Model DT109D

Dual Pass Opacity Measurement System

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SECTION 1 - OPACITY MEASUREMENT SYSTEM OVERVIEW

1. MONITOR OVERVIEW

a. Monitor Description

The Datatest Model DT109D Smoke and Particle Monitor is a double-pass monitoring system designed for continuous opacity or mg/M^3 (Mass Emission) measurement of smoke or particulate concentration in a stack or flue. The model DT109D is ideal for use as a bag house monitor or as a Continuous Emission Monitor.

The Model DT109D reflects the state of the art in detector and electronic hardware design. The transmitter/receiver features dual pass optical system that delivers +/- 2% opacity accuracy.

The optical sensor sends a millivolt signal to the DT109D controller. The controller processes this signal and displays the measurements on a 80 character LCD display. The processed signal is also converted to a 4-20 mA output, as well as made available on a Modbus RTU based serial link.

The electronic package incorporated within the DT109D features microprocessor technology that greatly expands the versatility and capabilities of the Smoke and Particle Monitor. Self- diagnostics, over emission alarm, purge blower out and LED out alarms are provided so that minimal operator attention is required.

The display prompts the operator during the set parameter routine, displays Date and Time, Instant and Average opacity, Pre and Over opacity alarm set points, Exit Correction, Offset Adjust and Recorder Range.

An RS-232 / RS-422 /RS485 Modbus RTU communication port is also provided to allow communication with other data acquisition systems.

The keypad overlay provides a completely sealed keyboard to assure that its touch-sensitive contacts are not subject to dust retention.

b. Theory of Operation:

The measurement of opacity is accomplished by measuring the amount of optical attenuation of a transmitted light beam across a stack or duct. The Model DT109D takes the difference of the light beam passing through the duct (I) and compares it to the reference light from the LED (Io). This method cancels out any variations due to changes in the LED.

A differential amplifier compares the intensity of the LED in the transceiver to the intensity of the light beam after it has gone through the stack or duct. Light intensity is measured using a Silicon Cell.

The millivolt output created by the Silicon Cell and amplifiers is given by the following opacity equation.

$$\text{Opacity} = [\, I - (\tfrac{I}{Io})^{**}1/2] \times 100\%$$

where I = Light thru the stack (I < Io < 1).
Io = Reference for the light source (Io < 1).

c. Opacity, Transmittance, and Optical Density

The fractional amount of incident light that is attenuated by effluent particulate matter is defined as the opacity (Op). Conversely, the fractional of incident light that is transmitted through the effluent is known as the transmittance (Tr). Thus the relation between opacity and transmittance may be expressed as:

$$Op + Tr = 1$$

or

$$Tr = (1\text{-}Op)$$

Opacity and transmittance are logarithmically related to the “optical density”, which is defined as:

$$OD = \text{Log}(Tr)$$

and

$$OD = \text{Log}(1\text{-}Op)$$

d. Electronic Controller.

The DT109D microprocessor controller electronically controls display measurements, calibrations, functions, and provides isolated analog outputs that are proportional to measured opacity concentrations. Normally Open (N.O.) Relay contacts are provided for Pre and Over Emission set points alarms and fault diagnostics.

The microprocessor accepts analog voltage signals (I, Io) generated by the sensing cells and differential amplifiers and converts this signal to an isolated 4-20 mA current output to be used by remotely connected recording devices.

e. Monitor Features

1. Parameter editing is achieved through a 16-key tactile feedback membrane keyboard.

2. 4-line, 80 character LCD display prompts the operator during the set parameter routine, displays date and time, measurement of opacity, average opacity, alarms, etc.

3. A communications port is also provided to allow communication with other data acquisition systems.

4. An overlay provides a completely sealed keyboard to assure that its touch-sensitive contacts are not subject to dust retention.

5. Alarm indications of fault conditions with independent set points alarms.

6. Averaging time and measurement ranges are selectable by the operator through the keypad.

7. Isolated current (4-20 mA) outputs.

8. Continuous monitoring of the transmitter LED source intensity.

SECTION 2 – SPECIFICATIONS

Model DT109D Opacity Monitor

1.Measurement System

Range	0-100% Opacity (0-4000mg/m^3)
Accuracy	+/- 2% Opacity
Resolution	0.1% Opacity (1mg/m^3 per 1000mg/m^3)
24Hr Drift	Less than 2% of full scale
Light Source:	High intensity wide band LED, average life 6 years
Operating Principle:	Cross stack, dual or single beam. DT109D double pass,
Measurement Path length:	DT109S single pass
Response Time:	DT109D up to 20 ft., DT109S up to 40 ft.
Spectral response	Less than 5 seconds
Power Supply:	400 to 700 nanometers
Stack Mount Electronics Operating	120V AC. 50/60 or Hz 230 VAC 50/60 Hz optional
Temp:	-40 °F to 122 °F (-40 °C to 50 °C)
Enclosure:	NEMA 4. / IP65
Max Flange Temp:	600 °F (315 °C)
Relative Humidity	95%, noncondensing

2.Purge Air Blower System

(800-31/32) for Positive Pressure stacks

Outlets:	Single or Dual (Dual is required where transmitter and retro reflector are both more than 5 foot from the Blower enclosure)
Voltage / Current	115 or 230V AC. 50/60 Hz. / 3.4/5 Amps.
Volume:	47 or 63CFM (1.3CMM)
Weight:	80 lbs. (36Kg)

3.Control Unit

Enclosure	Panel mount or NEMA 4 / IP65 available)
Dimensions:	Panel mount 9 1/2” x 7” x 14”, NEMA 4 / IP65 wall mount 10” x 12” x 6”
Ambient Operating Temp:	20 °F to 122 °F (-30 °C to 50 °C)
Analog Outputs:	Dual Channel, 4-20 MA for Instantaneous and average outputs
Communications:	Modbus RTU serial RS232, 485, or 422
Digital / Relay outputs	Potential free for status and alarms
Relay Rating:	10 A at 250 VAC
Audible Alarm:	Piezo electric buzzer.
Display:	80 Character backlit LCD with adjustable contrast control.
Electronics:	Microprocessor based with analog I/O, digital I/O and serial capabilities.

Keypad:	Tactile keys
Power Supply:	115V, 3.5A +/- 10%, (230V optional)
Transmitter to sensor distance:	200 ft. Max.

4. Calibration

Optical Audit Device	Optical filters for clear stack zero and span (optional)

5. ALARMS

Pre and Over Emission	0-100% Opacity, or mg/M^3 user selectable
LED Out	Transmitter LED Out
Air Purge Blower Internal Audible 60 dB alarm	Denotes problem with Air Purge
External Alarm Condition	Normally open (N.O.) single pole single throw Relay Contacts, 10 Amps at 250V AC
All Alarms are Reported to Screen.	

6. PORTS

Transmitter Connections	3” NPT Pipe Nipple, 6” long.

7. SLOTTED PIPE (Optional)

Slotted Pipe Material	3” Black Iron Pipe for 750°F / Alternative Stainless Steel for 1500°F (815°C)

SECTION 3 - INSTALLATION

1. OVERVIEW*:*

This section covers the installation of the Model DT109D Smoke and Particle Monitor. When installing, observe the following precautions.

a. HAZARDOUS LOCATIONS: Do not operate the optical transceiver in an explosive atmosphere unless a suitable purge system is fitted to the transceiver.

b. CONTROL UNIT LOCATION: The Control Unit location must be dry and not exposed to freezing temperatures. Formation of condensation must be avoided. Do not place Control Unit in direct sunlight.

d. ELIMINATE VIBRATIONS: Structural vibrations, machinery vibrations, etc. will affect the operation and life of the monitor. Find a vibration free structural wall or a similar place for firm mounting of the Optical Transceiver and Retro-reflector.

e. CONTROL UNIT MOUNTING DISTANCE: Mount the Control Unit within 200 feet of the sampling point.

f. WIRING: All wiring must be in accordance with national and local wiring codes.

g. MAXIMUM DUCT CROSS SECTION: The span should cover the widest portion of the duct or stack, thereby increasing the accuracy of the measurement.

h. TURBULENCE: The instrument should be as far away as possible from bends of pipe or pipe entrances (length > 5 x diameter of the duct). This will allow a smooth flow past the instrument and increase the accuracy of the measurement.

i. CONDENSATION: Condensed water vapor at the instrument location will increase the opacity measurement. Locate it away from the pipe exit so that the temperature is high enough to keep the water in gaseous form. If the instrument is too close to the exit, rain or snow will cause a false opacity measurement.

j. ACCESS TO THE TRANSMITTER AND RETRO REFLECTOR: It is necessary to be able to get to the transmitter and reflector to clean the optical windows.

k. AMBIENT LIGHT: Direct or indirect sunlight will cause the instrument to read a lower opacity. Minimize the ambient light to the instrument where possible.

l. The presence of stray light from equipment such as furnaces will also reduce the accuracy of the system since the glow of firebricks and so on will change frequently and interfere with the systems ambient light detection system.

2. CONTROL UNIT INSTALLATION

a. Mechanical Installation**:** The monitor Control Unit enclosure requires installation in a location free from significant temperature changes, and electrical noise. Ambient temperatures must be between 20°F and 122°F (-30 to +50°C).

b. Electrical Connection: Power input: 115 or 220 VAC, +/-10%, single phase, 50 or 60 Hz, 5 Amps.

2. The power cable should comply with the safety regulations in the user's country. The wire size should never be smaller than 18 AWG.

3. ANALOG SIGNALS: The Model DT109D has 2 x standard 4-20mA current outputs. The outputs are calibrated assuming a 250 Ohm load impedance. These output signals can be fed to an external load such as a recorder, or the signal can be used to drive external meters or recorders, as desired.

4. RS-232/422/485 CONNECTIONS: The Model DT109D is equipped with a serial port. This allows the Model DT109D to report its data to a computer or to a PLC for permanent data storage. The communications protocol is Modbus RTU.

5. RELAY OUTPUTS: Several relay outputs are available for High/Excess alarm set points and system fault. The following relay outputs are available for the Model DT109D:

System Alarm
In Cal
Pre Emission
Over Emission
Blower Alarm
LED Out Alarm

3. MECHANICAL INSTALLATION

The following Drawings should be referred to for the mechanical connections to the Transceiver and Retro reflector of the Model DT109D.

Drawing Number	Model and Description
04-3831	DT109D NEMA 4 Controller Single Blower
04-3832	DT109D NEMA 4 Controller Dual Blower
04-3840	DT109D NEMA 4 Controller No Blower (neg. pressure stack)

04-3864	DT109D Panel Mount Controller Single Blower
04-3865	DT109D Panel Mount Controller Dual Blower
04-3863	DT109D Panel Mount Controller No Blower
04-3900	DT109D Rack Mount Controller Single Blower

The retro reflector included standard with the DT109D system can withstand temperatures up to 150°F (66°C). If the unit is to be mounted in a location where the temperature exceeds this, check to see if an additional air purge blowers will help to lower the temperature across the retro reflector. Otherwise, a high temperature retro reflector can be supplied. See the drawings mentioned above for installation details.

4. ELECTRICAL INSTALLATION

The following drawings should be referred to for electrical connections between the control unit and the transceiver for the Model DT109D.

Drawing Number	Model and Description
06-3830	DT109D NEMA 4 Controller Contractor Wiring
04-3871	DT109D Panel Mount Controller Contractor Wiring
06-3902	DT109D Rack Mount Controller Contractor Wiring

5. OPTICAL ALIGNMENT

The following procedure is required to Optically Align the Transceiver and the Retro reflector using the mounting brackets.

a. Remove the retro reflector and put a piece of transparent material in front of the hole.

b. Adjust the mounting brackets on the transceiver to center the light beam.

c. Replace the Retro reflector.

4. ACCESSING THE MAIN MENU

The Main Menu can be accessed from other instrument conditions as follows:

1. From the Run Mode – simply press <CLR>.

2. From Parameter routine – press <CLR>.

3. From Utility Menu – press <CLR>.

If the Main Menu is accessed for any reason during the Run Mode, it is necessary to return to the Run Mode by pressing either '1', Run.

7. ZERO OR LOW VALUE ADJUSTMENT AND 100% ADJUSTMENT

This zero adjustment in this section can only truly be achieved under 2 circumstances. The first is with a completely clear stack, the second is with the monitor removed from the stack and set up in a workshop at the exact same span distance as it would be in the stack.

Should neither of the above conditions be available , then an EPA Method 9 (http://www.epa.gov/ttn/emc/promgate/m-09.pdf) approach can be taken and instead of doing a zero value adjustment, the low number can be entered in to the control unit following the instructions below.

In this case instead of doing a ZERO adjust it would be a LOW VALUE adjust. The control unit accepts numbers other than zero and so supports calibration under EPA method 9.

The Model DT109D should be adjusted periodically to ensure that the monitor is in calibration. To calibrate the Model DT109D, access the Zero Adjust parameter in the Utilities Routine. Use the following procedure for Zero Adjustment:

1. Select the Main Menu by pressing <CLR>. The display shows:

*** * * MAIN MENU * * ***
1-RUN
2-PARAMETERS
3-UTILITIES

2. Utilities is selected by pressing < 3 > from the Main Menu. The display now appears as follows:

>Offset Adjustment

Pressing the down arrow steps to the next prompt and so on

>Zero Adjustment
>100% Adjustment
>Signals
>Analog Output
>Digital I/O
>Software Version
>Clear memory

3. When **>Offset Adjustment** is on the bottom line of the display, Pressing the ENT Key will cause the following prompt to be displayed.

ADJUSTING OFFSET

After approximately 1 minute, the following will be displayed:

OFFSET ADJUSTED

4. When **>Zero Adjustment** is on the bottom line of the display, Pressing the ENT Key will cause the following screen to be displayed.

Online Opacity

Percent = 0.0

If the Enter key (SEE NOTE 1) is pressed at this time, the control unit assumes a clear stack and the unit begins a zero calibration sequence. The following message is displayed.

ADJUSTING ZERO

After approximately 10 seconds, the following prompt will be displayed:

ZERO ADJUSTED

The unit then returns to the main utilities menu

NOTE 1: If a clear stack condition is not attainable and a method 9 observer determines that the opacity is a number other than zero, then this number may be entered at this time. Once the ENTER key is pressed the control unit now sets the opacity to this new number.

NOTE: A Zero adjustment should always be performed after an Offset adjustment has been made.

3. The 100% adjustment tells the control when there is absolutely no light being returned from the retro-reflector and allows the unit to be scaled for 100% opacity. To do this, block the light path as close to the transceiver as possible. Once the light is blocked off, proceed as follows:

   When **>100% Adjustment** is on the bottom line of the display, Pressing the ENT Key will cause the following screen to be displayed.

ADJUSTING 100%

After approximately 1 minute, the following screen is will be displayed:

100% ADJUSTED

The unit then returns to the main utilities menu

NOTE, if a 100% adjustment is done when there is light entering the receiver this will cause an error and the unit will not calibrate properly. If this does happen, re-do the ZERO ADJUSTMENT and then REDO the 100% ADJUSTMENT in this order.

SECTION 4 - STARTUP AND OPERATION

1. INTRODUCTION

When the Model DT109D has been set up as described in Section 3, it is then ready for operation. This section describes what the Model DT109D does and what is needed from the operator. A detailed discussion of the diagnostic messages, various parameters of operations, modes of information available, alarm operations and the like, will be given in other sections.

2. INITIAL STARTUP

Initially it is suggested that the Model DT109D be operated with the same parameters that were in the instrument on arrival. Likewise, the same calibration can be used that the instrument received during test. This will insure that there is no problem with the hardware. The following procedure is therefore recommended.

3. SET UP PROCEDURE

It is suggested that before configuring the instrument for your specific needs you verify its performance. The test parameters from the factory reside in the instrument memory, therefore its performance can be verified. The following procedure will allow you to verify this performance.

1. Turn the power switch to the Control Unit to the ON position.

2. The Model DT109D will go into the RUN Mode and the run screen will appear as follows.

INSTANT = XX % where XX is the opacity being read AVERAGE = XX % OK HH:MM

3. The monitor will measure the opacity in which the Transceiver and Retro reflector is located.

4. SETTING PARAMETERS

When the Model DT109D is ready to run, the run screen shown above will be seen on the display. All operations occur from the "Main Menu".

The Main Menu can be accessed during the warm-up period by accessing the keyboard in the same fashion and then pressing <CLR>. To set the instrument operating parameters, the operator selects the Main Menu by pressing <CLR>. The display shows:

*** * * MAIN MENU * * ***
1-RUN
2-PARAMETERS
3-UTILITIES

Note: By default the displays are shown in % opacity, however, if the display is programmed to show in mg/M^3 (see page 20, MG/OPACITY SETUP) the corresponding menu items will be in mg/M^3)

Set parameters are selected by pressing <2> from the Main Menu.

The display now appears as follows.

***** PARAMETERS MENU *****

The screen will prompt the operator for the different parameters.

The display scrolls up with the bottom line reading:

PRE EMISSION ALARM

This parameter sets the Opacity Pre-Emission set point alarm. It is recommended that this alarm be set high enough so that it does not trigger during start up (ex. 15 pct, or the equivalent mg/M^3). To set the Opacity Pre Emission alarm set point press <ENT>. The following prompt will be displayed:

PRE-EMISSION ALARM

PRE = XXX.X pct (or mg/M^3)

Enter the new Alarm Pre-Emission set point and press <ENT> to accept this value. Advance to the next parameter by pressing the Down Arrow < ↓ >.

A parameter may be changed as many times as needed to get it right. The value retained by the Model DT109D will be the value present when the <ENT> Key. Pressing the Down Arrow < ↓ > moves to the next parameter.

OVER EMISSION ALARM

This parameter sets the Opacity Over Emission set point alarms. It is recommended that this alarm be set high enough that it does not trigger during start up (ex. 20 pct). To set Opacity Over Emission alarm set point press <ENT>. The following prompt will be displayed:

OVER EMISSION ALARM

OVER = XXX.X pct (or mg/M^3)

Enter the new Alarm Opacity Over Emission Set point and press <ENT> to accept this value. Advance to the next parameter by pressing the Down Arrow key < ↓ >.

The display scrolls up with the bottom line reading:

ALARM DELAY

This parameter sets the Opacity Pre-Emission and Over Emission Alarm Delay. This delay prevents false excess emission alarms that may occur during start-up or during the combustion process for very short periods of time. An alarm delayed buffer of up to 60 seconds will allow a Pre-Emission or Over Emission alarm set point to alarm only after the emission has exceeded the set point by that amount of time. This prevents multiple alarms to occur due to sudden emission spikes.

To edit the Alarm Delay press <ENT>. The following prompt will be displayed:

ALARM DELAY

DELAY = XX sec

Enter new Delay. Accept the value by pressing <ENT>. Advance to the next parameter by pressing the Down Arrow key < ↓ >.

AVERAGE TIME

This parameter allows the operator to change the opacity measured averaging time in RUN Mode. The measured averaging time is user selectable from 1 to 60 minutes. To edit the measured averaging time, press <ENT>. The following prompt will be displayed.

AVERAGE TIME
TIME = XX min

Enter the new measured averaging time (From 1 to 60 minutes). Accept the value by pressing <ENT>. Advance to the next parameter by pressing the Down Arrow Key < ↓ >.

The display scrolls up with the bottom line reading:

EXIT CORRECTION
For monitoring regulations that require opacity monitors to indicate the opacity at the stack outlet when the monitor measurement is at a different location with a different path length, exit correction is required. For those measurements where the stack exit path length is the same as the measurement path length, stack exit ratio equals 1.

The stack exit correction factor is equal to the stack exit path length divided by the monitored path length or:

$$\frac{L(exit)}{L(Monitor)} = \text{Stack Exit Correction Factor}$$

To edit the Stack Exit Correction Ratio, press <ENT>. The following prompt will be displayed:

EXIT CORRECTION

RATIO = XX.XX

To edit the Stack Exit Correction Ratio, enter the proper value (XX.XX) and press <ENT>. The Stack Exit Correction Ration should be 1.0 if no Stack Exit Correction is required. Advance to the next parameter by pressing the Down Arrow < ↓ > Key.

The displayed scrolls up with the bottom line reading:

POSITIVE OFFSET
During Start-up and Clear Stack operation, no offset is required. If the opacity measured is smaller than visual or other opacity measurements and the Opacity

cannot be Zero adjusted for Clear Stack Conditions, a Positive Offset can be applied to the measured opacity measurement. This is in essence another way of achieving a low value calibration when a true zero cannot be achieved.

To edit the Positive Offset value, press <ENT>. The following prompt will be displayed:

POSITIVE OFFSET

POSITIVE = 0.0

Edit the Positive Offset value (from 0 to 10.00) and press <ENT> to accept this value. For initial start-up or after a clear-stack Zero Adjustment, it is recommended that initial values be left at zero positive offset.

Note: - Positive Offset is added as a %. If the unit is set to measure mg/m^3, when the unit returns to the run mode, the display will measure the correlated value in mg/m^3.

Advance to the next parameter by pressing the Down Arrow < ↓ > Key.

The display scrolls up with the bottom line reading:

NEGATIVE OFFSET

During Start-up and Clear Stack operation, no offset is required. If opacity indicates measured readings larger than visual or other opacity measurements and the Opacity cannot be Zero adjusted for Clear Stack Conditions, a Negative Offset can be applied to the measured opacity measurement. To edit the Negative Offset value, press <ENT>. The following prompt will be displayed:

NEGATIVE OFFSET
NEGATIVE = 0.0 pct

Edit the Negative Offset value (from 0 to 10.00 pct) and press <ENT> to accept this value. For initial start-up or after a clear-stack Zero Adjustment, it is recommended that initial values be left at zero negative offset. Advance to the next parameter by pressing the Down Arrow < ↓ > Key.

MG/OPACITY SETUP

****It should be noted that in order to use the DT109D for mass emissions measurements (mg/m^3), a correlation between mass emissions and opacity for the particular plant must be determined. Methods for this vary, but in essence a gravimetric test needs to be done and various mass emission levels must be measured and plotted against opacity. The system allows the user to make such a test enter up to 5 such points.**

To obtain readings in mg, as opposed to the analyzers standard of opacity, press <ENT>. The screen will display as follows:

mg/m^3 Measurement
0=Disable, 1=Enable
mg/m^3 Enable = 0

Select 0 (Disable) if the mg/m^3 is not desired, and the default Opacity display is acceptable. Select 1 (Enable) to change the display to read in mg/m^3 in place of Opacity. Press <ENT>.

If 0 was chosen (mg/m^3 measurement Disabled) the display will return to the parameters Menu. Otherwise the next prompt screen in the mg/m^3 setup is displayed.

mg/Opacity Setup
# of Measured Points
Points = 1 (1-5)

The “Points” represents the number of test points where, at a given opacity value, the gravimetric tests have been performed. Further information on testing can be obtained from http://standards.mackido.com/is2/is-is24_view_5038.html

The larger the number of points the more accurate the mg/m^3 display value will be. For maximum accuracy five test points should be used. One test should be performed at the highest expected opacity, with the other tests evenly distributed over the normal operating range.

The points must be entered in order of opacity. Point 1 should be the lowest opacity value through point 5 which will be the highest.

As a suggestion, the low end test values can be obtained by changing the process to produce less particulate matter, and the high end test values can be obtained

by de-tuning the particulate control equipment to produce higher level of outlet particulate matter.

Select the number of points that will be used and press <ENT> to accept this value.

For each of the number of points that were selected the following prompt screens will appear:

mg/Opacity Setup
Correlation Point *n*
Opacity = xxx.x

For each of the above screens that appear (where *n* is the number 1 through the value entered under # of measured points) type in the opacity value (xxx.x) obtained for that test point. Press <ENT> and then type in the mg/m^3 for the point.

Pressing <ENT> takes you to the next point to enter.

Once you have reached the total number of points that needed to be entered the screen displayed will be as follows:

mg/Opacity Setup

Max Reading= mmmm.m where mmmm.m is the extrapolated value for 100% correlated to it's mg/m^3 value.

After the final entry, the maximum mass value at full scale (in mg/M^3) will be displayed. Pressing the <ENT> key takes you back to the menu.

When mg/m^3 is selected as the display mode the values entered for the Opacities and their corresponding Mass values (in mg/m^3) are used to develop a correlation curve that converts optical density into particulate mass loading. See Appendix I – Curve Fitting.

It is worth noting at this point that the instrument has an accuracy of better than +-2% of full scale. This means that opacity measured on the DT109D at 10% has an accuracy +-2% or 2 points.

This also means that should the opacity be measured in mg/m^3 then the software is responsible for calculating the max reading and thus the +-2% variance will be applied to this new max reading value.

RECORDER RANGE

The recorder range is user selectable from 10 to 100% where 100% is 20mA. Should the user wish to use a higher resolution graph and required that 50% be achieved at 20mA, then the recorder range is simply programmed to that 50% value and at that time the system is re-scaled such that 20mA becomes equal to 50% opacity.

Where the system is used for mass emissions measurements this facility becomes more useful since the max reading may not be a rounded up number. The software has extrapolated the number to a maximum.

At this time, the customer may choose there own recorder full scale. The system then rescales the 20mA output to that newly programmed value.

To change the recorder range press <ENT>. The following prompt will be displayed.

RECORDER RANGE
RANGE = 100 pct

Note: If the value of the 4 to 20 ma signal goes out of range, Asterisks (*****) will appear in the digital display.

Enter new recorder range (From 10 to 100%). Accept the value by pressing <ENT>. Advance to the next parameter by pressing the Down Arrow key < ↓ >.

The display scrolls up with the bottom line reading:

AMBIENT LIGHT CHECK

The automatic offset time is adjustable from 1 to 60 minutes. This is the time interval between checks for ambient light that may affect the actual opacity value. The automatic offset will compensate for ambient light that is detected.

To edit the Time press <ENT>. The following prompt will be displayed:

Ambient Light Check

Time = XX min

Enter the number of minutes desired and press <ENT> to accept this value.

Advance to the next parameter by pressing the Down Arrow key < ↓ >.
The display scrolls up with the bottom line reading:

DATE
To edit the date press <ENT>. The following prompt will be displayed:

DATE = MM/DD/YYYY

ENT to change
CLR to return

To edit the present Date, press <ENT>

SET DATE MM/DD/YYYY
Date =

Enter new Date (MM/DD/YY). Accept the value by pressing <ENT>. Advance to the next parameter by pressing the Down Arrow key < ↓ >.

The display scrolls up with the bottom line reading:

TIME
To edit the time press <ENT>. The following prompt will be displayed:

TIME = HH:MM

ENT to change
CLR to return

To edit the present Date, press <ENT>

SET TIME HH:MM

Time =

Enter new Time (HH:MM). Accept the value by pressing <ENT>. Advance to the next parameter by pressing the Down Arrow key < ↓ >.

The display scrolls up with the bottom line reading:

(COMMUNICATIONS) COMMS. SETUP

To edit the setup press <ENT>. The following prompt will be displayed:

MODBUS I.D #

I.D = 0

To edit the I.D, input the new I.D and press <ENT>

The Screen now displays

MODBUS Port Parity
0= Even, 1 = Odd
Parity = 0

To edit the parity input the new parity and press <ENT>

The Screen now displays

MODBUS Baud Rate
4800,9600,19200
Baud = 09600

To edit the Baud rate input the Baud Rate and press <ENT>

To return to the Main Menu, press <CLR>. The Main Menu will now be displayed on the screen.

*** * * MAIN MENU * * ***
1-RUN
2-PARAMETERS
3-UTILITIES

The selection of '1' from the Main Menu places the Model DT109D in automatic Run Mode.

SECTION 5 - UTILITIES MENU

1. ZERO OR LOW VALUE ADJUSTMENT AND 100% ADJUSTMENT

This zero adjustment in this section can only truly be achieved under 2 circumstances. The first is with a completely clear stack, the second is with the monitor removed from the stack and set up in a workshop at the exact same span distance as it would be in the stack.

Should neither of the above conditions be available, then an EPA Method 9 (http://www.epa.gov/ttn/emc/promgate/m-09.pdf) approach can be taken and instead of doing a zero value adjustment, the low number can be entered in to the control unit following the instructions below.

In this case instead of doing a ZERO adjust it would be a LOW VALUE adjust. The control unit accepts numbers other than zero and so supports calibration under EPA method 9.

The Model DT109D should be adjusted periodically to ensure that the monitor is in calibration. To calibrate the Model DT109D, access the Zero Adjust parameter in the Utilities Routine (See Section 4.6). Use the following procedure for Zero Adjustment:

1. Select the Main Menu by pressing <CLR>. The display shows:

*** * * MAIN MENU * * ***
1-RUN
2-PARAMETERS
3-UTILITIES

2. Utilities is selected by pressing < 3 > from the Main Menu. The display now appears as follows:

>Offset Adjustment

Pressing the down arrow steps to the next prompt and so on

>Zero Adjustment
>100% Adjustment
>Signals
>Analog Output
>Digital I/O

>Software Version
>Clear memory

3. When **>Offset Adjustment** is on the bottom line of the display, Pressing the ENT Key will cause the following prompt to be displayed.

ADJUSTING OFFSET

After approximately 1 minute, the following will be displayed:

OFFSET ADJUSTED

4. When **>Zero Adjustment** is on the bottom line of the display, Pressing the ENT Key will cause the following screen to be displayed.

Online Opacity

Percent = 0.0

If the Enter key (SEE NOTE 1) is pressed at this time, the control unit assumes a clear stack and the unit begins a zero calibration sequence. The following message is displayed.

ADJUSTING ZERO

After approximately 10 seconds, the following prompt will be displayed:

ZERO ADJUSTED

The unit then returns to the main utilities menu

NOTE 1: If a clear stack condition is not attainable and a method 9 observer determines that the opacity is a number other than zero, then this number may be entered at this time. Once the ENTER key is pressed the control unit now sets the opacity to this new number.

NOTE 2: A Zero adjustment should always be performed after an Offset adjustment has been made.

The 100% adjustment tells the control when there is absolutely no light being returned from the retro-reflector and allows the unit to be scaled for 100% opacity. To do this, block the light path as close to the transceiver as possible. Once the light is blocked off, proceed as follows:

5. When **>100% Adjustment** is on the bottom line of the display, Pressing the ENT Key will cause the following screen to be displayed.

ADJUSTING 100%

After approximately 1 minute, the following screen is will be displayed:

100% ADJUSTED

The unit then returns to the main utilities menu

NOTE, if a 100% adjustment is done when there is light entering the receiver this will cause an error and the unit will not calibrate properly. If this does happen, re-do the ZERO ADJUSTMENT and then REDO the 100% ADJUSTMENT in this order.

2. SIGNALS

For diagnostic purposes, an operator may review the Model DT109D measured opacity signal values. These values include Instant (I), Zero (Io), I and Io Offset and Zero Offset.

To review the Model DT109D Signal values, press < 3 >. The following signals will be displayed:

I = XXXX XXXX
Io= XXXX XXXX

ZERO ADJ = XXXX

The numeric values in the right hand column indicate 'I' offset and 'Io' offset respectively.

3. ANALOG OUTPUT

Press <ENT> to send 4 mA to the recorder
Press <ENT> a second time to send 20mA to the recorder
Press <ENT> a third time to send 12mA to the recorder
Press <ENT> a fourth time to return to the Utilities menu

4. DIGITAL I/O
Press <ENT> and the following screen appears:-

Digital I/O
DIN = _ _ _ _ _ _ _ _
DOUT = _ _ _ _ _ _

Each "_" will represent either an input of output that is present on the analyzer

5. SOFTWARE VERSION
Press <ENT> to see the software version fitted to the DT109D
Press <ENT> to return to the Utilities menu

6. CLEAR MEMORY
Press <ENT> and the following screen will appear

Clear memory
0 = No, 1 = Yes
Enter:- 0

Entering a "1" will reset all the system parameters and data to the factory default settings. Entering a "0" will return the system to the Utilities Menu.

Press <CLR> to return to Main Menu.

SECTION 6 - DIAGNOSTIC DISCUSSION

1. INTRODUCTION

During power up of the Model DT109D and while in Run Mode, various diagnostic messages may appear in the display. Each of these messages will be discussed as well as steps to be taken.

2. CANNOT ZERO

The processor receives a Zero Adjust signal from the Model DT109D Optical Transceiver that was less than expected when it read Zero Opacity during a Clear Stack Calibration. The problem can be a very low signal from the transceiver or a blocked optical path.

3. STATUS ALARMS

During Run Mode, the Model DT109D shall indicate any status alarms that may have occurred. These status alarms are indicated in the lower left portion of the LCD display.

PRE-EMISSION ALARM: Opacity has exceeded its Pre-Emission alarm set-point value.

OVER EMISSION ALARM: Opacity has exceeded its Over Emission alarm set-point value.

PURGE BLOWER FAULT: Air Purge Blowers are not operating or blower vane switch fault.

LED OUT ALARM: Transceiver LED out. Replace if necessary.

SECTION 7 - OPTICAL TRANSCEIVER AND RETRO REFLECTOR

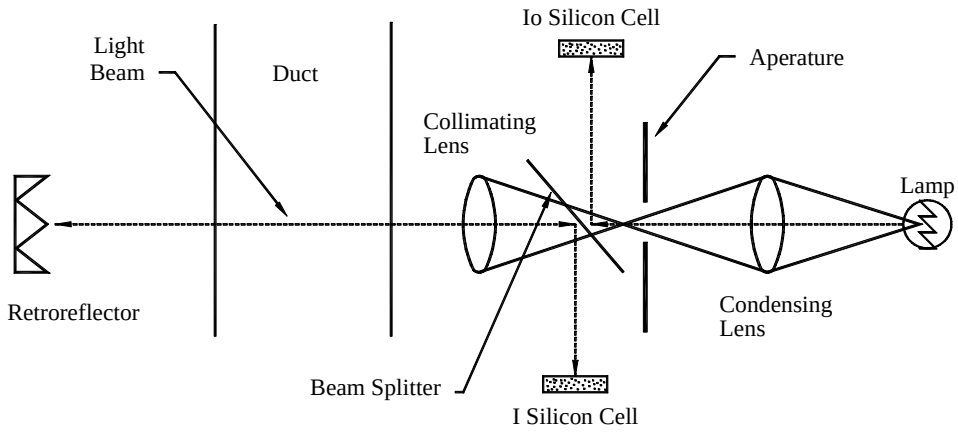
1. LED POWER SUPPLY BOARD

The LED Power Supply Board P2 (1485) is an DC-to-DC converter supplying up to 12 V DC to the Transceiver LED Emitter. The DC voltage is regulated by potentiometer R66.

During the factory set-up, the unit is calibrated to ensure the maximum light path can be achieved. Once the unit arrives in the field, the path may be less and as such the signals as discussed earlier may be locked at 1023. This means that the unit must be re-calibrated using Procedure RKXXXX

2. OPTICAL TRANSCEIVER - GENERAL

The Optical Transceiver consists of an LED, condensing lens, aperture, beam splitter, optical window lens and two silicon cells. The light from the LED is collimated to produce a narrow parallel light beam which is focused through an aperture. Horizontal light passing through the aperture strikes a beam splitter which allows some of the light from the LED to be reflected to the 'Io' silicon cell. Light reflected from the optical retro reflector again strikes the beam splitter and is reflected to the 'I' cell.



TRANSCEIVER OPTICAL SYSTEM

The current output of both cells is amplified to produced a voltage output. The two voltage signals, representing I and Io are measured by a A/D converter and converted to a digital signal.

The microprocessor compares the intensity of the LED in the transceiver to the intensity of the light beam after it has gone through the stack or duct. This difference in signal level is processed by the microprocessor which determines the emission level of the system.

The signal is not linear but logarithmic. The microprocessor linearizes this signal.

3. OPTICAL RETRO REFLECTOR

The retro reflector reflects the light beam back to the transceiver in the same path as the transmitted beam. This reflected beam strikes the beam splitter where it is measured by cell 'I'.

The retro reflector included standard with the DT109D system can withstand temperatures up to 150°F (66°C). A purge air blower cools down the gas to allow the retro reflector to be used in a higher temperature ambient. High temperature environments are accommodated by using glass retro reflectors.

SECTION 8 - TROUBLE SHOOTING

1. OVERVIEW

The system troubleshooting section is divided into two parts that describe how to identify and isolate opacity monitor faults. The first part describes sensor faults and the second describes electronic faults. The alarms and messages caused by either may overlap.

2. SPECIAL TROUBLESHOOTING NOTES

a. Grounding:

It is essential that adequate grounding precautions are taken when system is being installed. Thoroughly check all grounding connections before and after fault finding.

b. Loose Integrated Circuits:

The electronics uses a microprocessor and supporting integrated circuits. Should the electronics receive rough handling during installation, or is installed in a location that is subject to severe vibration, an integrated circuit (IC) could work loose. The fault finding guide, table 11-1, shows results of a variety of failure symptoms. Make sure all IC's are fully seated before system troubleshooting begins.

c. Electrostatic Discharge:

Electrostatic discharge can damage the IC's used in the electronics unit. It is essential before removing or handling the processor board or the IC's used on it, that the user ensure he/she is at ground potential.

SECTION 9 - SERVICE AND NORMAL MAINTENANCE

1. OVERVIEW

This section describes routine maintenance of the Model DT109D Smoke and Particle Monitor. Spare parts referred to are available from Datatest. Observe warning and caution labels.

2. LENS CLEANING

The most important maintenance function on this equipment is to make sure that the Air Purge is sufficient, clean, and dry. If the air is moist, than a film of condensed water will form on the optical windows and increase the opacity measurement. The frequency for cleaning the optical windows is site specific. The user should determine the frequency of cleaning based on how quickly the optical windows become dirty. However, they should be cleaned every three months whether it is needed or not.

The retro reflector as well as the lenses should be cleaned with a lens cleaner or water. Do not use alcohol or other solvents as it may damage the optical surfaces.

1. Remove the top plate of the mounting cross at the transmitter/receiver unit.

2. Put some degreasing solution (such as lens cleaner) on a clean cloth and clean the lens.

3. Replace the top plate

4. Repeat 1, 2 and 3 for the retro reflector.

3. TRANSMITTER LED REPLACEMENT

The LED voltage at the transceiver can be adjusted up to 12 VDC..

Normal LED life is about 6 years.

a) Turn power OFF and take the Transceiver to the repair shop.

b) Remove the 4 screws from the back plate.

c) Remove the two (2) screws on each side of the LED bracket.

d) Take the LED assembly out and remove the set screw that holds the LED in place.

e) Remove the LED and unsolder the wires. If wire nuts are in place, use them.

f) Replace LED.

g) Reconnect the Transceiver and turn the system ON. Adjust the LED with the single screw on the rear of the LED bracket so that the image of the filament is at the center of the lens and in a vertical position.

4 LAMP FAILURE

This alarm will be display if the LED is low or if the LED has burned out. It could be due to other causes such as a defected LED supply, wiring, defective silicon cell, etc.

5. SPARE PARTS

Table 9-1
Recommended Spare Parts for Sensor

PART NUMBER	DESCRIPTION	QUANTITY
DK5078	LED Bracket Assembly	1
DT109D-PCB	PC Board	1
DK5046	LED Power Supply - PC2	1
DK5021	Collimating Lens	1

6. RETURNING EQUIPMENT TO THE FACTORY

If factory repair of equipment is required, proceed as follows:

a. Secure a return authorization from Datatest Industries before returning the equipment. Equipment must be returned with complete identification in accordance with Datatest instructions or it will not be accepted.

In no event will Datatest be responsible for equipment without proper authorization and identification.

b. Carefully pack unit in a sturdy box with sufficient shock absorbing material to insure that no additional damage will occur during shipping.

c. In a cover letter, describe completely:

1. The symptoms from which it was determined that the equipment is faulty.

2. The environment in which the equipment has been operating.

3. Site from which equipment was removed.

4. Whether warranty service or non warranty service is requested.

5. Complete shipping instructions for return of equipment.

d. Enclose a cover letter and purchase order and ship the equipment according to instructions provided in Datatest Return Authorization, prepaid to:

DATATEST Inc.
300 Valley rd
Hillsborough NJ 08844
TEL: (908) 369 1590
FAX: (908) 369 1594
Web: http://www.datatest-inc.com
email: info@redkoh.com

If warranty service is requested, the unit will be carefully inspected and tested at the factory. If failure was due to conditions listed in the standard Datatest warranty, the unit will be repaired or replaced at Datatest option, and an operating unit will be returned to the customer in accordance with shipping instructions furnished in the cover letter.

For equipment no longer under warranty, the equipment will be repaired at the factory and returned as directed by the purchase order and shipping instructions.

6. WARRANTY

Datatest Industries guarantees this system for a period of one (1) year from date of installation, but not in excess of fifteen months from shipment, to be free from defects in material and workmanship. Our obligation under this guarantee is limited to repairing or replacing any instrument or part thereof which shall, within the above specified time, be returned to us with transportation charges prepaid, prove after our examination to be thus defective.

In the event that the customer requires a Datatest field service technician or engineer on site, the customer will be billed for this service at our standard rate. This applies whether the equipment is in or out of warranty. This daily rate is based on the man-days spent 'on site', plus travel time. Expenses for travel and living are billed at cost.

Instruments returned under this warranty will not be accepted at the Datatest plant without prior authorization by Datatest personnel.

Returned Equipment: Freight **must** be prepaid by the user. Datatest will assume the cost of shipping the unit back to the user by common carrier. If the user wishes it returned by other, the user will be billed for the additional charges.
We reserve the right to discontinue instruments without notice, and to make modifications in design at any time without incurring any obligation to make such modifications to instruments previously sold.

Appendix I – Curve Fitting

The data points used to develop the correlation curve that converts Optical Density into Particulate Mass loading are entered via this screen. These

Data points are derived by monitoring the Optical Density (or Opacity) output while simultaneously performing isokinetic extractive testing to determine the source Particulate Mass. Each point consists of an Optical Density (or Opacity) value and a correlating Particulate Mass value.

Optical Density (O.D.) is calculated with this formula:

$$O.D. = \log \frac{1}{1 - \text{opacity}}$$

Opacity is calculated with this formula:

$$\text{Opacity} = 1 - \frac{1}{10^{O.D.}}$$

Particulate Mass is then derived from O.D. as a straight-line approximation, using up to five line segments. The first segment has zero as its origin and ends at the first O.D./Particulate Mass pair of numbers entered. The second segment is a line from the first number pair to the second O.D./Particulate Mass pair of numbers. The third segment runs from the second number pair to the third O.D./Particulate Mass pair of numbers and so on.

This is shown on the following graph.