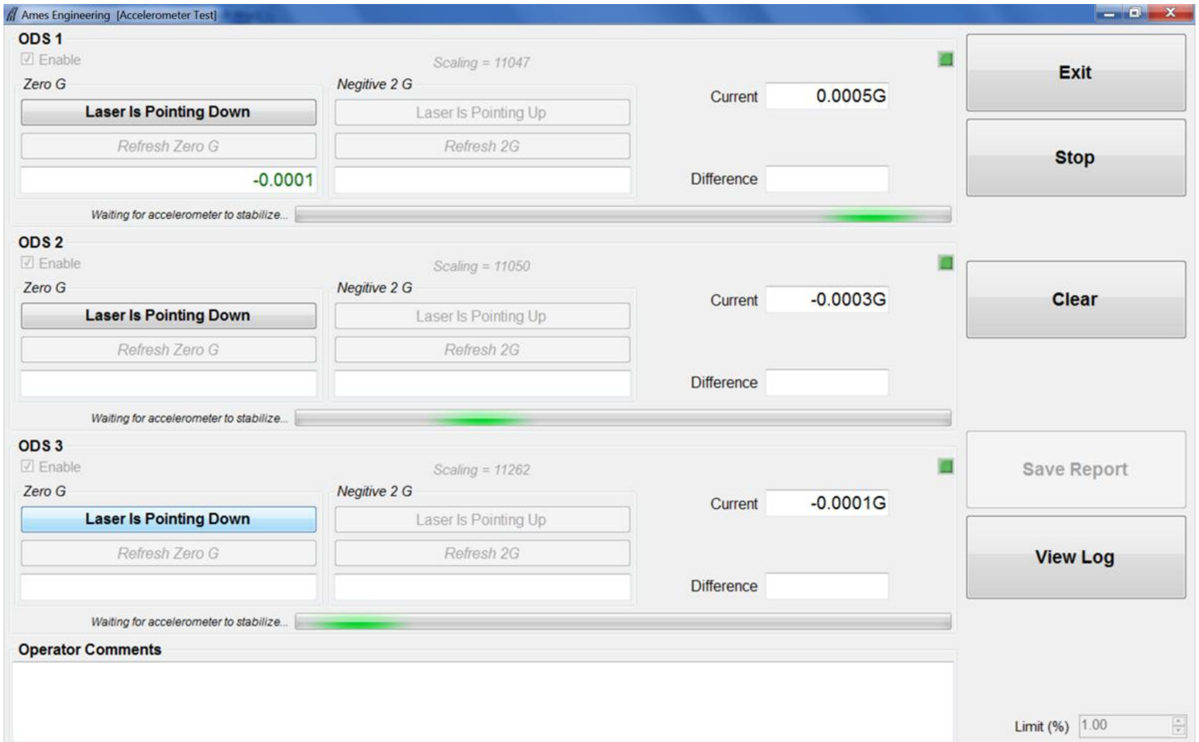


Figure 98. Screen after starting accelerometer test.

5. Select "Laser Is Pointing Down" button for all three accelerometers and the system will wait twenty seconds before storing the current value. This value is a moving average of the accelerometer over about a twenty second interval. The appearance of the screen at this stage is similar to the one shown in figure 99. If the operator wants to refresh the current value press the Refresh Zero G button and the current value will replace the first value that was stored after 20 seconds.

6. Rotate all three sensors by 180° such that the sensor glass is on the top, and place the rotated sensor within the enclosure associated with each sensor. Because of plugs coming in contact with the sensor bar frame, after being rotated, the center sensor needs to be turned by 180° and placed snug against the DAU so it will be stable. Select "Laser Is Pointing Up" button (see figure 100) for all three accelerometers.

7. After about twenty seconds, the system will store the current accelerometer reading and display it in the text box (see figure 101). If the operator wants to refresh the stored value, press the Refresh 2G button and the value that was stored after twenty seconds will be replaced.

   The difference between the two measurements (laser pointing upward and downward) for each accelerometer is displayed in the "Difference" window (see figure 101).

   The value displayed in the "Difference" window for each accelerometer must be within ± 1% of 2g (i.e., between 1.98g to 2.02g) in order for the accelerometer to pass the calibration check. A Pass or Fail message is displayed for each accelerometer. If an accelerometer fails to pass the check, repeat the test. If the accelerometer still fails the test, contact the RSC and decide on a suitable course of action.

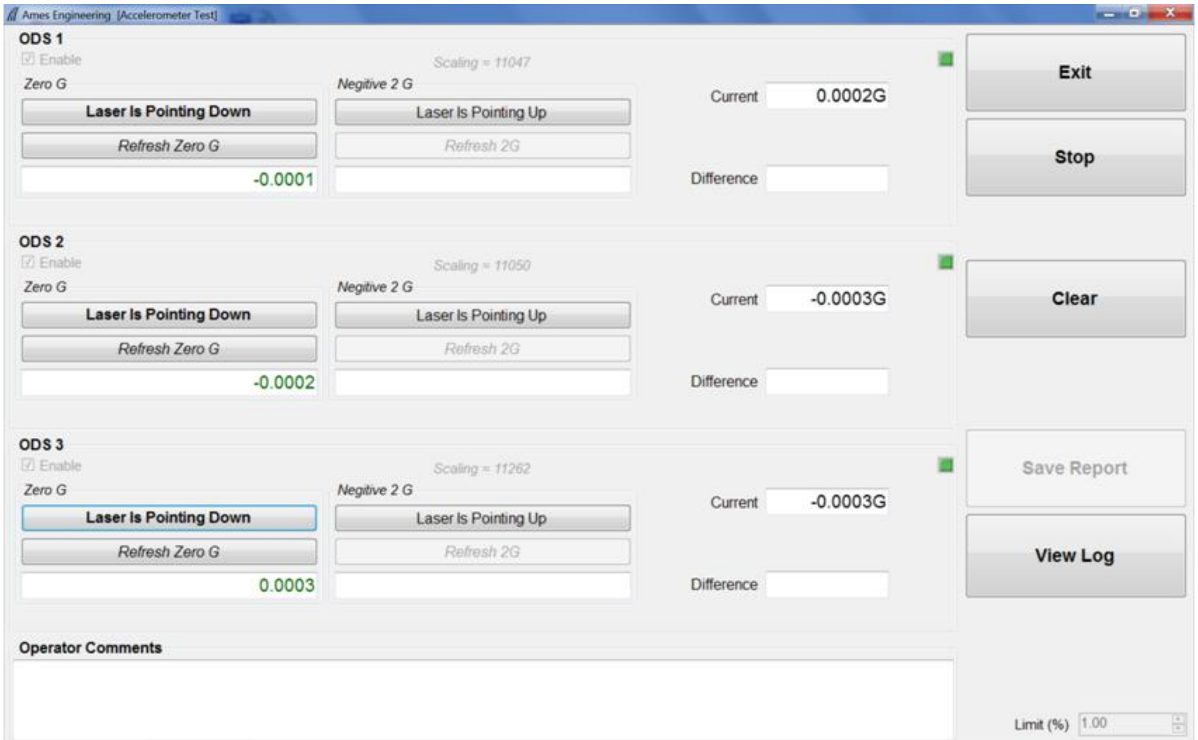


Figure 99. Screen after completion of test with lasers pointing downwards.

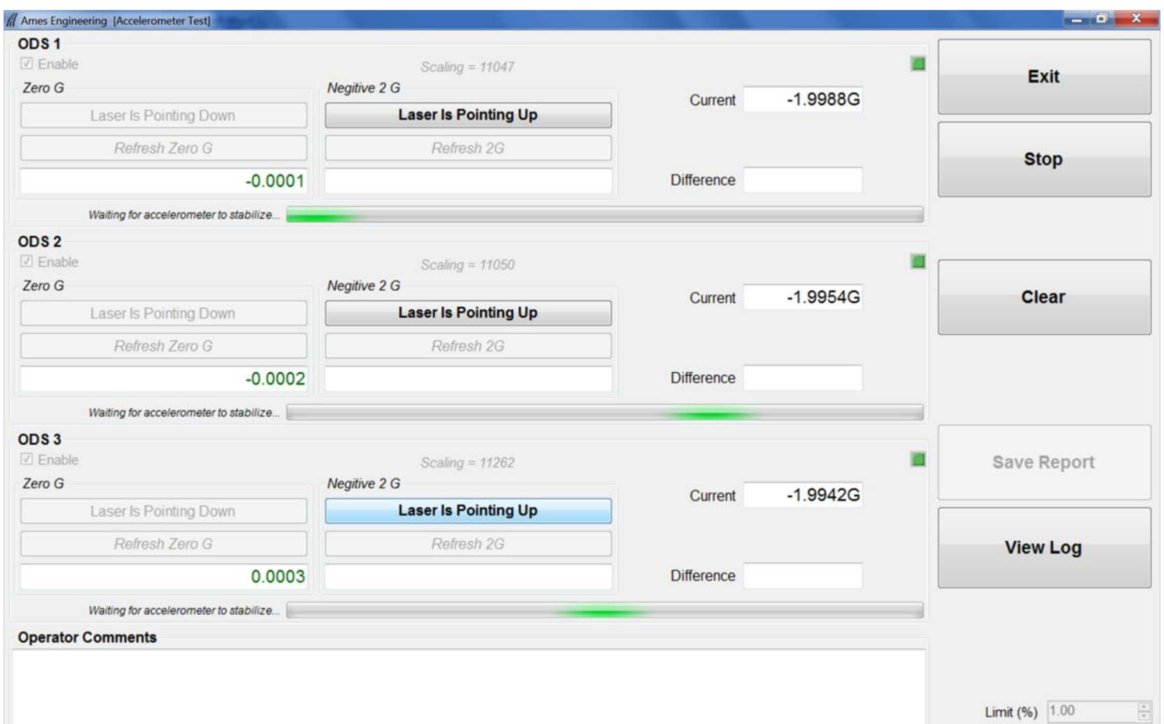


Figure 100. Screen after lasers are rotated with sensor glass on top.

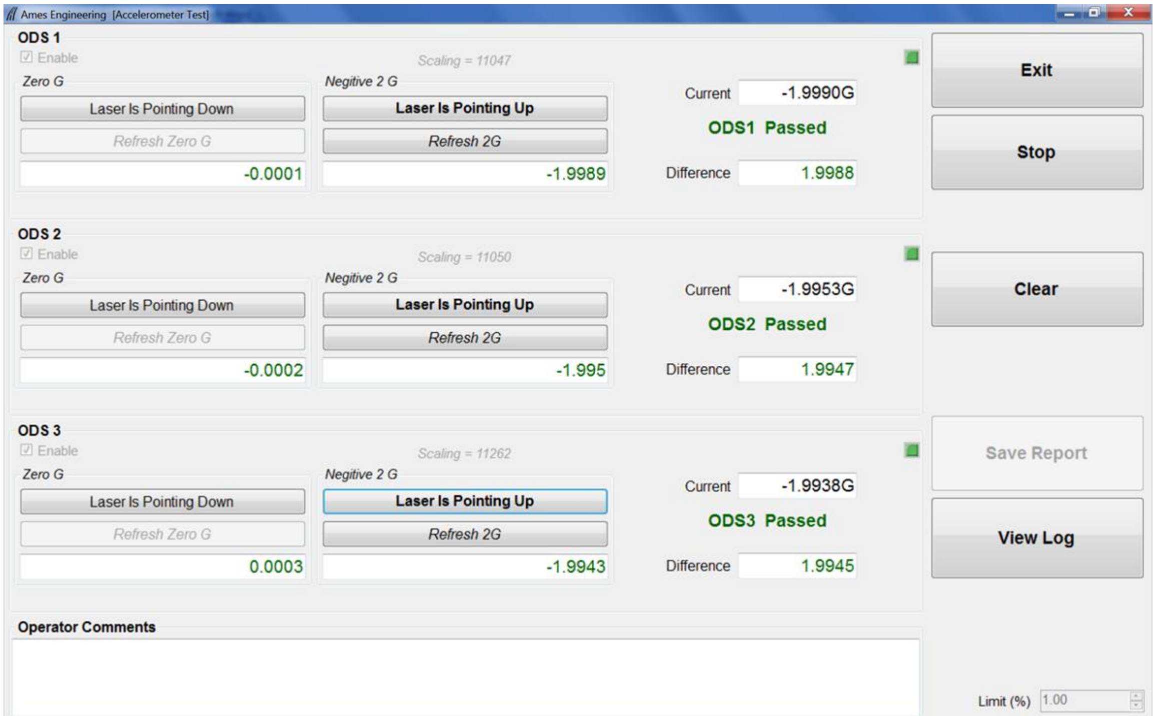


Figure 101. Screen after completion of test with lasers pointing upward.

8. Select "Save Report" button to save results from the accelerometer test. The results are saved in a comma separated value (CSV) file. The results from test are appended to the file so that results from all tests are available in one file. Fill form PROF-5, Laser Sensor, Accelerometer, DMI Calibration/Calibration Check Form, which is included in appendix B.

9. At the end of the calibration check, the laser window in the height sensor will be in an upward position. Visually inspect the height sensor window for dirt and cracks. Clean the sensor glass using the procedures indicated in section 2.5.2. Visually inspect the rubber vibration mounts that hold the sensor boxes containing the profile height sensors to the beam. If any of the rubber mounts appear to be cracked they should be replaced. Turn the height sensor such that the laser is pointing down and latch the sensor box to the beam. The labels on the sensor box should be in normal reading orientation when standing in front of the van when the sensor box has been attached to the beam correctly.

10. Visually inspect the sensor glass of the texture height sensors for dirt and cracks. The texture height sensor has two sensor glass faces that must be inspected, one is associated with the part that emits the laser light and the other is associated with the part that detects the laser light. Clean the sensor glass using the procedures indicated in section 2.5.2.

2.12.5 Full Calibration Check of Profile and Texture Height Sensors

The profile height sensors and the texture height sensors have been calibrated in the factory and operators cannot calibrate these sensors. A calibration check on these sensors is performed before data collection in the field (see section 2.9.2.2). In the calibration check, profile and texture height sensors are checked to see if they can accurately measure the height within a specified tolerance by using a 25 mm block. However, this procedure only checks the accuracy of the height sensor over a 25-mm distance within its measuring range. A more comprehensive check of profile and texture height sensors must be performed at a maximum interval of 30 days, which will check the accuracy of the profile and texture height sensors over a 100-mm measuring range. This check is referred to as the Full Calibration Check of profile and texture height sensors to distinguish it from the Calibration Check of height sensors that is performed before data collection in the field. This check should be performed after the Accelerometer Calibration check is performed, as the sensor glass is specified to be inspected and cleaned at the end of the accelerometer calibration check (see steps 9 and 10 of section 2.12.4).

Both profile and texture height sensors are attached to the sensor bar such that the mid-point of the measuring range of the sensor is approximately at the ground surface. During full calibration check, vehicle is elevated so that the accuracy of each height sensor over a distance from below the mid-point of measuring range to above the mid-point of measuring range can be checked.

2.12.5.1 Supplies for Calibration Check

Van Support Ramps: As described previously, the van is elevated when the full calibration check is performed. This is accomplished by driving the van onto ramps that are placed in front of the tires. Each ramp consists of two stacked 38-mm high boards screwed onto each other, with a portion of the ramp containing only one board (see figure 103). The ramps are securely mounted behind the rear bench sheet. To remove ramps, loosen the two knobs and lift ramps vertically. A felt cloth is placed between the ramps to prevent the ramps from bonding together.

Calibration Base Plates: Three base plates are provided with each device (see section 2.2.17 and 2.5.9.1). The base plates have three feet for support, and these can be used to level the plate.

Calibration Targets: Three targets are provided with each device (see section 2.2.17 and 2.5.9.2). Each target has a shiny side and a dull (matte) side. Measurements are always obtained by the height sensors on these targets on the dull side.

Calibration Blocks: Three sets of blocks having nominal heights of 25, 50, 75, and 100 mm are provided with each device (see section 2.2.17 and 2.5.9.3). A block identifier is engraved on the side of the block. The exact heights of the blocks are shown in table 2. The exact height of each block should be entered into the Ames Engineering software following the procedures described in section 2.5.9.3 before performing the full calibration check. Once entered, the block heights are saved by the software.

2.12.5.2 Setup Profiler

Ideally, the full calibration check of profile and texture height sensors should be performed in an enclosed building with a level concrete floor. The engine of the vehicle should be off when performing this test. If full calibration check is performed in the field, location where the check is performed should protect device 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 when performing this check if the voltage of the auxiliary battery is low. The following procedures should be used to setup the profiler to perform the full calibration check and to check if the sensors are set at the correct position.

1. The tire pressure can have an effect on the results of this check. Therefore, the cold tire pressure of all tires must be checked to ensure that they are at the values specified in section 2.5.5.

2. Before elevating vehicle onto ramps, in the Ames Engineering software start-up window (see figure 102) observe the "Height" values indicated below ODS1, ODS2, ODS3, ODS4, and ODS 5. The operator should be outside of vehicle. The displayed Height values should be between -15 and 15 mm. If sensor bar is perfectly level, the floor is perfectly level, and the height sensors are mounted such that the mid-point of the measurement range is located exactly at the ground surface, all height values should indicate zero. However, because variations in all of these factors, the displayed Height values are unlikely to be exactly zero. Record the Height values under ODS1, ODS2, ODS3, ODS4, and ODS 5 in form PROF-5, Laser Sensor, Accelerometer, DMI Calibration/Calibration Check Form, which is included in appendix B. The "Height" values should not change between calibration checks unless sensors have been moved or replaced since the previous calibration check. If any of the displayed "Height" values do not meet the specified tolerance, check the levelness of the bar (see section 2.5.3) and check if sensor is latched on properly at the correct position.

3. Place ramp in front of each tire as shown in figure 103, and then drive vehicle onto the ramps such that all four tires rest on the upper part of each ramp. Figure 104 shows the van in the elevated position.

2.12.5.3 Performing Full Calibration Check on Profile Height Sensors

The full calibration check is first performed simultaneously on all three profile height sensors and thereafter this check is performed simultaneously on the two texture height sensors. Use following procedure to perform this check:

1. In the Calibration Menu (see figure 90) press F4 key or select "Extensive Test" icon and the Extensive Test screen shown in figure 105 will be displayed. A check mark should appear in front of all sensors shown in the bottom right corner of the screen

2. Operator should be outside vehicle when this check is performed. Operator should adjust laptop computer so that the screen can be seen from outside the vehicle, and the laptop computer dock should be rotated such that the keyboard is accessible from outside of the vehicle. Do not enter vehicle, bounce or bump vehicle, or lean on vehicle during calibration check.

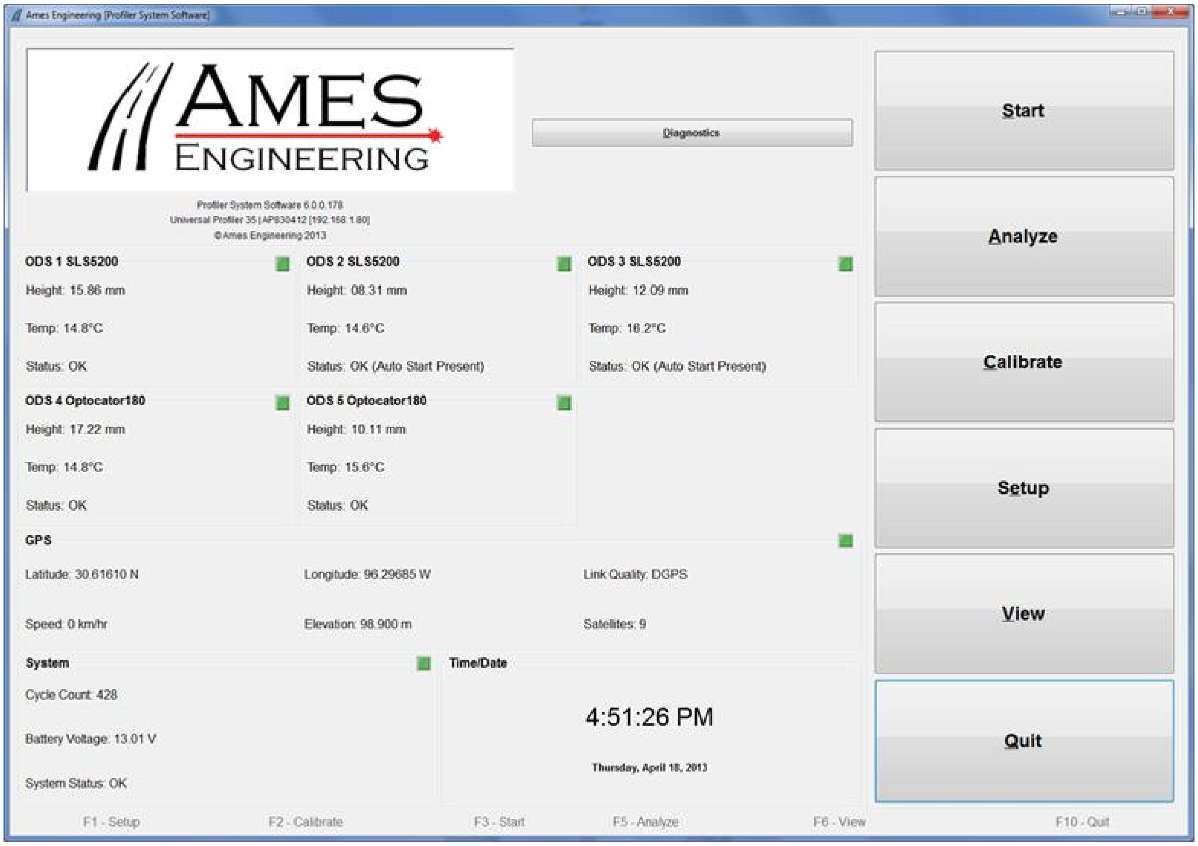


Figure 102. Ames Engineering software start-up screen.

Figure 103. Ramps placed in front of the tire before driving vehicle up the ramp.

Figure 104. Device on top of ramps.

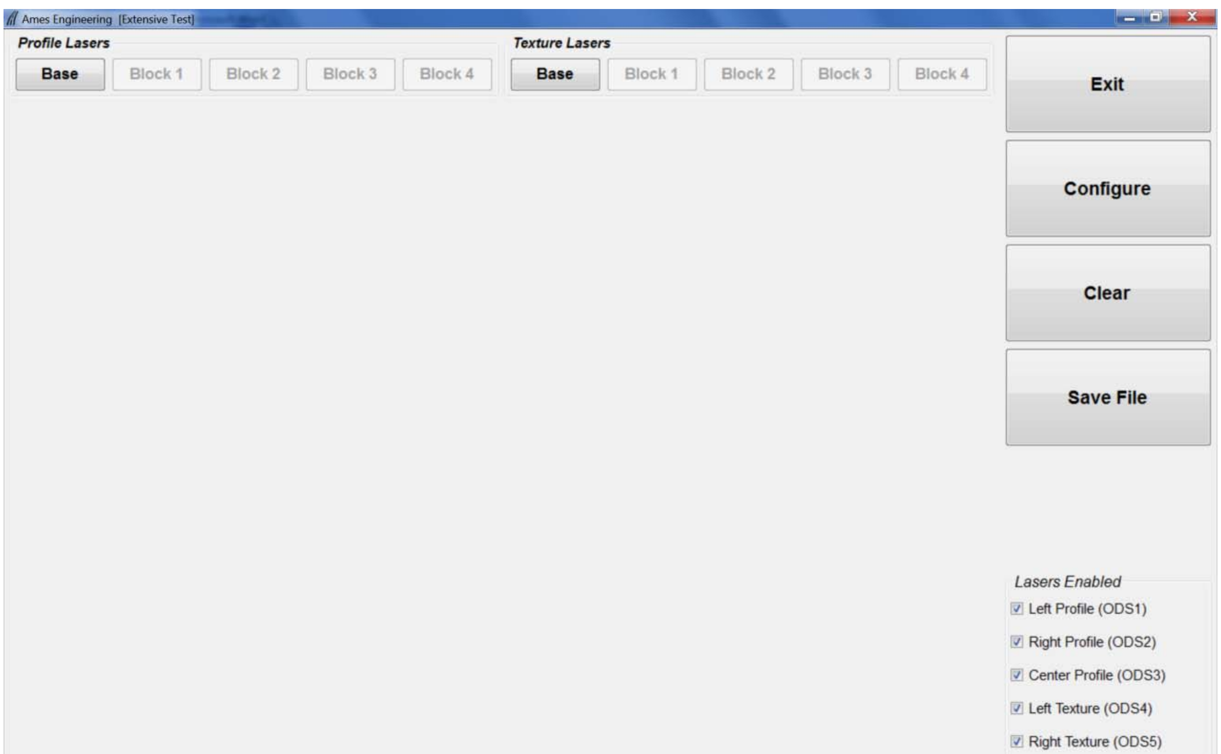


Figure 105. Extensive test screen.

3. Clean the top of the calibration base plates as needed, and place a calibration base plate on the ground under each profile height sensor such that two screws on the base plate are parallel to the sensor bar and the red laser dot on each plate is centered on the plate (see figure 106). Level the plate using the two screws parallel to the sensor bar using the digital level as a guide. Then place level on plate perpendicular to the senor bar and level plate using other screw and digital level as a guide. The plate is considered level when the reading on the level is less than or equal to 0.05° at the two positions described previously.

Figure 106. Laser dot centered on base plate.

Note: As stated previously, ideally, the full calibration check should be performed at a location where the floor is level. If this check has to be done away from the office, and it is not possible to find a location where the floor is not perfectly level, use following procedure to level the base plate. <u>This procedure should not be used if check is performed when vehicle is on a level surface.</u> Place digital level on top of a laser box such that the digital level is parallel to the sensor bar and record reading displayed on digital level (see figure 107). Then place digital level perpendicular to sensor bar on top of laser box and record reading displayed on the digital level (see figure 108). Clean the top of the calibration base plates as needed, and place the calibration base plate on the ground under that sensor such that two screws on the base plate are parallel to the sensor bar and the red laser dot is centered on the plate. Adjust plate using the two screws parallel to the sensor bar such that the slope of the plate matches the reading obtained by digital level on top of laser box when placed parallel to the sensor bar. Then adjust level of plate perpendicular to the senor bar using other screw such that the slope of plate perpendicular to the sensor bar matches the slope measured by digital level on top of laser box perpendicular to the sensor bar. Repeat procedure for the other two profile height sensors.

4. Place a calibration target on top of each base plate with dull side facing up within the square marked on the base plate and place the 25 mm block behind the target plate to provide stability to base plate (see figure 109). In the software (see figure 105) under Profile Lasers select “Base” to take a measurement on top of target plate that is placed on each base place. Six sets of measurements are taken on each target plate. Figure 110 shows an example of the screen after measurements have been obtained. The readings displayed are in the following order: left height sensor, center height sensor, and right height sensor.

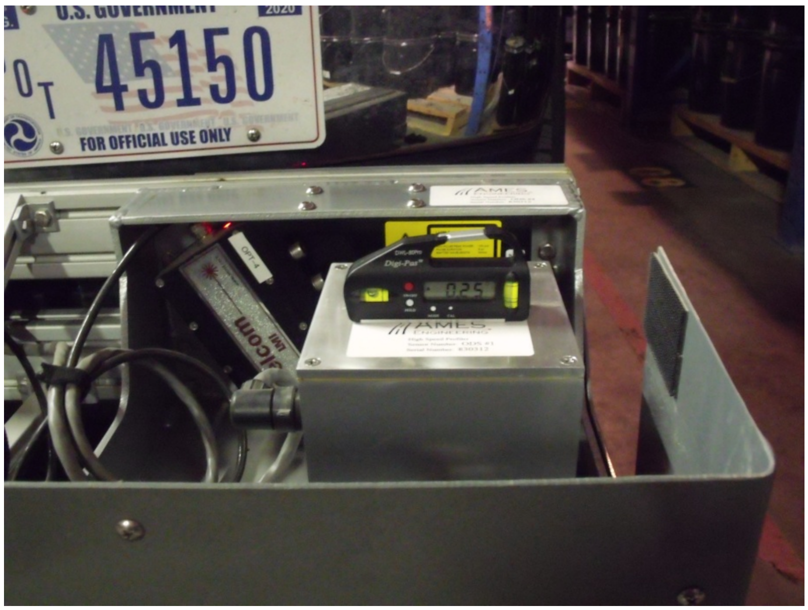


Figure 107. Level placed on top of laser box parallel to sensor bar.

Figure 108. Level placed on top of laser box perpendicular to sensor bar.

Figure 109. Target placed on base plate.

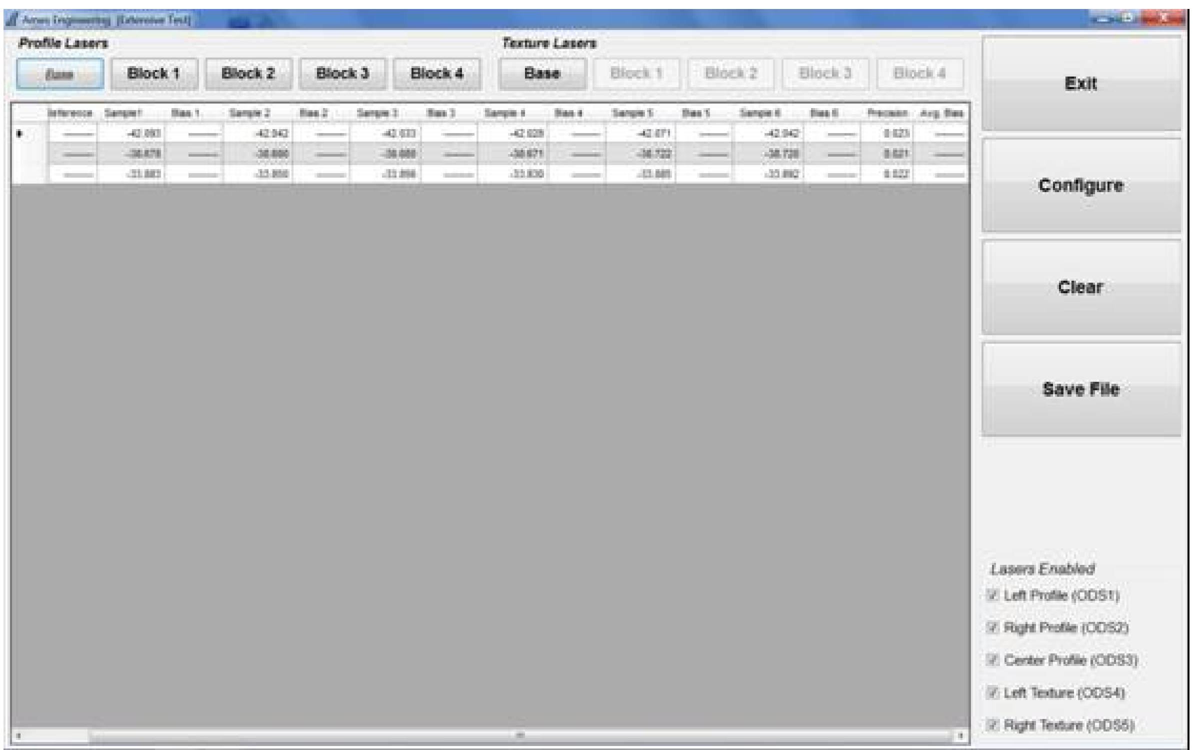


Figure 110. Screen after readings have been obtained on target placed on base plate.

5. Remove target and 25 mm block from calibration base plate, place the 25 mm block associated with the sensor on top of base plate within the square marked on the base plate such that the block identifier faces the operator. Place calibration target plate with dull side facing up on top of the block (see figure 111). Repeat procedure for the other two sensors. In the software, under Profile Lasers, select Block 1 to take measurements on top of target plate (see figure 110). Six sets of measurements are taken on each target plate. An example of the screen after readings have been obtained in this position is shown in figure 112. Check the average bias value. The average bias value for each sensor must be within ± 0.25 mm. Repeat test if average bias is outside this value.

Figure 111. The 25 mm block with target plate on top of block.

6. Remove 25 mm block and calibration target plate. Do step 4. Remove target and 25 mm block from calibration base plate and then place the 50 mm block associated with the sensor on top of base plate such that the 50 mm height is vertical and block is placed within the square marked on the base plate. Place calibration target plate with dull side facing up on top of the block (see figure 113). Repeat procedure for the other two sensors. In software, under Profile Lasers, select Block 2 to take measurements on top of target plate (see figure 112). Six sets of measurements are taken on the target plate. The average bias value for each sensor must be within ± 0.25 mm. Repeat test if average bias is outside this value.

7. Remove 50 mm block and calibration target plate. Do step 4. Remove target and 25 mm block from calibration base plate and place the 75 mm block associated with the sensor on top of base plate such that the 75 mm height is vertical and block is placed within the square marked on the base plate. Place calibration target plate with dull side facing up on top of the block (see figure 114). Repeat procedure for the other two sensors. In software, under Profile Lasers, select Block 3 to take measurements on top of target plate. Six sets of measurements are taken on the target plate. The average bias value for each sensor must be within ± 0.25 mm. Repeat test if average bias is outside this value.

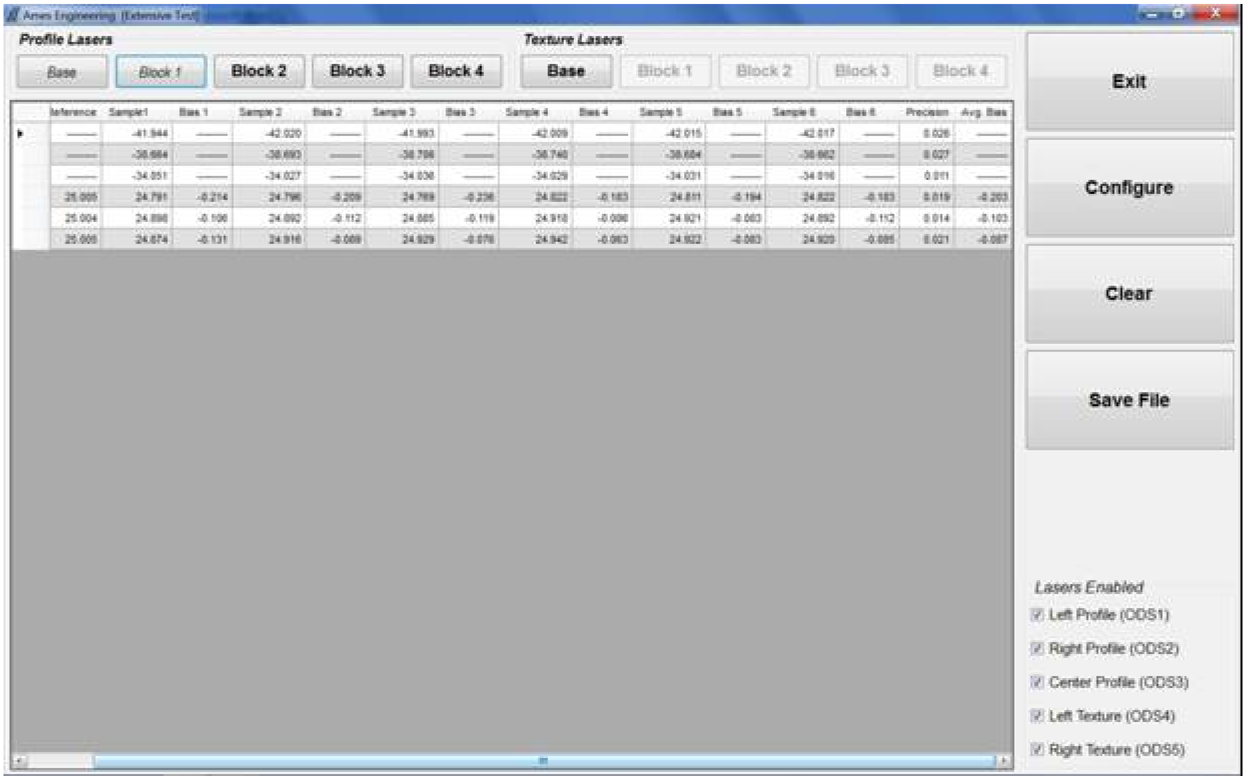


Figure 112. Screen after readings have been obtained on the 25 mm block.

Figure 113. Readings being taken on 50 mm blocks.

Figure 114. Readings being taken on 75 mm blocks.

8. Remove 75 mm block and calibration target plate. Do step 4. Remove target and 25 mm block from calibration base plate and place the 100 mm block associated with the sensor on top of base plate such that the 100 mm height is vertical and block is placed within the square marked on the base plate. Place calibration target plate with dull side facing up on top of the block (see figure 115). Repeat procedure for the other two sensors. In software, under Profile Lasers, select Block 4 to take measurements on top of target plate. Six sets of measurements are taken on the target plate. The average bias value for each sensor must be within ± 0.25 mm. Repeat test if average bias is outside this value.

Figure 115. Readings being taken on 100 mm blocks.

9. Figure 116 shows how the screen appears after calibration check has been performed with all four blocks.

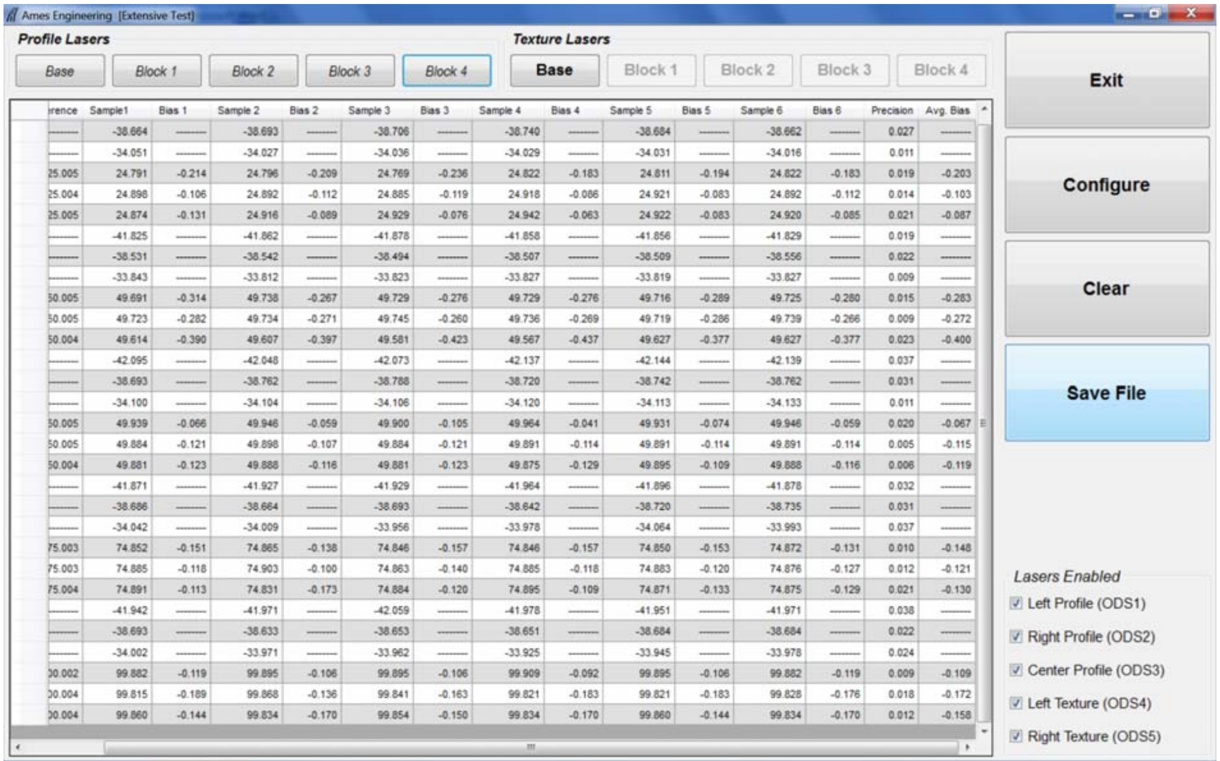


Figure 116. Readings being taken on 100 mm blocks.

If a profile height sensor fails to meet the specified bias criterion (i.e., average bias within ± 0.25 mm) for any block position, check levelness of the sensor bar. If sensor bar is not level, level bar following procedures described in section 2.5.3 and repeat check. If a profile height sensor still fails to meet the specified bias criterion, contact the RSC office to decide on a suitable course of action.

Full calibration check of the texture height sensors should be performed immediately after performing the full calibration check on the profile height sensors. Use following procedure to perform this check:

1. Place a base plate below each texture height sensor and level plate as described in step 3 above (disregard note in referenced step 3).

Note: Ideally this check must be performed at a level location. If this check has to be done away from the office, and it is not possible to find a location where the floor is not perfectly level, use following procedure to level the base plate. <u>This procedure should not be used if check is performed when vehicle is on a level surface.</u> Place digital level on top of a texture laser such that the digital level is parallel to the sensor bar and record reading displayed on digital level (see figure 117). Then place digital level perpendicular to sensor bar on top of texture laser and record reading displayed on the digital level (see figure 118). Clean the top of the calibration base plates as needed, and place the calibration base plate on the ground under that sensor such that two screws on the base plate are parallel to the sensor bar and the red laser dot is centered on the plate. Adjust plate using the two screws parallel to the sensor bar such that the slope of the plate matches the reading obtained by digital level on top of texture laser when placed parallel to the sensor bar. Then adjust level of plate perpendicular to the senor bar using other screw such that the slope of plate perpendicular to the sensor bar matches the slope measured by digital level on top of texture laser perpendicular to the sensor bar. Repeat procedure for the other texture height sensor.

Figure 117. Level placed on top of texture laser parallel to sensor bar.

Figure 118. Level placed on top of texture laser perpendicular to sensor bar.

2. Place a calibration target plate on top of each calibration base plate with dull side facing up within the square marked on the base plate and place the 25 mm block behind the target plate to provide stability to base plate (see figure 109). In the software, under Texture Lasers select Base to take a measurement on top of target plate that is placed on each base place (see figure 116). Six sets of measurements are taken on the target plate. Then remove the calibration target plate and the 25 mm block from the calibration base plate.

3. Place the 25 mm block associated with the sensor on top of base plate within the square marked on the base plate such that the block identifier faces the operator. Place calibration target plate with dull side facing up on top of the block (see figure 111). Repeat procedure for the other sensor. In the software, under Texture Lasers, select Block 1 to take measurements on top of target plate. Six sets of measurements are taken on the target plate. Check the average bias value. The average bias value for each sensor must be within ± 0.25 mm. Repeat test if average bias is outside this value.

4 Do step 2. Place the 50 mm block associated with the sensor on top of base plate within the square marked on the base plate such that the block identifier faces the operator. Place calibration target plate with dull side facing up on top of the block. Repeat procedure for the other sensor. In the software, under Texture Lasers, select Block 2 to take measurements on top of target plate. Six sets of measurements are taken on the target plate. Check the average bias value. The average bias value for each sensor must be within ± 0.25 mm. Repeat test if average bias is outside this value.

5 Do step 2. Place the 75 mm block associated with the sensor on top of base plate within the square marked on the base plate such that the block identifier faces the operator. Place calibration target plate with dull side facing up on top of the block. Repeat procedure for the other sensor. In the software, under Texture Lasers, select Block 3 to take measurements on top of target plate. Six sets of measurements are taken on the target plate. Check the average bias value. The average bias value for each sensor must be within ± 0.25 mm. Repeat test if average bias is outside this value.

6 Do step 2. Place the 100 mm block associated with the sensor on top of base plate within the square marked on the base plate such that the block identifier faces the operator. Place calibration target plate with dull side facing up on top of the block. Repeat procedure for the other sensor. In the software, under Texture Lasers, select Block 4 to take measurements on top of target plate. Six sets of measurements are taken on the target plate. Check the average bias value. The average bias value for each sensor must be within ± 0.25 mm. Repeat test if average bias is outside this value.

7. Select "Save File" button to save the results from this test. The results from the test on profile height sensors as well as texture height sensors are saved to a single file. The results are saved in a CSV) file that can be imported into an Excel file. Fill form PROF-5, Laser Sensor, Accelerometer, DMI Calibration/Calibration Check Form, which is included in appendix B.

Note: If a texture height sensor fails to meet the specified bias criterion (i.e., average bias within ± 0.25 mm) for any block position, and the test was performed on a level surface, check levelness of the sensor bar. If sensor bar is not level, level bar following procedures described in section 2.5.3 and repeat check. If a texture height sensor still fails to meet the specified bias criterion contact the RSC office to decide on a suitable course of action.

2.12.6 Dynamic Calibration Check of Texture Height Sensors

A calibration check of the texture height sensors in the dynamic mode is performed using the texture reference test device provided by Ames Engineering. A description of this device was presented in section 2.2.18.

2.12.6.1 Setup Procedure for Test

It is recommended this test be performed immediately after performing the full calibration check on the texture height sensors. Use following procedure to setup this test:

1. If performing this test after performing the full calibration check of the texture height sensors, drive vehicle down from second step of ramp to the first step, and proceed to step 2. Otherwise, place a ramp in front of each tire (see figure 103) and drive the vehicle up the ramp to the first step. Performing this test with the vehicle up on the first step of the ramp ensures the test occurs with the lasers taking measurements near the mid height of their measuring range.

2. In the Calibration Screen (see figure 90), press F6 key or select "Texture Disk Test" icon. This will bring up the Texture Disk Test window shown in figure 119.

   The Setup parameters for the test are Segments, target MPD, and Limit. These setup parameters are shown in the lower right corner of the screen. The setup parameters should be set so they have the following values:

   Segments: This value indicates the number of 100 mm segments that are averaged to compute the MPD. This parameter should be set to 100. The test will terminate once sufficient data have been collected.

   Target MPD: This is the theoretical MPD value for the reference disk. This parameter should be set to 0.75 mm.

   Limit (%): This value indicates the tolerance that is placed on the MPD computed from the data collected during test in order to pass this test. This parameter should be set to 7.5. Therefore, in order to pass this test, the MPD computed from the data collected during this test should be between 0.694 and 0.806 mm.

   Once the parameters are set they are automatically saved when you exit the program. Therefore, the user does not need to enter these values at the start of each test after the values are set initially.

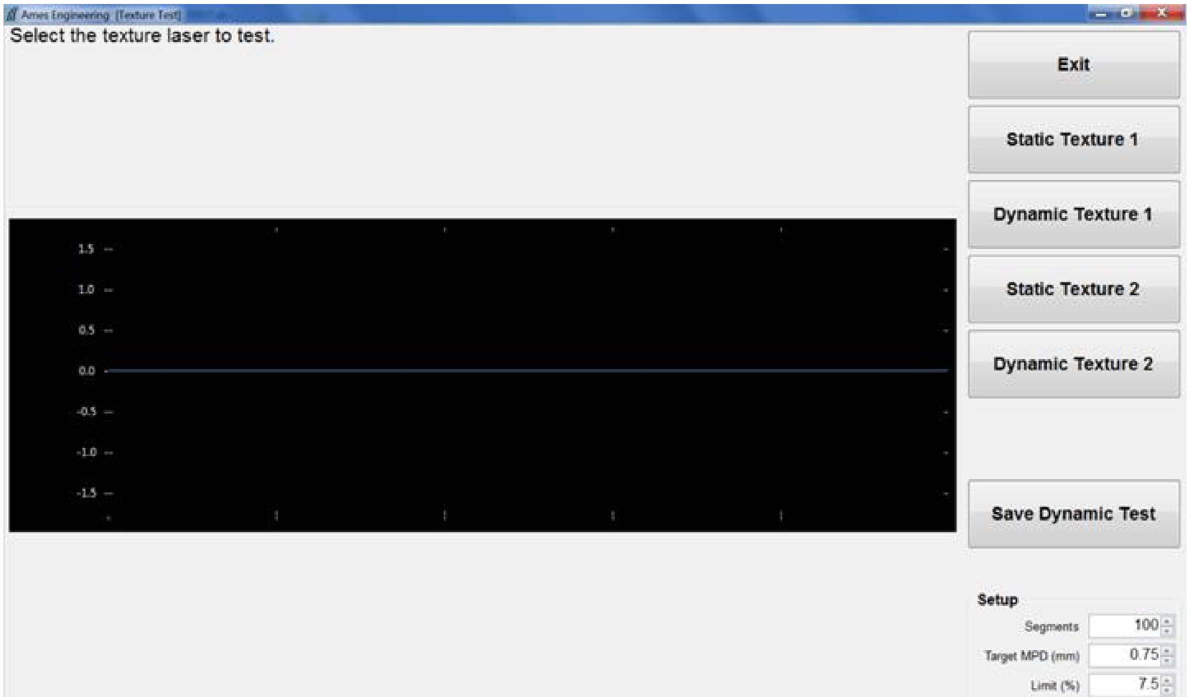


Figure 119. Texture disk test window.

2.12.6.2 Procedure for Performing Test

1. Open the sensor bar cover. Disconnect the encoder input from the DAU. Plug in the black connector attached to the reference device (see figure 120) to the DMI input port in the DAU.

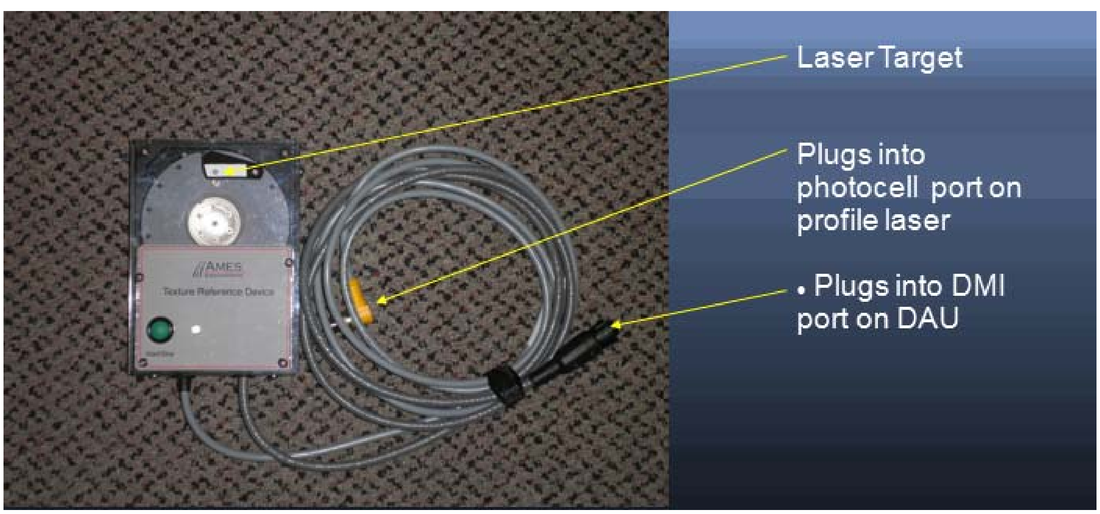


Figure 120. Texture reference test device.

2. Disconnect the vertical photocell input from the center profile height sensor box. Plug in the yellow connector attached to the reference device (see figure 120) to the photocell input port.

Power to the reference test device is provided from this port. Note: The yellow connector can be connected to photocell input in any laser box. However, because of length limitation of this cable, it may not be possible to perform the test on the right texture height sensor if the cable is connected to the left sensor box and vice versa. Therefore, the best method to perform this test is to plug the yellow connector to the photocell input in the center sensor, so that the test can be easily performed on both texture sensors. However, the yellow cable can be plugged into the photocell input of the left laser box if the cable is of sufficient length so that the test can be performed easily on both sensors.

3. Place reference test device below the left texture height sensor. The reference device has a moveable cover with a target label attached to the top (see figure 121). Aligning the laser dot on the target ensures the laser will strike the spinning disc in the proper spot. The static test is performed with the laser dot targeting the crosshairs (cover closed) and the dynamic test is performed with the laser dot targeting the spinning disk (cover open). With the cover closed, align the laser dot on the cross hairs of the target.

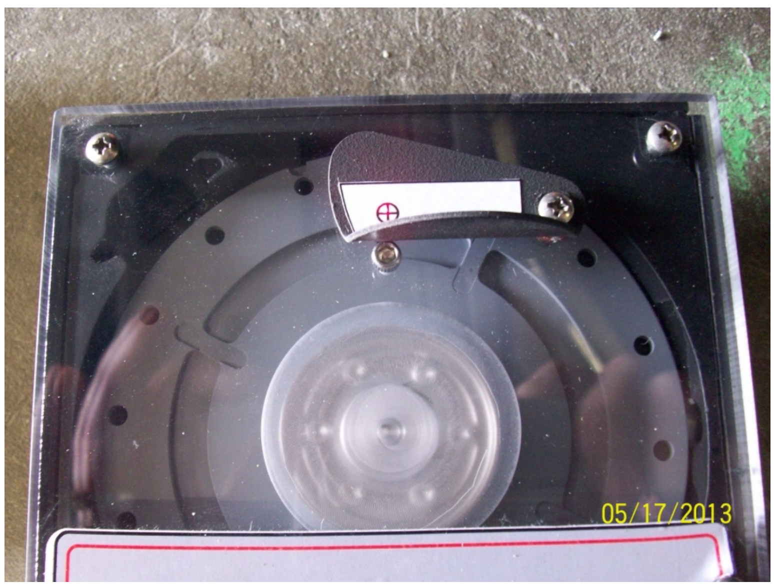


Figure 121. Target on texture reference test device.

4. To initiate the test select “Static Texture 1” (see figure 119). This puts the software in a standby mode. Hold the reference device firmly to the ground and make sure the laser dot is targeting the crosshairs of the cover. Press the green button on the reference device to spin the disk. After the disk is up to speed the test will automatically start and five rapid beeps will be heard. After a sufficient amount of data has been obtained the test will terminate automatically and a long single beep will be heard indicating that the test has ended. The green button must be pressed twice if a retest of the sensor is to be performed.

   The operator has the option of stopping the spinning of the disk sooner after completion of the test rather than wait for the disk to spin down and stop automatically. This can be accomplished by pressing the green button after the beep at the end of the test is heard. If the test was terminated this way, and a retest is desired, press the green button once.

When the static test is complete, the laptop computer screen will display the average MPD for the static test (see Figure 122). Ames Engineering has established a threshold MPD of 0.33 mm for the static test. This threshold cannot be changed by the operator. If the MPD from the static test is above 0.33 mm the static test result will be displayed in red. If the static test MPD is above 0.33 mm repeat the test. If the value is still above 0.33 mm after repeating the test several times contact the RSC office and decide on a suitable course of action.

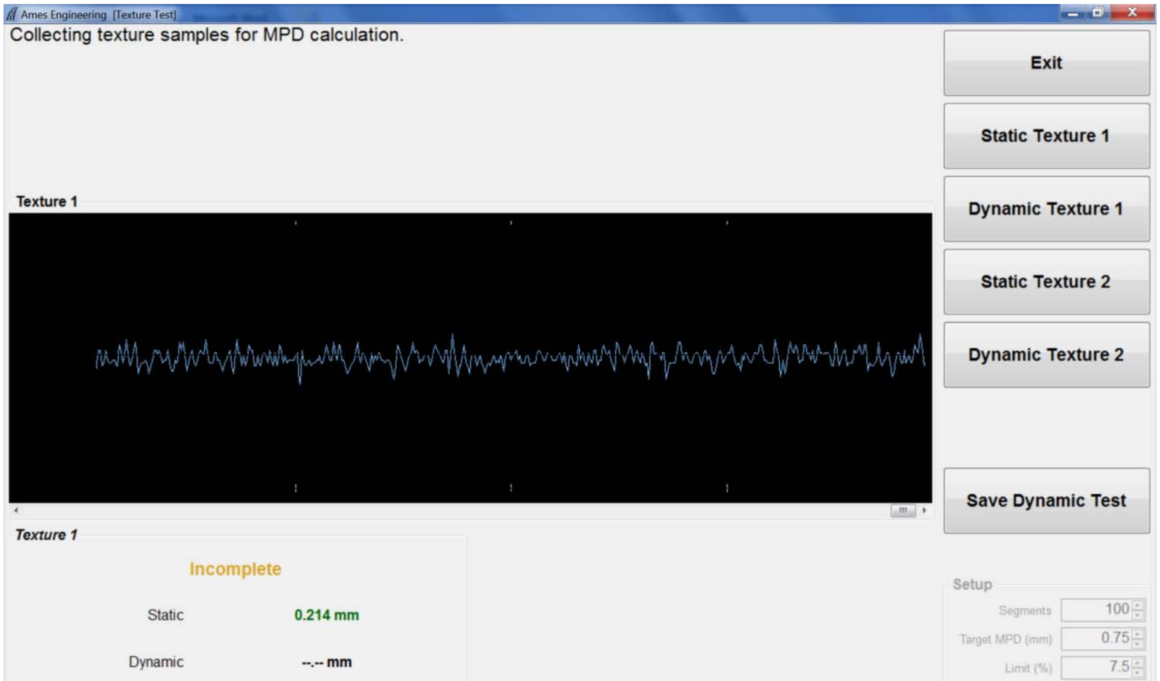


Figure 122. Texture reference test screen after static test.

5. After the static test has been performed, and if the MPD from static test is below 0.33 mm, select the "Dynamic Texture 1" button (see figure 119). Align laser on the cross hairs of the target on the cover, and then hold the reference device firmly to the ground. Gently open the cover on the texture reference device (see Figure 123) and press the green button on the reference device to spin the disk. After the disk is up to speed the test will automatically start and three beeps will be heard at the start of the test. After sufficient amount of data has been obtained the test will terminate automatically and three beeps will be heard indicating that the test has ended. When the test is completed, the laptop computer screen will display the average MPD for the segments tested, and a PASS or FAIL message will appear on the screen (see figure 124). In order for the PASS message to appear the MPD from the static test must be less than 0.33 mm and the MPD from the dynamic test must be within the specified 7.5 percent limit of 0.75 mm (i.e., between 0.694 and 0.806 mm). If a FAIL message appears repeat the test. If it is not possible to get a PASS for this test after repeating test several times contact the RSC office and decide on a suitable course of action.

6. Repeat the procedure outlined in steps 3 through 5 for the right texture sensor. When performing the test for the right texture sensor "Static Texture 2" and "Dynamic Texture 2"

have to be selected. Once the test has been completed for both sensors, and both sensors pass the test, select the "Save Dynamic Test" button on the software (see figure 125) to save the file that contains results from this test. Complete form PROF-5, Laser Sensor, Accelerometer, DMI Calibration/Calibration Check Form, which is included in appendix C.

Figure 123. Cover open on texture reference test device.

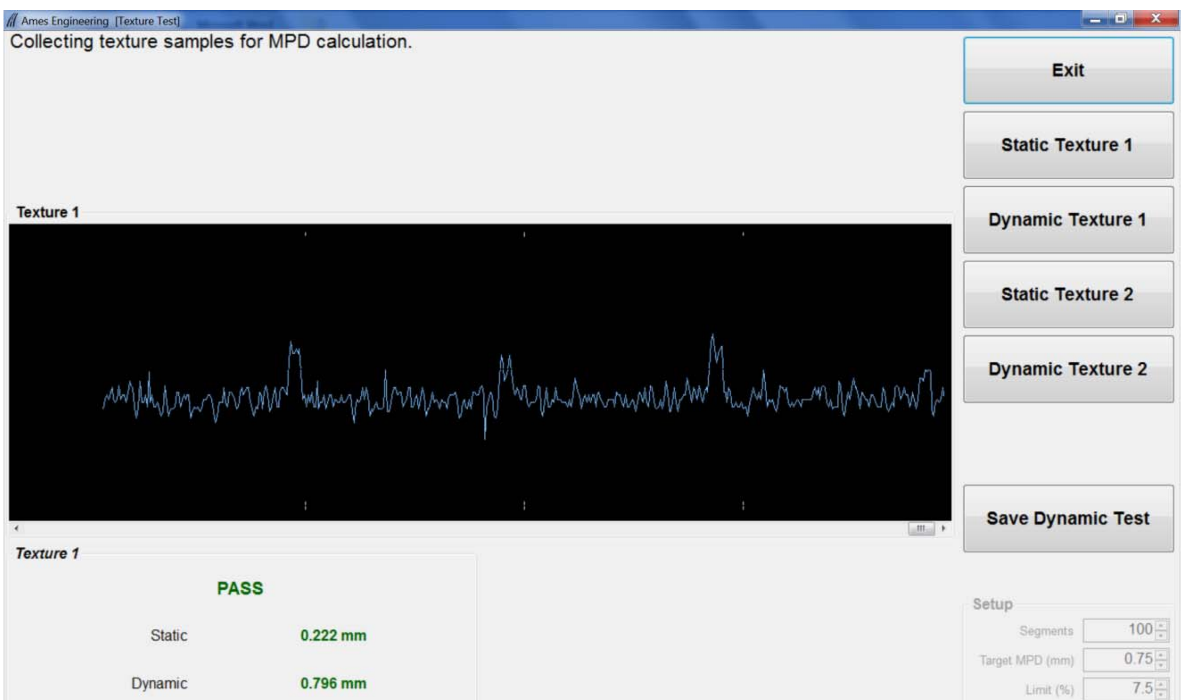


Figure 124. Texture reference test screen after dynamic test on left sensor.

Figure 125. Completed texture calibration.

2.12.7 Bounce Test

After completing full calibration check on the profile and texture height sensors, drive the vehicle off the ramps to the ground. Perform a bounce test following the procedures indicated in section 2.9.2.4.

2.12.8 Calibration Check of Ambient Temperature Sensor

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. Power up the system, start the laptop computer, and launch the Ames Engineering software using the procedures described in section 2.8.1. Wait 15 minutes for the equipment to warm-up.

3. The ambient temperature sensor has two temperature probes and the temperatures measured by both probes are displayed in the display unit located on the dashboard on the driver's side (see section 2.2.12). Observe the temperature readings displayed for the two probes and wait until the readings stabilize.

4. Place a thermometer close to the temperature probe and record the reading of the thermometer.

5. Note the readings for the two temperature probes that are displayed on the display box.

6. The following two conditions must be satisfied in order for the ambient temperature sensor to pass the calibration check:

   (a) The difference between the two temperature readings from the two temperature probes that are shown on the display must be within ± 2° C.

   (b) The difference between each temperature probe reading that is displayed on the display box and the temperature obtained from the thermometer must be within ± 2 °C.

7. The ambient temperature sensor is considered to be acceptable if criterion (a) and (b) indicated in the previous step are met. If one or both criterion described in (a) and (b) above is not met, repeat steps 4 and 5. If one or both criterion are still not satisfied, contact RSC and decide on a suitable course of action.

8 Complete form PROF-6, Ambient Temperature Sensor, Pavement Surface Temperature Sensor, and GPS Calibration Check Form, which is included in appendix B.

2.12.9 Calibration Check of Pavement Surface Temperature Sensor

A NIST traceable mercury thermometer is required to perform this test

1. Power up the system, start the laptop computer, and launch the Ames Engineering software using the procedures described in section 2.8.1 Open cover of the temperature probe (see section 2.2.9). Wait 15 minutes for the equipment to warm-up.

2. Observe the pavement surface temperature that is shown on the display unit located on the dashboard on the driver's side (see section 2.2.12) and wait for reading to stabilize if it is changing.

3. Record pavement surface temperature measured by the temperature senor that is shown on the display unit. Use an infra-red temperature gun to record the temperature of the pavement surface at the location that is directly below the temperature sensor.

4. Prepare an ice water bath. Place ice and water in a suitable container that can be placed under the van on the ground below the pavement surface temperature sensor. Stir until the temperature of the ice and water mix measured by the thermometer is less than or equal to 2 °C.

5. Place container containing the ice and water mix under the temperature sensor and allow the temperature measured by the temperature sensor that is displayed on the display unit to

stabilize. Record the temperature shown on the display unit and also record the temperature of the ice and water mix measured using the thermometer.

6. The pavement surface temperature sensor is considered to be acceptable if the difference between the two temperature readings noted in step 3 and step 5 are within ± 2 °C.

7. If the difference between the two temperatures is outside this tolerance for either step 3 or step 5 or both, repeat appropriate test. If the difference between the two temperatures is still outside the specified tolerance consider the pavement surface temperature sensor to be unacceptable, and contact RSC and decide on a suitable course of action.

8. Complete form PROF-6, Ambient Temperature Sensor, Pavement Surface Temperature Sensor, and GPS Calibration Check Form, which is included in appendix B.

2.12.10 Calibration Check of GPS Receiver

Use following procedure to perform a calibration check on the GPS receiver:

1. Use Google Earth to obtain the latitude and longitude of a known location where the device can be parked. This location can be in the parking lot of the office, or an adjacent location, and must be clear of any high buildings that might interfere with satellite signals. Record the latitude and longitude of the approximate location where the light bar of the device will be located when parked.

2. Park the vehicle at the location that was identified. Power up the system, start the laptop computer, and launch the Ames Engineering software using the procedures described in section 2.8.1

3. The latitude and longitude measured by the GPSR in the profiler is displayed on the start-up screen of Ames Engineering software (see figure 102). Look at Link Quality that is displayed on the screen to see if it is DGPS. If not, another location where Link Quality is DGPS is needed to perform this check.

4. Record the latitude and longitude values that are displayed on the start-up screen. If the recorded values agree up to four decimal places with the latitude and longitude that was obtained from Google earth, the GPS is considered to be functioning properly. If agreement is not obtained for four decimal places, pick-another location and repeat procedure. After repeating procedure, if agreement is still not obtained, consider the GPSR is not functioning properly and contact RSC and decide on a suitable course of action.

5. Complete form PROF-6, Ambient Temperature Sensor, Pavement Surface Temperature Sensor, and GPS Calibration Check Form, which is included in appendix B.

2.12.11 Check on Photocell Initiation

Historically in the LTPP program, the first profile data point recorded at a section has been at a distance of 114 mm from the leave edge of the section start stripe. Software settings in the Ames Engineering devices are set such that the first data point obtained at a section is at a distance of 114 mm from the leave edge of the section start stripe.

Each RSC should annually verify if the device is obtaining the first data point between a distance of 114 and 152 mm from the leave edge of a reflective tape placed on the pavement surface if data collection is initiated using the vertical photocell, or from the leave edge of a reflective tape that is placed on a cone if data collection is initiated using the horizontal photocell. Each RSC should maintain a log that indicates the results from this test.

The following sections describe the field procedure for performing the test and the procedure to analyze the collected data.

2.12.1 Site Preparation

The test procedure involves attaching artificial bump targets to the pavement and then collecting a series of profile runs. The testing location should be a straight stretch of pavement that is not subjected to traffic. The purpose of performing this test on a pavement that is not subjected to traffic is because of the artificial bump that is placed on the pavement. Ideally this test should be performed at a speed of 80 km/h. However, the test can be performed at 64 km/h. 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 device is driven over the location. Select a suitable bump target made of wood with the dimensions 13 mm thick, 38 mm wide and 750 mm long. Place the bump target on the pavement parallel to 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 height 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 data collection runs. Affix the bump target to the pavement with an appropriate adhesive tape such that the adhesive tape will not affect the profile collected by the center laser. Figure 126 illustrates the positioning of the section stripe and bump target. Thereafter, place several layers of 38 mm wide duct tape along the left and right wheel paths such that the approach edge of the duct tape is in line with the approach edge of the bump target, and the layers of duct tape are at least 8 mm high. The duct tape should be placed in such a way that the left and the right profile height sensors of the device will run over the tape when collecting data.

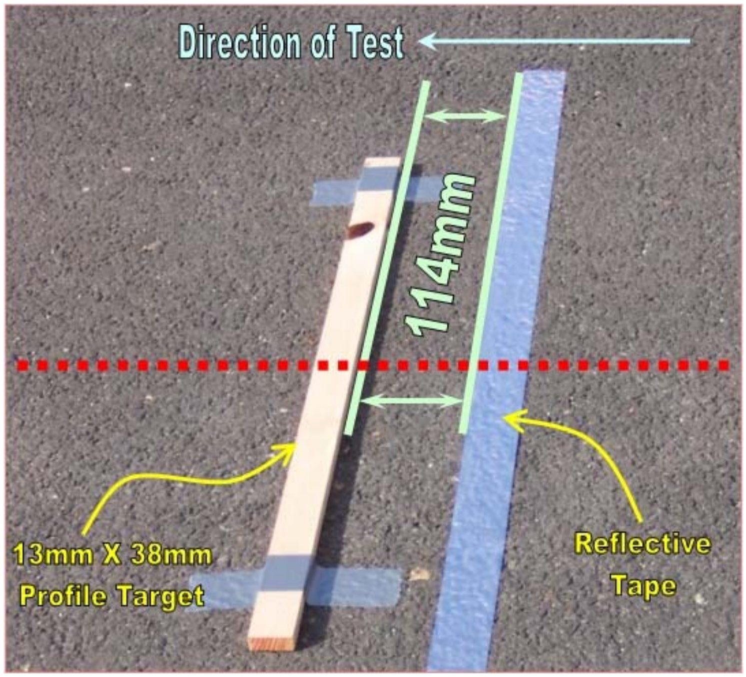


Figure 126. Section starting stripe and bump target placed on the pavement.

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 127 illustrates the proper placement of the horizontal photocell target in relation to the starting stripe and bump target.

2.12.2 Profile Data Collection

The photocell initiation test is performed in a manner consistent with standard LTPP profile data collection procedures. It is important that the DMI be calibrated beforehand in accordance with section 2.12.3 of this manual, and the tires in the profiler are sufficiently warmed-up with air pressures matching the pressure noted during the DMI calibration. Perform the standard daily height sensor check and bounce test in accordance with section 2.9.2 of this manual before collecting data.

For this test, a set of data (three runs) is collected with the vertical photocell being used to initiate data collection. Thereafter, a set of data (three runs) is collected with data collection initiated using the horizontal photocell. For this testing, the profile data of concern is the data immediately after the start stripe. Therefore, it is not necessary to collect a large amount of profile data during each run. Only about 20 m of profile data after the section start stripe need to be collected.

Figure 127. Placement of vertical photocell target in relation to section starting location.

The following procedure should be followed for collecting data:

1. In the Header Screen (see figure 84) set the Stop Method to DISTANCE and enter a value of 20 in the Distance field.

2. Set the vertical photocell to be active by checking the Auto Trigger under ODS 3 (see figure 84). Auto Trigger under ODS2 should not be checked. Collect three profile runs at the section using standard LTPP data collection procedures. Data collection for these runs is initiated by the vertical photocell.

3. Set the horizontal photocell to be active by checking the Auto Trigger under ODS 2 (see figure 84). Auto Trigger under ODS3 should not be checked. Collect three profile runs at the section using standard LTPP data collection procedures. Data collection for these runs is initiated by the vertical horizontal photocell.

2.12.3 Data Analysis

If the device obtains the first data point within at a distance between 114 to 152 mm from the leave edge of the stripe placed at the start of the section, the first data point would have been obtained on the targets that was placed on the pavement. Use following procedure to analyze the data:

1. Create ERD files for the collected profile and texture data.

2. Import the profile data into Excel and plot the center sensor profile data in each file vs. distance for a distance of 500 mm. Evaluate plots to see if the first data point or the first two data points are at a higher elevation compared to the rest of the data. Figures 128 and 129 show example plots illustrating such a situation. If the collected center sensor data exhibit such a feature for all profile runs collected with the vertical photocell, the vertical photocell is considered to be functioning properly. If the collected center sensor data exhibit such a feature for all profile runs collected with the horizontal photocell, the horizontal photocell is considered to be functioning properly. If collected data does not show such a feature for data collection initiated with vertical photocell, horizontal photocell, or both, repeat appropriate test or tests, and evaluate the data. If the collected data is still not satisfactory, contact RSC and decide on a suitable course of action.

3. Plot the data for the left and right profile sensors vs. distance for a distance of 500 mm for data in each file. Also import the collected texture data into Excel and plot the data in each file for the left and right texture sensors vs. distance for a distance of 500 mm. Evaluate the plots to see if the first data point or the first two data points are at a higher elevation compared to the rest of the data. The elevation difference will not be as high as that seen for the center sensor where the height of the bump target was 13 mm, as the height of the layers of duct tape placed on the pavement will not be that high. If the first data point or first two data points are at a higher elevation for data collected by left and right profile and texture sensors this means the first data pint by these sensors are collected at a distance between 114 and 152 mm from the leave edge of the start stripe. If collected data does not show such a feature for data collection initiated with vertical photocell, horizontal photocell, or both, repeat appropriate test or tests, and evaluate the data. If the collected data is still not satisfactory, contact RSC and decide on a suitable course of action.

2.13 EQUIPMENT MAINTENANCE AND REPAIR

2.13.1 General Background

Responsibility for equipment maintenance and repair rests with each RSC. Decisions required for proper maintenance and repair should be based on testing schedule and expedited as necessary to prevent disruption of testing. Maintenance activities on the device should be performed before mobilization for testing. During a testing period, there will be little time to do more than the required daily checks before testing. Specific detailed maintenance procedures are contained in the manuals provided with each piece of equipment (see references 1, 2, 11, 12, and 13). Operator must become familiar with maintenance recommendations contained in all equipment manuals. Maintenance/repair work to be performed can be classified as routine maintenance, preventive maintenance, and unscheduled maintenance.

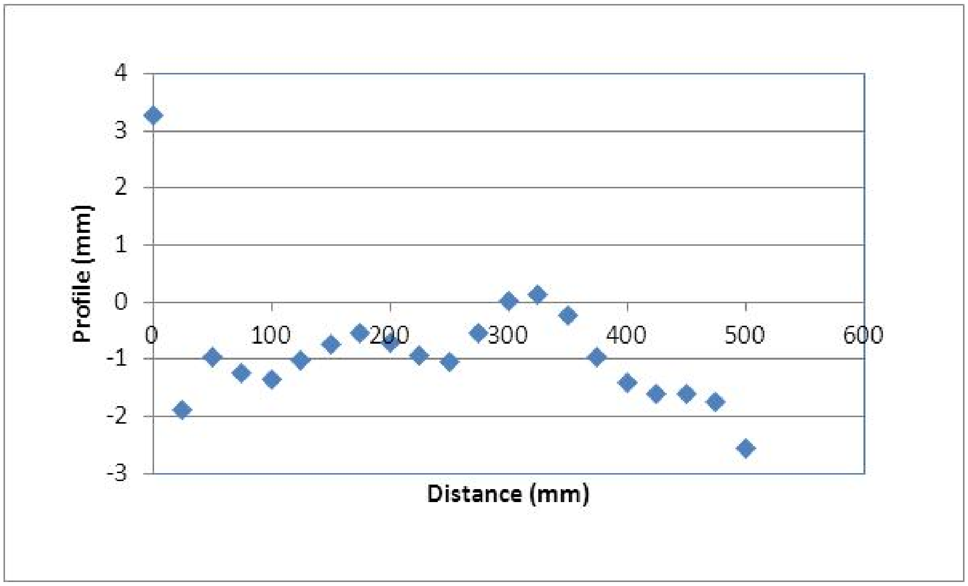


Figure 128. Example plot of data from photocell initiation test with one point on the target.

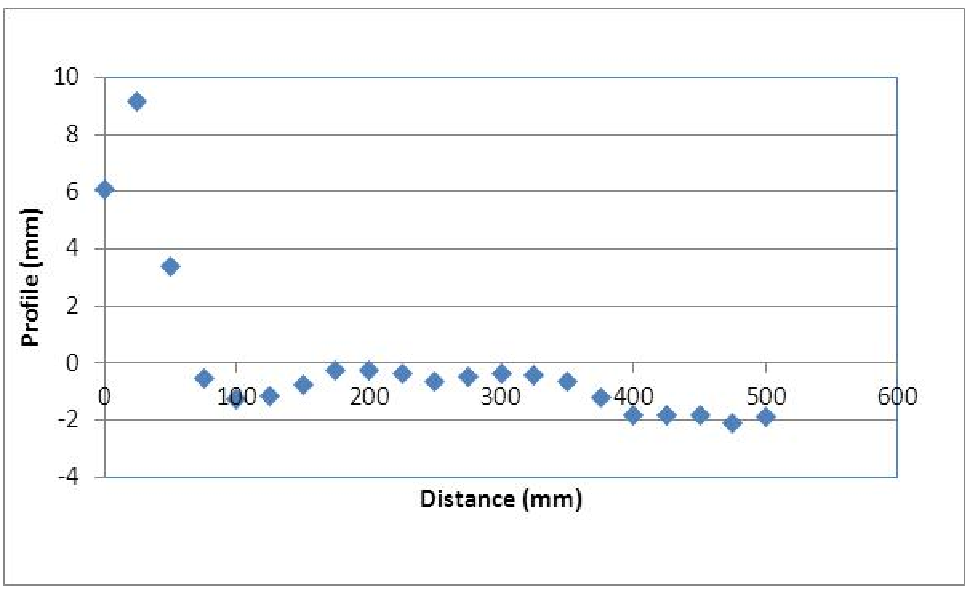


Figure 129. Example plot of data from photocell initiation test with two points on the target.

2.13.2 Routine Maintenance

Routine maintenance includes work that can be performed by operator. The Daily Check List (see appendix B) includes a list of activities to be performed every day. These include checking vehicle lights, checking under vehicle for fluid leaks, checking fluid levels in vehicle, and inspecting glass face of profile and texture height sensors. These items are the most basic and easily performed maintenance measures and should always be done before using equipment every day. If any problems are noted, they should be entered in the Profiler Log (section 2.14.3), which should be maintained in the vehicle, and appropriate action should be taken to correct noted problems.

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

2.13.3 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 manufacturer's heavy use guidelines. These include activities such as oil change. Checking drive belts, hoses, battery cable connections etc., should be performed when the oil is changed in the vehicle.

Form PROF-4, LTPP Major Maintenance/Repair Form, which is included in appendix B must be used by operator to report necessary services performed and will also serve to inform RSC of the condition of device on a regular basis.

2.13.4 Unscheduled Maintenance

These are unscheduled repairs. These repairs must be reported on form PROF-4, LTPP Major Maintenance/Repair, which is included in appendix B 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 2.6.3 should be followed after a sensor is replaced or repaired.

2.14 RECORD KEEPING

There are eight types of records that should be forwarded to the RSC by the profiler 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. Laser Sensor, Accelerometer, DMI Calibration/Calibration Check Form.
6. Ambient Temperature Sensor, Pavement Surface Temperature Sensor, and GPS Receiver Calibration Check Form
7. Profiling of WIM Sites: Data Summary Sheet.
8. Sidekick Checklist Form.
9. 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 being recorded by operator following standard operating procedures of 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.

2.14.1 LTPP Profiler Field Activity Report

The Field Activity Report (form PROF-1 in appendix B) 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 vehicle and uses IRI values as a check when section is profiled subsequently. The form has a column for recording IRI from center sensor. The current version of ProQual cannot compute the IRI from the center sensor data. A region may elect to compute IRI for the center sensor data at GPS sections using the Ames Viewer program and recording the IRI values in this form.

2.14.2 Status of the Regions Test Sections

The Status of the Regions Test Sections Form (form PROF-2 in appendix B) 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.

2.14.3 Profiler Log

Operator should maintain a Profiler Log in vehicle. Format of log is shown in form PROF-3 that is included in appendix B. When operator performs daily checks on equipment, items needing attention should be noted on the Profiler Log.

2.14.4 LTPP Major Maintenance/Repair Form

This form (see form PROF-4 in appendix B) should be filled 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.

2.14.5 Laser Sensor, Accelerometer, DMI Calibration/Calibration Check Form

The form PROF-5 included in appendix B must be filled when the following activities are performed at a maximum interval of 30-days:

- Full calibration check is performed on the profile and texture height sensors.
- Accelerometer calibration check is performed on the accelerometers.
- DMI is calibrated.

- Texture lasers are checked using the texture laser reference device.

Operator should regularly backup the calibration/calibration log files. Results from the accelerometer calibration check are appended to a single log file. The results from the DMI calibration and full calibration check of the profile and texture height sensors are saved in separate files that have the date stamp in the file name.
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2.14.6 Ambient Temperature Sensor, Pavement Surface Temperature Sensor, and GPS Receiver Calibration Check Form

The form PROF-6 included in appendix B must be filled when the following activities are performed at a maximum interval of 30-days:

- Calibration check of the ambient temperature sensor.
- Calibration check of the accelerometers.
- Calibration check of the GPSR.

2.14.7 Profiling of WIM Sites: Data Summary Sheet

The profiler operator is required to fill form PROF-7, Profiling of WIM Sites: Data Summary Sheet, when profile data are collected at a WIM site. This form is included in appendix B.

2.14.8 Sidekick Checklist Form.

The Sidekick checklist form included in appendix B must be completed after QC checks are performed using Sidekick.

2.14.9 ProQual Reports and Profile Plots

The Site Visit Report generated by ProQual contains a statistical summary of IRI's 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), liquid crystal display (LCD) panels, and a battery for power supply. The Dipstick® sensor is mounted in such a way that its axis and line passing through 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 United States) or provincial highway agency (in Canada). Layout of site should not be undertaken until all applicable traffic control equipment/devices are in-place.

3.2.2 LTPP Procedures

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

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 testing schedule and expedited as necessary to prevent disruption of testing.

Accidents: In event of an accident, operator shall inform RSC of incident as soon as practical after mishap. Details of event shall subsequently be reported in writing to RSC. The corporate policy of the RSC should be followed in event of an accident. A police report of the accident should be obtained.

3.2.3 Footpad Spacing of Dipstick®

Field studies performed with LTPP 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.

The RSCs are required to determine the footpad spacing of all Dipsticks® in their possession annually using the procedures described in appendix F. 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 F 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 F should be used to obtain the footpad spacing of all Dipsticks® operated by the RSC.

When performing longitudinal Dipstick® measurements, the RSC 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.

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).

Task 2: Site Inspection
a. General pavement condition (within test section limits).
b. Identify wheel paths (when performing longitudinal measurements).

Task 3: Dipstick® Measurements
a. Mark wheel paths (when performing longitudinal measurements).
b. Operational checks on Dipstick®.
c. Obtain Dipstick® measurements.
d. Quality control.

Task 4: Forms DS-1 through DS-7 should be completed for longitudinal profile measurements. Form DS-7 and DS-8 should be completed for transverse profile measurements. These forms are included in appendix E.

On arrival at a site, operator will carefully plan activities to be conducted to insure most efficient utilization of time. While many activities can only be accomplished by 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 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 130, measurements start at Station 0+00 in the right wheel path and proceed in the direction of traffic toward end of section. At end of section, transverse measurements are made to the end point of survey line in 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 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.

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 travel lane. Use following procedure to locate center of travel lane:

Case I: Where wheel paths are easily identified, midway point between two wheel paths should be used as center of lane.

Case II: If wheel paths are not clearly identifiable, but two lane edges are well defined, center of travel lane is considered to be midway between two lane edges.

Case III: Where wheel paths are not apparent and only one lane edge can be clearly distinguished, center of lane should be established at 1.83 m from that edge.

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

1. 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 beginning of monitoring portion of test section. If this location is not marked with a stripe, establish a transverse chalk line to define the beginning 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 location of two longitudinal elevation survey lines 0.826 m from center of lane. Mark these locations at intervals equal to length of chalk line used for marking. Use chalk line to mark a straight line between previously established points. Using a tape measure (measuring wheels are not acceptable), carefully measure length of each longitudinal elevation survey line to establish end points at 152.4 m, or at 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. At the end of the section in the left wheel path, mark a 0.61 m diameter circle centered on the intersection of the marked transverse line and the longitudinal survey line. 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 elevation survey loop.

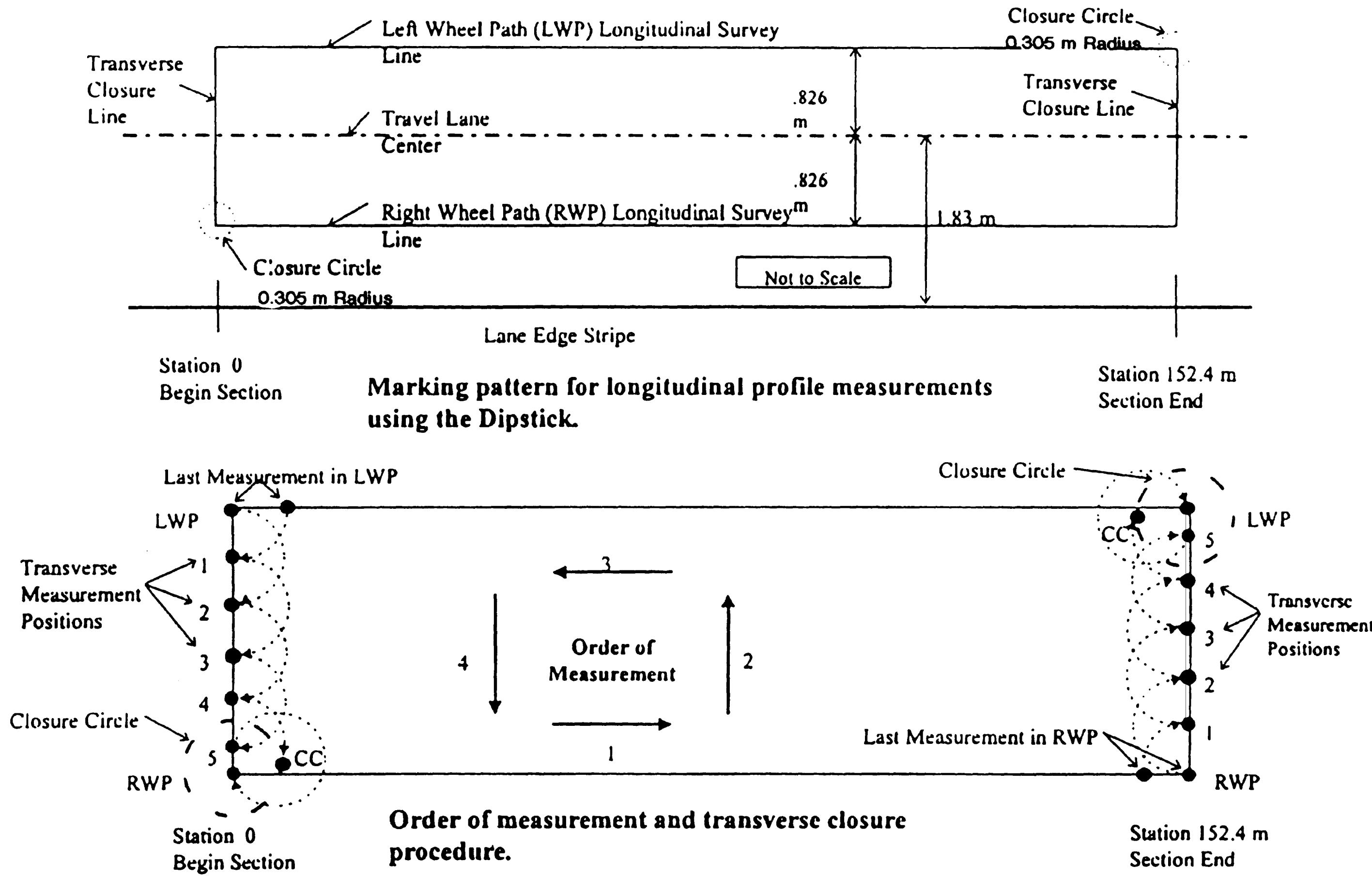

Figure 130. Site layout and measurement procedure for measuring longitudinal profiles with the Dipstick®.

3. On data collection sheet or field notebook note method used to establish location of lane center and any discrepancies between painted and measured section end locations. 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®

Checks to be performed on the Dipstick® before testing are described in this section.

1. Check condition of footpads and replace if necessary with extra set in the Dipstick® case. Clean and lubricate ball and socket joints on the footpads to insure smooth pivoting of instrument. When joint is dirty, pivoting becomes difficult and slippage of 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. If using Model 1500 Dipstick®, install a fresh set of rechargeable batteries in the instrument and securely close battery compartment. 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 battery compartment. Batteries in either of these units should be changed after 4 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, re-tighten handle on the instrument.

4. Perform Zero Check and Calibration Check, which are described next. According to manufacturer, 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 before performing these two checks.

Manual Dipstick® (Model 1500)

Zero Check: Form DS-7 included in appendix E should be filled when this test is carried out. A zero verification is performed by this test. 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 footpads and note reading on display at 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 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 average of two Dipstick® readings; e = 0.5 (R1 + R2).

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

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

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

5. Addition of R1o and R2o readings should be within tolerance; if not, repeat adjustment procedure until two readings are within tolerance.

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

Calibration Check: Calibration of the Dipstick® is fixed during manufacture and cannot be altered by the user. User can verify calibration against a standard calibration block that is provided with the Dipstick®. After zero check and adjustments are performed, calibration of device must be checked. 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. Form DS-7 (see appendix E) 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 previous reading. If this tolerance is not obtained, a LTPP Major Maintenance/Repair Form (form DS-10 in appendix E) should be completed and the Face Company should be contacted through RSC office to repair Dipstick®.

Automated Dipstick® (Model 2000 and 2200)

Zero Check: 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 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 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 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 E) at the appropriate location to indicate that the zero check was performed.

Calibration Check: Follow procedure described for the manual Dipstick® (Model 1500) to perform this check. Form DS-7 (see appendix E) should be completed when this test is carried out.

3.3.3.2 Longitudinal Profile Measurement

Complete header information on form DS-1 (see appendix E). 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 air temperature before and after profile measurements.

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

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

2. After reading stabilizes, reading should be recorded under the right wheel path (RWP) column on form DS-2 (included in appendix E) on the row corresponding to Reading Number 1. The Dipstick® should then be rotated 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, operator should check the handle of the Dipstick® at frequent intervals to make sure it is not loose, and if handle is loose it should be tightened. After reading has stabilized, it should be recorded on the next row of form DS-2 labeled Reading Number 2. This procedure should be repeated for entire length of 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) Handle of Dipstick® should be held in a vertical position when taking measurements.
   (c) Lateral pressure should not be applied to handle during a measurement.
   (d) If at a particular placement, a footpad is to fall into a wide crack or a pothole in the pavement, avoid placing the footpad into such a feature. 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) If for any reason measurements must be stopped, circles should be drawn around both footpads with the start arrow in the direction of traffic at last measurement position. When restarting, the Dipstick® shall be returned to this position and adjusted so that current measurement agrees with the measurement prior to stoppage.
   (f) If it is not possible to mark the footpad positions prior to stoppage or to successfully reposition the Dipstick® in the same position, then data must be discarded and the measurement procedure restarted from the beginning.

3. After last measurement in right wheel path at Station 152.4 m, the location of the back end of front Dipstick® footpad should be compared with the location of the transverse line that was marked at the end of the test section. If the back end of the front footpad is within 275 mm of marked transverse line, proceed with transverse closure measurements as indicated in step 4. If front footpad is not within this interval, perform the following:
   (a) Draw circles around each footpad and note direction of start arrow.
   (b) Check data sheets for skipped or missing measurements.
   (c) If no apparent anomalies are present in data, re-measure length of longitudinal survey line to verify position of end point. If re-measured location of end point is within 304 mm of back end of front footpad of the Dipstick®, remark transverse line at this location and proceed. If end-point is not within 304 mm of the back end of the front foot, discard data as suspect and restart survey from Station 0+00.

4. After location of last measurement in right wheel path has been verified, transverse closure measurements should be initiated by rotating rear foot of the Dipstick® toward left wheel path and placing it on pre-marked transverse closure line. Measurements along 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 E). When the Dipstick® reaches point in which next measurement along transverse survey line passes location of 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 device so that footpad rests on top of 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 130.

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

7. After location of last measurement in left wheel path has been verified, transverse closure measurements should be initiated by rotating rear foot of Dipstick® toward right wheel path and placing it on pre-marked transverse closure line (located at Station 0+00). Measurements along 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 E). When the Dipstick® reaches point in which next measurement along transverse survey line passes location of 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 device so that footpad rests on top of 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 130.

3.3.3.3. Post Data Collection Check

After completing survey, 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). Place 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). Draw circles around the two footpads, and note reading at the switch-end of the instrument (R1). Then rotate 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 manual Dipstick® (Model 1500) and 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 zero check as well as calibration check should be entered on form DS-7 (see appendix E). Based on results from these checks, follow one of the applicable procedures presented below:

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

2. If Dipstick® passes zero check, but fails 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 Dipstick® passes both tests, the closure error computations that are described in section 3.3.3.4 should be performed.

If Dipstick® failed zero check, but can successfully be adjusted to pass 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. Closure error computations must be performed in the field prior to leaving site.

2. Readings in each column on forms DS-2 through 6 (see appendix E) should be summed and recorded in last row of each column. Measurements in transverse closure measurement tables on forms DS-2 and DS-6 (see appendix E) should be summed across row and entered in last column.

3. Column summations should be entered on form DS-1 (see appendix E) in locations corresponding to labels shown in each summation cell.
4. On form DS-1 (see appendix E), elevation sums in the RWP and LWP should be added together and recorded in indicated cells.

5. Transverse sums should then be added to each of these sums and the result recorded in the total row at bottom of closure calculation table.

6. The two totals should then be added together and the result entered into cell labeled closure error.

7. If closure error is not within ±76 mm, data should be discarded as suspect and test section re-surveyed until closure error is within 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 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 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 shade area, using the following procedure.

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

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

3. If the difference between the two temperatures is greater than 2 °C, wait at least 5 minutes and repeat steps 1 and 2. If the difference is still greater than 2 °C, wait at least 5 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 manufacturer of probe to resolve the problem.

4. If there are any questions regarding the accuracy of the temperature probe, a cold temperature check shall be performed on the sensor. 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.

Results of the calibration check must be recorded 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 PCC 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 transverse cross slope of pavement.

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 schedule of profiling trips, or by delaying actual measurements until acceptable conditions exist. Layout and mark straight lines for transverse profile measurements. Lines should be perpendicular to edge of pavement and located at 15.24 m intervals, starting at station 0 and ending at station 152.4 m (or end of section if length of 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 non-representative 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®

Operator should check equipment using procedures described in section 3.3.3.1. Checks will include both the zero check and the calibration check. Operator should fill out the LTPP Dipstick® Data Collection Form DS-7 (see appendix E).

3.3.5.2 Entering Header Information in Transverse Profile Form

After performing the pre-operational checks on the equipment, the operator should fill the header information in the Transverse Profile Data Collection Form (form DS-8 in appendix E). Guidelines for filling 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 fill 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 condition of pavement as either V.GOOD, GOOD, FAIR, or POOR (use capital letters). Use 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. Outside lane is the outermost traffic lane. Nearly all LTPP sections are located in the outside lane. 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 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 in-built 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 comment.

3.3.5.3 Transverse Profile Measurement

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 outside edge of pavement and should extend over full lane width, with actual distance depending on lane width and pavement striping. Starting point should be junction of transverse measurement line and inside edge of white paint stripe along outside edge of the lane. If no outside edge stripe is present, or if outside edge stripe is on the shoulder, then beginning point for measurements should be either shoulder-lane joint or a point approximately 0.91 m from center of outside wheel path. A comment should be entered in the data sheet indicating how 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, Dipstick® is placed at outside edge of pavement starting at Station 0+00 with start arrow pointed towards pavement center line. Measurements should be recorded on the Transverse Profile Data Collection Form DS-8 (see appendix E). 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).

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.

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, Dipstick® is placed at Station 0+00 at the shoulder joint with start arrow pointed towards pavement center line. Measurements should be recorded on the Transverse Profile Data Collection Form DS-8 (see appendix E). Operator should complete two runs at each transverse profile location; 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).

3.3.5.4 Post Data Collection Check

After completing survey, 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). Place 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). Draw circles around the two footpads, and note reading at the switch-end of the instrument (R1). Then rotate 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 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 E). Based on results from these checks, follow one of the applicable procedures presented below:

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

2. If Dipstick® passes zero check, but fails 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 Dipstick® passes both tests, the closure error computations that are described in section 3.3.5.5 should be performed.

If Dipstick® failed zero check, but can successfully be adjusted to pass zero check and also passes 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 Sum column of form DS-8. Then at each station, add the values in 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 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 5.1.

Table 5. 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 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 FHWA, with a copy to the Technical Support Services Contractor (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 to the RSC office while the second copy should be retained by operator in case the first copy fails to reach the RSC.

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 Dipstick® fails calibration check it should be returned to manufacturer for repair.

The RSC should ensure that the gauge block used for 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 gauge block may need to be performed more frequently, depending on presence of oxidation, evidence of corrosion, and possible damage caused by accidental mishandling in 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 last check of block are suspect and may have to be disregarded.

3.4.2 Frequency of Checks

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

3.5 EQUIPMENT MAINTENANCE AND REPAIR

3.5.1 General Background

Scheduled preventive maintenance will serve as a means of ensuring 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 on-site 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 operator be constantly aware of proper functioning of equipment. There will be little time to accomplish more than the required initial checks at 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 rate of equipment deterioration is the responsibility of the RSC and individual operators. Detailed maintenance procedures are contained in the equipment manuals and 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 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 skill of operators or RSC staff. The LTPP Major Maintenance/Repair Form DS-10 (see appendix E) should be used by operator to report repairs that are performed. This form will also serve to inform RSC of condition of 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 on-site, significant problems in scheduling and coordination could develop. To help minimize impact of equipment problems, it is essential that operator immediately notify RSC and any other agencies or individuals about such problems.

Responsibility for equipment maintenance/repair activity rests with each RSC. However, RSC should keep LTPP staff informed of any major problems concerning equipment. When repairs are necessary and must be performed by an outside agency, operator should report this information on the LTPP Major Maintenance Report/ Repair Form (form DS-10 in appendix E) as an unscheduled maintenance activity.

3.6 RECORD KEEPING

Dipstick® operator will be responsible for maintaining the following Forms/Records.

1. For Longitudinal Profile Measurements: Longitudinal Profile Forms DS-1 through DS-6.

2. For 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 E. 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 filled at every section where longitudinal profile measurements are performed with a Dipstick®. Follow guidelines presented in section 3.3.5.2 to fill the header fields in form DS-1 (Note: Pavement temperature is not recorded for longitudinal profile measurements. However air temperature is recorded. Follow guidelines in section 3.3.3.5 to record air temperature.) 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 site should be included in this form. Names of these personnel will be invaluable if an accident occurs at test site. Operator should keep original of these forms and forward copies to RSC.

3.6.2 Transverse Profile Measurements

The form DS-8 should be filled at every section where transverse profile measurements are performed. Follow guidelines presented in section 3.3.5.2 to fill the header fields in this form. Operator should keep original of this form and forward a copy to RSC.

3.6.3 Zero and Calibration Check Form

This form DS-7 should be completed whenever the zero and calibration checks are performed.

3.6.4 LTPP Major Maintenance/Repair Form

The LTPP Major Maintenance/Repair Form (form DS-10) must be completed when any major maintenance or repair is performed by an outside agency,

3.6.5 Air Temperature Probe Calibration Check Form

The form DS-11 must be filled 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 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 RSC. However, all traffic control activities at test sites will be performed by personnel from either the state or provincial highway agency. Layout of 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 resolution needed for pavement profile measurements. Precision leveling instruments are required for pavement profile measurements. Instrument used for profile measurement should satisfy resolution criterion given in table 6, which was obtained from the ASTM Standard on Measuring Road Roughness by Static Level [14].

Table 6. Resolution requirement for rod and level measurements.

IRI Range (m/km)	Resolution (mm)
0 ≤ IRI < 0.5	0.125
0.5 ≤ IRI < 1.0	0.25
1.0 ≤ IRI < 3.0	0.5
3.0 ≤ IRI < 5.0	1.0
5.0 ≤ IRI < 7.0	1.5
IRI ≥ 7.0	2.0

Rod used should be equipped with a bubble level so that it can be accurately held vertically. A suitable base may be selected for 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 bottom of rod.

4.2.3 LTPP Procedures

Maintenance of Records: Operator is responsible for forwarding all data collected during testing to the RSC.

Accidents: In event of an accident, operator shall inform RSC of incident as soon as practical after mishap. Details of event shall subsequently be reported in writing to RSC. The corporate policy of the RSC should be followed in event of an accident. A police report of the accident should be obtained.

4.3 FIELD TESTING

4.3.1 General Background

The following sequences of fieldwork tasks are required.

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).

Task 2: Site Inspection
- a: General pavement condition (within test section limits).
- b: Identify wheel paths.

Task 3: Rod and Level measurements.
- a: Mark wheel paths.
- b: Obtain rod and level readings.

Two persons are needed to measure pavement profile using rod and level. One person is needed to hold rod (rod-person) and another to operate level and take readings (instrument operator). If level is not capable of automatically recording readings, having an additional person to record readings (record keeper) will make the process quicker.

According to 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 of rod by rod-person, reading level by instrument operator, and recording of measurements by 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 area of both wheel paths of loose stones and debris to prevent slippage of rod during measurements.

2 Identify location of two longitudinal elevation survey lines 0.826 m from center of lane.

Case I: Where wheel paths are easily identified, midway point between two wheels paths should be used as center of lane.

Case II: If wheel paths are not clearly identifiable, but two lane edges are well defined, center of travel lane is considered to be midway between two lane edges.

Case III: Where wheel paths are not apparent and only one lane edge can be clearly distinguished, center of lane should be established at 1.83 m from that edge.

3. Mark these locations at intervals equal to length of chalk line used for marking. Use chalk line to mark a straight line between previously established points.

The method by which wheel paths were located should be noted in the comments field of the Rod and Level Data Collection Form (see appendix G). This will help in locating wheel paths used for profile measurements at a future date.

Measurements have to be taken along wheel paths at 0.3 m intervals. Locations at which readings are to be taken can be determined by either of the following methods:

1. Lay surveyor's tape along 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 distances on 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 tape, as well as several intermediate points on tape with adhesive tape. Distances along section can be referenced from the tape. After distance corresponding to length of tape is leveled, tape will have to be repositioned.

4.3.3 Longitudinal Profile Measurements

The first reading taken after level is setup is referred to as a backsight, while last reading taken at that setup before 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 described next.

1. Complete required header information in the Rod and Level Data Collection Form (forms are included in appendix G).

2. Setup level at a suitable location taking into account range of level. With some instruments, it might be possible to cover entire test length from one instrument setup, located near center of test section. Level should be setup at a position where it will not be disturbed due to passing traffic. In addition, it should be setup at a stable location that will not settle. Set tripod as low as practical to reduce error caused by rod not being held exactly vertical. Thereafter, level instrument using leveling screws.

3. Rod-person should place rod at zero position of section and using bubble level attached to rod as a reference, hold rod vertically. Once rod is held vertically, rod-person should signal to instrument operator to take a reading. If readings are recorded manually by a third crew member, instrument operator should call out reading to record-keeper. Readings should be recorded in the form included in appendix G. If an automated system is being used, instrument operator should make sure that reading is saved.

4 Next, rod-person should place rod 0.3 m away from initial reading, and a new reading should be recorded. This process should be continued until either entire test section is surveyed or horizontal range or vertical range of level is exceeded. Horizontal range of level is exceeded if distance between level and rod is too short or too long to focus properly. Vertical range of level is exceeded if rod cannot be read due to slope of the road. When range of the level is exceeded, level has to be relocated.

5. If range of level is exceeded during measurements, instrument has to be relocated. Mark location at which rod is to be held for last reading. This position is called a pivot point. Thereafter, place rod at location where first reading was taken with current setup of 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 instrument, all readings taken from the current level position have to be repeated. If readings agree, place rod on pivot point and take last reading from current setup of instrument (foresight). Then setup instrument at new location. Place rod at pivot point and take reading (backsight). Continue leveling process as before, taking readings at 0.3 m intervals. If instrument has to be repositioned again, the procedure has to be repeated.

6. When the end of the test section is reached, use one of the following procedures depending on how the measurements were performed.
   (a) Entire survey performed from one instrument setup: Place rod at 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 start of the survey within resolution of instrument. If readings do not agree, profile measurement has to be repeated.
   (b) Instrument Repositioned During Survey: Place rod at last pivot point and take a reading. This reading has to agree with earlier reading taken at this position within resolution of instrument. If they do not agree, profile has to be measured again from last pivot point to end of section.

Measurement of pavement profiles using rod and level is labor intensive, and time consuming. Therefore, it is advisable to check accuracy of measured data at regular intervals. This can be performed by establishing a set of control points along wheel path, for example at 30 m intervals starting from beginning of section. After leveling a distance of 30 m, rod has to be placed at previous control point and another reading taken. This reading has to agree with previous reading taken at this control point within resolution of instrument. If readings do not agree, the distance between 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, above procedure can still be applied by treating 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.

1. If level is sensitive to temperature variations, it might need to be covered with an umbrella to protect it from direct sunlight.

2. During windy conditions profile measurements should be avoided, as movement of level could occur.

3. If level has to be setup at more than one position during profile measurements, make length to backsights and foresights equal. This will eliminate errors due to curvature and refraction at turning points.

4. Setup 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 readings of level using procedures described in section 4.3.3. Computation of elevation profile from these data will be done in the office. This section briefly describes how data recorded in field is used to obtain longitudinal profile of pavement.

For profile computations, elevation of location where 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:

Instrument Height (IS) = BM + RR1 ......(4.1)

Relative Elevation of a Point = IS – RR.....(4.2)

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........(4.3)

where,

Nht = New instrument height,
Oht = Old instrument height,

BS = Backsight at pivot point, and
FS = Foresight at pivot point.

Relative elevation of points measured from this new instrument location can be determined by using equation 4.2 and using new instrument height (Nht) instead of Initial Instrument Height IS.

4.3.6 Quality Control

A quality control check must be performed in the field to ensure that no movement of level took place during current setup of level. This check must be performed every time before level is moved and when end of test section is reached. Once the last reading at the current location of the level has been taken, before moving the level, place rod at location at which first reading was taken with current setup of level, and take a reading. Both readings have to agree within resolution of 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 on how to perform adjustments to instrument. Different makes/models of levels will require different adjustments. The following are some common adjustments that are required in levels in order to obtain accurate measurements. The user manual should be consulted to determine if the following adjustments are needed for level being used and, if so, how to perform the specific adjustment.

1. Make Axis of Level Bubble Perpendicular to Vertical Axis: After setting up level, center bubble. Move telescope 180 degrees about vertical axis. If bubble moves, instrument needs adjustment.

2. Adjust Horizontal Cross Hairs: This adjustment will ensure that horizontal cross hairs are truly horizontal when instrument is leveled.

3. Adjust Line of Sight: This adjustment will make axis of sight perpendicular to vertical axis and also make it parallel to axis of level. The method of adjustment for this error is commonly referred to as the two-peg method.

Rod has to be checked to verify accuracy of markings. A standardized tape should be used for this.

4.5 EQUIPMENT MAINTENANCE

Shockproof packaging should be used when transporting instrument. Always clean instrument after measurements are completed. Before cleaning lenses, blow dust off lenses, then clean lenses using a soft cloth. Lenses should not be touched with fingers. If instrument becomes wet in field, make sure that it is completely dry before packing. Tripod should be inspected regularly to ensure that connections are not loose.

4.6 RECORD KEEPING

The Rod and Level Data Collection Form (see appendix G) should be used to record readings when profile measurements are performed using rod and level. A comment should be made on this form as to how wheel paths were located. All items in this form should be completed by 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 to the RSC office while the second copy should be retained by the operator in case the first copy fails to reach the RSC.

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, the ProQual software 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, 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 the ProQual software needed to perform data processing and quality assurance checks are described. Detailed information on the operation of the ProQual software is presented in the ProQual Manuals (see references 6, 7, and 8).

The RSCs are not required to process profile data collected at WIM sites 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 an inertial profiler.

1. Check Analysis Parameter Screen and Equipment Screen in ProQual

   After starting ProQual, check if settings in Analysis Parameter Screen and Equipment Screen are set to values described section 2.4.4.

   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 2.4.4).

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. (Note: Vertical Photocell Offset and Horizontal Photocell Offset fields should be blank).

2. Compute Roughness Indices

   In ProQual, select data set to be analyzed and select "All" icon to compute all roughness indices (i.e., IRI, RMSVA, Slope Variance).

3. Review 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.

   Time: The time of profiling shown is obtained from the laptop computer in the device during testing. Review time to see if it is reasonable. If unreasonable, the time shown in the laptop computer of the device should be checked for possible errors. If errors are detected, check with the operator to obtain correct time when profile data were collected.

   Sequence: Check if 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.

   Software: The software version that is shown should be 6.0 followed by a space, then SN, followed by the Ames Engineering identification code for the device (e.g., 6.0 SN830112 will appear in this field for the North Atlantic device). The Ames Engineering identification code shown here is the value that was entered into the Serial # field in ProQual (see section 2.4.4)

   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; profile data will have to be re-collected. Also, check the settings of the Filter Wavelength in the header screen of the Ames Engineering software in device to ensure that it is set to a value of 100.

   Crew: Check if operator and driver initials have been entered correctly. Operator and driver should be identified by two characters each, 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 one person operation, operator and driver name should be the same (e.g., CK/CK).

   Road: This field should show the route number where section is located (e.g., I-88). Check if information is correct.

   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.

Direction: This field refers to travel direction when profiling site. Valid entries for this field are NORTH, EAST, SOUTH, or WEST. Check if travel direction is correct.

Begin: This is entry made for field Beginning Description in profiler software. Check to see if the milepost has been entered in this field. If not, this field should show NONE.

End: This is entry made for field Ending Description in profiler software. This field should show NONE.

Surface: This field shows surface condition of 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 26 of section 2.9.3.2. 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).

Temperature: This field shows ambient temperature at time of profiling in degrees Celsius. Check if value appears reasonable based on season/month of testing. If the temperatures appear to be questionable, check with operator who collected the data.

Clouds: This field shows cloud condition at 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 entry is correct.

Weather: The value in this field corresponds to field "Other Weather Conditions" that was entered in the Ames Engineering software. In the Ames Engineering 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, LOW SUN ANGLE. As this field is selected in the header screen of the data collection software by selecting an appropriate entry from the six available choices, an entry will always be present for this field. If there is a question about this entry, check with profiler operator to verify entry is correct. The information in this field should be used when evaluating profile data (see step 5).

Start Method: The start method for profile data collection is always PHOTOCELL. The code assigned to photocell is 1. Verify that this field shows 1. If a method other than Photocell has been used to collect the profile data, discard the profile data; profile data will have to be re-collected.

Stop Method: The stop method for profile data collection is always DISTANCE. The code assigned to distance is 3. Verify that this field shows 3.

Stop Distance: The stop distance for GPS sections is 152.40 meters; verify that value is correct. For SPS projects see if value appears reasonable; stop distance shown for SPS projects is length of entire profile run.

Wavelength Initialization: This value should be null (i.e., blank).

Average Speed: This field shows 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.

Run End Note: This field shows entry made in field by operator at end of a profile run. The operator has the option of choosing one of the following entries at the end of run: RUN OK, PAVEMENT SURFACE DAMP, TRAFFIC CONGESTION: SPEED VARIABLE, DIFFICULT TO MAINTAIN CONSTANT SPEED: GRADE, and DIFFICULT TO MAINTAIN WHEEL PATH LOCATION. 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 five available options, check if Run End Note follows guidelines described in section 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).

Operator Note: This field shows comments made by operator in the field after data have been reviewed through ProQual. Review comments and see if they follow the guidelines presented in section 2.7.9. Comments will be useful when graphically comparing profile plots (step 5) and when evaluating IRI values of profiler runs (step 8).

Device Code: The code shown in this field should be P.

Manufacturer: This field shows the profiler manufacturer and should reflect value set in Equipment screen of ProQual (see section 2.4.4). Check if manufacturer is AMES ENGINEERING.

Model: This field should indicate PSM8300.

Model Code: This field shows model code assigned to profiler and should reflect value shown in Equipment parameter screen of ProQual, which is 3.

Sample Size: This field shows sample interval for profile data, which was assigned to "Sample" in the Analysis Parameter screen of ProQual (see section 2.4.4). Sample size should show a value of 150.

If there are errors in any of the headers that can be corrected, go to "Identification and Conditions" menu under "Run Details" tab and correct the header. If there are errors that cannot be corrected (e.g., not using photocell to initiate data collection, using an incorrect filter) discard data. Profile data will have to be re-collected.

4. Check Profile Data Interval

Go to "Profile Details" tab in ProQual and check if data are at 150 mm intervals and that data for 152.4 m are available (Sections 2 and 5 in SPS-6 projects should have data for 304.8 m).

Although Analysis Parameters screen was checked to see if 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 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 Profile

The "Spikes" tab under "Data Sets" in ProQual shows the locations where spikes were detected in the profile. Review Operator Notes to determine cause(s) of spikes. If spikes were noted, it is mandatory that operator note if 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 Graphical Visit-to-Visit Comparison of 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 Ames Engineering data are compared to data collected with ICC profilers, differences in profile plots will be seen (see appendix D). However, sharp upward and downward features in both profiles that are indicative of short wavelength features should occur at the same location. When the comparison involves only Ames Engineering 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 sub-sectioned (e.g., SPS sections), the visit-to-visit graphical profile comparison can be used to determine if sub-sectioning was performed correctly. If horizontal offset of profile features is noted between visits, this may indicate a problem with sub-sectioning. If 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 sub-sectioning problem is suspected, re-evaluate the sub-sectioning performed for the SPS project (or other cases where sub-sectioning was performed).

8. Review Profile Indices

   If a spike was logically marked, the "All" icon in "Analysis" submenu of "Data Sets" tab has to be selected again to re-compute roughness indices. If no spikes were logically marked, it is not necessary to re-compute the roughness indices. Print Site Visit Report and Site Summary Report.

   Use 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 (average IRI of left and right wheel paths) 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% for a wheel path (when average 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 RCO Code and RCO Note

   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.

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, and (d) indicate cause(s) for variability in profiles.

The following comments are available in the drop-down list: PROFILE DATA OK, SPIKES ARE PAVEMENT RELATED, VARIABLE PROFILES, SPIKES IN ___ WHEELPATH REMOVED, POOR PROFILE MATCH: DMI DIFFERENCE, and 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 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. Store Data

The profile data files collected by the device (hereafter referred to as raw profile data) as well as all files generated by ProQual during processing of raw profile data should be stored by the RSC. For the Ames Engineering device the raw profile data for each run is stored in a file having the extension ARD. All files generated by ProQual for each site should be stored in conjunction with the raw profile data files. Use the file structure indicated in directive Profiler data files should be organized into subdirectories in the hard drive as outlined in LTPP directive GO-48 , AIMS Electronic Data Format, Submission, Standards, and Dates, or current version of that directive.

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 Dipstick® Passed Pre- and Post-Measurement Checks and if Data Met 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 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 (see references 6, 7, and 8). To enter header information of a site into ProQual, select "Manual" from main menu, and then select "Longitudinal" option. Thereafter, select 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 "Insert Data Set" icon (+ icon) and edit/enter information in the following fields in the Manual Data Set part of the screen:

   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 date and time in this field to show data collection date and time at which data collection was started. This information is contained in form DS- 1.

   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.

   Date: Enter date of data collection from sheet DS-1.

   Time: Enter time data collection started from sheet DS-1.

   Equipment: Select 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-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 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-1. Check if entries meet the following criteria (described in section 3.3.5.2) and enter information into appropriate field in ProQual.

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).

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.

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.

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.

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.

Lane: Use drop-down list and enter lane, which can be either OUTSIDE or INSIDE. Check if lane is correct.

Direction: This is traffic direction of test section. Use drop-down list and select NORTH, EAST, WEST, or SOUTH. Check if direction is correct.

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).

Clouds (Cloud Conditions): Valid entries for this field are CLEAR, P. CLOUDY, or CLOUDY. Use drop-down list in ProQual to select appropriate entry.

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 operator.

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.

Surface Type: Use drop-down list to select surface type; A-CC for asphalt surfaced pavements and P-CC for portland cement concrete surfaced pavements based on surface type entered in form DS-1.

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).

Operator Comment: Enter operator comments in capital letters, if the operator made any comments.

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 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 data by selecting the Printer icon. Check Dipstick® data values along left and right wheel paths in printout with values in Forms DS-2 through DS-6 to make sure all data have been entered correctly.

4. Sum Dipstick® Data and Filter Profile Using Surface Dynamics Filter

   After checking data and making corrections as needed, select sum button to obtain elevation profile as well as elevation profile that has been filtered with the Surface Dynamics upper wavelength cut-off filter. This action will cause the four data columns right of the left profile reading column to be populated with data. (Note: The Surface Dynamics filter included with the ProQual software was used in the K.J. Law T-6600 profilers as the upper wavelength cut-off filter). Thereafter, select 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 Data

   The data set can now be treated as a profiler run that was obtained using an inertial profiler by selecting "Profiles" menu from the main menu of ProQual, and then selecting the "Data" submenu. Select data set to be analyzed and in "Analysis" submenu of "Data Sets" menu select “All” icon to compute all roughness indices (i.e., IRI, RMSVA, Slope Variance). Review if spikes are present in profile. If spikes are present, check to make sure that spikes were not caused by errors during data entry. Print Site Summary Report to review the values computed for IRI, Spike Count, RMSVAs, Mays Output, and Slope Variance. Plot profiles along left and right wheel paths and review profile plots to see if they are reasonable.

6. Compare Data With Data From Previous Visit.

   Compare IRI values obtained along each wheel path with those obtained during previous site visit. If difference is greater than 10% for a wheel path, investigate reason for difference. Graphically compare profiles along each wheel path with those generated from 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 Operator Comment and Run End Comment

   The Operator Comment as well as the Run End comment were 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 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), and (e) if required, review distress maps to investigate spikes in data.

   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: PROFILE DATA OK, SPIKES ARE PAVEMENT RELATED, VARIABLE PROFILES, SPIKE(S) IN ___ WHEELPATH

REMOVED, POOR PROFILE MATCH: DMI DIFFERENCE, and 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 longitudinal Dipstick® profile file for upload and create 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. Store Data

    Store all files related to the site that were created by ProQual. Use the file structure indicated in directive Profiler data files should be organized into subdirectories in the hard drive as outlined in LTPP directive GO-48, AIMS Electronic Data Format, Submission, Standards, and Dates, or current version of that directive.

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 RCO code to profiler data is described in section 5.2 in step 9. The assignment of RCO code to longitudinal Dipstick® data is described in section 5.3 in step 8.

The assignment of 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.

RCO Code = 1

A RCO Code of 1 should be assigned to a profile run if there are no data problems. Such profile runs have the following characteristics:

- If there is variability between multiple profile runs, the operator comments explain that the cause of this variability is pavement related.
- 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.
- Profile data plots are in good agreement with those collected during previous site visits. This procedure provides a check on errors caused by incorrect sub-sectioning of SPS sites, incorrect labeling of sites, and incorrect start locations for profile data collection.

RCO Code = 2

A RCO Code of 2 should be assigned to a profile run if any of the following features are identified in the data:

- 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 2.

- Spikes in 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 2. 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 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 2.

RCO Code = 3

A RCO Code of 3 should be assigned to a profile run if any of the following conditions are identified:

- When compared to other profile runs collected during site visit, there is a large IRI difference that cannot be explained.

- There are spikes in the profile data that are not explained by operator comments.

- There are differences in the profile data when compared to other profile runs collected during the site visit, but differences cannot be explained by operator.

- Profiler runs collected during site visit are repeatable, but they are different from those collected during previous site visits, and 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. But 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 Dipstick® Passed Pre- and Post-Measurement Checks

   Check form DS-7 to verify that Dipstick® passed zero check and calibration check prior to and after data collection.

2. Enter 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 (see references 6, 7, and 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 "Insert Data Set" icon (+ icon) and edit/enter information in the following fields in the Manual Data Set part of the screen:

   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 date and time in this field to show data collection date and time at which data collection was started. This information is contained in form DS-8.

   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.

   Tests: The number of readings taken for a transverse profile. Enter number of readings by reviewing data on form DS-8.

   Date: Enter date of data collection from sheet DS-8.

   Time: Enter time data collection started from sheet DS-8.

   Equipment: Select 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 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.

Road Name: This is 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.

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.

Visit: 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 LTPP PPDB.

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.

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.

Direction: This is traffic direction of test section. Use drop-down list to select NORTH, EAST, WEST or SOUTH. Check if direction is correct. This information is not entered into the LTPP PPDB.

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).

Clouds (Cloud Conditions): Valid entries for this field are CLEAR, P. CLOUDY, or CLOUDY. Use drop-down list in ProQual and enter cloud conditions. This information is not entered into the LTPP PPDB.

Temperature: The pavement temperature in degrees Celsius obtained with an infrared device is entered in this field. Check if temperature appears to be reasonable based on season/month when test was performed and enter value. This information is not entered into the LTPP PPDB.

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 From DS-8 corresponds to one of the predetermined comments, use drop-down list to select appropriate entry. If comment is different, type comment noted in form DS-8 (use capital letters). This information is not entered into the LTPP PPDB.

Surface Type: Use drop-down list to select surface type noted in form DS-8. A-CC for asphalt surfaced pavements and P-CC for portland cement concrete surfaced pavements. This information is not entered into the LTPP PPDB.

Surface Condition: Enter condition of pavement as either V.GOOD, GOOD, FAIR, or POOR. Use 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 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 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: (a) run from edge of pavement to centerline, (b) from centerline to edge of pavement, and (c) sum of two elevation measurements.

Once data have been entered, review and see if graphical "Sum" plot is a horizontal line. If 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, select "Verify Profiles." Confirm that closure error limit has been met. If not, recheck 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 other transverse locations. Follow the procedures outlined above to check those data.

4. Use Graphic Profile Option to Check Profiles

After data for all transverse profile runs have been entered, use "Graphic Profile" option to plot profile data. When this option is selected, a graph showing the profile plots for all transverse locations is displayed. Check if profiles reasonably match between stations. If a plot for any specific station appears to be different from the rest of the profiles, check data that were entered for that location.

5. Run Rut Analysis

   Select “Rut Analysis” icon to compute rut depths and then print Rut Report using the “Rut Report” icon. Review rut depths computed along left and right wheel paths at different transverse locations. If rut depth at any location appears to be different from those for the other locations, check if data have been entered correctly.

   If RSC maintains record of rut depths computed by ProQual for previous site visit, compare current rut depths with those from 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 Operator Comment, Run End Comment, and RCO Comment

   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 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 issue and recreate RIMS upload files, as needed.

8. Submit RIMS files to 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. Store Data

   Store all files related to the site that were created by ProQual. Use the file structure indicated in directive Profiler data files should be organized into subdirectories in the hard drive as outlined in LTPP directive GO-48, AIMS Electronic Data Format, Submission, Standards, and Dates, or current version of that directive.

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 Profiler data files should be organized into subdirectories in the hard drive as outlined in LTPP directive GO-48, AIMS Electronic Data Format, Submission, Standards, and Dates, or current version of that directive.

For ICC profiler the raw profile data files that need to be stored are the files with extensions of p, e, and v. For Ames devices store the files with file extension ARD that contain the raw data. All files generated by ProQual for each site should be stored in conjunction with the raw profile data files.

The storage of working files should be done in accordance with LTPP Directive Profiler data files should be organized into subdirectories in the hard drive as outlined in LTPP directive GO-48, AIMS Electronic Data Format, Submission, Standards, and Dates, 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 B) for each occasion a WIM section has been profiled.

5.7 STORING IMAGE FILES

The Ames devices are equipped with cameras for obtaining right-of-way images at approximate intervals of 25 m. Store the obtained images following the procedures outlined in LTPP directive GO-48 , AIMS Electronic Data Format, Submission, Standards, and Dates, or current version of that directive.

CHAPTER 6. INTER-REGIONAL COMPARISON TESTS

6.1 INTRODUCTION

This chapter describes a plan for periodic comparison of the Ames Engineering profile/texture devices used in the LTPP program. This comparison is usually performed on an annual basis at a date and location determined by 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 longitudinal profile on those test sections using a suitable reference device. 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 reference profile measurements, non-host RSCs will travel to the test sites and, together with host RSC perform data collection over an approximately four-day period with their respective device.

The Dipstick® has been traditionally used to collect the longitudinal reference data at test sections. Currently, rolling profilers such as the SurPRO manufactured by ICC can collect data at 25 mm intervals. As LTPP profilers collect data at 25 mm intervals, the Dipstick® is not the best device to use to collect reference profile data as it has a data recording interval of 304.8 mm. A rolling profiler such as the SurPRO is ideal for collecting reference profile data as its data recording interval matches the data recording interval of the LTPP profilers. However, the LTPP program currently does not have a SurPRO in its possession.

A report summarizing the results of the comparison tests and associated data must be submitted by each RSC to the FHWA LTPP Office, with a copy to the LTPP TSSC contractor within 21 days after completion of the tests. Inter-regional comparison and analyses of the 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:

- Selecting dates for comparison testing of devices in coordination with FHWA, TSSC, and other RSCs.
- Site selection.
- Logistical arrangements (reserve block of rooms at or near selected site, meal arrangements, traffic control arrangements, etc.).
- Communication of final logistical arrangements to FHWA, TSSC, and other RSCs.
- Measurement of longitudinal profiles at the test sections using a suitable reference device.

6.3 TEST SECTIONS

The host RSC will be responsible for selecting and marking the test sections that will be used for the comparison of devices. Five test sections for profile/texture testing and one test section for

DMI testing should be selected by the host RSC. The five test sections for profile/texture testing should be selected based on the following guidelines.

- Section 1 (AC-l), Smooth AC: AC pavement with a mean IRI < 1.6 m/km.
- Section 2 (AC-2), Rough AC: AC pavement with a mean IRI > 2.2 m/km.
- Section 3 (PCC-l), Smooth PCC: Jointed PCC pavement with a mean IRI < 1.6 m/km.
- Section 4 (PCC-2), Rough PCC: Jointed PCC pavement with a mean IRI > 2.2 m/km.
- Section 5: Chip sealed section.

The test sections used for profile/texture testing should meet the following criteria:

- The AC pavement sections should not be PCC sections that have been overlaid with AC.

- The test sections should have a marked outside lane edge stripe that can be used as an outside lane edge reference.

- All test sections should be located on flat tangent sections with sufficient length at each end to allow for acceleration to a constant speed before the section and safe deceleration past its end.

- The speed limit of the roadways containing the test sections should be at least 80 km/h.

- Each test section should be 152.4-m in length, with the beginning and end marked.

- Where possible, test sections should be located within a centralized locale with short travel distances between each test section to reduce travel time.

- Test sections do not have to be located on LTPP test sections. However, LTPP test sections can be used when convenient.

An accurately measured 300 m long section 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 REFERENCE DATA COLLECTION AT TEST SECTIONS

A suitable reference device (e.g., SurPRO, Dipstick®) that has been approved by the FHWA should be used to obtain longitudinal reference measurements along both wheel paths and along the center of the lane at all test sections. If a Dipstick® is used, measurements should be obtained using the procedure described in section 3.3.3 of this manual. If a SurPRO is used, the procedures described in section 3.3.3 modified accordingly to accommodate the SurPRO should be used. The reference data collection should be performed within 14-days of the comparison tests. On PCC test sections, the reference data collection 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 reference data collection at all test sections, with approval from FHWA, the RSC should perform data collection only at the smooth AC test section

6.5 COMPARISON TESTING OF DEVICES

The following sequence should be followed in performing tests during the comparison test.

1. Full calibration check of profile and texture height sensors.
2. Dynamic calibration check of texture height sensors.
3. Calibration check of accelerometers and bounce test.
4. Calibration of DMI and collecting data to check bias and precision of DMI.
5. Collection of profile/texture data at the test sections.
6. Verification of DMI.

Details on each of these tests/checks are described in the following sections.

6.5.1 Full Calibration Check of Profile and Texture Height Sensors

A full calibration check of the profile and texture height sensors should be performed following the procedures described in section 2.12.5 of this manual.

6.5.2 Dynamic Calibration Check of Texture Height Sensors

A dynamic calibration check of the texture height sensors should be performed following the procedures described in section 2.12.6 of this manual.

6.5.3 Calibration Check of Accelerometers

A calibration check of the accelerometers should be performed following the procedures described in section 2.12.4 of this manual. Thereafter, perform a bounce test following the procedure described in section 2.9.2.4 of this manual.

6.5.4 DMI Test

Calibrate the DMI following procedures described in section 2.12.3 of this manual. Then perform a “Horizontal Test” using the “Horizontal Test” option in the Ames Engineering software (see section 2.12.3) to obtain the distance between the reflective marks on the DMI section. Record the displayed distance. Repeat this procedure five more times. The tire pressure may be checked and adjusted if necessary before performing each run such that it matches the tire pressure during DMI calibration. Compute the average and standard deviation of the six recorded distances.

6.5.5 Profile/Texture Data Collection

Profile and texture 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 approximately at the same time when reference data were collected at the sections.

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 performing the verification testing. Warm-up the tires using the procedures that were used when the tires were warmed-up before calibrating the DMI. Then perform a "Horizontal Test" using the "Horizontal Test" option in the Ames Engineering software (see section 2.12.3) to obtain the distance between the reflective marks on the DMI section. Record the displayed distance. Repeat this procedure five more times. The tire pressure may be checked and adjusted if necessary before performing each run such that it matches the tire pressure during DMI calibration.

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 data that should be submitted.

6.6.2 Format of Report

The report should consist of the following items:

1. Height sensor measurements form for profile height sensors (see form COMP-1 in appendix H).

2. Height sensor measurements form for texture height sensors (see form COMP-2 in appendix H).

3. Accelerometer calibration check, bounce test, and texture sensor dynamic check form (see form COMP-3 in appendix H). Report the results from bounce test performed immediately after full calibration check of laser sensors.

4. DMI Measurement form (see form COMP-4 in appendix H).

5. DMI Verification form (see form COMP-5 in appendix H).

6. IRI Values Table: Compute the IRI of the five runs at each site that would have been selected for upload to the PPDB using the current version of ProQual. Enter the IRI values into the IRI Values table that is included in appendix H (form COMP-6). Compute average and standard deviation of IRI for each wheel path at each site.

7. MPD Values Table: Compute the MPD values for the five runs that were included in the IRI Values table. Enter the MPD values into the MPD Values table that is included in appendix H (form COMP-7). Compute average and standard deviation of MPD for each wheel path at each site.

8. 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, right, and center 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.

9. Bounce Test Results: Create a table and show IRI values for static and dynamic portions of the bounce test for each test day.

10. If any data anomalies are noted for the full calibration check of the profile and texture height sensors, DMI testing, IRI values at a test section, MPD values at a test section, or repeatability of profile plots, discuss the possible causes for these anomalies.

11. Include the Site Visit report generated by ProQual for each site in the report.

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/texture 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 photographs of test sections in the report.

2. Include a table showing the IRI values computed from reference device measurements. Indicate date, start time, and end time for reference data collection

6.6.3 Data Submission

The following data should be submitted on a CD. Organize the data into the CD in a logical manner.

1. Results from the full calibration check of the profile and texture height sensors that are saved after the test.

2. The accelerometer calibration check log.

3. The texture data (ARD file) that is saved after performing the dynamic check on the texture height sensors.

4. The DMI calibration report that is saved after calibrating the DMI.

5. The bounce test files (ERD format) that is saved each day.

6. Raw data files (ARD files) containing the data collected at the five test sections.

7. ERD files containing profile data collected at the five test sections at 25 mm intervals, and ERD files containing texture data collected at the five test sections at 0.5 mm intervals.

8. Files created by ProQual when data were processed.

9. Submit an Excel file with separate sheets in the file for each of the following items: Height sensor measurements form for profile height sensors (see form COMP-1 in appendix H); Height sensor measurements form for texture height sensors (see form COMP-2 in appendix H); DMI Measurements form (see form COMP-3 in appendix H); DMI Verification form (see form COM-4 in appendix H); results from the accelerometer calibration check, bounce test, and texture sensor dynamic check (see form COMP-5 in appendix H); IRI values form (see form COMP-6 in appendix H), and MPD values form (see form COMP-7 in appendix H).

10. The host RSC should submit the data files containing the reference profile data.

6.6.4 Preparation of Report by TSSC

On receipt of the RSC reports and data, an inter-regional 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. Static accuracy of the profile and texture 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. Results from the accelerometer check: The results from the accelerometer check will be evaluated to determine if they meet the criterion specified in this manual

3. Results from the bounce test: The static and dynamic IRI values from the bounce test will be evaluated to determine if they meet the criteria specified in this manual

4. Results from the dynamic check of the texture height sensors: The MPD values obtained from the test will be evaluated to determine if they meet the criterion specified in this manual

5. Accuracy and Stability of the DMI: The results obtained from the DMI tests will be evaluated to determine if bias of the DMI is within 0.15 m (0.05% of the length of the section), and that the precision of the DMI is less than 0.075 m. The data from the tests performed immediately after the DMI was calibrated as well as the data from the DMI verification testing will both be analyzed to evaluate the accuracy and stability of the DMI.

6. IRI values obtained by the devices: The IRI values obtained from the reference device data will be compared with IRI values obtained for the data collected by the devices: The IRI values will be evaluated to determine if: (a) the precision of the IRI along a profiled path is less than 0.04 m/km, and (b) if difference in IRI for a profiled path between the reference device IRI and average device IRI obtained from the five runs is within 0.10 m/km. for paths having an IRI less than 1.6 m/km and within 0.15 m.km for paths having an IRI greater than 2.2 m/km.

7. Repeatability of devices using cross-correlation: The IRI-filtered cross-correlation for all possible profile pairs for each profiled path at each section will be computed, and then these values will be used to compute the average IRI-filtered cross-correlation value. The average IRI-filtered cross-correlation for each profiled path at all sections must be greater than or equal to 0.92.

8. Accuracy of devices using cross-correlation: This analysis will only be performed if reference profile data are available at 25-mm intervals or less. The IRI-filtered cross-correlation between the reference profile data and each repeat profile run for each profiled path will be computed, and these values will be used to compute the average IRI-filtered cross-correlation value for each path. The average IRI-filtered cross-correlation must be greater than or equal to 0.90 for each profiled path.

9. Repeatability of profile data using profile plots: The profile data collected by each device along each profiled path at all sites will be visually evaluated by examining overlaid profile plots.

10 Compare profile data obtained by the four devices: The profile data collected by the four devices will be visually evaluated by preparing overlaid profile plots for each path at each test section by selecting one representative profile run for each device at each test section.

11. Compare MPD values obtained by the devices: The average MPD values obtained along each wheel path at each section will be compared among the four devices.

REFERENCES

1. Ford Motor Corporation, Ford E-150 XLT Vehicle Manual.

2. Ames Engineering, Ames Engineering Profiler Software, Software Version 6.0, Users Manual, December 2013.

3. Ames Engineering, Hardware Presentation Handout, Operator Training, College Station, Texas, April 2013.

4. Ames Engineering, Binder Containing Manuals for Components in Ames Engineering Profiling Texture Device.

5. Ames Engineering, Software Presentation Handout, Operator Training, College Station, Texas, April 2013.

6. Macpherson, D., Olmedo, C., and Merril, C., ProQual 2012, User Guide, Federal Highway Administration, March 2013.

7. Macpherson, D., ProQual 2012 Overview, Federal Highway Administration, March 2013.

8. Macpherson, D., ProQual 2012, Utilities, Federal Highway Administration, March 2013.

9. Olmedo, C., ProQual Sidekick User Guide, Report No FHWA-TS-12-004, Federal Highway Administration, April 2013.

10. Distress Identification Manual for the Long-Term Pavement Performance Program, Fourth Revised Edition, Publication No. FHWA-RD-03-031, Federal Highway Administration, Washington, DC, March 2003.

11. Dipstick® Model 1500 User Manual, Face Company.

12. Dipstick® Model 2000 Manual, Face Company.

13. Dipstick® Model 2200 Manual, Face Company.

14. Standard Test Method for Measuring Road Roughness by Static Level Method, Designation E 1364-95, American Society of Testing and Materials.

APPENDIX A. PROFILE/TEXTURE 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/texture monitoring activities, the FHWA LTPP team has designed a Profile/Texture 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 profile/texture 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 reduces probability of problems being forgotten or falling through the cracks.

A PROFPR must be submitted whenever there are equipment problems in the profile/texture device, problems with data collection or data processing software, problems with data collection guidelines, other problems related to profile/texture activities, or profile and texture data. If a problem was encountered, and it was resolved, and the profiler operator/coordinator feels that this information would be useful to the other RSCs, an informational PROFPR should be submitted. When submitting an informational PROFPR, indicate that the PROFPR is being submitted for informational purposes in the description part of the form.

The PROFPR 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 Technical Support Services Contractor, and O for others.

A number code representing the PROFPR number for the submitting agency is sequential, starting from 1. 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 must be transmitted electronically by an attachment to an e-mail message. A complete set of the PROFPR submittals will be maintained by the FHWA LTPP Team and LTPP TSSC. A copy of the report with the bottom part completed will be sent to the RSCs for their information and action as appropriate after the problem report has been reviewed/resolved by the FHWA and TSSC..

Agency: ______
PROFPR #:____

LONG-TERM PAVEMENT PERFORMANCE (LTPP)
PROFILE/TEXTURE PROBLEM REPORT (PROFPR)

Attention: ______________________________________
____
____
____
____

Type of Problem Guidelines __________ Equipment __________ Software __________ Name __________ Version __________ Other __________	Reported by: ____________________ Agency: ____________________ Date: ____________________ Urgent (Y/N) ____ Page _of ___
Description:	

THIS SECTION FOR USE BY FHWA AND TSSC	
Received by: ____________________ Referred to: ____________________ Date Referred: ____________________	Date Received: ____________________ Approved by: ____________________ Date Approved: ____________________
Resolution:	
Notes:	

APPENDIX B. STANDARD FORMS FOR PROFILER OPERATIONS

DAILY CHECK LIST

ITEM
Under Hood
Fluids
Engine Oil
Brake Oil
Windshield Washer Fluid
Radiator Coolant
Transmission Oil
Exterior
Lights
Front
Rear
Emergency
Turning Signals
Light Bar
Directional Warning Light
Strobe lights
Glass Cleaning
Windshield
Check Cleanliness of Sensor Glass
Profile and Texture Height Sensor
Photocell
Other
Tires Properly Inflated
Fluid Leaks
Ambient and Pavement Temperature Sensors
Interior
Temperature Range

LTPP PROFILER OPERATIONS LTPP PROFILER FIELD ACTIVITY REPORT FORM PROF-1	REGION STATE CODE LTPP SECTION ID	

FILE NAME: ______ TESTING: ______ UNIT: ______

LTPP EXPERIMENT CODE: ______ ROUTE/HIGHWAY NUMBER: ______ DIRECTION: ______

TESTING DATE: ______ SURFACE: ______ TIME ZONE: ______

PROFILOMETER VEHICLE BEFORE OPERATION CHECKS: ______ (Initials)

	TIME	ODOMETER
START TRAVEL		
BEGIN TEST		
END TEST		
END TRAVEL		

DOWN TIME: ______ REASON : ______

LASER SENSOR DAILY CHECK

Profile	*Identifier*	*Label*	*Reference*	*Bias*
LEFT (1)	ODS 1			
RIGHT (2)	ODS 2			
CENTER (3)	ODS 3			
Texture	*Identifier*	*Label*	*Reference*	*Bias*
LEFT (1)	ODS 4			
RIGHT (2)	ODS 5			

Identifier: Laser Sensor PASS (Y/N): ______

Label: Assigned 25mm block (ex. A-1) Bias Pass: ± 0.25 mm

Reference: 25mm Block Height (mm)

Bias: Average Difference between Sample and Reference

Run Number	Average IRI (Left & Right)	Center (IRI)	Selected Run Y/N
1			
2			
3			
4			
5			
6			
7			
8			
9			

BOUNCE TEST

	LEFT (1)	CENTER (3)	RIGHT (2)	Pass (Y/N)
Static(IRI ≤ 0.08)				
Dynamic				
Difference(≤ 0.1)				

TIRE PRESSURE (psi)

	LEFT	RIGHT	COMMENTS
FRONT			
REAR			

10% IRI CHECK AFTER TESTING

FORMULA FOR 10 % IRI CHECK

100x(CURRENT VISIT - OLD VISIT) / OLD VISIT

	DATE	LEFT	RIGHT	BOTH
CURRENT				
OLD VISIT				
10% CHECK				

ADDITIONAL REMARKS :

PROFILER CREW : DRIVER: ______ OPERATOR : ______

OTHERS PRESENT (LIST NAMES AND AGENCIES) : ______

LTPP Profiler Operations
Status of Regions Test Sections
Form PROF-2

LTPP ID	Exp.	Highway				Thermoplastic White Stripes at				Thermoplastic or Paint Marks	Delineators at		Signs at		PK Nails at		Any	Insp. Date	Operator	Co-ord. Book need	Comments
	Type	Route	Dir'n	# Lane per Dir'n	MP marker	-500	0	500	750	0 - 500	0	500	-500	0	0	500	Rehab. ?	(M/D/Y)	Initials	update ?	

LTPP Profiler Operations Profiler Log Form PROF-3

Date	Noted Problem	Action Taken and Date

LTPP Profiler Operations **LTPP Major Maintenance/Repair** **Work Order** **Form PROF-4**	**Region** ______ **Serial Number** ______ **Odometer** ______ **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: ______

LASER SENSOR, ACCELEROMTER, DMI CALIBRATION/CALIBRATION CHECK FORM		Form PROF-5

PROFILOMETER		DATE (DD/MMM/YYYY)	
		TIME (24Hr)	
OPERATOR		MILEAGE	

SENSOR CALIBRATION CHECK

IRI SENSORS		Block Height (mm)	25 mm Bias	50 mm Bias	75 mm Bias	100 mm Bias	GROUND LEVEL CHECK 25 mm Block	Bias	Pass (Yes / No)
LEFT (ODS 1)									
Height:									
RIGHT (ODS 2)									
Height:									
CENTER (ODS 3)									
Height:									
TEXTURE SENSORS									
LEFT (ODS 4)									
Height:									
RIGHT (ODS 5)									
Height:									
COMMENTS:								Tolerance	≤0.25

BOUNCE TEST RESULTS

Sensor	Initial Static Segment 2 IRI (m/km)	Dynamic Segment 4 IRI (m/km)	Final Static Segment 7 IRI (m/km)	Seg. 2 - Seg 7 IRI (m/km)	Pass (Y/N)	Seg.4-Seg2 IRI (m/km)	Pass (Y/N)
LEFT (ODS 1)							
RIGHT (ODS 2)							
CENTER (ODS 3)							

Segment 2 - Segment 7 must be within ±0.01 m/km. Segment 4 - Segment 2 must be ≤ 0.1 m/km

COMMENTS:

DISTANCE MEASURING INSTRUMENT (DMI) CALIBRATION

Photocell Used (Horizontal or Vertical):		Calibration Length (m):	304.80	Date Performed:
Distance from Horizontal Test (m):		Number of Runs Used in Average:	6	

TIRE PRESSURE (Rear tire pressure to be adjusted per DMI run)			OLD CALIBRATION FACTOR:	
	FRONT (50-55)	REAR (80-85)	NEW CALIBRATION FACTOR:	
LEFT	psi	psi	% CHANGE FROM LAST:	
RIGHT	psi	psi	*STD DEV OF CAL FACTOR (must be ≤0.07)*	

ACCELEROMETER CALIBRATION

ACCELEROMETER	ZERO G	NEG. 2 G	DIFFERENCE	PASS (Y/N)
Left-ODS 1				
Right-ODS 2				
Center-ODS 3				

COMMENTS:

TEXTURE SENSOR CALIBRATION CHECK

Performed with van on first step of ramp

Static Texture Test	MPD VALUE	PASS (Y/N)
Left -Texture (ODS 4)		
Right-Texture 2 (ODS 5)		

To Pass MPD less than 0.33

Dynamic Texture Test	MPD VALUE	PASS (Y/N)
Left -Texture (ODS 4)		
Right-Texture 2 (ODS 5)		

To Pass MPD between 0.694 and 0.806 mm

AMBIENT TEMPERATURE SENSOR, PAVEMENT SURFACE TEMPERATURE SENSOR, AND GPS RECEIVER CALIBRATION CHECK FORM	Form PROF-6

PROFILOMETER		DATE (DD/MMM/YYYY)	
		TIME	
OPERATOR		MILEAGE	

AMBIENT TEMPERATURE SENSOR CALIBRATION CHECK

Probe 1 Temp. (°C)		Thermometer Temp. (°C)		Difference (°C)		Pass (Y/N)	
Probe 2 Temp. (°C)		Thermometer Temp. (°C)		Difference (°C)		Pass (Y/N)	

Diff. between Probe 1 and Probe 2 Temp. (°C)		Pass (Y/N)	

Difference between Probe 1 Temperature and Thermometer Temperature must be within ±2 °C

Difference between Probe 2 Temperature and Thermometer Tempertaure must be within ±2 °C

Difference between Probe 1 Temperature and Probe 2 Temperature must be within ±2 °C

COMMENTS	

PAVEMENT SURFACE TEMPERATURE SENSOR CALIBRATION CHECK

Readings Taken on Ground Surface

Reading from Pavement Temperature Sensor (°C)			
Reading from Temperature Gun (°C)			
Difference (°C)		Pass (Y/N)	

Reading Taken on Ice and Water Mix

Reading from Pavement Temperature Sensor (°C)			
Reading from Temperature Gun (°C)			
Difference (°C)		Pass (Y/N)	

Difference in temperature must be within ±2 °C for both cases

COMMENTS	

GPS RECEIVER CHECK

	Latitude	Longitude
Latitude and Longitude of Location from Google Earth		
Latitude and Longitude from GPS Receiver		
Latitude/Longitude Agree to Four Decimal Places (Y/N)?		

Latitude and Longitude must agree to four decimal places

ADDITIONAL 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 ________________

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).

SIDEKICK CHECKLIST

Date (DD/MMM/YYYY): ______ SHRP ID: ______ Region: ______

Vehicle: ______ Surface (AC/PCC): ______ Completed by: ______

QC Report Components

1.) Header Information

Proqual Sidekick Active Database: ______

2.) Texture

Pavement Texture Type:

- ☐ Asphalt - Fine
- ☐ Asphalt - Coarse
- ☐ Open Graded / Friction Course
- ☐ Chip Seal
- ☐ Concrete - Transverse Tines
- ☐ Concrete - Diamond Ground
- ☐ Concrete - Broom Finish

	Acceptable Criterias or Options	Acceptable or Within Range?			
		Yes	No	Yes	No
		Left Sensor		Right Sensor	
a) Average Mean Profile Depth (MPD)	Range for AC = 0.30 - 6.00 mm	☐	☐	☐	☐
	Range for PCC = 0.30 - 9.00 mm	☐	☐	☐	☐
b) Average Standard Deviation	(If < 1.0 mm)	☐	☐	☐	☐
c) Dropout %	(If < 10%)	☐	☐	☐	☐
d) Texture Type	(Positive, Negative, or Neutral)	______		______	

3.) Global Positioning System

		Latitude		Longitude	
a) Start Coordinates		☐	☐	☐	☐
b) End Coordinates		☐	☐	☐	☐
c) Distance Check	(If ≤ 3 m)	☐	☐	☐	☐
d) Station Check	(If ≤ 6 m)	☐	☐	☐	☐

4.) Air Temperature

		Sensor 1		Sensor 2	
a) Standard Deviation	(If < 0.1 °C)	☐	☐	☐	☐
b) Average Temperature Difference Check	(If < 0.5 °C)	☐	☐		

5.) Surface Temperature

a) Surface Temperature Standard Deviation	(If < 1.0 °C)	☐	☐
b) Reference Temperature Standard Deviation	(If < 1.0 °C)	☐	☐
c) Difference between Surface & Reference Check	(If < 5 °C)	☐	☐

6.) Comments:

Pavement Surface Distress Summary:

APPENDIX C. 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 data.
2. Miscalibrated DMI, incorrect tire pressure, or tires not properly warmed-up.
3. Early start of data collection.
4. Different profiles.

To detect items 3 and 4, the profile data in question must be compared to those collected during the previous site visit. However, item 3 can also be detected when comparing repeat runs obtained at a section. Previous site visit profile data is needed to detect a miscalibrated DMI or tires that are set to an incorrect tire pressure. Tires not being properly warmed-up can be detected when evaluating data collected by the repeat runs.

A brief description of each of these problems is presented in this appendix along with plots illustrating such conditions. In order to perform an accurate and valid comparison with profile data from the previous site visit, the previous site visit data 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 Data

Spikes can be introduced in the profile data as a result of pavement features, equipment problems, due debris on the road, or objects blowing below the sensor. Objects blowing past below the sensor can include paper, leaves, weeds, insects, etc. Debris on the road can include paper, leaves, tire pieces, etc. The 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 131 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 a pavement feature, debris on the road, objects blowing below the sensor, or due to equipment problems. The operator can observe the pavement at the location where the spike occurred to determine if the spike was caused by a pavement feature. It will not be possible to determine if the spike was caused by objects blowing past below the sensor unless operator noted such a situation when collecting data. If it was caused by debris, the location of the debris may have shifted or it may have blown outside of the pavement by passing traffic. If multiple upward spikes are noted on a run, or in repeat runs, with no pavement feature or debris on the road that can explain the cause of the spikes, equipment problems can be suspected.

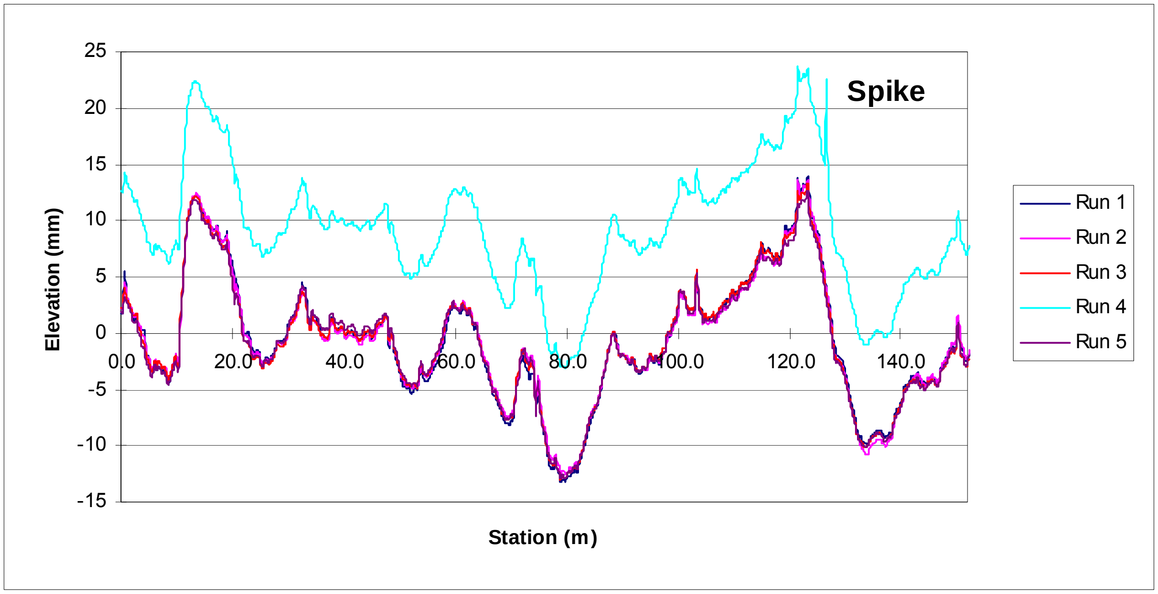

Figure 131. Spike in profile data (profile data for run 4 has been offset for clarity).

2. Miscalibrated DMI, incorrect tire pressure, or tires not properly warmed-up.

A miscalibrated DMI or tires being set to an incorrect tire pressure 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 or if tires have been set to an incorrect tire pressure. 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 132; data for May 2, 1990 was collected using a miscalibrated DMI.

When this problem is encountered, 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, operator should adjust tire pressure so it matches tire pressure when 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.

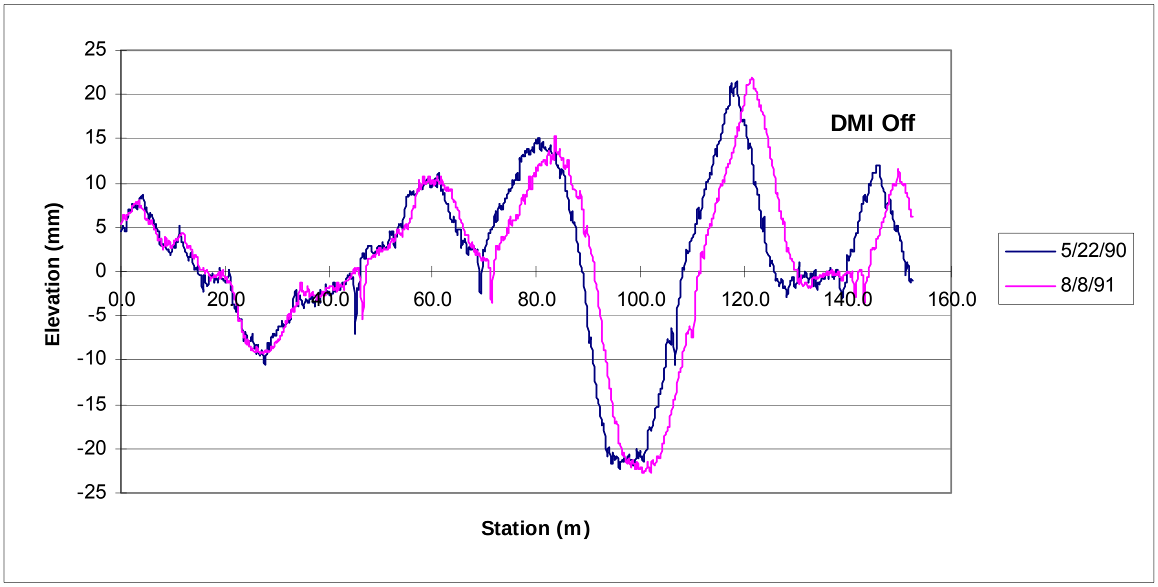

Figure 132. Data collected with a correctly calibrated and a miscalibrated DMI.

1. The operator can determine if the DMI is calibrated correctly by running the section using the photocell as the stop option and noting the length over which data were collected. 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. Currently it is expected that all test sections would have at least two previous profile data sets. 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. 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 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 sections that are located towards the end of the SPS site. 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.

If a profile plot similar to that shown in figure 132 is observed when repeat runs collected by the device at the site are compared, this means the tires in the device have not been warmed-up sufficiently.

3. Early Start of Data Collection

An early profile start can occur when the photocell triggers data collection before 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 133, 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 before the start of the test section, the operator can use the horizontal photocell to initiate data collection.

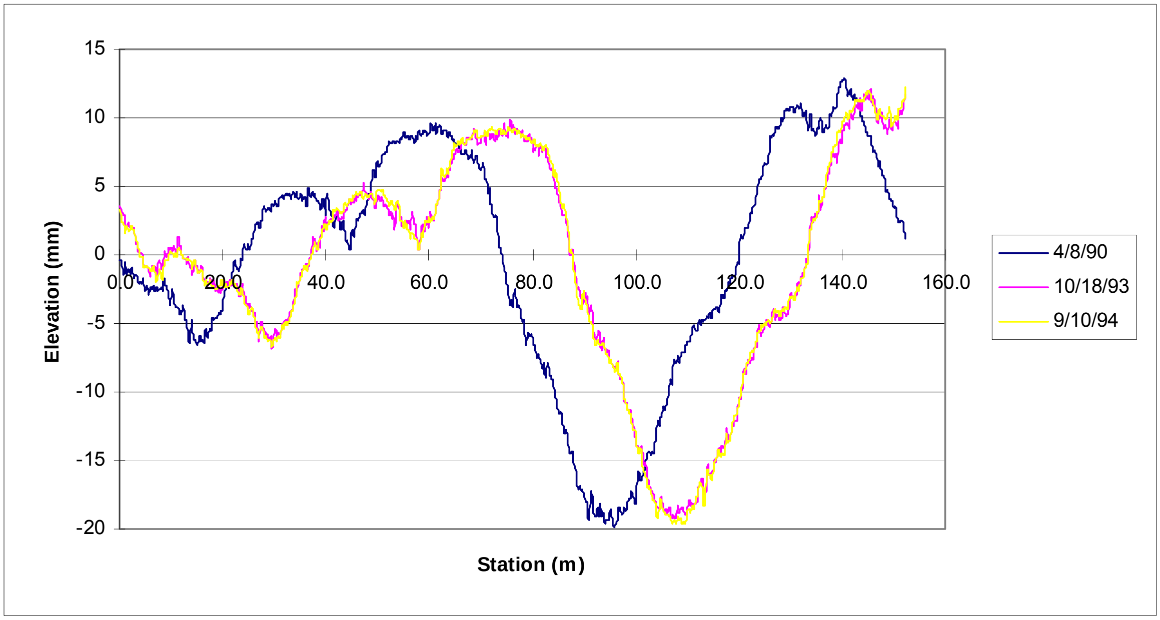

Figure 133. Example of early profile start.

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 133. 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 2.9.4) is obtained. If the early start problem is caused by a mark on the pavement that is located before the start of the test 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 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 operator compares current data with that from previous site visit (also error free), the two sets of profiles appear to be different.

Such a 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 134 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 sometime 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 134 will also be seen.

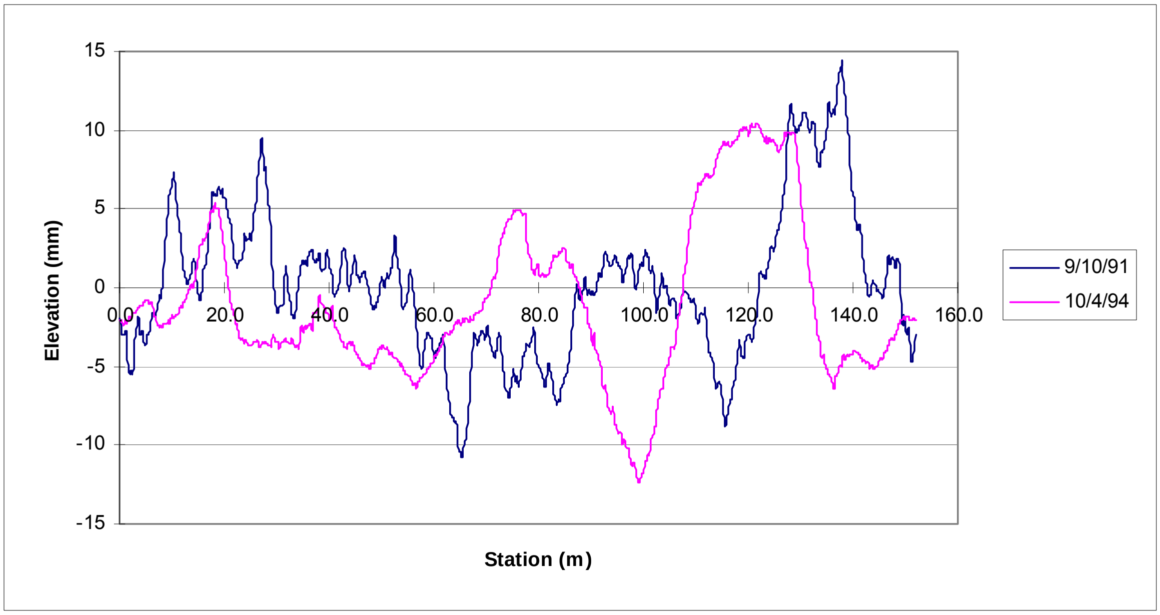

Figure 134. Differences in profile due to rehabilitation of section.

If a case such as that shown in figure 134 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.

An example where maintenance has occurred on a portion of the test section between site visits is illustrated in Figure 135. 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 135 is encountered, the operator should look to see if there is evidence of maintenance activities in the portion of the pavement where profiles are different. 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.

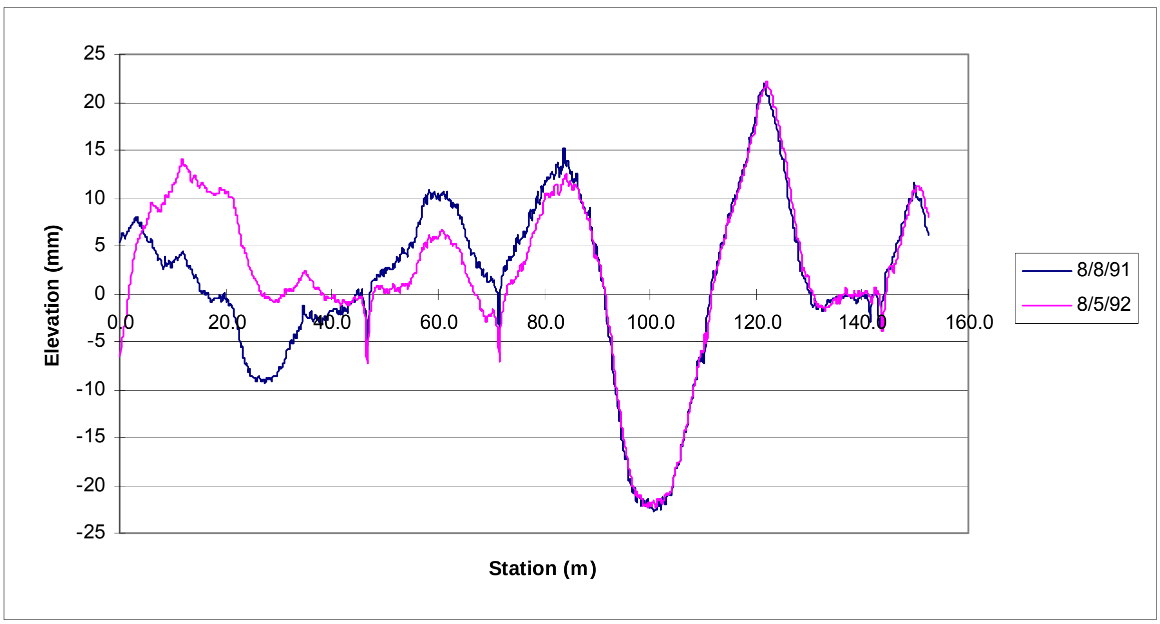

Figure 135. Differences in profile due to maintenance within section.

APPENDIX D. DIFFERENCES BETWEEN ICC AND AMES PROFILE DATA

When profile data are plotted, differences between profile data collected by ICC devices and Ames Engineering devices can be observed. These differences occur because of differences in the upper wavelength cut-off filter that is applied on the data by the two devices. Although both devices apply a 100 m upper wavelength cut-off filter on the profile data, there are differences in the upper wavelength cut-off filter that is used by each device.

Figure 136 shows the left wheel path profile data collected by the ICC and Ames Engineering devices at a test section. The profile data collected at this section by the two devices look very different. Figure 137 shows the power spectral density (PSD) plot of the profile data shown in figure 136, and this plot shows the two devices collected similar spectral content at this section with some differences seen for wavelengths close to 100 m, which is the upper wavelength cut-off used for both data sets.

.

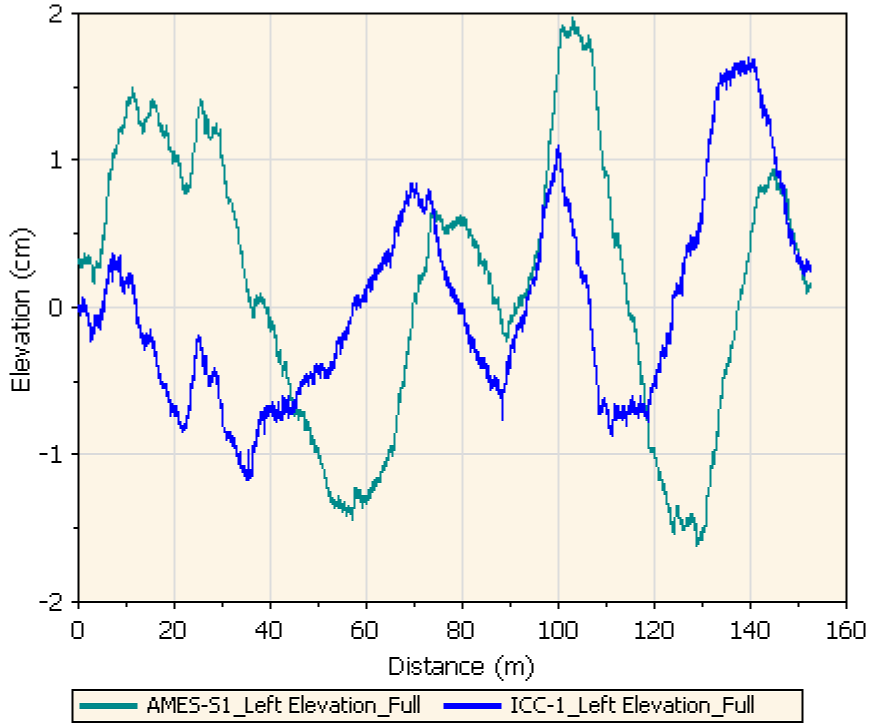

Figure 136. ICC and Ames profile data collected at Section 1.

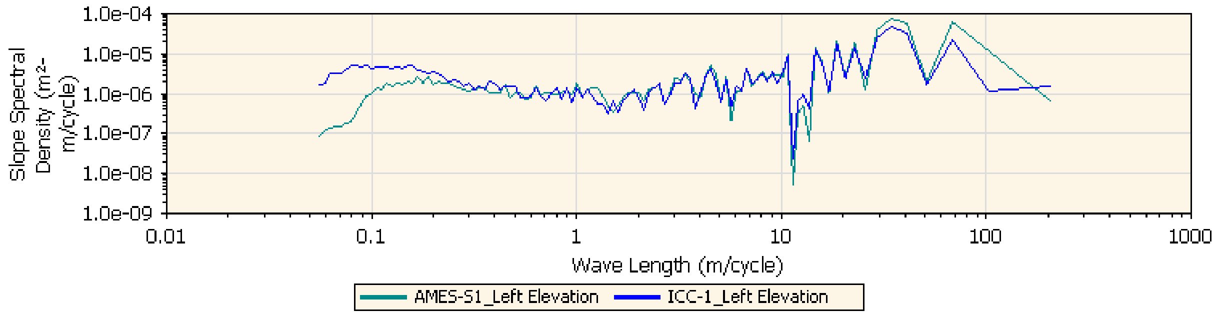

Figure 137. PSD plot of profile data collected by ICC and Ames devices at section 1.

Figure 138 show the left wheel path profile data collected by the ICC and Ames Engineering devices at another test section. Similar to figure 136, the profile data collected at this section by the two devices look very different. However, some of the sharp upward and downward features in the two profiles occur at the same distance. Figure 139 shows the PSD plot of the profile data shown in figure 138, and the plot shows the two devices collected similar spectral content at this section, except for some content close to 100 m, which is the upper wavelength cut-off used for both data sets.

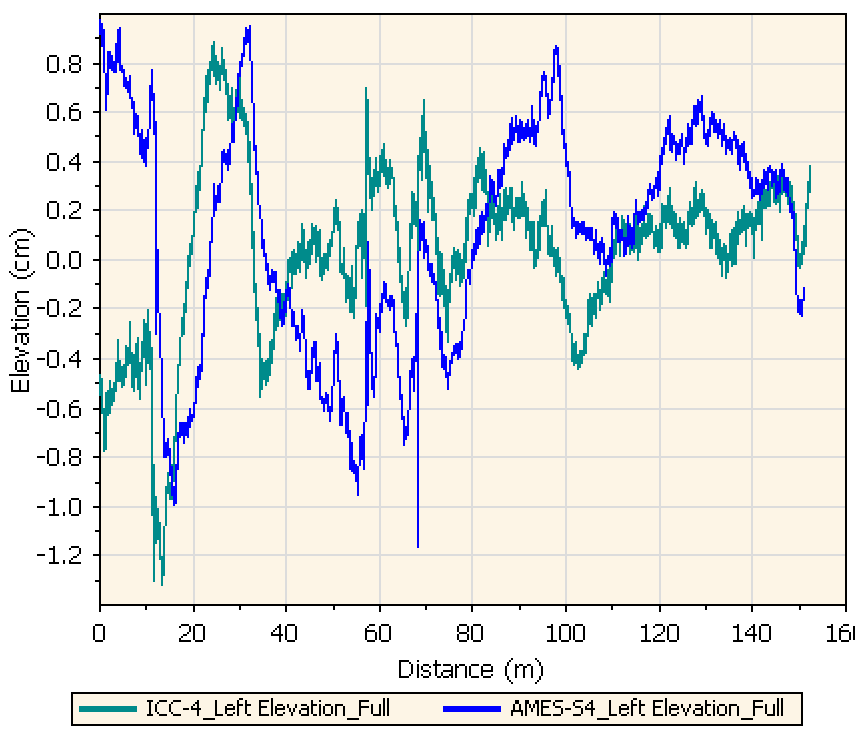

Figure 138. ICC and Ames profile data collected at Section 4.

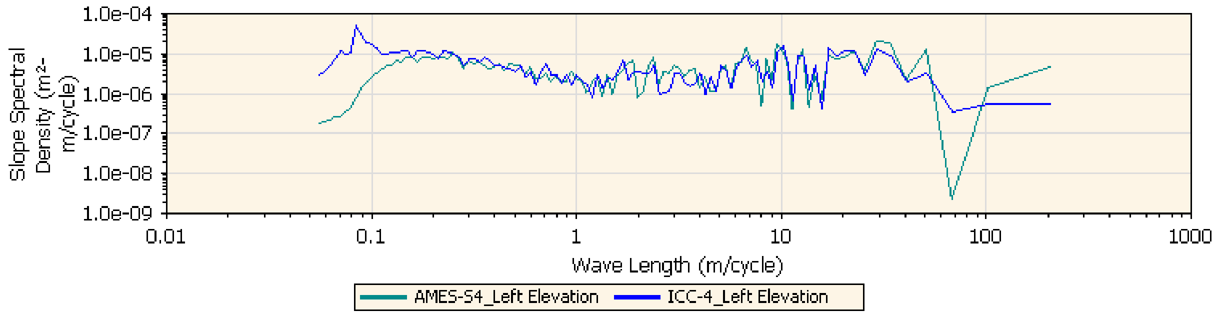

Figure 139. PSD plot of profile data collected by ICC and Ames devices at section 4.

Section 2.9.4.1 of this manual indicates that operators should compare profile data collected during a site visit with previous data collected at the site as a quality control measure to verify that the data were collected at the same section and as a check on the proper functioning of the equipment. However, as shown by the two examples in this appendix, comparing profile data collected by the Ames device with profile data collected by the ICC device at the same section can be problematic as profile plots of the two data sets look different. Accordingly, the operator should instead look at sharp upward and downward features in the two profile plots to see if they coincide.

APPENDIX E. 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: 1500/2000/2200 Dipstick Fitted With 32 mm footpads? ___

Footpad Spacing (mm): [_ _ _ . _ _] Operator: [_ _] Recorder: [_ _]

Site Type: GPS/SPS/WIM/Other Surface Type: [_ - _ _] Pavement Condition: V.GOOD/GOOD/FAIR/POOR

Road Name:____________________________________ Lane: Inside/Outside

Direction: NORTH/EAST/SOUTH/WEST Cloud Conditions: CLEAR/P. CLOUDY/CLOUDY

Start Air Temperature: ___°C End Air Temperature:__°C Average Air Temperature:__°C

Weather Comment:____

Start Time (military): ____ : ____ __ __ Stop Time (military): ____ :____ __ __

Closure Error Computation

Right Wheel Path		Left Wheel Path	
No	Elevation Sum	No	Elevation Sum
O1		I1	
O2		I2	
O3		I3	
O4		I4	
O5		I5	
O6		I6	
O7		I7	
O8		I8	
O9		I9	
O10		I10	
O11		I11	
O12		I12	
O13		I13	
O14		I14	
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
Total OA+OB	OC	Total IA + IB	IC

Traffic Control Crew:

Other Personnel At Site:

Closure Error
OC+IC

LTPP Dipstick Data Collection Form Longitudinal Profile Form DS-2 Reading 1 to 100	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

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

LTPP Dipstick Data Collection Form Longitudinal Profile Form DS-4 Readings 201 to 300	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 ⇑
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-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 #: [___ ___ ___ ___ ___]   Dipstick® Model #: [___ ___ ___ ___]
Operator: [___ ___]   Recorder: [___ ___]   Site Type: [___ ___ ___]   Visit: [___ ___]
Surface Type: [___ - ___ ___]   Condition: ______________________________

State Code [___ ___]
LTPP Section ID [___ ___ ___ ___]
Date (dd/mmm/yy) __ __ / __ __ __ / __ __
Time [___ ___ : ___ ___]

Road Name: ______________________________   Lane: Outside / Inside (Circle One)   Direction: [___ ___ ___ ___ ___]

Clouds: ____________   Temperature (°C): [___ ___ . ___]   Weather Comment: ______________________________

Location	Dipstick® Readings (mm)																Sum	Closure
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16		
0 m																		
Difference																		
15.24 m																		
Difference																		
30.48 m																		
Difference																		
45.72 m																		
Difference																		
60.96 m																		
Difference																		
76.20 m																		
Difference																		
91.44 m																		
Difference																		
106.68 m																		
Difference																		
121.92 m																		
Difference																		
137.16 m																		
Difference																		
152.4 m																		
Difference																		

COMMENTS: ______________________________

There is no Form DS-9

LTPP Dipstick Operations LTPP Major Maintenance/Repair Form DS-10	Region [ ] Serial Number [ ] 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	
Air Temperature Probe Calibration Check	**Region** [_ _]
	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 F. 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 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 140 shows the layout of the test section.

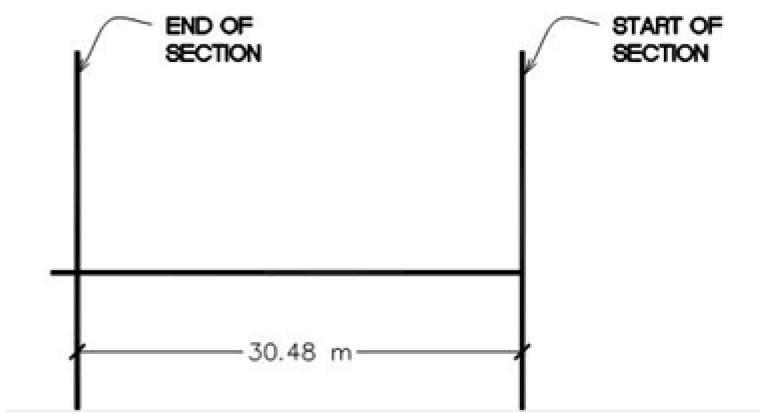

Figure 140. Test section layout.

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 141).

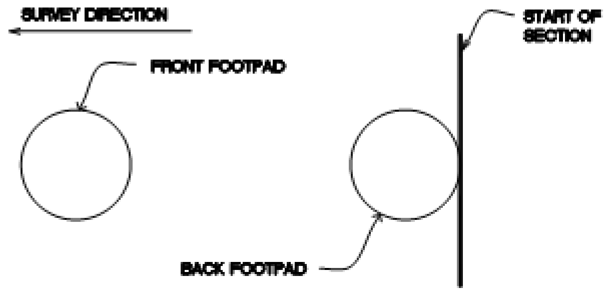

Figure 141. Location of back footpad of Dipstick® at start of the section.

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 142). The distance to be measured is the distance X indicated in figure 142. 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 143). The distance to be measured is the distance X indicated in figure 143. 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.

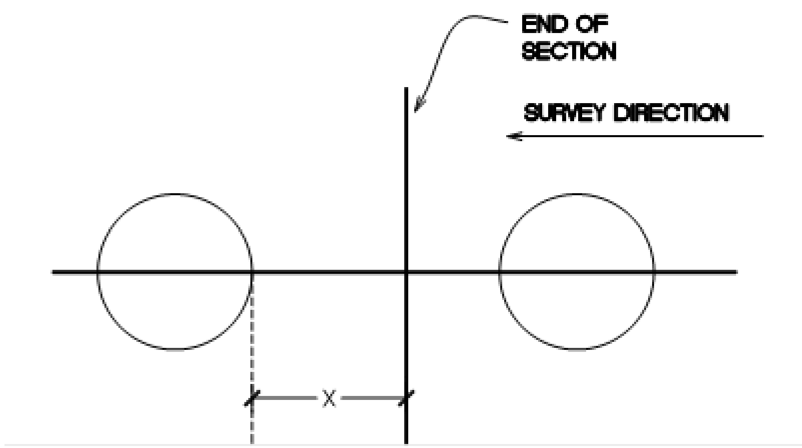

Figure 142. Back end of front footpad is past the end of the test section when last reading is obtained.

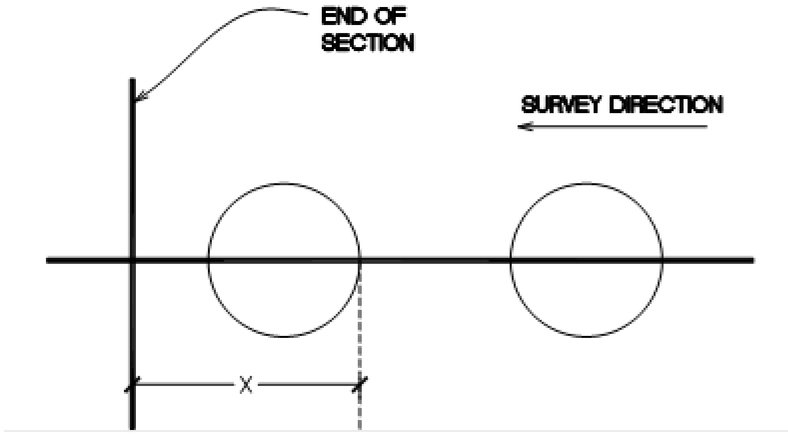

Figure 143. Back end of the front footpad is before the end of the test section when last reading is obtained.

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 142), use the following formula to compute footpad spacing.

   Footpad spacing (mm) = (30480 + X) / 100, 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 143), use the following formula to compute footpad spacing.

   Footpad spacing (mm) = (30480 - X)/100, 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).

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 G. DATA COLLECTION FORM FOR ROD AND LEVEL PROFILE MEASUREMENTS

LTPP Rod and Level Data Collection Form Longitudinal Profile Measurements Form RL-1

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:

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:

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 Rod and Level Data Collection Form Longitudinal Profile Measurements Form RL-5

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 H. FORMS FOR INTER-REGIONAL PROFILER COMPARISON TESTS

PROFILE HEIGHT SENSORS - STATIC HEIGHT SENSOR MEASUREMENTS | FORM COMP-1

RSC: ________
Date: ________

Value of Height (mm) when Device is on a Level Surface: ODS1: ______ ODS2: ______ ODS3 ______

Left Sensor

Position	Block Height (mm)						Avg. of Heights (mm)	Actual Block Height (mm)	Bias (Average-Actual) (mm)	Std Dev. of Heights (mm) (Note 1)
	Sample Number									
	1	2	3	4	5	6				
Block Height Measured by System - 25 mm Block										
Block Height Measured by System - 50 mm Block										
Block Height Measured by System - 75 mm Block										
Block Height Measured by System - 100 mm Block										

Center Sensor

Position	Block Height (mm)						Avg. of Heights (mm)	Actual Block Height (mm)	Bias (Average-Actual) (mm)	Std Dev. of Heights (mm) (Note 1)
	Sample Number									
	1	2	3	4	5	6				
Block Height Measured by System - 25 mm Block										
Block Height Measured by System - 50 mm Block										
Block Height Measured by System - 75 mm Block										
Block Height Measured by System - 100 mm Block										

Right Sensor

Position	Block Height (mm)						Avg. of Heights (mm)	Actual Block Height (mm)	Bias (Average-Actual) (mm)	Std Dev. of Heights (mm) (Note 1)
	Sample Number									
	1	2	3	4	5	6				
Block Height Measured by System - 25 mm Block										
Block Height Measured by System - 50 mm Block										
Block Height Measured by System - 75 mm Block										
Block Height Measured by System - 100 mm Block										

Note 1: Calculate standard deviation using the STDEVP function in Excel

TEXTURE HEIGHT SENSORS - STATIC HEIGHT SENSOR MEASUREMENTS — FORM COMP-2

RSC: ________
Date: ________

Value of Height (mm) when Device is on a Level Surface: ODS4: ______ ODS5: ______

Left Sensor

Position	Block Height (mm)						Avg. of Heights (mm)	Actual Block Height (mm)	Bias (Average-Actual) (mm)	Std Dev. of Heights (mm) (Note 1)
	Sample Number									
	1	2	3	4	5	6				
Block Height Measured by System - 25 mm Block										
Block Height Measured by System - 50 mm Block										
Block Height Measured by System - 75 mm Block										
Block Height Measured by System - 100 mm Block										

Right Sensor

Position	Block Height (mm)						Avg. of Heights (mm)	Actual Block Height (mm)	Bias (Average-Actual) (mm)	Std Dev. of Heights (mm) (Note 1)
	Sample Number									
	1	2	3	4	5	6				
Block Height Measured by System - 25 mm Block										
Block Height Measured by System - 50 mm Block										
Block Height Measured by System - 75 mm Block										
Block Height Measured by System - 100 mm Block										

Note 1: Calculate standard deviation using the STDEVP function in Excel

ACCELEROMETER CALIBRATION CHECK, BOUNCE TEST, AND TEXTURE DYNAMIC CHECK FORM	FORM COMP-3

Region		

STATIC AND DYNAMIC BOUNCE CHECK

	Initial Static Segment 2 IRI (m/km)	Dynamic Segment 4 IRI (m/km)	Final Static Segment 7 IRI (m/km)	IRI Seg. 4 - Seg. 2 (m/km)	Pass (Y/N)	IRI Seg. 7 - Seg. 2 (m/km)	Pass (Y/N)
LEFT (ODS 1)							
RIGHT (ODS 2)							
CENTER (ODS 3)							
COMMENTS							

ACCELEROMETER CALIBRATION

ACCELEROMETER	ZERO G	NEG. 2 G	DIFFERENCE	PASS (Y/N)
Left-ODS 1				
Right-ODS 2				
Center-ODS 3				
COMMENTS				

TEXTURE SENSOR CALIBRATION CHECK

Performed with van on first step of ramp

SENSOR	MPD (mm)	PASS (Y/N)
Left -Texture (ODS 4)		
Right-Texture 2 (ODS 5)		

DMI MEASUREMENTS FORM	FORM COMP-4

RSC ______________

Date ______________

Left Rear Tire Pressure Before Test (psi): ______________

Right Rear Tire Pressure Before 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)
1		
2		
3		
4		
5		
6		
Average		
Std Dev		

Note 1: Use the STDEVP function in Excel to calculate Std.Deviation

DMI VERIFICATION FORM	FORM COMP-5

RSC ________________
Date ________________

Left Rear Tire Pressure Before Test (psi): ____________________
Right Rear Tire Pressure Before 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)
1		
2		
3		
4		
5		
6		
Average		
Std Dev		

Note 1: Use the STDEVP function in Excel to calculate Std.Deviation

IRI VALUES	FORM COMP-6

Left Wheelpath

Site Number	Site Description	Left Wheelpath 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 Wheelpath

Site Number	Site Description	Right Wheelpath 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 STDVP function in Excel to calculate standard deviation

MPD VALUES	FORM COMP-7

Left Wheelpath

Site Number	Site Description	Left Wheelpath MPD (mm)					Average MPD (mm)	Standard Deviation (mm) (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 Wheelpath

Site Number	Site Description	Right Wheelpath MPD (mm)					Average MPD (mm)	Standard Deviation (mm) (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 STDVP function in Excel to calculate standard deviation