



6500

smoke meter



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WARRANTY

Seller expressly warrants to Buyer (a) that the equipment will comply with the description set forth herein; (b) that the components and parts fabricated by Seller will be free from detrimental defects in workmanship and materials.

If it appears within one year from date of shipment by Seller that the equipment does not meet these express warranties and Buyer gives Seller prompt and reasonable notice, Seller shall, at its option, either repair or replace at its expense, F.O.B. Seller's works, but not dismantle or reinstall, the defective parts provided, upon request such parts are shipped freight prepaid to Seller's works.

These warranties shall not apply if equipment is subjected to other than normal and proper storage, handling, installation, operation and maintenance or to unauthorized repairs or alterations. Equipment, components and accessories made by other manufacturers are warranted only to the extent of the original manufacturer's warranties to Seller.

The foregoing warranty obligation of the seller shall constitute the sole and exclusive remedy of the buyer and the sole liability of the seller, except as set forth herein and except as to the title it is expressly agreed (a) that there is no warranty of merchantability of any other warranty, express, implied or statutory, nor any affirmation of fact or promises by Seller with respect to the equipment or parts or otherwise which extend beyond the specifications mutually agreed upon in writing by Seller and Buyer, and (b) that the Buyer acknowledges that it is purchasing the equipment solely on the basis of the commitments of Seller expressly set forth herein, in no event shall Seller be liable for special, indirect, or consequential damages including, without limitation, anticipate profits.

GENERAL

The WAGER Model 6500 Smoke Meter is in full compliance with the requirements of the SAE J1667 test criteria—the current U.S. standard.

The software supplied with your unit(s) (V5.12 or above) allows the user to apply the algorithm for ambient conditions (see SAE J1667 document, Appendix B) either during the actual test or convert saved opacity data.

The meter's simple design and portability makes it easy to obtain accurate measurements. It provides an accurate means ($\pm 1\%$) of detecting and measuring the opacity of smoke emitted by a diesel engine.

The use of the Model 6500 Smoke Meter promotes combustion efficiency for fuel economy and ensures compliance with diesel emission standards set by environmental air quality codes.

The program document for SAE J1667 is Surface Vehicle Recommended Practice. It can be obtained from:

SAE International
400 Commonwealth Drive
Warrendale, PA 15096-0001 Telephone: 724/776-4970

Or electronically at: <http://www.arb.ca.gov/msprog/hdvp/saej1667.pdf>

It is also part of the Heavy-Duty Vehicle Inspection Program Periodic Smoke Inspection Program issued by the Mobile Source Operation Division, California Environmental Protection Agency, Air Resources Board. One copy can be downloaded free of charge from: www.arb.ca.gov/msprog/hdvp/saej1667.pdf









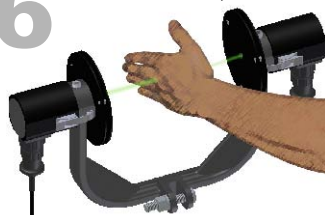

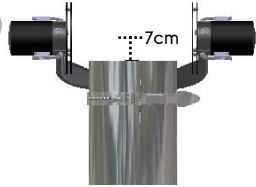
Weather data for each individual city can be obtained by

- ▶ Use of an inexpensive desk-top weather station
- ▶ Call to a local radio or television station
- ▶ Internet through <http://www.weather.com> (or a number of other locations)

QUICK START INSTRUCTIONS

It is important that the tester is familiar with the safe operation, features, and maintenance of this unit as well as the SAE J1667 document.

To give you the opportunity to test the unit when it is received, we have prepared the following:

<p>1</p>  <p>Take the sensor head and the control unit out of the carrying case.</p>	<p>2</p>  <p>Connect the sensor head to the control unit's mating receptacle (lock into place by turning the locking ring • turn clockwise)</p>	<p>3</p>  <p>Press the ON/OFF switch to activate the unit. It automatically performs self-calibration.</p>	<p>4</p>  <p>Select the stack size by pressing the  button until your measurement appears.  Press SAVE.</p>
<p>5</p>  <p>The Horsepower shown is the default setting. If it does not agree with your engine's specifications, press SELECT until the correct HP range is shown.</p> <p>Press SAVE. </p>	<p>6</p>  <p>Pass your hand through the light path until unit displays 100%. Remove your hand to cycle to 0%.</p>	<p>7</p>  <p>If it does not show "0" (zero) press the ZERO button.</p>	<p>8</p>  <p>Attach the sensor head as described in the SAE J1667 booklet (be sure to observe all safety regulations shown later in this manual).</p>

Disclaimer

Operator must use caution when working around a hot stack. Protective gloves are required.

If you chose not to use the extension pole, please be advised that the installation and/or attachment of the sensor head manually is not recommended.

Manual installation, which may require the operator to use a ladder, climb upon the equipment being tested, or any other unsafe maneuver, constitutes a waiver of liability for any and all personal injury sustained by the operator in the use of this equipment.

Robert H. Wager Co., Inc. does not warrant, guarantee or insure the safety of any person or persons not in compliance with this instruction manual.

SYSTEM DESCRIPTION

Model 6500 Smoke (Opacity) Meter System Components

Description	Part Number
Control Unit	194-0003
Sensor Head Assembly (Complete)	147-0166
Transmitting Unit	147-0164
Receiving Unit	147-0165
5" Mounting Clamp Assembly	194-0005
Sensor Head Assembly Partial Flow	194-0016-F
Curved Nozzle	194-0018-C
Straight Nozzle	194-0018-S
Partial Flow Filter Assembly	194-0029
5" Mounting Clamp Assembly	194-0005
Power Supply Transformer	194-0004
25' Connecting Cable	192-0003A
25' Extension Cable (optional)	191-0011
Carrying Case	147-0150
Extension Pole for Full Flow Head	147-C0092
Extension Pole for Partial Flow Head	147-0092-PF
Melles Griot Neutral Density Filter (.2) Full Flow	544-0002
Partial Flow Filter Assembly	194-0029
Impact Printer	195-0008
CPU Interface Cable with Software (2 Floppies)	194-0009
Instruction Manual	6500 Manual

Optional Items, Consumables

Description	Part Number
12V. Sealed. Lead-Acid Battery	800016
Power Supply Transformer (220V)	194-0006
Connecting Cable 40'	191-0012
Fuse	820015
Printer Ribbon	555-0008
Printer Paper	566-0004
Linseis Recorder, Single Pen	147-0151

"System"

The complete system consists of a control unit, sensor head assembly, impact printer, CPU interface software on two floppy disks, extension pole, various connecting cables, calibration filter, instruction manual, and a carrying case.



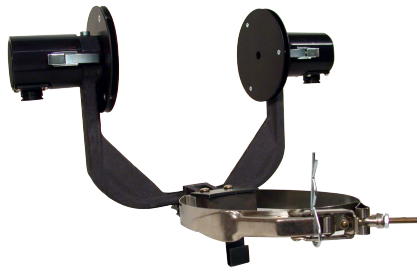
CONTROL UNIT

The control unit is operated by a membrane keypad, which consists of eight tactile feedback push buttons.

The display is an alphanumeric LCD, containing 16 characters by two rows. In low light situations, the display can be backlit. The display shows the prompts the operator follows throughout the test sequence(s).

Up to 100 test can be stored in the system's memory.

The RS232 connection permits an interface to a printer or CPU. The banana jacks (red and black) allow a 0 -1 VDC output for a chart recorder.



SENSOR HEAD ASSEMBLY

The sensor head assembly is attached to the vehicle exhaust in accordance with the criteria in the SAE J1667 document. (The document describes the different stack configurations and the placement of the sensor head).



CABLE

The connecting cable is 25 feet long. Optional lengths of up to 50 foot are available.



POWER

The meter is shipped with an AC Adapter/Charger which operates in 110V (220V Export Version).

The 12 V sealed, lead-acid cell battery will allow up to 40 hours of continuous operation with a full charge. This is reduced to about 20 hours, if the display is backlit.

The time-out feature will turn the unit off automatically if none of the front panel buttons are pressed for 20 minutes.

(See Appendix F to set this feature).

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smoke meter



CALIBRATION FILTER

To assure continuous accuracy, the .2 Neutral Density (Melles Griot) Filter is supplied with the system. We recommend a check before and after the day's testing.



EXTENSION POLE

An extension pole is supplied with each system to allow the operator to attach the sensor head to the stack from the ground.



CARRYING CASE

All the system's components, except the extension pole, can be fitted into the plastic carrying case. Foam inserts are specially molded to fit the components and protect the electronics.

TECHNICAL SPECIFICATIONS

The Wager Model 6500 Smoke Meter meets SAE J1667 specification for full flow meters. Appendix C, using the required algorithm.

Accuracy

The unit's accuracy is $\pm 1.0\%$ nominal \pm one digit. The control unit is initially calibrated under clear stack conditions with checks at 0% and 100% opacity. The accuracy of the unit is verified by use of the .2 Melles Griot neutral density filter supplied with the system.

Ambient Conditions

The unit operates in 32° to 120° F (0° to 50° C).

The software supplied with the unit allows the user to

1. perform tests with a direct connection to the CPU, with entry of ambient conditions at the time of the test. The opacity stored will include corrections for ambient conditions.
2. If the test has been performed and downloaded to the CPU, the data can be retrieved and the conversion applied through the "Convert Existing Data" calculation function.

Reliability

Zero stability at less than 1% drift per use.

The pulsed green LED has infinite life expectancy.

Check filter provided for easy calibration

All solid state electronics.

Manufactured by an ISO 9002 company.

Applications

The Model 6500 Smoke Meter can be used on any diesel engine, with primary application in testing trucks, busses, and cars.

Contact WAGER for special applications, such as stand-by power, mining operations, railroad use, boating/maritime, industrial, etc.

Functional Description

When the unit is activated, the transmitter emits a light beam at a known intensity. As the light passes through the smoke plume, some or all the light is diverted.

The sensor head consists of two components, a light source (transmitter) and a light detector (receiver).

The light detector measures the amount of light received, and compares this with the amount of light being emitted. The difference between the two values is opacity.



SET-UP FOR TESTING



INSTALLATION OF SENSOR HEAD(S)

Full Flow Sensor Head

Position the sensor head over the top of the exhaust stack with the extension handle. The hook attachment will aid the operator on the ground to visually aid in the placement of the head and the strong magnet clamp keeps the position without effort. Adjust the angle and position of the sensor head assembly as described in the SAE J1667 document.

Partial Flow Sensor Head

Attachment of the partial flow head depends on the shape of the stack. Both a straight and curved end is provided. The nozzles are attached with simple snap buckles. The bayonet (straight) nozzle hooks over the straight stack. The curved nozzle has a stop that allows correct positioning. The unit is held with strong magnets, which are part of the extension pole assembly.



ATTACHMENT OF CONNECTING CABLES

The connecting cable is attached to the control unit and the sensor head assembly by means of "MultiMate" connectors. The ends of the cable have connectors that will fit into matching grooved receptacles.

Align the pins on a connector with the holes on its mating receptacle. Insert the connector into its mating receptacle.

Lock the connector in place by screwing the locking ring clockwise until a firm connection is made.

Repeat these steps for the second connector.

SNAP ACCELERATION TEST

The Model 6500 Smoke Meter has been designed in accordance with the specifications of SAE J1667.

The meter will prompt the operator through the required three test sequence compute the average and the "spread". However, the operator must be familiar with the document to make the determination if the test(s) meet the SAE J1667 and/or the individual state's (province's) test requirements.

Important:

To assure continuous accuracy of the test performed, a .2 Melles Griot Neutral Density Filter is provided with the system. Turn the unit on and lay the filter on the baffle plate (receiving side). This first test value should be recorded and kept with the filter. Once the calibration check has been complete, return the filter to the protective sleeve.

See the table in Appendix A (Maintenance) for Conversion of Optical Density vs. Percent Transmission.

Note: The filter's optical properties change with exposure to light and over time. Filters will have to be replaced periodically.

SNAP ACCELERATION TEST

<p>1 -----></p>  <p>Bring your engine to operating temperature and turn off</p>	<p>2 -----></p>  <p>Make certain the sensor head is clear of any obstructions.</p>	<p>3 -----></p>  <p>The opacity meter is factory set in the test series mode. (snap acceleration testing). To switch to the follow mode (real life opacity readings) You must press the ZERO button immediately.</p>	<p>4 -----></p>  <p>After selecting the mode, the unit automatically performs a self calibration.</p>	<p>5 -----></p>  <p>To set the exhaust stack size of your vehicle, press the SELECT button until your measurement appears.(2" through 5") If you are using a partial flow sensor head you must always select a 5" exhaust stack size. Press Save.</p>
<p>6 -----></p>  <p>The HP displayed is the default horsepower rating for the selected size. If it agrees with your engine's specifications, press SAVE. If not press select until the correct rating appears. Then press save.</p>	<p>7 -----></p>  <p>Block the light path (with your hand) The result is a reading of 100%. Remove your hand and check that the result is 0.0%.</p>	<p>8 -----></p>  <p>If it does not show "0" (zero) press the ZERO button.</p>	<p>9 -----></p>  <p>Attach the sensor head as described in the SAE J1667 booklet (www.sae.org).</p>	<p>10 -----></p>  <p>Start your engine.</p>
<p>11 -----></p>  <p>The display will give you the prompt START TEST and indicate T1= for the first test to be performed.</p>	<p>12 -----></p>  <p>With the engine in Neutral gear or in Park, rapidly accelerate the engine for four to five seconds. Return to idle (The display will show the current opacity readings and the peak value reached during the test).</p>	<p>13 -----></p>  <p>Press SAVE</p>	<p>14 -----></p>  <p>The unit will display T2= and START TEST. Press START TEST and repeat steps 12 and 13. Press SAVE.</p>	<p>15 -----></p>  <p>The unit will display T3= and START TEST. Press START TEST and repeat steps 12 and 13 again. Press SAVE.</p>
<p>16 -----></p>  <p>The three tests must be within 5% of each other for the test to be considered valid. This is shown as "Spread" on the test result. You may then press the COMPUTE AVERAGE button.</p>	<p>17 -----></p>  <p>Save to store test record into memory.</p>	<p>18 -----></p>  <p>Connect the impact printer and turn on by pressing "1" (the number one) and press PRINT on the control unit.</p>	<p>19 -----></p>  <p>Turn the unit off</p>	

Remove the sensor head from the stack. Use extreme caution when working around a hot stack.

The tests are numbered sequentially. If the test is printed later, note the number of the record with the vehicle identification. Up to one hundred tests can be saved, until the memory has to be cleared. (See Appendix A for instructions on clearing tests from memory).

Printer Operation

Connect the printer to the control unit's RS232 port. Press "1" (number one) on the printer to turn it on.

You can print any test by pressing the PRINT button either before you save the test, immediately after the test, or at a later time. You may print the same test as often as you require.

(Printing stored test at a later time is described in detail under "Printing Saved Tests" later in this section.)

The printed test strip includes:

- Record number
- Date and time of the test
- Stack size and horsepower ratings
- Peak values of the three tests in percentage
- Average of the three tests
- Spread
- Pass/Fail

In addition, the printer strip allows for addition of the VIN number and the operator's signature.

Note:

If the memory holds 100 tests (maximum), the control unit will automatically enter the PRINT mode when you turn the unit on. You have the option to delete test(s) before you can perform another test. This prevents you from performing a test that cannot be saved.

A description of the software download and data management is listed in the "Software" section of this manual.

Installation for Rolling Test

Undo the clamp bolt and nut and remove the extension handle. The magnetic clamp assembly will also separate from sensor head.

Reinstall the magnetic clamp assembly directly to the sensor head.

If the exhaust stack is equipped with an exhaust flapper, remove the flapper cover assembly. If this is not practical, tighten the hinge bolt on the flapper cover assembly to maintain the flapper in its maximum open position.

Install sensor head assembly on exhaust stack, using the magnetic clamp assembly. (See above and SAE J1667 document for instructions). Secure the unit with locking pin.

For actual road tests, you may need to adjust the sensor head assembly, so that the measurement is not affected when the vehicle is in motion.

Follow Mode Test

The "Follow" mode provides a means of providing a continuous "real life" opacity reading and performing tests under load, either on the road or on a dynamometer.

Follow the instructions listed in Installation Sections for attaching the sensor head to the stack of the vehicle. Make a special point of securing the sensor head if a road test is performed.

Press the ON/OFF button on the control unit. The unit will perform a self-calibration.

Press the SELECT button until the desired stack size is displayed (factory default is 5"). Press the SAVE button.

The HP shown corresponds to the default horsepower. If your engine has different specifications, press SELECT until the correct value is displayed. Press SAVE.

Press the START TEST button.

Follow your state's test requirements as to RPM and load factors.

When you have reached the governed load, press SAVE.

Note:

Follow mode tests cannot be printed on the impact printer. However, the data can be captured and displayed graphically through the software supplied with your CPU interface.

The data can be printed in "real time" by keeping the optional Linseis Recorder attached while the test is performed.

Printing Saved Tests

The WAGER Digital Smoke Meter Model 6500 can save up to 100 tests. After the memory is full, you have the following options:

- Print test(s) and delete
- Download to a CPU and delete (Download to a CPU is covered in the "Software" section)

To print, connect the printer cable to the control unit's RS232 (printer) port. Press "1" (number one) button on your printer.

On the control unit, press and hold the PRINT button and then touch the ON/OFF button.

The unit will display number of the last test performed. Press SELECT to scroll to the record number you want to print. Press PRINT when you have reached the test.

To delete test from memory, press ZERO button.

Chart Recorder (Optional)

The WAGER Model 6500 Smoke Meter outputs a 0 - 1 V signal through the banana jacks (located next to the AC power input plug).

The output voltage reflects the opacity output where 0 V is 0 % opacity and 1 V = 100% opacity.

Refer to the chart recorder's documentation for instructions.

Printing To Other Printers

You may use any serial printer using the following serial protocol:

Baud Rate	Data Bits	Stop Bits
9600	8	1

See your printer's documentation for instructions on configuring to match these settings.



INTERFACE SOFTWARE

The proprietary software was written specifically to simplify the process of extracting smoke opacity data from the Wager 6500 Smoke Meter to the customer's hard drive. In addition, it provides a graphic interface of the test sequence. The operator must be familiar with the operation of the Model 6500.

THIS SOFTWARE AND THE ACCOMPANYING FILES ARE SOLD "AS IS" AND WITHOUT WARRANTIES AS TO PERFORMANCE OR MERCHANTABILITY OR ANY OTHER WARRANTIES WHETHER EXPRESSED OR IMPLIED.

In particular, because of the various hardware and software environments into which WAGER65 may be put, NO WARRANTY OF FITNESS FOR A PARTICULAR TEST IN ANY COUNTRY, STATE OR OTHER GOVERNMENTAL AGENCY IS OFFERED.

Good data management procedures dictates that any program be thoroughly tested with non-critical data before relying on it. The user must assume the entire risk of using the program. ANY LIABILITY OF THE SELLER WILL BE LIMITED EXCLUSIVELY TO PRODUCT REPLACEMENT OF ORIGINAL DISKS.

Detailed instructions and technical details are on Disk 2 in several common word processing formats. The following is a brief overview only.

Installation

The program is supplied on two 3.5" (1.44MB) floppy disks. Installation on most computers is a one step process, however, some computers require a re-boot to complete the installation.

Insert Disk 1 in floppy drive. From Windows 95 "Start" button, select "Run" and type "a:\setup.exe". Press "OK". The first pass of the setup program will install the Visual Basic 5.0 run-time files.

Insert Disk 2 when prompted. Restart the computer when the first installation pass is complete.

Repeat Step 1 above to install the Wager Data Utility program (necessary on some computers).

Note:

You must be running a screen resolution of at least 800 X 600 pixels to view the entire program screen and print correctly.

The item "Wager65" will be added to your "Start" Programs menu as the default setting. On-line Help is available from the "Help" menu.

Use of the Wager65.exe Program

To perform a diesel smoke opacity test, there are three possible scenarios:

- Download previously saved SAE J1667 test results
- Capture raw Bessel-filtered transmittance data without SAE J1667 testing (meter in "FOLLOW" mode or operator presses "Escape" key on PC prior to completing SAE J1667 testing in "TEST" mode)
?
- Capture raw Bessel-filtered transmittance data with SAE J1667 test results (3 pre-conditioning and 3 snap-idle test, results averaged and Beer-Lambert corrections applied).

Connecting the Model 6500 to a PC

Connect the Model 6500 to the PC. Use only the cable supplied with the system, normal printer cables are not suitable. Also note that the communications ports are: Serial 1 is COM1:, Serial 2 is COM2:)

File Structure

This program uses standard MS-DOS filenames with 8 characters and a 3 character extension. Windows95 long filenames are not supported by the CAPTURE.EXE, FPDUMP.EXE and UPLOAD.EXE command files.

All files should be saved in the C:\Wager directory for easy access.

The following files must be in the C:\Wager directory for the program to function:

WAGER65.EXE
CAPTURE.EXE
FPDUMP.EXE
UPLOAD.EXE

The following directories MUST exist (they can be created at installation time by running the MAKEDIRS.BAT file)

C:\WAGER\
C:\WAGER\BIN\
C:\WAGER\DATA\
INI File

Please review the full documentation on Disk 2 for technical details, such as .BIN for raw binary data files created by the "Capture" function .CSV (Comma-Separated Values) for all text format files created by the "Capture", "Convert", and "Download" functions.

Setting The Active Communications Port

The default setting is COM2: Click on the appropriate "radio button" in the "Communications Port" frame. You can change the last entry in the "Wager65.ini" file in the C:\WAGER directory to COM1: so the program will use this as the default.

Applying the Beer-Lambert Correction

By checking the "Beer-Lambert Correction" Box in the "Options" frame, you will be prompted for the engine horsepower rating and the measured stack size. The next time you display a raw transmittance data file, the Beer-Lambert correction will be applied and the result displayed in the graphics window. The data file will not be altered.

If you select the Beer-Lambert Correction before a capture or conversion process, the resulting opacity file will have the correction applied to the raw data and stored in the file along with the engine horsepower and stack size. The transmittance data file never has a Beer-Lambert correction applied.

Command Buttons

Download Saved Test Records

Click this button to prepare the computer to receive stored SAE J1667 test results from the smoke meter.

Press the "PRINT" button on the 6500 to prepare for the download, and press the "Save" button to start the data transfer.

Capture New Data

Click this button to initialize the raw data capture process. You will be prompted for a filename. Specify up to 8 characters with no extension, the program will add the ".BIN" extension.

With the meter setting at TEST MODE or FOLLOW mode, press the START TEST button. The capture.exe program will begin saving raw transmittance data to the binary file specified. Pressing the "Escape" key will terminate the capture process but no SAE J1667 snap test results will be stored.

If a set of three SAE J1667 snap tests are completed (using the "START TEST" and "SAVE" buttons), the capture process will terminate automatically and the snap results are stored at the end of the data file.

Click the "OK" button to proceed with converting the binary data file to text format using the FPDUMP.EXE program.

Display Existing Data

Click this button to display a transmittance or opacity data file. You will be prompted to choose a file to display.

Correcting for Ambient Conditions (Mandated in Arizona)

By checking the "Ambient Correction" box in the "Options" frame, you will be prompted for the
Ambient Temperature (F)
Relative Humidity (%)
Barometric Pressure /Inches of Mercury (in-Hg)
Comments (any additional information such as date, time, location, etc.)

If you selected the Ambient Correction before performing the opacity test (connected to your CPU), the opacity results will have the correction applied to the computed average. This value will be stored in the file, along with the temperature, humidity, barometric pressure and the comments from the input fields.

If test was performed off-line, the test data can be retrieved and the "Convert Existing Data" calculator applied.

Please note:

The SAE J1667 document contains guidelines for the acceptable ambient test conditions. To comply with these conditions, the program does not allow input outside the following ranges:

Ambient temperature: -40 to 140° F
Relative humidity 0 to 100%
Barometric pressure 27.00 to 33.00 in-Hg

The program will not accept any input not within these ranges to proceed.

Print Form

Click this button to print the data screen exactly as it appears on the computer monitor.

End

Click this button to end or quit the program.

Downloading Stored SAE J1667 Test Results

Click the "Download Stored Test Results" button in the SAE J1667 frame to prepare the computer to receive stored SAE J1667 test results.

The program calls the file "UPLOAD.EXE" using the communications port specified in the Communications Port frame and the filename you specify in the dialog box. The filename extension ".CSV" is added automatically.

Press the "PRINT" button on the 6500 to prepare for downloading and press the "SAVE" button to send the data to the waiting PC. When all records are sent, the process terminates and the data is saved in the specified text file.

Capturing Raw Bessel-Filtered Transmittance Data (Binary Format)

Click this button to initialize the raw data capture process. You will be prompted for a filename.

Once the 6500 is in the "Follow" mode, or a test sequence starts, the CAPTURE.EXE program will begin saving raw transmittance data to the file specified. Press the "Escape" key to terminate the capture process.

Click the "OK" button to proceed with converting the binary data file to text format using the FPDUMP.EXE program. Specify a new (different) filename for the transmittance text file. You will be prompted for a vehicle ID description which will be displayed on the screen and saved to the opacity data file.

Data Files Created by the Program

- Raw binary (Bessel-filtered) transmittance data captured from the 6500 in either "Follow" mode or "Test" mode. Test mode files will also contain SAE J1667 Snap Acceleration test results.
- Raw transmittance data converted to text format (.CSV - Comma-Separated Values) which can be read by any text editor, word processor or spreadsheet. Microsoft Excel spreadsheet will recognize the .CSV extension as text.
- Raw smoke opacity data in text (.CSV) format. The filename will be the same as the transmittance text file but with the last character changed to an "O" for opacity. (e.g. Test1aO.csv)
- Vehicle data file "vehicle.csv" which is appended each time a file is converted to text format. Each record in this file contains:
 - Date and Time of Binary Data Capture
 - Vehicle ID information
 - Tester ID
 - Transmittance data filename
 - Opacity data filename

Overall SAE J1667 Test Result (if present in data file)

Engine Horsepower
Exhaust Stack Size

This file can be used to determine the filenames used for previous tests to facilitate their review.

- A fifth type of file is created when the "UPLOAD.EXE" support program is used by the "Download Stored Test Results" function. This file will have a .CSV extension and contain the previously saved SAEJ1667 test results.

Exiting the Program

Clicking the "End" button will exit the program. Selecting "Quit" from the "File" menu performs the same action.

APPENDIX A. MAINTENANCE

Battery Replacement

Remove the two screws and carefully lift off the top to expose the attached wires. Remove all four connectors from the front panel. Place the front panel aside.

Turn the unit over. Remove the four screws holding the battery bracket in place. Remove the two connectors from each end of the battery. Place the new battery back and screw the holding bracket back into place over the battery. Re-attach the four front panel connectors. Replace the front panel the right and left screws.

Cleaning Lenses

To assure regular easy access to the lenses, we have provided two snap closures. The lenses can be wiped with a soft cloth.

We strongly recommend that a regular procedure of calibration and cleaning the lenses is established. During light use, a daily cleaning may be enough. During heavy testing, we recommend a frequent cleaning throughout the day.

To remove soot, dip soft cloth in denatured rubbing alcohol (make sure to let it dry) and rub gently over lenses.

In laboratory settings and heavy commercial use, please note that we have provided connectors for an external air purge.

Connecting Cables

Connecting cables are subject to wear, based on incorrect handling, abuse, and contact with a hot stack. Check, repair, and replace cables when their condition affects the operation of the smoke meter.

Printer

Please review the printer manual in Appendix E for instructions.

Calibration with Neutral Density Filter

The Melles Griot Neutral Density Filter allows you to verify that the system operates within the $\pm 1\%$ tolerance.

Each filter is attached to a chart, which shows that particular filter's calibration line. The column on the right will show the corresponding percent transmission value.

Conversion Table of Optical Density vs. Percent Transmission

DENSITY	% TRANSMISSION OR REFLECTION
0.24	57.54
0.23	58.88
0.22	60.26
0.21	61.66
Mean Line .2 → 0.20	63.10
0.19	64.57
0.18	66.07
0.17	67.61

For this example, we assume that this filter's line is slightly below the .20 line. (greyed area in the chart above). The calibration line is at 0.19. This gives you a density of 64.57.

To obtain the opacity reading, subtract 64.57 from 100 (total blockage of light) for an opacity reading of 35.43.

When you use this filter to check your unit, a reading between 34.43 and 36.43 is considered "within specification."

Please make a note of your filter's original value when it is factory fresh. The deterioration of the filter with exposure to light is gradual and may not be detected unless compared to the original values.

Full Flow Sensor Head:

The filter is placed close to the baffle plate.

Partial Flow Sensor Head:

The filter is in a holder, which is placed into the notched section in the middle of the sensor head.

APPENDIX B. TROUBLE SHOOTING

The WAGER Model 6500 Smoke Meter has been designed to be nearly trouble free for many years of use.

However, some components are subject to unintentional abuse, which is not covered in our warranty.

Sensor Head

Always carry the sensor head assembly by the metal "yoke". Dangling the sensor head assembly from the cable causes extreme stress and could lead to premature failure.

Battery

The re-chargeable lead-acid battery can withstand many charges/discharges. They gradually lose their ability to hold a charge. Replace the battery when the shortened intervals interfere with your normal operation of the unit.

Power Failure

If the control unit will not power on, check to see if the battery is fully charged. If yes, check the fuse.

Error Messages

CABLE FAILURE DISCONNECTED?

The light source is fully powered, but no light is detected receiver. This could be caused by several factors:

- The sensor head assembly cable is not connected to the control unit
- The light source in the sensor head assembly has failed.
- The connecting cable is malfunctioning.

Action:

Check to make sure that the cable is firmly attached to the unit.

If another unit's sensor head assembly and cable is available, try to see if this corrects the error.

If the message disappears, then you need to send in the sensor head assembly and/or cable for repair.

Contact WAGER Technical Services for further instructions and/or return of the unit for repair.

SENSOR FAILURE REQUIRES REPAIR

This indicates that the light source is functioning, but the receiver is not receiving the output.

A dirty lens on either the transmitter and/or the receiver side.
Malfunction in the sensor head assembly or cable.

Action:

Clean the lenses as described in "Maintenance" section. If this does not correct the problem, call WAGER Technical Services for assistance.

RECHARGE BATTERY

The battery is fully discharged. This message is displayed for a few seconds before the unit turns itself off.

Action:

Recharge the battery or run the unit using the AC power adapter.

BATTERY LOW RECHARGE SOON

The battery is getting low and needs recharging.

Action:

Recharge the battery or run the unit using the AC power adapter. (The unit will continue to function normally after displaying this message.)

MEMORY FULL DELETE TESTS FIRST

The unit saved 100 tests and has reached full storage capacity.
Either you have saved 100 tests, or the unit has experienced some electrical shock that has reset the number of saved tests. The unit immediately goes into the Print and Delete Test Series mode after displaying this message.

Action:

Use the ZERO to delete test series.

PRINTER NOT ATTACHED

The unit could not find a printer attached to the serial port.

Action:

Make sure both ends of the printer cable are firmly attached. Also make sure the printer is configured for serial operation (see documentation in Appendix E).



APPENDIX C. SPECIFICATIONS

Electrical Specifications

Light Source	Led - Green Gallium Phosphide 570 NM
Light Sensor	Si Photo Diode with IR Filter
Display	(Backlit) Liquid Crystal Display (LCD)
Meter Accuracy	±1.0% Nominal, ±10th digit
Peak Hold	No Drift
Recorder Output	0-1 Volt or 0-1 MA
Battery	12V, 2.2 amp hour, sealed, lead acid cell
Charging Transformer (Model AD-1880)	120 VAC 22 Watts in /18 VDC @800 MA out

Mechanical Specifications

	Size	Weight
Control Unit	4" W x 8" D x 4" H	5.0 lb.
Sensor Head	14" W x 10" D x 4" H	3 lb. w/o cables
Stack Clamp Assembly	5" Through the Stack	

Performance Specifications

Range:	0.0% - 100.0% opacity
Warm up Time:	Negligible
Response Time/Display*	0.45 seconds for 0-90% opacity
Response Time (Chart Recorder Output)	0.45 seconds for 0-90% opacity
Linearity	± 1% from 0-100% opacity
Zero Stability (Drift)	Less than 1% in 60 minutes
Temperature Stability, Sensor Heads	± 1% from 32 Degrees - 120 Degrees F
Battery Life	40 hours; 1 hour after low battery indication, 8 hours to full charge
Battery Life (night light on)	half of the above

APPENDIX D. DEFINITIONS

Follow Mode

A Configuration mode selectable item that allows the unit to continuously read opacity and maintain a "peak hold" reading. The alternate mode is Test Series Mode.

Opacity

The percentage of light transmitted from a source that is prevented from reaching a light detector.

Preliminary Snap Acceleration Test

A series of Snaps (usually at least 3) performed before testing begins to clear the exhaust system of residual particles.

Snap Acceleration Test

The engine is allowed to run at maximum RPM's for 4 to 5 seconds and brought back to idle. Three "snaps" are taken for this test. Each individual test is stored and a mathematical formula applied to provide an "average." See Page 14 for step-by-step instructions.

SAE J1667

A document created to outline specifications to manufacturers of opacity meters, as well as test criteria for performance of opacity (smoke) readings.

Test Series Mode

A Configuration mode selectable item that causes the Model 6500 to run a fixed series of Snap Acceleration Tests as dictated by the Society of Automotive Engineers (SAE) in specification J1667. The alternate mode is Follow Mode.

APPENDIX E. PRINTER MANUAL

Please note that for safety reasons, the printer is shipped with no charge in the batteries.

RS232 Interface

Printers with an RS232 serial interface are fitted with a D25 socket. Connections to this socket are as follows:

Function	Direction
TX	OUT
RX	IN
CTS	IN
GND	-
DTR	OUT

Note that RTS is not implemented but pin 4 is pulled up to +10V via a 1 K Ω resistor.

Power Supply

Internal Ni-Cad batteries. A supply of 9V DC unregulated or 12V regulated at 0.6 A (nominal) is sufficient to recharge the batteries.

An initial charge of approximately 20 minutes will be sufficient both to operate the printer and charge the batteries. The maximum on-load terminal voltage supplied to the printer must be limited to 12V. A full battery charge will take approximately 14 hours.

The printer incorporates a power saving feature, which turns the printer off after five minutes' inactivity (user selectable). This feature may be disabled, if desired.
Power-On Procedure

Check the batteries are sufficiently charged or that the power supply is correctly fitted and operational.

Open the lid and ensure that paper and a ribbon are present and that there are no foreign objects inside the paper well or mechanism. Close the lid, ensuring that the paper passes through the paper exit slot. Switch on the printer by pressing the "I" on the switch panel. The power-on indicator will light and the mechanism will reset.

APPENDIX E. PRINTER MANUAL

Paper Loading

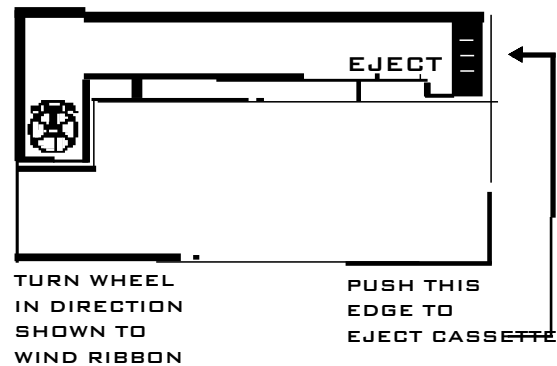
If the paper roll needs replacing open the lid and remove the remaining paper using the feed switch. Do not pull paper out of the rear of the mechanism. Reel off a few inches from the new paper roll and check that the end is square. Seat the new roll in the paper well with the paper emerging from the bottom of the roll.



Make sure the printer is on and offer the paper into the back of the mechanism while pressing the feed switch. Keep the feed switch depressed until enough paper is fed out of the mechanism to pass through the exit slot in the lid. Feed the page through this slot and close the lid

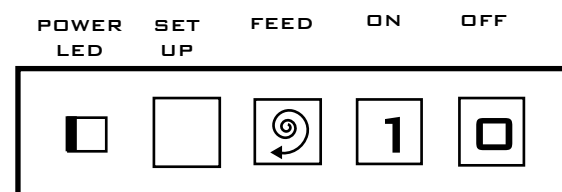
Ribbon Change

The ribbon cassette will clip off on one side and can be easily removed. After checking that the ribbon is taut, clip it into position making sure that the paper still feeds between the ribbon and the cassette body correctly. Wind the knob to take up any slack in the ribbon. Close the lid ensuring that the paper passes through its exit slot.



Paper Feed

For a single line paper feed press and release, the feed switch. For continuous line feed keep the switch depressed



Default Settings

The printer is supplied with the following default settings:

Data bits	8
Parity	None
Baud Rate	9600
Character Set	USA
Print Mode	Text
Auto-Off	5 minutes
Emulation	560

Self Test

To initiate self test press the power and feed switch together until the test starts.

This will check all the mechanics and a large proportion of the software and hardware (except that dealing with the data interface) without the need for connection to a host.

The software issue is printed in double height, double width text, followed by the character set in normal text and a list of the current settings of the user selectable options. If the settings are correct for your host you are ready to connect the printer to your system; otherwise you will need to reprogram the printer. The self-test is repeated until the power is switched off. Power on again for normal operation.

WARNING (USA)

Changes or modifications to this unit not expressly approved by the manufacturer could void the users' authority to operate the equipment

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment.

This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, this equipment may cause interference to radio communications.

Operation of this equipment in a residential area is likely to cause harmful interference, in which case the user will be required to correct the interference at his own expense.

If this equipment does cause interference to radio or television reception, which may be determined by turning the equipment off and on, the user is encouraged to correct the interference by one of the following measures:

- ? ● Reorient or relocate the receiving aerial
 - ? ● Increase the separation between the equipment and the receiver
 - ? ● If the equipment is AC powered, connect to an outlet on a different circuit to that on which receiver is connected.
 - ? ● Consult your supplier or an experienced radio/TV technician for advice.
- Shielded cables must be used with this unit to ensure compliance with Class A FCC limits.

WARNING (Canada)

This digital apparatus does not exceed the Class A limits for radio noise emissions from digital apparatus set out in the Radio Interference Regulations of the Canadian Department of Communications.

APPENDIX F. CONFIGURING CONTROL UNIT

Configuration Mode

In the configuration mode, the user can change the following items in the control unit:

Time including hour, minutes, and format (12 hour or 24 hour clock)

- Date including month, day, year, and format (American or European)
- Time-out battery saving feature
- Reset to factory defaults
- Print current configuration

To access the "Configuration Mode" turn on the unit and press ZERO and START TEST at the same time. Press these two buttons within 2 seconds.

The "Configuration" display will give you the following selections:

START TEST =exit
SELECT=next,
ZERO=change
SAVE=store.

Set Time:

Press the SELECT button. The LED displays the following:
ZERO= set time XXXXX (your current time setting)

Press the ZERO for "setting mode."

Press ZERO to change time format (toggles between 12 and 24 hour clock).

Press the SELECT for "hour" mode.
Press ZERO to scroll to your correct hour.

Press the SELECT for "minute 10's digit mode. (12:00 a.m.)
Press the ZERO to scroll to the correct minute 10's digit.

Press the SELECT for "minute 1's digit mode. (12:00 a.m.)
Press the ZERO to scroll to the correct minute 1's digit.

Set Date

Press SELECT twice.

Press ZERO for "set date" mode.

Press ZERO to change date format (toggles between the formats dd/mm and mm/dd).

Press SELECT to set month 10's digit. (06-12-98)
Press ZERO to scroll to your correct month 10's digit.

Press SELECT to set month 1's digit. (06-12-98)
Press ZERO to scroll to your correct month 1's digit.

Press SELECT to set day 10's digit. (06-12-98)
Press ZERO to scroll to your correct day 10's digit.

Press SELECT to set day 1's digit. (06-12-98)
Press ZERO to scroll to your correct day 1's digit.

Press SELECT to set year 10's digit. (06-12-98)
Press ZERO to scroll to your correct year 10's digit.

Press SELECT to set year 1's digit. (06-12-98)
Press ZERO to scroll to your correct year 1's digit.

Time-Out/Battery Saving Feature

Press SELECT three times for "Time Out" mode.

Press ZERO to change time out feature (toggles between enabled and disabled).

Reset Factory Default

Press SELECT four times for "reset" mode.

Press ZERO to reset factory defaults (as you received the unit from WAGER).

Press COMPUTE AVERAGE to confirm reset to factory default.

Print Configuration

Connect printer cable to control unit. Press "1" (figure one) on your printer to turn the unit on.

Press SELECT five times for "Print Configuration" mode.

Press PRINT for configuration print out.

Exit Configuration Mode

Press START TEST to exit the configuration mode at any time. Any changes you have made up to that point will be saved (become the default setting).