



Skid System Operator's Manual

Presented by: Construction Division,
Materials & Pavements Section (CST-M&P)



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Chapter 1 – Skid System Overview

Section 1. Introduction

Resistance to skidding is an important criterion for measuring road surface quality. Roads become less skid resistant as traffic wears down the road or oils and tar begin to coat the surface. We quantify the road's skid resistance to identify roads that may require treatment.

Section 2. Skid Data Collection and Data Analysis

TxDOT began collecting skid resistance data in 1973 using a towed two-wheeled trailer with a tire that locked causing it to skid along the pavement. An electronic torque ring strain gauge located on the axle of the skidding tire produced strain measurements that were plotted on a paper strip chart. A pressurized water sprayer in front of the tire provided a layer of water (about 1.5 gallons) upon

which the tire skidded. The water served as a lubricant to prevent the skidding tire from jerking the trailer to the side, and it simulated the skid resistance of the road during wet conditions. When manually processed, the strip charts yielded skid resistance or *skid number*.



Figure 1 - Two-wheeled trailer with left wheel path locking tire.

The same data collection method is used today; but a computer controls the mechanical systems and performs data analysis in real time.

Skid data is normally collected at half-mile intervals along highways at 50 mph, but may be gathered at shorter intervals of 300 feet or less. The half-mile interval satisfies two needs: 1) to obtain a representative sampling of any section of road and 2) to minimize wear on the skid tire while conserving water. Shorter intervals of roadway sampling is done to test new surfacing or to obtain an average skid number using multiple skids.

Skid data is stored with Pavement Management Information Systems (PMIS) highway locations and later uploaded to TxDOT mainframe systems.

An individual skid cycle is usually conducted in about two seconds. The following table outlines the steps performed in the automatic skid cycle process:

Steps Performed During an Individual Skid Cycle

Step	Action
1	Spray water in front of the tire.
2	Lock the wheel $\frac{1}{2}$ second after the water begins to spray.
3	Skid the wheel along the pavement.
4	After skidding 75 feet, release the brake.
5	Stop water spray $\frac{1}{2}$ second after tire is unlocked.

During the skid cycle, an embedded personal computer (EPC) module in the trailer controls the water sprayer and braking system. The EPC module simultaneously collects strain gauge data from the torque ring strain gauge over a two second period at a rate of a hundred times a second. This data is transmitted to the personal computer (PC) in the truck cab over the RS485 network to be processed in real time and stored on the hard drive.

The torque ring strain gauge sensor changes voltages as it experiences an increase in torque force. Torque force is defined as the rotational force required to rotate an object and is measured in ft-lbs. A properly calibrated ASTM E274 TxDOT trailer produces about 500 ft/lbs for a skid number of 48.

A graph showing the skid cycle is shown here. The horizontal axis is in hundredths of a second, ranging from 0 to 2.00 seconds, while the vertical axis shows skid numbers on a scale of 1 to 100. The skid number is calculated using the recorded ft-lbs. of torque, various factors and constants, and then scaled to be within a range of 1 to 100 (the actual equation is shown in Chapter 3, under Section 3, Mechanical Setup and Tests Window, Figure 21. An example of the Equations window.). Finally, the red line is drawn to display how the calculated skid value fits with the data collected. The gallons per minute (GPM) tag shows the water flow rate calculated during the skid.

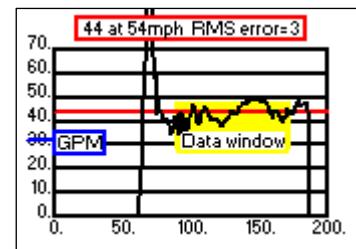


Figure 2 – Skid Graph example of a skid cycle.

When the brake is applied during the skid cycle (at 0.54 seconds), the initial torque produced is higher than the scale. As the tire begins to skid on the film of water (0.72 seconds), the torque produced drops and then levels out (0.80 to 1.80 seconds).

A data window defined over this interval (area in yellow) is where the skid number is computed. The brake is released at 1.80 seconds and the torque exerted on the wheel returns close to zero; at the same time, the water is turned off.

A root mean square (RMS) error is calculated to give an indication of the skid number calculation is accurate. In the skid graph shown, the skid value is 44 with an accuracy of ± 3 skid numbers. A lower RMS value would have been obtained if the data values rested more on the red horizontal line representing the calculated skid number value.

Each year, skid data is collected on 25% of the state highway system and 50% of the interstate highway system. The data collected is made available to TxDOT engineers through PMIS and is used for various pavement analyses.

Section 3. Computer Hardware/Software Description

The current hardware configuration required for operating the skid system includes:

- ◆ one PCA-6186 computer with:
 - Intel P4 3.06 GHz processor
 - LAN
 - Sound Blaster Live Sound card
 - VGA
 - 2 GB 2.66 MHz RAM
 - 80 GB hard drive
 - Star Tech RS485 Serial Adapter Card for the VAMOS computer
- ◆ keyboard
- ◆ LCD monitor
- ◆ trackball mouse
- ◆ Ethernet hub
- ◆ DMI/GPS computer
- ◆ Houtex Laser Computer and
- ◆ an embedded personal computer (EPC) module. The EPC module is connected using the RS485 interface through COM port 5 of the VAMOS computer.

Currently, Windows XP is the supported Windows operating system; the PC programming software is Visual Basic; the software used in the DMI/GPS and EPC module is written in C programming language.

Chapter 2 – Skid Truck and Trailer

The truck cab houses the DMI/GPS computer, main PC computer, display devices, power inverter, and console control panel . The back of the truck holds the water tank, and generator.

Section 1. Truck Cab

A typical cab is shown in the photo, “Skid System Cab.” Components include:

- ◆ Right of Way (ROW) Video Camera
- ◆ Flat Panel VGA Monitor
- ◆ Keyboard
- ◆ Console Control Panel

Console Control Panel

The Console Control Panel shown in the photo labeled “Console Control Panel” provides a set of switches that are connected to various components of the skid truck and trailer. LED indicators show whether the switch is on and off. When starting up the truck and equipment, turn the switch ON in the proper sequence (see Chapter 3 for sequence details). During the skid cycle, the main computer signals the trailer EP module to turn the water and brake ON; this activity can be monitored by the indicator lights lighting when each item is ON.

In the event the computer malfunctions, the operator can turn the water and brake ON and OFF manually from the Console Control Panel. If the computer program freezes in the middle of a skid cycle, turn the brake and water switches ON then OFF again. If this fails, turn the hydraulic pump off, which releases the brake. Note that both the water pump and hydraulic pumps must be ON for either the brake or water systems to work.



Console Control Panel



The DMI/GPS computers box can be found in the rack mounted behind the passenger seat. A distance measurement instrument (DMI) sensor is attached to the truck transmission and sends a pulse at each axle revolution to the DMI/GPS box.

The Ethernet Switch, Houtex Laser Computer, and VAMOS computers are also found in the rack, behind the passenger seat. Each connection to the Ethernet Switch can be found by following the Ethernet cable from the Ethernet Switch to the connected device. When operating properly, a green light should be present for each cable running to the Ethernet switch.

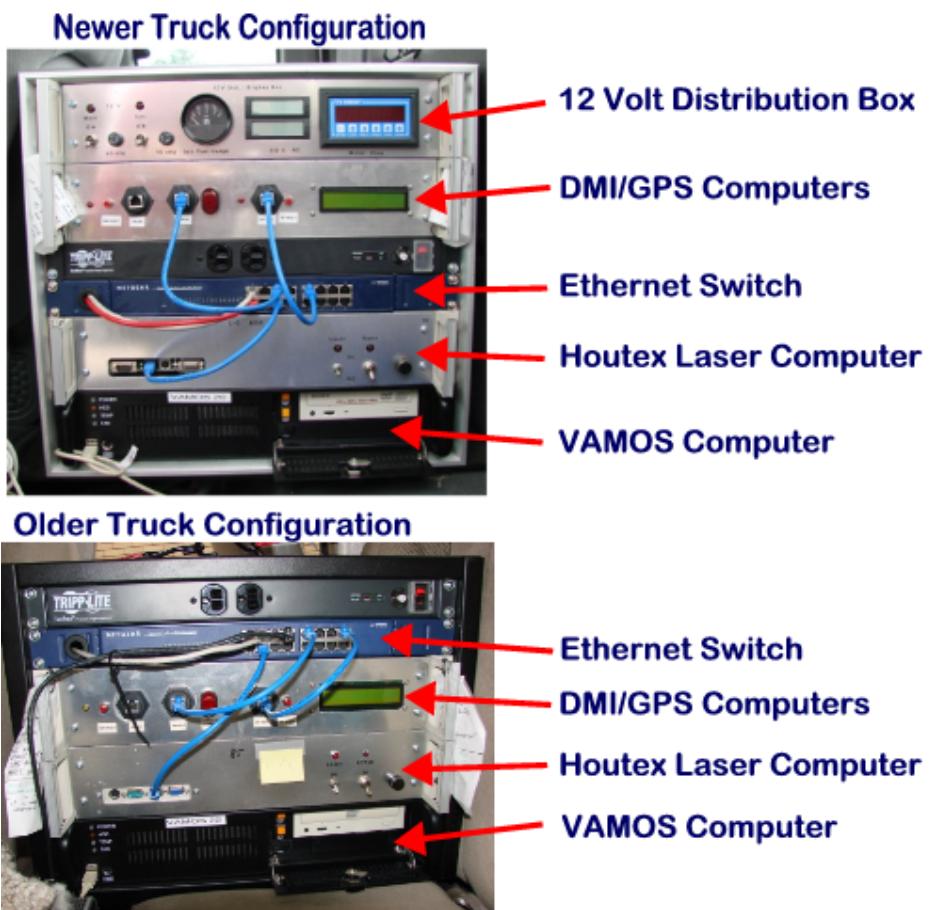


Figure 3 – Equipment Rack, two configurations.

Newer trucks will also have a 12-Volt Distribution / Display Box mounted in the rack. Figure 4, displays the functions of this box.

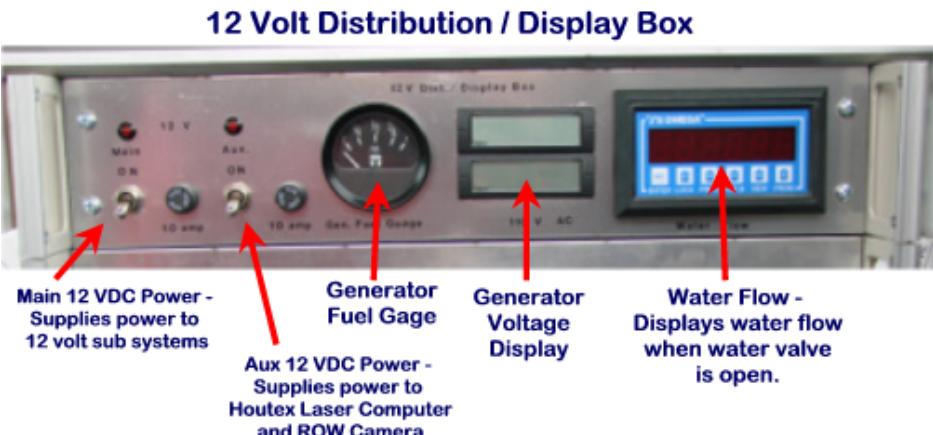


Figure 4 – 12 Volt Distribution / Display Box

Section 2. Truck Bed

Two views of the back of the truck bed are shown below to illustrate the location of the water tank, generator, and location of the water flow control valve. The fire hydrant wrench, used to attach the fire hose to a fire hydrant, is stored in the compartment with the fire hose.

Water Flow Control Valve -

The water flow control valve is attached to a water line coming out of the water tank. Increase or decrease the backpressure on the water pump by using the manual control valve regulates the flow of water. As backpressure increases, more water is forced through the trailer valve then back into the water tank; therefore, *closing* the valve (clockwise rotation) increases the flow to the trailer.

Water Tank

The water tank holds approximately 250-300 gallons of water, depending upon tank model. The tank is refilled by connecting a fire hose to a fire hydrant. Use the following procedure to fill the tank:

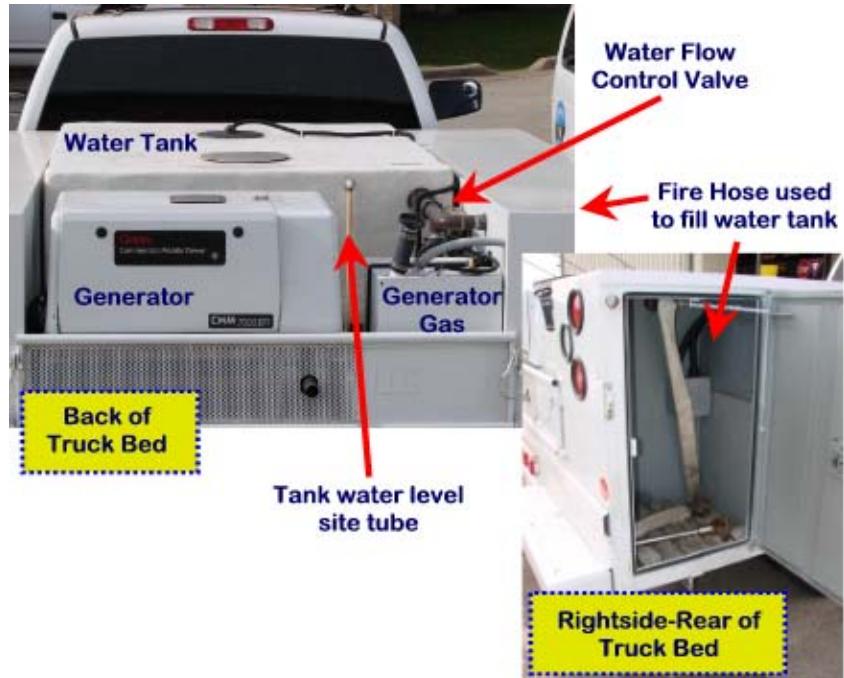


Figure 5 – Equipment locations in bed of truck.

Step	Action
1	Uncoil the fire hose from the back of the truck, making sure there are no kinks in the hose.
2	Before attaching the hose to the hydrant, open the hydrant until the water runs clear.
3	After the hydrant has been cleaned out, attach the hose.
4	Use the hydrant wrench to slowly open the fire hydrant.
5	Once the hose is filled and water is running into the tank, open the fire hydrant valve all the way.
6	Monitor the water level by looking at the fill tube located on the tank or watch for overflow from the tank vent.
7	After filling the tank, close the fire hydrant valve, disconnect the fire hose, and lay the hose neatly back in truck.
8	Replace all fire hydrant caps; then store the hydrant wrench in the hose storage compartment.
NOTE: The water tank can also be filled using overhead water supplies at some TxDOT offices.	

Generator

The generator supplies 120 volt AC power to the water pump, hydraulic motor, and other electronics in the trailer. However, the computers and equipment in the truck cab are not powered by the generator; they are powered by a DC to AC inverter located in the truck cab, with voltage supplied by the truck power system.

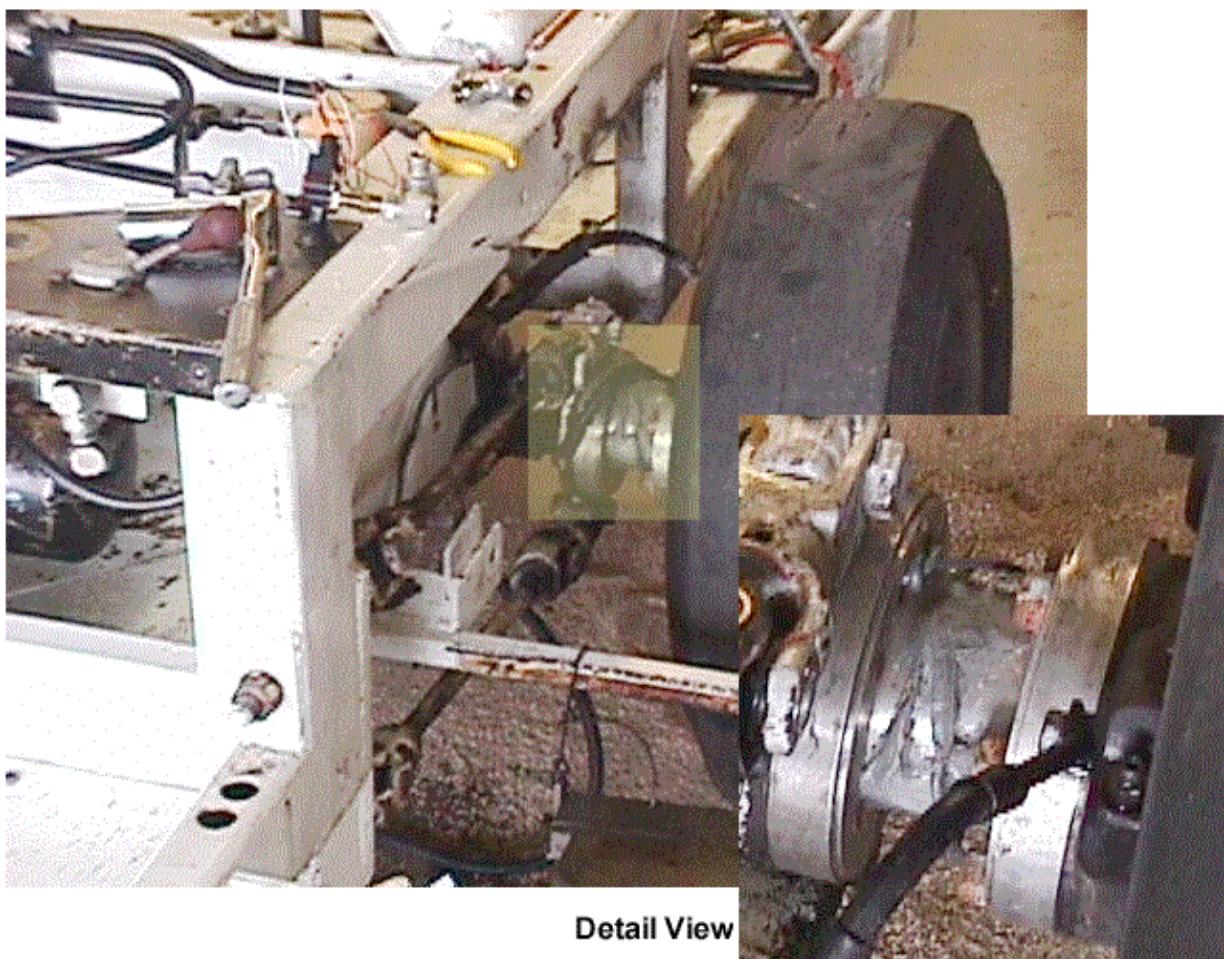
Section 3. Skid Trailer

The skid trailer houses the torque ring sensor, water delivery system, water flow meter, and hydraulic system. The trailer is connected to the truck electronically through a multi-wire cable located above the trailer hitch. Two spare tires are stored in the rear compartment. The lid on the top of the trailer allows access to the EPC, hydraulic system, and other electrical connections.

Torque Ring Sensor

The torque ring sensor is an aluminum ring containing a Wheatstone bridge circuit. The bridge circuit attaches to the axle and brake assembly. A rotational force exerted on the ring causes a difference in electrical resistance proportional to the torque. The actual change in electrical resistance is very small and is amplified by the Wheatstone bridge circuitry.

Torque Ring Sensor on Skid Tire Axle



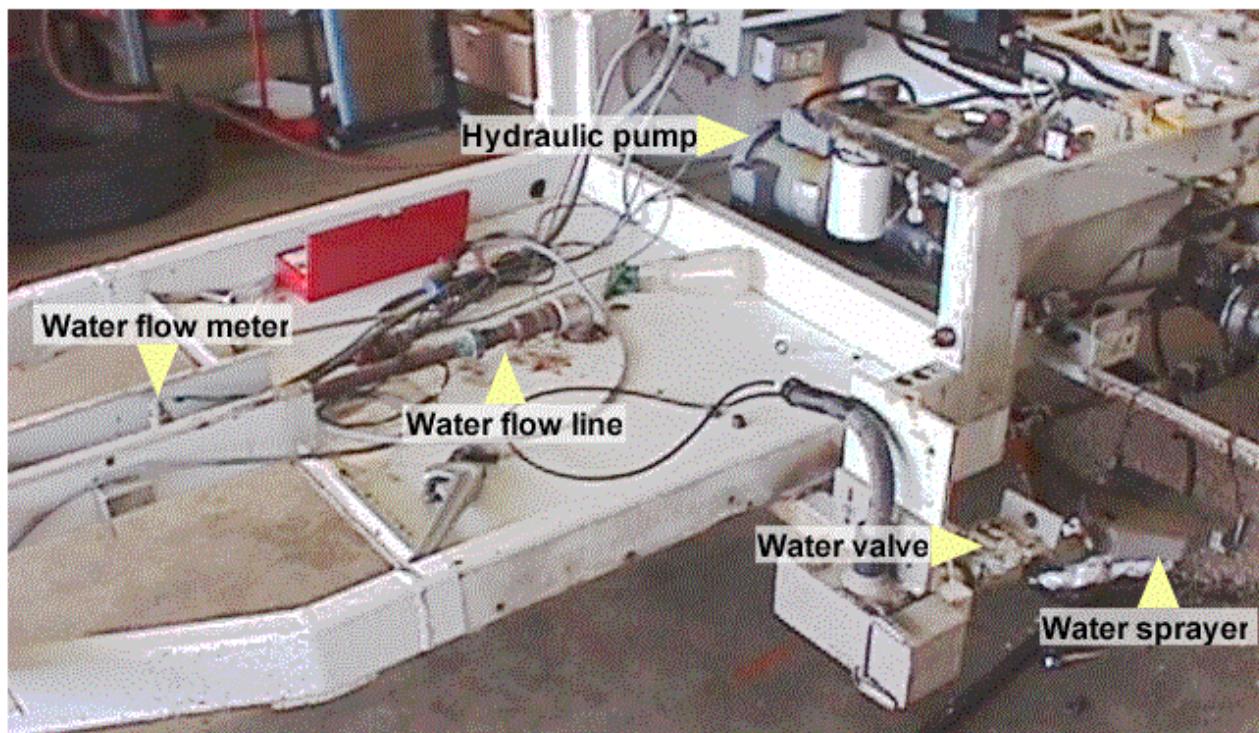
Water Distribution System

The water distribution system of the trailer (below) is composed of:

- ◆ a water sprayer mounted directly in front of the skid tire
- ◆ an electrically-controlled water valve
- ◆ water flow line and
- ◆ a water flow meter.

The water flow meter is a turbine that rotates as water flows through the meter. A full rotation produces a voltage pulse detected by the EPC module, and measured as a water count. Each count is added to produce the current water count. The EPC module transmits the water count to the cab computer, which calculates the water flow using a water calibration factor.

Water Distribution System in Trailer



Hydraulic System

The trailer houses a hydraulic pump powered by the generator in the back of the truck. The hydraulic pump supplies fluid for the skid tire brake and trailer jacks. A control valve under the access cover of the trailer operates the trailer jacks.

Chapter 3 – Skid2007 (Data Collection Software)

Section 1. Introduction

The Skid2007 software is found on the VAMOS computer installed in the truck cab. Skid2007 and the other VAMOS software are currently configured to use the Windows XP operating system. Output is displayed on a flat panel monitor, mounted next to the dashboard.

The PC COM port 5 is connected to an EPC module in the trailer using an RS485 cable. The EPC module acquires the data and interfaces with the switches and controls of the skid system and trailer. The PC provides the user interface, initiates the skid cycle, calculates the skid number, and saves that number with associated PMIS header information.

The program also has a simulation mode where it can be run on a user's desktop.

Section 2. Main Program Window

After the computer initializes and displays the main Windows desktop, double-click the VAMOS icon (see Figure 6 - VAMOS shortcut icon.) installed on the desktop.



After the AppMgr program has finished loading, press the **Start** button, located next to the SKID indicator, to start the Skid2007 program.

Figure 6 - VAMOS shortcut icon.

In the application title bar “Skid2007 Loading” displays until the application has finished loading. After loading is complete, the message “Ready to SKID!” is displayed just above the text display window on the left side. In this particular example, the message “***SKID

PROGRAM IN SIMULATION

MODE*”** is shown indicating that the program is running in simulation mode rather than normal data collection mode.

NOTE: “Connection for SKID4 received...” should be displayed. If not, close the skid program and restart. Repeat this step until the proper text is displayed.

When the **Skid2007** program window is opened for the first time each day, the pop-up message (see Figure 8), “Perform daily tests. . .” instructs the operator to perform the daily calibrations. This message serves as a reminder to complete the calibrations before beginning data collection.

At the same time, the **Mechanical Setup and Tests**

window appears; functions on this window will be used as the daily calibrations are completed.

After the daily calibrations have been performed, neither of these windows will appear automatically again until the next day.

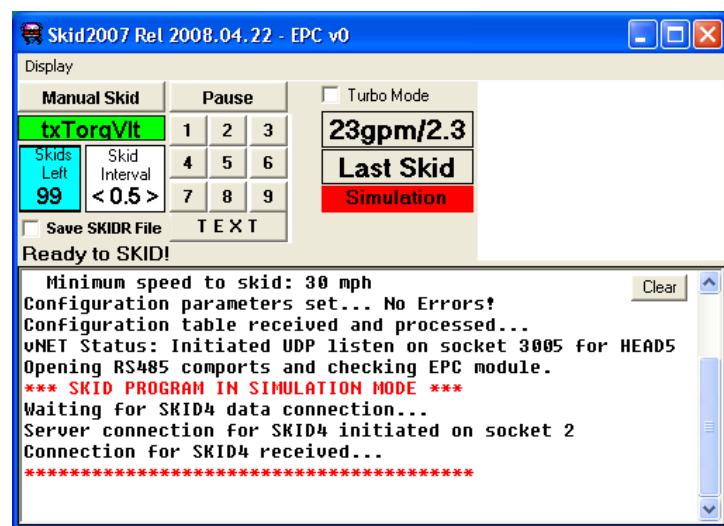


Figure 7 - Screen shot showing the application is ready for use.



Figure 8 - Screen shot of SKID2007 opening program window with reminder message.

NOTE: The program prevents the user from collecting data until the system has been calibrated; the “Perform daily tests. . .” message will appear again when the user attempts to collect skid data before the daily calibrations have been completed.

The Skid2007 program application has several features that are available in the main program window and several available by accessing pull-down menus. The controls on the main program window are discussed first.

Section 3. Main Program Window Features

Manual Skid and Pause Buttons

In the upper left corner of the program window, there are two buttons: **Manual Skid** and **Pause**. To activate either button, position the pointer over the button and click the left mouse button.

The **Manual Skid** button is used to perform skids at precise points along the highway or to supplement the existing interval data collection. The button may also be used to pause and resume the system if the operator doesn't want to wait for another skid interval to obtain a data collection point. Another possible usage of this function is to force a skid when the last skid was skipped due to speed below 30 mph.

NOTE: When using **Manual Skid** to attempt skids at a precise point, factor in about a one-second delay prior to skid initiation.

The **Pause** button is only available during data acquisition in the RUN mode. When **Pause** is selected, the Skid2007 program does not perform skids, but other programs will continue normally. Also, when selected, the **Pause** button's caption will change to **Resume**; pressing the button again resumes skidding at the next scheduled skid interval or PMIS section.

This feature can be useful to avoid skidding in construction zones or other areas where valid skid data is unable to be collected without stopping and restarting data collection.

Skids Left Indicator

To enable the proper operation of the Skids Left indicator, only reset the display after filling the water tank. To reset the display, double-click on the **Skids Left** display and choose “Yes” to fill up the tank.

NOTE: Double-click the **Skids Left** display only when the operator has verified the water tank is full.

The **Skids Left** display updates after each skid and provides a visual reference to the number of skids remaining before the water tank is empty. On program exit, the Skids Left number is saved and resumes from the last number saved when the program is restarted.

Skid Interval

Click on the “<” or “>” sign to increment or decrement the value of the skid interval.



Figure 9 - Upper left corner of the program window with the 'Manual Skid' and 'Pause' buttons.

Skid interval is measured in miles and can be set between 0.0 and 0.5 miles. For normal PMIS data collection, the interval should be set to 0.5 mile; for manual skid data collection, set to 0.0 mile.

If the current PMIS section is 0.5 miles in length and the interval is set to 0.5 miles, then one skid is performed at the beginning of the PMIS section. If the PMIS section length is 0.7 miles and the interval is still set to 0.5 mile, then a skid is taken at the beginning of the section and another at a 0.5-mile distance.

In the second example, two skids would have occurred. Whenever the section length is the same or less than the skid interval, only one skid is taken at the beginning of each PMIS section; however, if the section length is greater than the skid interval, then one skid is taken at the beginning of the PMIS section and another each time the skid interval distance is encountered.

The skid interval is usually set before data acquisition begins and should not be changed during acquisition.

Comment Buttons

Numbered comment buttons are found below the **Pause** button. The system uses the following comment codes:

- 1-Flushing in lane
- 2-Patching in lane
- 3-Intersection
- 4-Bridge
- 5-Pavement change
- 6-Curve
- 7-Missing reference marker
- 8-Begin construction
- 9-Skid error/ bad data
- TEXT**-Adds an operator-created comment to the data file.

Clicking a comment button inserts a comment code in the last skid record taken. Note, only the *last* record written is modified; place comments *after* the skid has taken place. For example, if a skid was just taken in an intersection, the user indicates this in the data file record by clicking button 3. A comment of intersection is entered with the skid data.

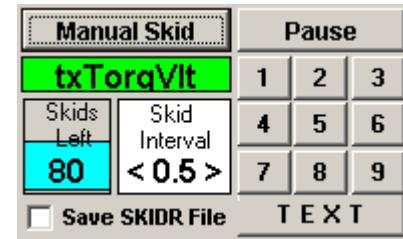


Figure 10 - Upper left corner of the program window with numbered comment buttons below the 'Pause' button.

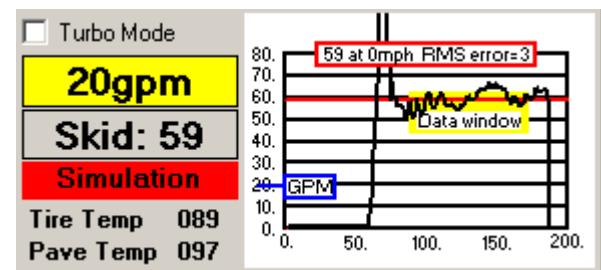


Figure 11 - Below the 'Turbo Mode' checkbox, values for water flow (20gpm) and last skid value (Skid: 59) are displayed.

Water Flow, Skid Values, and Turbo Mode

Below the **Turbo Mode** checkbox are the displays for water flow and last skid value. Water flow provides a visual indicator to monitor water flow. Keep in mind this display is not the calibrated flow indicator and may vary at times. When the water flow reading falls below 20 gallons per minute (GPM), the background will turn yellow. If the water flow indicator is yellow for more than one skid stop, check for problems with the skid system (i.e. no

water in tank, clogged water filter, malfunction water flow meter, etc). Last skid value is the skid number of the last skid that was completed.

Turbo Mode function is used to take skid measurements as fast as the system allows. Currently, this is about one skid every four seconds or about one every 300 feet at the normal data collection speed of 50 mph.

To activate Turbo Mode, check the **Turbo Mode** check box. The default skid interval display should read 0.0 and the **Manual Skid** button will now read “**Turbo Skid**.” To start turbo skidding, click **RUN** on the **AppMgr** window. When you reach the desired section to start skidding, select “Turbo Skid.” The **Turbo Skid** button will turn green. To stop turbo skidding, press the “**Turbo Skid**” button again or press the **STOP** button on the **AppMgr** before the completed end of the section. To exit the Turbo Skid mode and return to normal PMIS data collection: 1) uncheck the check **Turbo Mode** box and 2) reset the skid interval to 0.5.

When **Turbo Mode** is checked, another option is available. By selecting “**TurboSkid Starts on RUN**” found under the Display pull-down options, turbo skidding will start as soon as the **RUN** button is pressed. Figure 13 shows examples of the two operation modes.

Temperatures

Tire Temp and Pave Temp are displayed below the “Last Skid Value” only when they are active. If either is active, the operator must ensure each is displaying a temperature +/- 5 degrees from the temperature measured with the handheld Infrared (IR) Thermometer Gun. If the temperature is not displaying correctly, turn OFF the temperature sensor in the SKID configuration parameters (double-click on the **SKID** button and uncheck the box next to Tire Temp or Pave Temp). Each temperature can be turned OFF independently, so only the temperature outside of acceptable parameters should be turned OFF.

Skid Graph

An example skid graph is shown above in Figure 11. The horizontal axis displays hundredths of a second ranging from 0 to 2.00 seconds and the vertical axis shows skid numbers on a scale of 1 to 100. A caption at the top of the graph shows the computed skid number, speed, and RMS error. The Data Window displayed on the graph shows the area of collected data used for the skid number calculation. Finally, the red line is drawn to give an illustration of how the calculated skid value fits with the data collected. The GPM tag shows the average water flow rate during the skid.

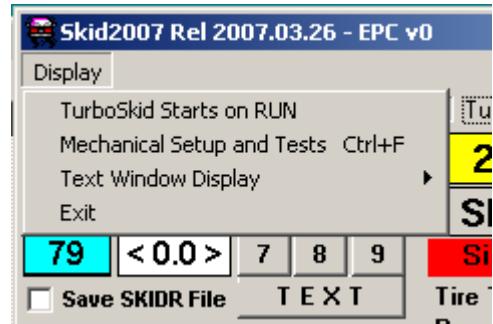


Figure 12 - When Turbo Mode is checked, dropdown menu provides an option for “TurboSkid Starts on RUN.”

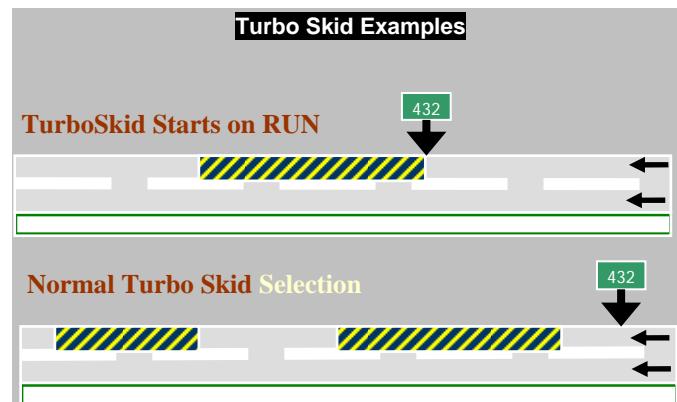


Figure 13 – Examples of the two operation modes.

Program Shut Down

Select the X in upper right hand corner of the **Skid2007** program window to shut down the program window, or select Display > Exit. Close all open windows and shut down Windows computer completely before turning off the Systems power switch on the **Console Control Panel**.

WARNING!: Never shut down the system by simply turning OFF the Systems power switch on the **Console Control Panel**. This may cause files critical for the system and program operation to become corrupt. If this happens, the computer should run Scandisk while booting the next time. This may or may not repair any corrupted files.

Text Window

The bottom half of the **Skid2007** program window is used to display text. The operator can select the type of text displayed. Selection options are discussed under the **Display** pull-down menu options. In addition to the selected text options, other text messages displayed are data collection errors and helpful program status updates (i.e. *** DATA COLLECTION ENDED ***).

During data collection, the operator should monitor this window after every skid to ensure the skid was captured properly.

Text displayed in this window accumulates and remains in the window until the program is exited, the window memory buffer is full, or the **Clear** button, found in the upper right hand corner of text window, is clicked. The operator can look back at previous text

by using the window scroll bar found on the right side of the window. The accumulated text from this window can be saved by selecting the lines of interest; using Ctrl + C to copy the selected text; then pasting the copied data to a new text file opened by the operator.

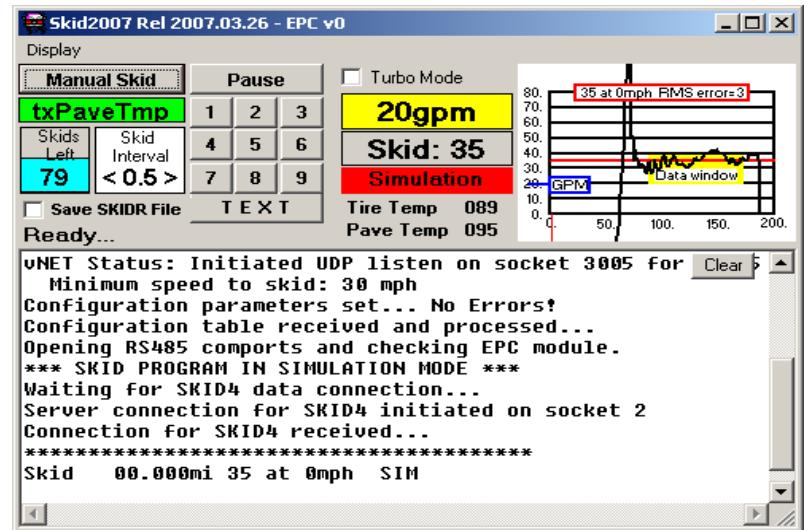


Figure 14. View of the text display located on the bottom half of the Skid 2007 program window.

Display Pull-Down Menu Options

Since we have discussed the operations of the main program window, the following discusses each of the options available by accessing the Skid2007 program **Display** pull-down menus.

Selection of **Display/TurboSkid Starts on Run** is only available when the **Turbo Mode** is selected in the main **Skid2007** program window. When this option is selected and the RUN button is pushed, Turbo Skidding measurement will start immediately after the RUN button is pushed. By selecting this option, turbo skidding can only be started and stopped by using the RUN/STOP button, which will affect the starting and stopping of data collection.



Figure 15. Options available by accessing the Skid2007 program ‘Display’ pull-down menus.

When the **Display/TurboSkid Starts on Run** option is not selected, the operator can choose when to start and stop turbo skid mode at any time without starting and stopping data collection. Turbo mode can be accessed repeatedly during data collections, and could also be accessed during a PMIS data collection run.

Display/Mechanical Setup and Tests will be discussed further in Section 4. Mechanical Setup and Tests Window. This option will bring up the **Daily Calibrations** window that opens by default at the start of each work day.

Display/Text Window Display option menu. Selecting the **Display/Text Window Display** option menu enables different program output to the text window. Each option can be selected by clicking on the option name with the left mouse button. When the option is active, a check mark is shown in front of the option. To deactivate the option, select the option again and the check mark is removed.

The four possible program outputs that can be displayed to the text window:

- ◆ Show SKIDP data – displays skid data in SKIDP format in the text window.
- ◆ Show PF99 data - displays the skid data in PF99 format in the text window.
- ◆ Show Debug data - displays program debug data in the text window. This option should not be used for normal data collection; however, this option is useful for program development and debugging.
- ◆ Show EPC Chatter - displays communications between the EPC and PC. This option is useful for program development and debugging.

Data Storage

Data files are created during the skid process include the BA99 data files (.ba9 extension), PF99 data files (.pf9 extension), and SkidR project files (Hwy_Date.skr).

NOTE: The SkidR data file is only created if the “Save SKIDR File” box is checked (box is located just below the Skids Left indicator in the Skid2007 application window).

These file are located in sub-folders under the VAMOS folder. The following illustrations show example storage locations for each data type and also an example of the actual data file.

IMPORTANT NOTE: Right of Way (ROW) camera images and the Houtex Texture Data are embedded only in the .ba9 file located in the BA99 directory.

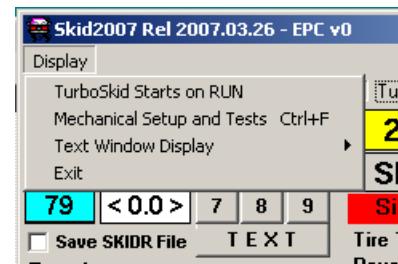


Figure 16. Program window display when the ‘Turbo Mode’ option is selected.

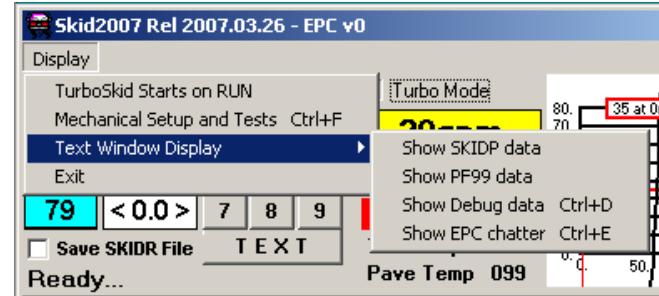
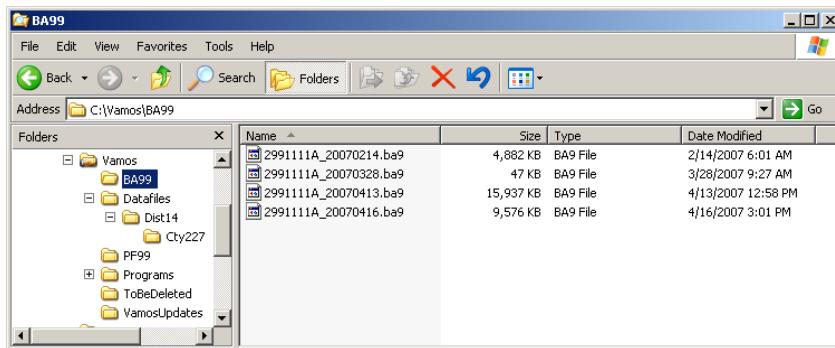
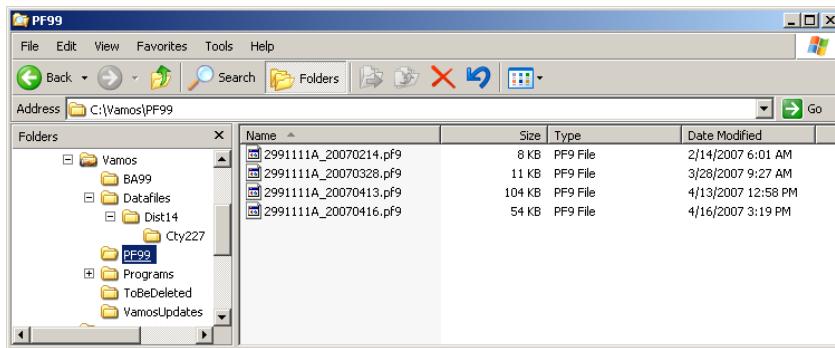


Figure 17. List of different program output options accessed by selecting ‘Display/Text Window Display.’

BA99:



PF99:



SkidR:

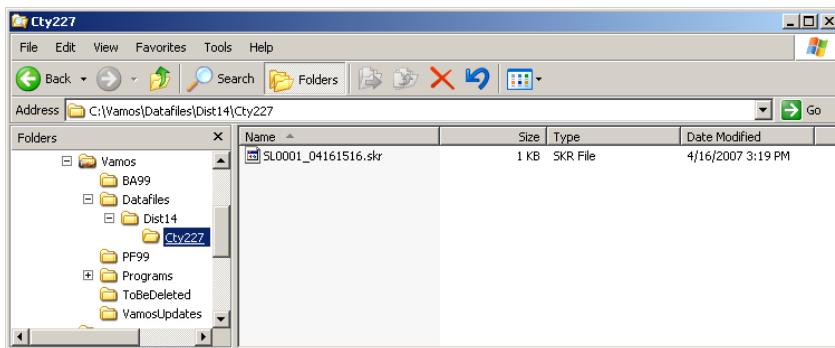


Figure 18. Example of storage locations for each data type.

The figure displays three separate Notepad windows, each containing a single line of text representing a sample record for a specific data type.

- 2991111A_20070214.ba9 - Notepad:** Contains a header followed by a single line of data. The data line starts with "START," followed by timestamp "20070214114624.484000" and a series of parameters including "PMET1," "DMI," "Versions," "Softwaredesc," and various coordinate and timestamp values.
- 2991111A_20070214.pf9 - Notepad:** Contains a header followed by a single line of data. The data line starts with "START," followed by timestamp "20070214114624.484000" and a series of parameters including "PMET1," "DMI," "Versions," "Softwaredesc," and various coordinate and timestamp values.
- SL0001_04161516.skr - Notepad:** Contains a header followed by a single line of data. The data line starts with "#SKIDP," followed by parameters such as "SkidNumber," "Distance," "MPH," "Lane," "SkidRMS," "WaterFlow," "TruckID," "Timestamp," "Lat," "Long," and "Comment," followed by a series of coordinates and timestamps.

Figure 19. Sample records from each data type are shown above.

Section 4. Mechanical Setup and Tests Window

The **Mechanical Setup and Tests** window is displayed when the Skid2007 program is started for the first time each day and is used for the Daily Calibration Procedures. This window may also be opened by selecting **Mechanical Setup and Tests** from the **Display** menu or using the Ctrl+F (hold down the Ctrl key while pressing the F key) keyboard shortcut when the Skid2007 program window is the active window.

Water Valve Test and Calibration Frame

The controls in this frame operate the water valve and set the calibration values for the VAMOS water flow calculations.

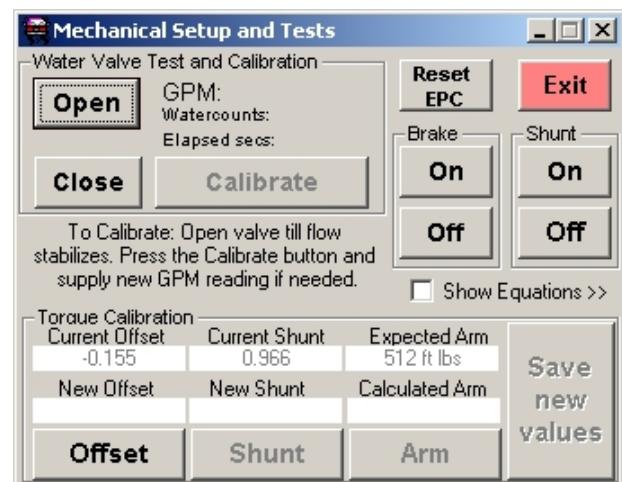


Figure 20. Mechanical Setup and Tests display.

Brake and Shunt Frame

The **Brake** test frame allows the operator to apply the brake on the trailer skid tire while the **Shunt** test inserts a 3-volt current into the Wheatstone bridge circuitry. If the **On** button in the **Brake** test frame is selected, the operator should see the brake light indicator lit on the console control panel. Turning the **Shunt** ON does not light up an indicator light. However, if the **Show Equations** window is selected, the operator will note torque voltages readings are about 3 volts higher.

The **Reset EPC** button is used to send a reset command to the EPC module. This is required only if the module freezes, which is a rare occurrence.

Show Equations Frame

The **Show Equations** check box expands the window to display equations and constants used in the calculations during data acquisition. The information in this window is used for program development, debugging, and system calibrations.

This screen shows the computed skid number (shown as **SN**) and skid number adjusted (shown as **SN adjusted**), displayed in the very bottom right hand corner of the window. The **SN (adjusted)** value displayed should read close to zero when the vehicle is at rest. If the value is not, recalibrate the system using the Torque Calibration procedure.

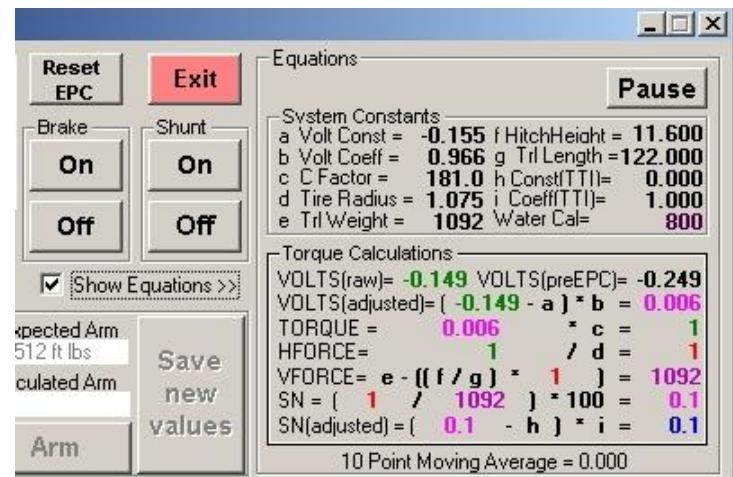


Figure 21. An example of the Equations window.

Torque Calibration Frame

These controls are used for the daily calibration process.

Chapter 4 - Equipment Checks and Startup

Section 1. Equipment Checks Procedure

Before beginning data collection, check the following items for proper operation:

- 1) Lights – Check headlights, taillights (truck and trailer), and warning lights.
- 2) Tires - Check pressure of all tires, especially the skid tire. Cold skid tire pressure should be 24 psi. For the recommended pressure of the truck tires, see manufacturer specifications.
- 3) Hydraulic jacks – The jacks should be completely raised.
- 4) Trailer - Check the trailer hook-up and safety chains for proper connections.
- 5) Tank water level - Check the tank's water level. If the water pump is turned on with an empty tank, the water pump can OR will overheat.
- 6) Water sprayer - Check the chains for wear or broken/kinked links. Look for obstructions in water flow.
- 7) Gas and oil levels – Check gas and oil levels for both the truck engine and the generator.
- 8) Trailer hydraulic oil level – Check the hydraulic oil level in the trailer. Check the level with the trailer jacks raised to their highest point off the ground.
- 9) Loose equipment – Check the truck and trailer for unsecured equipment, tools, or any other item that should be secured while the vehicle is in motion.

Section 2. Electrical Equipment Startup Procedure

The order the electrical equipment is activated is important. The correct order for equipment activation ensures each item activates properly for data collection. Follow these steps in the order shown below:

- 1) Start the truck engine with all the switches on the console control panel turned OFF.
- 2) Turn system switch ON.
- 3) Turn the Main and Aux 12-Volt Distribution Box power switches ON (not all trucks have them).
- 4) Turn DMI/GPS box ON.
- 5) Start the generator by holding the generator toggle switch **On** until the generator has started; however, do not hold the start switch **On** for more than five seconds at a time.
- 6) Turn Water Pump switch ON (make sure there is water in the tank).
- 7) Turn Hydraulic Pump switch ON.
- 8) Turn Trailer +/- 15-volt switch ON.
- 9) After turning ON the DMI/GPS box, wait for 2 minutes or wait for the LCD display to read “Network Ready.” Then turn power **On** to the VAMOS computer.
- 10) Turn the Houtex Computer Power Switch and the Houtex Laser Power switch ON. Laser power can be turned ON and OFF without affecting the Houtex Computer functions.
NOTE: This option is important for operator safety, while cleaning the laser glass.

After all of the electrical equipment has been turned ON, start the VAMOS software programs (AppMgr, Head, SKID, TXAPP) and perform the daily calibrations (see Chapter 6).

Chapter 5 – Skid Data Collection

Section 1. Step by Step Guide

A guide to getting on the road and acquiring PMIS skid data

1. Perform the Equipment Checks Procedure (outlined in Chapter 4).
2. Follow the Electrical Equipment Startup Procedure (outlined in Chapter 4).
3. Perform the Daily Calibration Procedures and Checks (outlined in Chapter 6).
4. Fill up the water tank and reset the **Skids Left** indicator (double-click on the **Skids Left** indicator in the **Skid2007** program window).
5. Select the PMIS section and lane to be skidded in the **Location Mapper** program window.
6. Set the skid interval to 0.5 miles.
7. Bring vehicle up to 50 mph, set cruise control, and check the speed indicated by the speedometer and **Location Mapper**. If the speed is not the same between the speedometer and **Location Mapper**, use the speed indicated by **Location Mapper** to set the 50 mph data collection speed.
8. Click the **Run** button on the **AppMgr** window to initiate data collection at the reference marker corresponding to the PMIS section selected.
9. When the skid cycle starts, monitor the truck console LED lights. The water and brake lights should cycle on and off as the skid is performed. Observe the skid graph. Does the graph and skid value look reasonable for the surface being tested? Was the water flow above 30 GPM?
10. At the last reference marker of the section, the system should automatically stop collecting data. To stop data collection before the automatic ending, click the **Stop** button on the **AppMgr** window.

NOTE: If the temperature varies more than $\pm 10^{\circ}\text{F}$ during the day, stop data collection when convenient and perform the Daily Calibration Procedures and Checks (outlined in Chapter 6) to ensure valid data collection. The calibration voltages are also monitored by the software and a prompt to re-calibrate appears approximately every 10 degrees of temperature change throughout the day.

11. Is there more data to be collected?
If **Yes** - Select the next PMIS section to skid and repeat steps 6-10.
If **No** - Data collection is complete, go to step 12.
12. Exit all programs.
13. Connect to the TxDOT LAN each week to upload data.

Section 2. Quality Control in Data Collection

A good method for ensuring data quality is to monitor the skid graph window throughout the data collection process. The skid graph displayed should look similar to the ones shown in this manual with skid values in the range of 5-70 and RMS error values less than 5. RMS value may increase greatly if the skid cycle crosses pavement changes or the trailer is bouncing.

Monitor the water supply indicators for both flow amount and the skids left in the tank. Remember, the **Skids Left** indicator is approximate only. When the display reads less than 20, monitor the water flow for each skid. Fill the water tank before the **Skids Left** indicator reads “0”.

WARNING!: DO NOT run tests with an empty water tank. Tests run with an empty water tank causes tire damage, water pump damage, and bad data. When the tank is almost empty, the flow indicator *may* display water flow readings below 20 GPM triggering the water flow indicator background to become yellow.

Section 3. Project Level Data Collection

Project level data collection can have many purposes. One purpose can be to perform acceptance testing for a contractor. TxDOT is utilizing special specifications that explicitly state minimum skid numbers to be maintained over time by contractors. Since falling below this minimum skid number will cost the contractor time and money to repair, it will be important for TxDOT to collect the acceptance skid data as accurately as possible.

Another important use for project level data collection is wet weather accident site testing. Since this data is analyzed and shared by many, it also should be collected as accurately as possible.

Listed below are a few items a skid system operator should consider before collecting data:

1. Before skidding, determine if the weather is best for accurate data collection. Do not collect acceptance data in the rain.
2. Monitor the data as it is being collected. If you encounter unusual data, traffic, or anything that will create a suspect skid numbers, make another pass and provide your notes of the encounter to those reviewing the data.
3. Evaluate the road the data is being collected on to determine the appropriate speed for data collection. Conduct data collection at 50 mph or calibrate the water flow to the level appropriate for the data collection speed to be used.

Speed	Water Flow
30 mph	21 gpm
40 mph	28 gpm
50 mph	35 gpm

Normal PMIS

Skid System Equipment

With the newest built skid systems, the operator has the ability to adjust water flow; however, there are a few skid systems in service that cannot be adjusted. Until the older skid systems are replaced, do not use them for acceptance testing if data cannot be collected at 50 mph. If the skid system being used is not capable of making accurate measurements, coordinate with the Materials & Pavements Section to schedule availability of a system has the capabilities necessary for accurate data collection.

IMPORTANT NOTE: This information not only applies to acceptance testing or Wet Weather Accident Sites, but is also important for any data collection. As a skid system operator, all setups and configurations should be followed to provide accurate data for all data collection.

Chapter 6 – Calibration Procedures and Checks

The following calibration procedures include both the daily and annual calibration procedures for the Skid2007 system. The daily tests are described first followed by the annual calibration procedures performed at the Materials & Pavements Section in Austin, Texas.

Section 1. Daily Calibration Procedures and Checks

Prior to any skid data collection, perform the following calibration procedures:

1. water flow check
2. brake check and
3. torque calibration

Before running these checks and procedures, verify all the equipment is turned ON and the Skid2007 software is running properly (described in Chapter 3). If the daily calibration procedures and checks have not been performed within 24 hours, the **Mechanical Setup and Tests** window is displayed automatically after the Skid2007 program has been initiated. Otherwise, open this window using the **Display** pull-down menu.

Water Flow Check

Check water flow by clicking the **Open** button. The Water Counts graph (displayed in the skid graph window) will begin to update and the GPM displayed next to the **Open** button should read ~35 gallons/min. \pm 5. If the flow is not near the expected value, repeat the procedure and check for water flow problems. If no flow is detected, an error message will appear with suggestions.

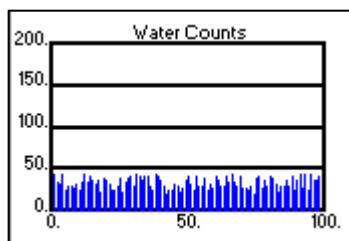


Figure 23. Water Counts graph (displayed in the skid graph window).

If the water flow is sufficient, make a visual check of the water flow as well. Look for an even spray from the water sprayer. The operator may find it helpful to perform the water check while filling the water tank; the tank can be topped off after the check is complete.

NOTE: DO NOT click the **Calibrate** button to recalibrate the water flow. The water flow displayed by the Skid2007 program is an indicator of water flow problems. This display should not be used to calibrate the water flow valve. The water flow valve is

calibrated as part of the “Annual Calibrations Procedures.”

Brake Check

Click the **On** button in the Brake Test frame. Verify the LED indicator for the brake relay lights up on the console control panel then press the **Off** button.

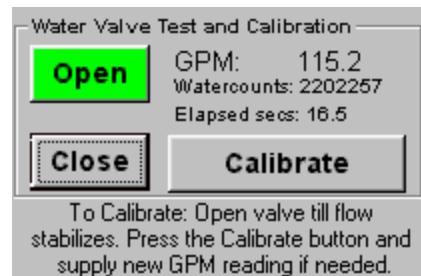


Figure 22. Water flow data displayed after the ‘Open’ button has been pressed.



Figure 24. Brake Test frame.

Torque Calibration Overview

The torque calibration procedure has 4 steps to perform:

1. **Offset** calculation
2. **Shunt** calculation
3. **Arm** test (only required to be performed once each day)
4. **Save new values**

Torque Calibration		
Current Offset	Current Shunt	Expected Arm
-0.155	0.966	512 ft lbs
New Offset	New Shunt	Calculated Arm
-0.155	0.966	543 ft lbs
Offset	Shunt	Arm

**Save
new
values**

Figure 25. Example of the Torque Calibration window frame.

“Step 3 **Arm** test” is only required to be performed at the beginning of each skid system operation day. This step can be skipped if it has been performed earlier in the day.

Offset calculation measures the bias of the torque ring sensor grid or the voltage that is produced when there is no load applied to the torque ring sensor. If the voltage is not zero, then the amount needed to bring it to zero is calculated, and applied to the calculations as an offset.

The *shunt calculation* applies a 3-volt offset to the system directly at the torque ring sensor. The recording system then measures the same 3-volt signal. If the returned signal does not measure exactly 3 volts, a multiplying factor (the shunt factor) must be calculated to raise the recorded value to 3 volts.

Like the Offset value found previously, the new Shunt factor is also stored. When collecting data, the offset value is combined with the torque ring voltage read then multiplied by the shunt factor to yield a compensated voltage. The calculated compensated voltage is then used for skid number calculations.

The Offset value and Shunt factor are temperature dependent. A $\pm 10^{\circ}\text{F}$ change in temperature requires recalibration. The **Equations** window shows a computed skid number at all times using these two numbers even when the skid equipment is idling. Quickly determine whether recalibration is required examining the **Equations** screen while the system is motionless. Look at the skid number value. If the value is more than 3 or is a negative skid number, recalibrate the system.

The final part of the torque calibration is to check a known torque value applied to the wheel by a weighted arm. This arm is stored in the side compartments of the truck. The arm is attached to the box end of the skid axle, set to a horizontal position, the brake locked, and the weights loaded upon it. The loaded arm simulates a 500-ft/lb load and should generate about 3 volts.

Offset /Shunt Calibration Procedure

If the torque calibration procedure has not been completed for the day, the Skid2007 program opens the **Mechanical Setup and Tests** window automatically and displays a message to complete the procedure.

The complete torque calibration procedure should be performed every morning prior to gathering skid data; however, repeat the **Offset** and **Shunt** calibrations when the temperature changes $\pm 10^{\circ}\text{F}$ from the last calibration or the software prompts to do so.

To start the “Offset” calibration process, click on the **Offset** button and follow the procedure stated in the pop-up messages displayed on the computer screen. After the Offset button turn from green to gray, press the **Shunt** button and again follow the procedures outlined on the computer screen. While each test is performed, the test button will turn green and test progress can be monitored in the skid graph window.

As stated in a pop-up message during the **Offset** calibration, the torque calibration requires the truck to be parked on level ground and the trailer lifted. The trailer contains a hydraulic jack system that can be activated by opening the panel on the trailer. Use the lever (shown in Chapter 4) to control the operation of the jacks. Turn the lever clockwise to raise the trailer; turning the lever counterclockwise lowers the trailer.

NOTE: The generator must be running, hydraulic pump ON, and brake OFF before the jacking system will function.

DANGER!: Watch your feet. If the jacking system malfunctions, the trailer could fall crushing whatever may be underneath it.

The Offset calibration will plot voltages in the skid graph window. When the process is complete, the new Offset value is displayed in the **New Offset** box of the **Torque Calibration** window. The allowable range for Offset is – 0.3 to 0.3. The graph should be similar in appearance to the one shown in Figure 26 with minor variations in voltage readings.

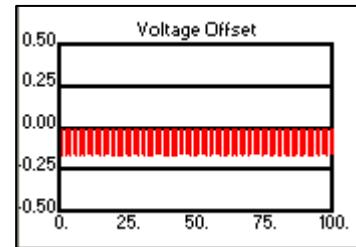


Figure 26. Example of Voltage Offset displayed during Offset calibration.

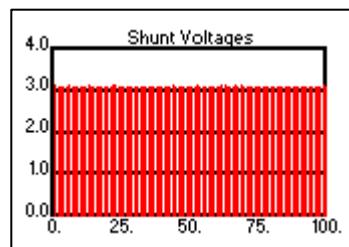


Figure 27. Example of Shunt Voltages displayed during Shunt calibration

The Shunt calibration will plot voltages in the skid graph window. When the process is complete, the new Shunt value is displayed in the **New Shunt** box of the **Torque Calibration** window. The allowable range for the Shunt is 0.9 to 1.1. Again, the graph should be similar in appearance to one shown in Figure 27.

When the calibration is complete, compare the new Offset and Shunt values with the old. If they are very different from the current values, investigate for a potential problem or consider calibrating more often.

If the Torque Arm Test will not be completed, click the **Save new values** button; however, if the Torque Arm Test is going to be completed, proceed to the Torque Arm Test procedure.

When the **Save new values** button is clicked, the calibration values are saved and a dialogue window appears to remind the operator to retract the jacks before moving. Only after the operator is certain the jacks have been retracted, click **OK** and then **Exit**.

If the **Save new values** was not selected before clicking **Exit**, the values are not saved and the Offset/Shunt Calibration Procedure must be completed again before data collection can occur.

Torque Arm Test

The arm and weights needed for this test can be found in the driver side tool compartment.

After performing the **Offset /Shunt Calibration Procedure**, a mechanical and electronic test of the system can be performed by clicking the **Arm** button

NOTE: This test cannot be performed until the Offset/Shunt procedure has been completed.

Instructions for this test are displayed in dialogue windows as each step of the test procedure is performed.

1. After selecting the **ARM** button, the display prompts the operator to rotate the skid tire. This step is important to ensure the torque arm is level with the ground, because the brake is locked in the next step. It is helpful to hold the arm to the tire to obtain a better alignment. When the alignment is complete, click **OK**.
2. The brake should be **ON** and console brake light lit. Place the torque arm on the box end wheel hub, load the weights, then click **OK**.
3. The Torque Arm Test is performed and the progress is updated in the skid graph window.
4. After the test completes, a dialogue window appears with the calculated torque arm value and asks if the operator would like to repeat the test. Compare the Calculated Arm to the Expected Arm values in the Torque Calibration frame. The Calculated Arm should be within 50 lbs. of the Expected Arm. Repeat the test if greater than 50 lbs or troubleshoot for problems before selecting **No** to the option to repeat the test.
5. After selecting **No** to the option to repeat the Torque Arm Test, the operator will be prompted to remove the arm and weights. To prevent damage to the arm and weights as well as operator injury, it is very important follow the directions provided in this dialogue window (see Figure 28). ***Do not click OK until the arm and weights have been removed.***



Figure 28. Dialogue window prompting removal of arm and weights with “WARNING!”

WARNING!: Clicking OK releases the brake. If the arm has not been removed, the weighted arm will crash to the ground. Any objects in the weight’s path may be damaged or injured.

6. If test results are satisfactory, click the **Save new values** button; this function is not performed automatically. If the **Mechanical Setup and Tests** window is exited without saving, no data is saved and the Torque Calibration Procedure must be completed again. A warning dialogue box appears to remind the operator to retract the jacks before moving. Click **OK** only after the jacks have been retracted to prevent damage to the jacks or skid trailer.

7. Click the **Exit** button on the **Mechanical Setup and Tests** window to close the window

Section 2. Weekly Verification Procedure

A local verification section is a route that can be run by the skid system to ensure that the skid numbers are the same over time and to check the skid system's dynamic functionality.

A local verification section should be established after the skid system has been through the annual calibration. When establishing sections, it is best to find sections that contain a wide variety of road textures within a 2 mile section length.

To create the master verification file, run your section at least five times to establish what variations exist. Start each run at exactly the same location each pass. If possible, change the driver at least once. Once established, this verification section should be run once a week.

Section 3. Monthly Verification Procedure

Every four to six weeks, the skid system should be taken to Austin to run the Austin verification sections. This verification data will be compared to the original master verification data collection before the skid system was delivered to the district.

Section 4. Annual Calibration Procedures

Since many of these calibration techniques require the use of special tools the districts do not have, Pavements Section personnel perform the annual calibrations. In addition, the Materials & Pavements Section maintains a skid system, known as Golden Rig, which is calibrated at the Texas Transportation Institute (TTI) in Bryan, Texas every year to the ASTM skid standards. The **Golden Rig** serves as a standard by which all other TxDOT skid systems are correlated.

Water Calibration Procedure

The Skid2007 program monitors water flow using a flow meter installed in the skid trailer; however, the actual water flow is calibrated by adjusting a water valve to achieve the desired flow rate. Since additional equipment is necessary to calibrate the water flow valve and the water flow meter, the calibrations are performed during annual calibrations in Austin. Do not adjust the water valve or attempt to perform further calibrations in the field unless you have been trained to do so.

Appendix A: Formulas

Water Flow (gallons):

Constant

Water Calibration (counts per gallon)

Variables

Current Water Count, Last Water Count

Formula

$$\Delta \text{ Water Count} = \text{Current Water Count} - \text{Last Water Count}$$

$$\text{Water Flow (gallons)} = \Delta \text{ Water Count} / \text{Water Calibration Constant}$$

Distance (miles):

Constant

Distance Measurement Instrument (DMI) Calibration Constant (counts per mile)

Variables

Current DMI Count, Last DMI Count

Formula

$$\Delta \text{ DMI Count} = \text{Current DMI Count} - \text{Last DMI Count}$$

$$\text{Distance (miles)} = \Delta \text{ DMI Count} / \text{DMI Calibration Constant}$$

Root Mean Square (RMS) error term:

Variables

Number of Samples, Sample Average, Sample Values Table (1 to number of samples)

Formula

$$\text{Sample Average} = \text{Summation of Sample Values Table} / \text{Number of Samples}$$

$$\text{RMS Error Term} = \sqrt{\{\text{Summation of the (Sample Values} - \text{Sample Average})\}^2}$$

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