Model DT109S
Opacity Measurement System

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Table of Contents

SECTION 1 - OPACITY MEASUREMENT SYSTEM OVERVIEW

1. MONITOR OVERVIEW

a. Monitor Description

The Datatest Model DT109S Smoke and Particle Monitor is a single-pass monitoring system designed for continuous opacity measurement of smoke or particulate concentration in a stack or flue. The model DT109S is ideal for use as a bag house monitor or as a Continuous Emission Monitor.

The Model DT109S 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 DT109S controller. The controller converts this signal to a 4-20 mA output, and displays measurements on a 80 character LCD display.

The electronic package incorporated within the DT109S 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 lamp out alarms are provided so that minimal operator attention is required.

Many other features included with the DT109S are a 4-line, 80 character LCD display and 16 element keypad which provides communication interface between operator and the Model DT109S.

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, Transient Detection and Recorder Range. A RS-232 / RS-422 /RS485 Modbus RTU communication port is also provided to allow two way 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.

The Model DT109S has certain parameters and facilities that are protected from unauthorized operation by the use of an access code which must be entered on the keypad.

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 DT109S takes the difference of the light beam passing through the duct (I) and compares it to the reference light from the lamp (I_o). This method cancels out any variations due to voltage changes and tungsten loss in the lamp.

A differential amplifier compares the intensity of the light beam in the Transmitter to the intensity of the light beam in the Receiver after the light beam has gone through the stack or duct. Light intensity is measured in the Transmitter and Receiver using Silicon Cells. The amplified signals goe to the Controller, and by using mathematical computations in the software produces the Opacity that is displayed and available for output at the Controller.

The “raw” values of these signals are also displayed for calibration purposes.

I = Light thru the stack ($I < I_o < 1$), signal from the Receiver.
I_o = Reference for the light source ($I_o < 1$), signal from the Transmitter.

c. Electronic Controller.

The DT109S microprocessor Controller electronically controls display measurements, calibrations, functions, and provides analog and serial outputs to other devices. Normally Open (N.O.) Relay contacts are provided for Pre and Over Emission set points alarms, and fault diagnostics.

d. Monitor Features

1. A 16-key tactile feedback membrane keyboard for parameter programming.

2. An LCD 4-line, 80 character display prompts the operator during the setup of parameters, display of date and time, measurement of opacity, alarms indication, etc.

3. A serial communications port providing two way communication with other data acquisition systems.

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

5. Indications of alarm or 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 lamp source intensity.

SECTION 2 – SPECIFICATIONS

Model DT109S Opacity Monitor

1. CONTROL UNIT

Standard Measurement Ranges	Measures opacity from 0-100%
Analog Outputs	2 x 4-20 mA
Accuracy	Less than 1.0% F.S.
Response Time	Less than 10 seconds (95%)
Sensitivity	0.2% F.S.
Span Drift	Less than +/- 0.5% opacity/day
Display	4-Line, 80 Character LCD
Temperature Range	Ambient -20 to 125°F (-28 to 52°C)
Relative Humidity	95%, non condensing.
Supply Voltage	115/220 Vac +/- 10% at 50/60 Hz.
Power Consumption	100 Watts at 115 VAC, 50/60 Hz.
Enclosure	Panel, Rack Mount, or NEMA 4 (X) Wall Mount.
Alarm Set Points	0-100% Opacity user selectable
Self-Diagnostic	Alarms for 'Lamp Out', 'Blower Out', High and Over Emission.

2. TRANSMITTER

Type	Silicon Cells
Spectral Response	400 to 700 nanometers at the 10% points.
Environmental	Severe environmental rated.
Optical Method	Single Pass
Detector Type	Light Sensitive Diodes
Lamp Source	Tungsten lamp, average life 3 years.
Ambient Temperature	-20°F to 150°F
Air Purge	Recommended for lens cleaning. 15 CFM min., each side for positive systems.

3. RECEIVER

Type	Silicon Cells
Spectral Response	400 to 700 nanometers at the 10% points
Environmental	Severe environmental rated
Optical Method	Single Pass
Detector Type	Light Sensitive Diodes
Ambient Temperature	-20℉ to 150℉
Air Purge	Recommended for lens cleaning. 15 CFM min., each side for positive systems

4. OUTPUTS

LCD Display	4-line, 80 character LCD
Analog	4-20mA option available
Serial Port	RS-232 & RS-422 & RS485 Modbus RTU communication ports for two way communications with other data acquisition systems
Relay Outputs (N.O., SPST, 1A)	High and Over Emission Set Points System Fault

5. CALIBRATION

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

6. ALARMS

High and Over Emission	0-100% Opacity, user selectable
Lamp Out	Transmitter Lamp Out
Air Purge Blower	Air Purge Blower Failure
Internal	Audible 60 dB alarm
External	N.O. SPST Relay Contacts, 1 Amp AC/DC
Alarm Condition	Reported to Screen

7. SLOTTED PIPE (Optional)

Slotted Pipe Material	3” Black Iron Pipe or PVC
Span Width	1 to 10 feet.
Process Temperature	Standard: 1500°F (815°C) max

8. AIR PURGE BLOWERS (Optional - Highly Recommended for Positive Pressure Stack)

Purge Air Flow Rate	15 CFM/port

SECTION 3 - INSTALLATION

1. OVERVIEW*:*

This section covers the installation of the Model DT109S Smoke and Particle Monitor. When installing, observe the following precautions.

a. HAZARDOUS LOCATIONS: Do not operate the optical transceiver in an explosive atmosphere.

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 the Control Unit where it will be in direct sunlight.

c. CONTROL UNIT TEMPERATURE: Ambient temperatures must be in the range of 0°C to 50°C (32°F to 120°F). If the Control Unit is used outside this operating range, the accuracy and error limit can not be guaranteed.

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 Transmitter and Receiver.

e. CONTROL UNIT MOUNTING DISTANCE: Mount the Control Unit within 200 feet of the Transmitter or Receiver.

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

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

h. TURBULENCE: The Transmitter and Receiver should be as far away as possible from bends in the ductwork or pipe entrances (length > 5 diameters of the bend). This will allow a smooth flow past the instrument and increase the accuracy of the measurement.

i. CONDENSATION: Condensed water vapor at the Transmitter/Receiver location will increase the opacity measurement level. Locate them in an area where the temperature is high enough to keep the water in a gaseous form. If the Transmitter/Receiver is too close to a duct or stack exit, rain or snow will cause a false opacity measurement.

j. ACCESS TO THE TRANSMITTER: It is necessary to be able to get to the Transmitter and Receiver to clean the optical windows. A platform should be provided at these points.

k. AMBIENT LIGHT: Direct or indirect sunlight shinning in the duct or stack will cause the instrument to read a lower opacity. Minimize the ambient light by installing the Transmitter/Receiver well away from the end of a duct or stack.

2. CONTROL UNIT INSTALLATION

a. Mechanical Installation - NEMA 4 Surface Mount: The Control Unit enclosure requires installation in a location free from significant temperature changes and electrical noise. Ambient temperatures must be between 32°F and 120°F (0-50°C).

b. Electrical Connection.

1. Power input: Designed for either 115 or 220 Vac, +/-10%, single phase, 50 or 60 Hz, 250 watts maximum.

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 DT109S has a standard 4-20mA current output. The outputs are calibrated assuming a 250 Ohm load impedance. This output signal can be fed to an external load such as a recorder, or the signal can be used to drive a single external meter or recorder, as desired.

4. RS-232/422/485 CONNECTIONS: The Model DT109S is equipped with a serial port. This allows the Model DT109S to report its data to a computer or to a PLC for permanent storage.

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 DT109S.

RELAY OUTPUT TB1	DESCRIPTION	Contact
21	Over Emission Set Point	(N.O.)
20	Over Emission Set Point	(COM)
19	Pre Emission Set Point	(N.O.)
18	Pre Emission Set Point	(COM)
15	System Fault	(N.O.)
14	System Fault	(COM)
23	Blower Alarm	(NO)
22	Blower Alarm	(COM)
25	Lamp Out Alarm	(NO)
24	Lamp Out Alarm	(COM)

3. ATTACHMENT OF TRANSMITTER TO DUCT OR STACK WALL:
The following process connections are needed for installation and operation of the Opacity Transmitter and Receiver of the Model DT109S.

4. RECEIVER
The standard Receiver included with the DT109S system can withstand ambient temperatures up to 66°C (150°F). If the unit is to be mounted in a location where the temperature exceeds this, check to see if additional air purge blowers will help to lower the temperature at the Receiver.

5. CABLE FROM TRANSMITTER TO CONTROL UNIT
a. Transmitter Lamp Power Supply Wiring
Refer to attached Wiring Diagram in Appendix I, use 2C-14 AWG insulated wire to run the transceiver lamp power supply from the Control Unit terminal block TB1 terminals 11 and 12 to the Transmitter Junction Box.

b. Transmitter Photocell Wiring
Refer to Wiring Diagram in Appendix I, the Shielded cable for carrying the silicon current from the Transmitter should be Belden #8777 or equivalent (6C-22 AWG shielded pairs).

c. Receiver Photocell Wiring
Refer to Wiring Diagram in Appendix I, the Shielded cable for carrying the photocell current from the Receiver should be Belden #8777 or equivalent (6C-22 AWG shielded pairs).

6. ANALOG SIGNAL CABLE FROM CONTROL UNIT TO A REMOTE DEVICE
Standard 4-20 mA analog signals are available from the Model DT109S Control Unit for recording and logging purposes. Use a pair of #22 AWG shielded cable to connect to the recorder. For the current outputs (4-20 mA), the units are tested with a 250 ohm load. See drawing in Appendix I for analog signal output connections.

7. OPTICAL ALIGNMENT
The following procedure is required to Optically Align the Transmitter and the Receiver using the mounting brackets.

a. Remove the Receiver and put a piece of translucent material in front of the hole.

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

c. Replace the Receiver.

8. ZERO ADJUSTMENT (Clear Stack)

In order to adjust the Opacity meter to zero, it is necessary to have a clear stack or duct. The Model DT109S should be Zero adjusted periodically to ensure that the monitor is in calibration. To calibrate the Model DT109S for zero opacity, access the Zero Adjust parameter in the Utilities Routine (See Section 4). Use the following procedure for a Clear Stack 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
>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 several seconds, the following prompt 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 prompt to be displayed.

ADJUSTING ZERO

After several seconds, the following prompt will be displayed:

ZERO ADJUSTED

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

The unit is now ready for use.

SECTION 4 - STARTUP AND OPERATION

1. INTRODUCTION

When the Model DT109S has been set up as described in Section 3, it is then ready for operation. This section describes what the Model DT109S 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 DT109S 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 DT109S will go into the RUN Mode and the run screen will appear as follows.

INSTANT	=	5.1 %
AVERAGE	=	4.8 %
OK		19:24

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

4 SETTING PARAMETERS

When the Model DT109S 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

Set parameters is 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. Each parameter will be discussed in detail in Section 5.

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 that it does not trigger during start up (ex. 15 pct). To set the Opacity Pre Emission alarm set point press <ENT>. The following prompt will be displayed:

PRE-EMISSION

PRE = XXX.X pct

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 DT109S 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

Enter the new Alarm Opacity Over Emission Setpoint 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 < ↓ >.

TRANSIENT MODE (FUTURE)

This parameter is toggled ON or OFF to compensate for dust accumulation that may occur on the lens. In this mode, only transients will be observed and the meter and outputs will be at constant opacity (ex. 0% opacity for clear stack) until an event occurs. An event could be a rupture in the seam of a bag in a baghouse or a small sudden discharge.

With Transient Mode ON, the Model 109 compensates for dust accumulation and minor transient changes so that the instantaneous Opacity measurement is a measurement of true opacity. With Transient Mode OFF, opacity measurement includes dust accumulation on the lens.

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

TRANSIENT MODE

MODE = 0

Enter '1' to turn Transient Mode ON, a '0' to turn it OFF. Accept the value by pressing <ENTER>. The following prompt will be displayed:

TRANS FULL SCALE

SCALE = XXX

This parameter allow the model DT109S to ignore minor transient changes from zero to 100 percent opacity. To edit the Transient value, enter the new Transient Full Scale value. 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 0 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 0 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 measurement where the stack exit path length is the same as the measurement path length, stack exit ration 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 opacity indicates measured readings 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. To edit the Positive Offset value, press <ENT>. The following prompt will be displayed:

POSITIVE OFFSET

POSITIVE = 0.0 pct

Edit the Positive 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 positive offset. 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/OPAC RATIO

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

mg/Opacity Ratio
Ratio = 0.00

Edit the ratio and press <ENT> to accept this value. Advance to the next parameter by pressing the Down Arrow < ↓ > Key.

RECORDER RANGE

The recorder ranger is user selectable from 10 to 100 %. To change the recorder range press <ENT>. The following prompt will be displayed.

RECORDER RANGE
RANGE = 100 pct

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:

DATE

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

DATE = 01/01/2008

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:

DATE = 00:45

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:

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 DT109S in automatic Run Mode.

5. 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.

6. CLEAR STACK CALIBRATION

After the Model DT109S Opacity Monitor has been installed and the Parameters have been installed by accessing the Utilities Routine from the Main Menu, the Model DT109S is now ready to be calibrated. In order to calibrate the Model DT109S, a Clear Stack or Duct condition must be obtained to Zero Adjust the monitor. The Model DT109S should be Zero Adjusted periodically to ensure that the monitor is in calibration. Follow the procedure outline below to Offset and Zero Adjust the Model DT109S.

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

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

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

Offset Adustment

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

>**Zero Adustment**
>Signals
>Analog Output
>Digital I/O
>Software Version
>Clear memory

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 several seconds, the following prompt will be displayed:

OFFSET ADJUSTED

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

ADJUSTING ZERO
After several seconds, the following prompt will be displayed.

ZERO ADJUSTED

SECTION 5 - PARAMETERS

1. INTRODUCTION

This section goes through each of the parameters that are needed by the Model DT109S for operation. The actual setting of these parameters was discussed earlier in this manual. The discussion here will detail the full features and limits of these parameters. The order of presentation will be the same here as the order they appear in the parameter routine.

2. PRE-EMISSION ALARM SET POINT

Opacity Pre-Emission set point alarms can be set to provide relay contacts and alarm messages for these conditions. If the opacity goes above the Pre-Emission set point value, the screen displays the alarm and a set of contacts within the electronics close for remote indication.

The display indication of an alarm condition alerts the operator to check the alarm status. The contact closure provides means for an external alarm such as a light, horn, siren, etc. The contact will handle up to 10 amp at 250VAC. If more current is needed, this contact closure can be used to activate an external relay that can handle a greater load.

When the opacity level goes below the Pre-Emission set point the relay closure opens to remove the alarm and the alarm statement in the Run Menu on the display is removed.

3. OVER EMISSION ALARM SET POINT

Opacity Over-Emission set point alarms can be set to provide relay contacts and alarm messages for these conditions. If the opacity goes above the Over-Emission set point value, the screen displays the alarm and a set of contacts within the electronics close for remote indication.

The display indication of an alarm condition alerts the operator to check the alarm status. The contact closure provides means for an external alarm such as a light, horn, siren, etc. The contact will handle up to 10 amp at 250VAC. If more current is needed, this contact closure can be used to activate an external relay that can handle a greater load.

When the opacity level goes below the Over-Emission set point the relay closure opens to remove the alarm and the alarm statement in the Run Menu on the display is removed.

4. ALARM DELAY

Alarm delay provides a buffer for excess emission spikes that may occur during start-up or normal operations. Pre-emission and Over emission alarms will not occur unless emission level exceed the set point by the time specified by the alarm delay. This set point delay prevent opacity emission spikes from producing multiple false excess emission alarms that are of very short duration.

An alarm delay or 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 alarm by that amount of time.

5. DATE

The date is entered by using eight digits. The first two digits (01-12) represent the month, the second two (01-31) are for the day, and the final four are for the year. This information is stored in the battery backed RAM. The battery portion will cause updating even when power is removed from the Model DT109S. The Model DT109S should read the correct date at any time unless the memory is lost. Even when the Model DT109S is not powered, the date and time are updated and changed. Each month is corrected for the proper days.

6. TIME

The time is entered on the basis of a 24 hour clock. Four digits are entered, the first two for the hour (00-23) and the second two for the minutes (00-59). The battery backed RAM keeps the clock running even if the Model DT109S is turned off. The time will **not** correct for Daylight Savings Time.

7. RECORDER RANGE

The recorder range relates to the analog signal available on the Model DT109S. This analog signal is obtained from the digital output and is thus a calibrated signal directly proportional to the instantaneous opacity measurement the Model DT109S detector is seeing. This signal is a 4-20mA. The full scale value for 20mA is set by the Recorder Range parameter.

8. AVERAGE TIME

This parameter allows the measured opacity to be averaged over the specified time entered by the operator. An averaging time from 0 to 60 minutes can be specified.

The averaging time is useful for reporting requirements or to prevent numerous excess emission spikes.

9. EXIT CORRECTION

Monitoring regulations require that opacity monitors indicate the opacity at the stack outlet. In-stack opacity measurements by an opacity monitor must be reported as stack exit opacity by making allowance for the measurement path length difference between the stack exit and the opacity monitor location. The stack exit correction predicts opacities as they would exist at the stack exit by adjusting the measured opacity at the monitor location.

Since the optical density of the effluent is proportional to the optical beam path length through the effluent, the stack exit opacity can be calculated by multiplying the in-stack optical density (measured by the opacity monitor) by the ratio of the stack exit diameter to the optical path length of the monitor.

$$OD(exit) = \frac{L(exit)}{L(monitor)} \times OD(monitor)$$

The length of the optical path is defined as twice the inside diameter of the stack. The stack exit correction factor is defined as:

$$\frac{L(exit)}{L(monitor)} = \text{Stack Exit Correction factor}$$

Stack Exit Correction Factor is incorporated into the calculation of stack exit opacity in the Stack Exit Correction equation.

10. POSITIVE OFFSET

Positive Offset allows a positive adjustment to the Opacity measurement when the process cannot allow a Clear Stack Zero Calibration of the Opacity monitor. The offset may have been caused by alignment changes due to temperature or interference problems.

11. NEGATIVE OFFSET

Negative Offset allows a negative adjustment to the Opacity measurement when the process cannot allow a Clear Stack Zero Calibration of the Opacity monitor. The offset may have been caused by alignment changes due to temperature or interference problems.

SECTION 6 - UTILITIES MENU

1. INTRODUCTION

The Utility portion of the Main Menu provides a number of features as explained below to the operator. To access the Utilities Menu, the operator selects the Main Menu by pressing <CLR>.

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

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

>Offset Adustment

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

Zero Adustment
>Signals
>Analog Output
>Digital I/O
>Software Version
>Clear memory

2. OFFSET ADJUSTMENT

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 several seconds, the following prompt will be displayed:

OFFSET ADJUSTED

3. ZERO ADJUSTMENT

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

ADJUSTING ZERO

After several seconds, the following prompt will be displayed:

ZERO ADJUSTED

Press <CLR> to return to Main Menu.

4. SIGNALS

For diagnostic purposes, an operator may review the Model DT109S measured opacity signal values. These values include Instant (I), Zero (Io), I and Io Offset and Zero Offset.

To review the Model DT109S 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.

5. 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

6. 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

7. SOFTWARE VERSION

Press <ENT> to see the software version fitted to the DT109S

Software Revision
DT109S Ver 1.02
Single Pass

Press <ENT> to return to the Utilities menu

8. 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 7 - CALIBRATION

1. INTRODUCTION

In order to Zero Calibrate the Model DT109S Opacity Monitor, the Transmitter must be properly aligned and measuring a clear stack or duct. It is important that the process be off-line and the model DT109S Transmitter is measuring a clear stack or duct. These methods are discussed earlier in this manual.

2. CALIBRATION

To begin a Calibration of the Model DT109S, one must get to the Main Menu. From the Run Mode this is done by pressing the <CLR> key. The display shows:

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

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

>Offset Adustment

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

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

3. OFFSET ADJUSTMENT

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 several seconds, the following prompt will be displayed:

OFFSET ADJUSTED

4. ZERO ADJUSTMENT

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

ADJUSTING ZERO

After several seconds, the following prompt will be displayed:

ZERO ADJUSTED

The system is now calibrated.

To return to Run Mode, press <1>.

SECTION 8 - DIAGNOSTIC DISCUSSION

1. INTRODUCTION

During power up of the Model DT109S 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 reference (Io) signal from the Model DT109S Optical Transmitter 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 transmitter or a blocked optical path.

3. STATUS ALARMS

During Run Mode, the Model DT109S shall indicate any status alarms that may have occurred. These status alarms are indicated in the lower left portion of the LCD display.

FAULT STATUS

Description of Fault

Pre-Emission Alarm
Over Emission Alarm
Purge Blower Fault
Lamp Out Alarm
Transient Mode ON (Future)

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

OVER EMISSION ALARM: Opacity has exceeded its Over Emission alarm setpoint value.

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

LAMP OUT ALARM: Transmitter Lamp out. Replace if necessary.

SECTION 9 – Transmitter and Receiver Description

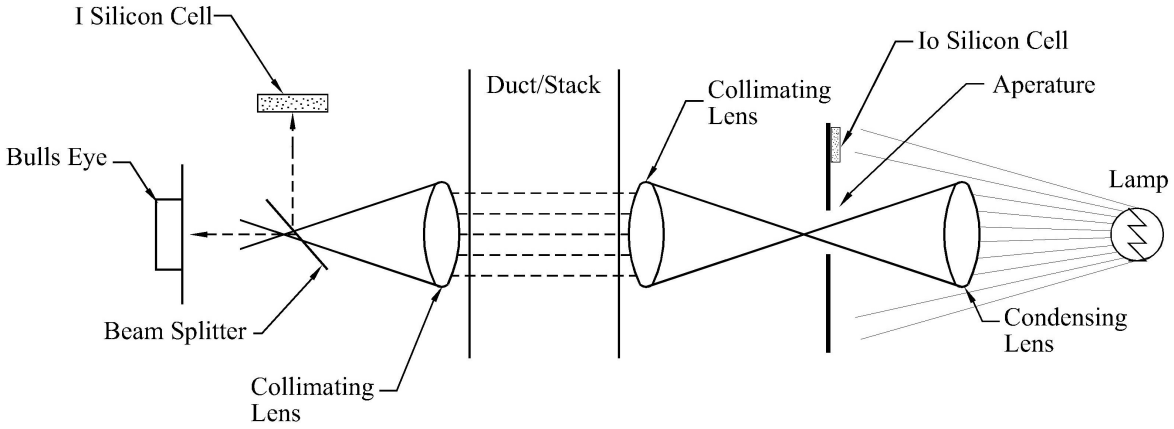
1. LAMP POWER SUPPLY BOARD

The Lamp Power Supply Board (PC2) is a DC-to-DC converter supplying up to 12 V DC to the Transmitter Lamp Emitter. The DC voltage is regulated by Lamp Voltage Pot (see drawing 06-3842).

During the factory set-up, the unit is calibrated to the path length provided in the customers specification to ensure the maximum light path can be achieved. If the actual path length differs by more than 1/3 of the specified path length the system should be returned to the factory for recalibration. If the path length differs by less than 1/3 the specified path length Datatest Industries should be called for technical help.

2. TRANSMITTER – GENERAL

The Transmitter consists of a lamp, condensing lens, aperture, beam splitter, Collimating lens and silicon cell. The light from the lamp is collimated to produce a narrow parallel light beam. Some of the light from the lamp reaches the 'Io' silicon cell.



TRANSMITTER OPTICAL SYSTEM

The current output of the Io cell is sent to the Controller where it is used as a reference and compared to the I signal sent from the Receiver

3. RECEIVER

The Receiver consists of a Collimating lens, a beam splitter, a silicon cell, and an amplifier board. The beam splitter sends some light to the silicon cell and some light to the bull's-eye screen located on the back of the Receiver. The current output from the silicon cell is amplified and converted to a voltage signal (I). This signal is sent to the Controller for comparison with Transmitter Io signal.

4. CONTROLLER

The controller receives the Io and I signals from the Transmitter and Receiver and through mathematical application displays a corresponding Opacity value. Programming of the various parameters of the system is also performed at the controller. The Controller has both a 4 to 20 mA and serial output to interface with other equipment and recording devices.

SECTION 10 - 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 the 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 shipment or installation, or is installed in a location that is subject to severe vibration, an integrated circuit (IC) could work loose**. Make sure all IC's are fully seated before system troubleshooting begins.** The fault finding guide, table 10-1, shows results of a variety of failure symptoms.

c. Electrostatic Discharge:

Electrostatic discharge can damage the IC's used in the electronics unit. It is essential that before removing or handling the processor board or the IC's used on it, that the user ensure he/she is at ground potential. A wrist ground strap could be used to insure proper grounding.

3. OPTICAL TROUBLESHOOTING

a. Sensor Faults:

Listed below are three symptoms of sensor failure.

1. The system does not respond to changes in opacity concentration.

2. The system responds to changes in opacity, but does not give correct indication.

3. The system does not give an acceptable indication of the value of opacity during Zero Adjust Calibration.

b. Fault Finding: Table 10-1 is a guide for finding faults of the above symptoms.

MALFUNCTION	FAULT	CHECK	REMEDY
No response to opacity concentration change	Electronic Circuit malfunction	Check opacity is changing at stack	Replace Main PC Board
System responds to opacity measurement changes but does not give correct reading.	Calibration error	System calibration	Recalibrate System
	Dirty optical window	Check transmitter and receiver optical window.	Clean transmitter and receiver optical window.
	Optical Misalignment	Optical Alignment	Re-align the Transmitter and Receiver
System does not give accurate indication of opacity.	Blocked slotted tube	Check optical path/ports	Clear obstruction
	Dusted lenses	Check lenses	Clean lenses

TABLE 10-1

4. ELECTRONICS TROUBLESHOOTING

The Model DT109S has many diagnostic features which aid fault finding. Normally the user will not need to use electronic testing equipment in fault diagnostic. Almost all reasons for system malfunction are displayed by either an alarm or a fault message on the liquid crystal display.

TESTING: To simplify troubleshooting procedures, the Model DT109S can test and display the following:

1. I Cell signal mV Output and I Offset. Signals - Function 3

2. Io Cell signal mV output and Io Offset. Signals - Function 3

The procedure for testing these functions is discussed in Section 8, Diagnostics. These functions are accessible in the Utilities Menu, function number 3, for Signals.

TESTING PARAMETERS:
To test functions other than the LCD display, use the following procedure.

1. Press <CLR> to access Main Menu.
2. Press < 3 > to access Utility Menu.
3. To view mV Signals and Offsets, Press < 3 >.

5. ALARM MESSAGES

The Model DT109S has various Diagnostic Alarm features which may appear on the LCD display are listed below. Each of these alarm messages are discussed in Section 8.

MESSAGE OR ALARM	FAULT CONDITIONS
PRE ALARM ...(1)	High opacity measurement.
OVER ALARM ..(2)	Excess opacity measurement.
BLOWER OUT ..(3)	Faulty Purge Air Blowers or Vane Switch.
LAMP OUT .....(4)	Transceiver Lamp Out.
TRANSIENT ...(5)	Transient Mode - ON

SECTION 11 - SERVICE AND NORMAL MAINTENANCE

1. OVERVIEW

This section describes routine maintenance of the Model DT109S Smoke and Particle Monitor. Spare parts referred to are available from Datatest Industries. Observe warning and caution labels.

2. PRELIMINARY CHECKS

The following preliminary checks will help isolate problems in the Controller. Run these checks before beginning any repair work. Check parameter and displays according to instructions in System Startup.

a. Check Display for Alarms:
Go through normal power up procedure. Check display for alarms. If there are alarms, troubleshoot according to Section 10.

b. Run Zero Adjust Calibration Check:
Run Zero Adjust Calibration check procedure according to Section 7.

If calibration is successful, no problem exists.

If calibration fails, shut off power and make sure that all wires are properly connected to monitor and transceiver.

Check optical path. If everything checks out properly, proceed to step c.

c. Check I and Io Cell Output:
Turn power on. Check I and Io mV output to microprocessor. It should be between 0 and 1023 counts.

3. MONITOR CALIBRATION:

The Datatest Model DT109S Opacity Monitor should be calibrated when installed (Zero Adjust). Under normal operation, the system will not require frequent calibration. When calibration is required, follow the procedures outlined earlier.

4. TRANSMITTER REMOVAL AND INSTALLATION:

a. TRANSMTTER REMOVAL:

This paragraph covers the Model DT109S Transmitter removal from the stack or duct. Use the following procedure to remove the Transmitter from the Model DT109S for repair or replacement.

1. Turn AC power OFF to Control Unit.

2. Disconnect and turn off AC power to the Opacity Control Unit. Do not attempt to work on the Transmitter assembly until it as cooled to a comfortable working temperature.

3. Disconnect the signal cable wiring leading to the Control Unit from the Transmitter.

4. Disconnect Vane Switch wiring leading to Air Purge Blowers (if supplied).

5. Disconnect flexible tubing leading to Air Purge Blowers (if supplied).

6. Using a Strap wrench, remove transceiver from its mounting cross.

b. TRANSMITTER REPLACEMENT:
Use the following procedure to install Model DT109S Transmitter to the stack or duct.

1. Using a Strap wrench, connect Transmitter to its mounting cross.

2. Connect flexible tubing leading to Air Purge Blowers (if supplied).

3. Connect Vane Switch wiring leading to Air Purge Blowers (if supplied).

4. Connect signal cable wiring leading from Control Unit or Junction Box to Transmitter. See drawings in Appendix I for wiring and connector connections.

5. Turn ON AC power to Control Unit.

5. CONTROL UNIT REPLACEMENT AND INSTALLATION

a. CONTROL UNIT REMOVAL:

This paragraph covers the Model DT109S Control Unit removal. Use the following procedure to remove the Model DT109S Control Unit.

1. Turn the power OFF to the Model DT109S Control Unit.

2. Disconnect the wiring from the Transmitter and Receiver to the Control Unit.

3. Remove Control Unit.

b. CONTROL UNIT REPLACEMENT:

Use the following procedure to install Model DT109S Control Unit to the rack or wall.

1. Mount the Model DT109S Control Unit in its rack or to wall.

2. Reconnect the wiring to the Model DT109S Transmitter and Receiver. See Datatest drawings in Appendix I for wiring and connector diagram.

3. Turn the power ON at the Control Unit

6. 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 change 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 lenses should be cleaned with a lens cleaner or water. Do **not use alcohol or other solvents as they may leave a film on the optical surfaces.**

1. Remove the top plate of the mounting cross at the Transmitter unit.

2. Put some lens cleaner or water on a clean cloth and clean the lens.

3. Replace the top plate on the mounting cross.

4. Repeat 1, 2 and 3 for the Receiver.

7. TRANSMITTER LAMP REPLACEMENT

The lamp voltage at the Transmitter can be adjusted up to 12 VDC. To determine the light output, read the Io signal on the Display on the Control Unit under Utilities. If the number is close to or at zero (0), replace the lamp.

Typically the unit operates between 800 and 900 counts, and the lamp voltage is typically 8.0Vdc.

Normal lamp life is about 3 years. One factor affecting lamp life is the vibration at the duct/stack. Using a slotted pipe guide between the Transmitter and the Receiver will reduce this vibration and thereby increase the lamp life. Also, keeping the number of power turn-offs to a minimum will increase lamp life.

Lamp replacement is as follows:

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

b) Remove the 4 screws from the back plate.

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

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

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

f) Replace lamp. Use a #1142 lamp. Make sure there is an insulation spacer between the lamp terminals and the socket.

g) Reconnect the Transmitter and turn the system ON. The filament should form an image on the front lens. Adjust the lamp with the single screw on the rear of the lamp bracket so that the image of the filament is at the center of the lens and in a vertical position.

8 LAMP FAILURE

This alarm will be display if the lamp is low or if the lamp has burned out. It could be due to other causes such as a defected lamp supply, wiring, defective silicon cell, etc. Before replacing the lamp, measure the resistance at terminals TB1 point

11 and 12 in the Control Unit. This should be between 1 and 2 ohms, depending on the length of line between the control unit and the Transmitter.

After about 3 to 5 years, the bulb may darken due to tungsten deposits on the inside glass surface. If this is the case, replace the lamp.

9. SPARE PARTS

Recommended Spare Parts for Sensor

PART NUMBER	DESCRIPTION	QUANTITY
DK5016	Transmitter Lamp	1
DT109S-PCB	PC Board	1
DK5046	Lamp Power Supply - PC2	1
DK5021	Collimating Lens	1

10. RETURNING EQUIPMENT TO THE FACTORY

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

a. Secure a return authorization number 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 item 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. 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 form, prepaid to:

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

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's 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.

12. WARRANTY

Datatest Industries warrants this system for a period of twelve (12) months from date of installation, but not in excess of fifteen (15) 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 to return the item to Datatest **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 than common carrier, 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 – Drawing List and Drawings

The following drawing numbers and drawings are provided for mounting and electrically connecting the DT109S components: