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6500

RACK MOUNT IN-LINE OPERATION MANUAL



WAGER
C O M P A N Y

Robert H. Wager Co., Inc.
570 Montroyal Road, Rural Hall, NC 27045

USA: 1-800-562-7024
CANADA: 1-800-655-5585
Telephone: +336 969-6909

FAX: +336 969-6375
Email: info@wagerusa.com
Homepage: <http://www.wagerusa.com>

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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 Rack Mount Smoke Opacity meter is in full compliance with the requirements of SAE J1667 test criteria. It is specifically for dynamometer test cells and stationary testing of stack emissions. The LCD displays opacity in percentage value, and the analog output at the rear of the unit outputs 0-1 VDC that corresponds to a digital readout. This analog output is used to go to a data acquisition system or a chart recorder.

The meter's simple design and rack mount makes it easy to access and obtain accurate measurements. It provides an accurate means (+/- 1%) of detecting and measuring the opacity of smoke emitted by a diesel engine.

The use of the Model 6500 IL promotes combustion efficiency for fuel economy and ensures compliance with diesel emission standards set by 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/hdvlp/saej1667.pdf>



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SYSTEM DESCRIPTION

Description	Part Number
Control Unit	194-0003-RACK
Power Supply	194-0004R
Connection Cable 50Ft.	192-0015
Receiver with Air and Water Chamber	194-0043
Transmitter with Air and Water Chamber	194-0044
Neutral Density Filter .2ND	194-0034
Fuse 2A 250VAC 5X20MM	4143551
Fuse Holder	627-0123
Instruction Manual	6500R Manual





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 banana jacks (red and black) allow a 0 -1 VDC output or data acquisition.



STACK PIECE/SENSOR HEAD ASSEMBLY

Stack Piece / Sensor Head Assembly

Stack Pieces are available in a variety of sizes. Standard stack size for an in-line is 8". Custom stack pieces are available in any diameter upon request. The standard material is schedule 40 carbon steel. Stainless steel is also available upon request. Connections may be flanged or welded.



● AIR CHAMBER FLANGE

The Air Chamber Flange is threaded and mated to the stack piece. It uses positive air pressure to help maintain the cleanliness of the lens sets.



● WATER CHAMBER FLANGE

The water chamber flange has two (2) retaining hooks that clip onto the optics. It contains a port for incoming flow of water, and one for outgoing. The flow of cold water reduces the temperature in the optics, and keeps them cool during lengthy testing procedures.



CONNECTING CABLE

The Connecting Cable is made to withstand high temperatures for long durations. Standard length is 50 feet. Additional lengths are available upon request.



POWER SUPPLY

The meter is shipped with an AC Adapter/Charger which operates under 110V or 220V with our export version.

The meter does contain a timeout feature that will turn the unit off automatically if none of the front panel buttons are pressed for 20 minutes.



NEUTRAL DENSITY FILTER

To assure continuous accuracy a .2 neutral density filter (Melles Griot) is supplied with the system. We recommend a check before and after each day's testing.

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 1.0% nominal 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). Control unit is for indoor use only and should not be exposed to water.

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.



INITIAL INSTALLATION

The inline optics require alignment once the stack piece is permanently mounted. In most application, the optics have a threaded air-chamber flange that screws onto the pipe of the stack. Positive pressure clean air hoses can be attached to the air flange to provide air flow keeping the internal glass free of soot and particles.

Bolted to the threaded air-chamber flange is the water-chamber flange. Two threaded ports are available on the water chamber to attach in-coming and out-going water hoses to keep the temperature of the assembly in a safe range. If you are using the flow of water, ensure that there are both in-coming and out-going pipes. In some high-temperature applications, a earth tone temperature-insulator ceramic block maybe be installed between the water and air chambers.



Two adjustable clips are used to attach the optic housing to the water chamber flange. Adjust the clips as to hold the housing firmly but not as to over-pressure the clips. The optic set consists of one transmitter (TX) and one receiver (RC). The transmitter emits a visible green light and can be identified by inspecting the connector. The connector on the TX has 7 pins. The receiver receives the green light and uses this light to determine opacity. The RC can be identified by the connector that has 5 pins.

Since the system uses light to determine opacity, the alignment of the beam is critical to system operation. The beam of light must be aimed as to illuminate the receiver directly and fully.



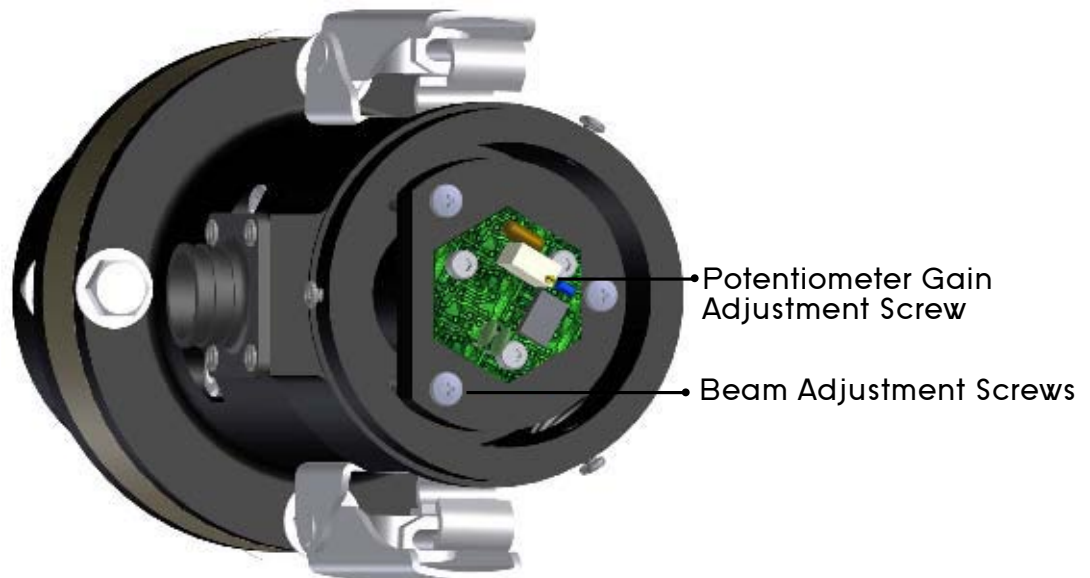
Receiver



Transmitter

Optical Beam Alignment Procedure

Once the hoses, pipes and optics are mounted, removing the 3 screws and protective cover will expose the electronics and lens tube. Remove the protective cover on both the TX and RC. Inspecting this area, you will see a green circuit board mounted with 3 screws and also will see 3 larger screws that mount the lens tube in the optic housing. The lens tube is spring-loaded with the 3 larger screws and acts as a tripod. Adjusting these larger screws will affect the direction of the beam and the angle of the receiver.



Connect the cable to TX, RC, and the control unit. The control unit has a diagnostic mode that will display the digital values of the amount of light within the optics.

Diagnostic Mode

Start with the control unit off. Hold the ZERO and START TEST buttons down while powering on. The control unit should display CONFIGURATION MODE. If not, turn the unit off and try again. Once you see CONFIGURATION MODE, release all buttons. Then press SELECT three times. Next press COMPUTE AVERAGE once. Finally, depress ZERO and then SELECT in a quick manner. This pressing of the SELECT freezes the automatic gain control and is required to stabilize the digital values.

Upon completion of this button series, the LCD will show three values. If you do not have 3 values, turn the meter off and start again.

The top left value is the LED DRIVE value and should not be changing and should be steady stable. The value is not important just as long as it is between 1500 and 3500 and is stable. The bottom left number is the TRANSMITTER value and the top right number is the RECEIVER value.



The goal of the optic alignment is to have the TX and RC values to be equal and around 2800.

ADJUSTMENT

Start on the transmitter. Inspect the value displayed and adjust the brass flat-head screw of the potentiometer on the circuit board. The potentiometer is a 20 turn device and has a self-protect mechanism. If you hear it click, you are at the limit and further turns will not affect the value. Clockwise (CW) increases the value and counter-clockwise (CCW) decreases the value. Adjust the transmitter potentiometer for a value of 2800. Once the TX value is 2800, no further adjustment of this potentiometer is required.

Staying at the TX, inspect the value of the RC on the display. Remember anything over 4000 is max limit. So if ever the receiver value displays 4000, turn the RC potentiometer CCW to 2800.

The three spring-loaded screws affect the beam angle. Remaining at the TX, adjust the screws CW one at a time to increase the RC displayed value to a maximum value. For example, adjusting screw A one turn will take the value from 1700 up to 2200 but any further turns on this screw will start to lower the RC value from 2200 back to 2000. So in this case, adjust screw A back to 2200. Then proceed to screw B. Adjusting screw B takes the value from 2200 up to 2350 but then starts to decrease again. Adjust screw B back to 2350. Repeat this process on the transmitter for all screws to obtain receiver maximum value.

Now proceed to the receiver. Repeat this procedure on the 3 spring-loaded screws on the RC. If at anytime the RC value goes above 4000, turn the RC potentiometer CCW to 2800. Lastly, after all the 6 spring-loaded springs have been adjusted for a maximum value on the receiver display, adjust the receiver potentiometer for a value of 2800.

Turn the meter off and go into the diagnostic mode and verify the values of the TX and RC are approximately equal and then re-install the protective covers.



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.

To set the unit to the follow mode, turn the unit on. After seeing the date and time, the top line of the display will show the mode the unit is operating in. If the unit displays "MODE = TEST SERIES" press the zero button to toggle the mode. Now the unit should display "MODE = FOLLOW".

Once you see CALIBRATION COMPLETED, it is too late to alter the mode and the unit should be powered off and then back on to gain access to the point where the mode can be changed.

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.



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.

Analog Output

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. The red jack is positive and the black jack is negative.



APPENDIX A. MAINTENANCE

Cleaning Lenses

To assure regular easy access to the lenses, we have provided two snap closures. The lenses can be wipeds 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.

Verification with Neutral Density Filter

The Melles Griot Neutral Density Filter allows you to verify that that the system operates within the $\pm 1\%$ tolerance. Once the unit is operational, insert the filter holder into the filter slot. The meter should display a reading that cooresponds to the filter value.



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.

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.

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.



Further troubleshooting can be found on our website at wagerusa.com. Click the red cross to quick link to the troubleshooting page.

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.

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.



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
Charging Transformer (Model AD-1880)	120 VAC 22 Watts in /18 VDC @800 MA out

Mechanical Specifications

	Size
Rack Dimensions	16 3/4" W x 6 1/2" D x 4 1/2" H

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



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. 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

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.



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

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.

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)

