Model DT109D
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 DT109D Smoke and Particle Monitor is a double-pass monitoring system designed for continuous opacity 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 converts this signal to a 4-20 mA output, and displays measurements on a 80 character LCD display.

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 lamp out alarms are provided so that minimal operator attention is required.

Many other features included with the DT109D are a 4-line, 80 character LCD display and 16 element keypad which provides communication interface between operator and the Model DT109D.

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 DT109D has certain parameters and facilities that are protected from unauthorized operation by the use of a limited 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 DT109D takes the difference of the light beam passing through the duct (I) and compares it to the reference light from the lamp (Io). This method cancels out any variations due to voltage changes and tungsten loss in the lamp.

A differential amplifier compares the intensity of the lamp 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, amplified and converted to a 4-20mA analog output.

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

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

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

$$Tr = (1-Op)$$

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

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

and

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

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 two way 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 lamp source intensity.

SECTION 2 – SPECIFICATIONS

Model DT109D 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. TRANSCEIVER

Type	Silicon Cells
Spectral Response	400 to 700 nanometers at the 10% points.
Environmental	Severe environmental rated.
Optical Method	Double Pass
Detector Type	Light Sensitive Diodes
Lamp Source	Tungsten lamp, average life 3 years.
Angle of view	4 deg max. (full angle)
Ambient Temperature	-20°F to 150°F
Air Purge	Recommended for sensor and retro reflector lens cleaning. 15 CFM min., each side for Positive systems.

3. OUTPUTS

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

4. CALIBRATION

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

5. ALARMS

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

6. PORTS

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

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 PVC: 200°F Max.

8. AIR PURGE BLOWERS (Positive Pressure Stack)

Purge Air Flow Rate	15 CFM/port

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.

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.

c. CONTROL UNIT TEMPERATURE: Ambient temperatures must be 32°F to 120°F (0°C to 50°C). If Control Unit is used outside operating range, 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 Optical Transceiver and Retroreflector.

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 maximum cross section 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 DIA). This will allow a smooth flow past the instrument and increase the accuracy of the measurement.

i. CONDENSATION: Condense 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: It is necessary to be able to get to the transmissometer to clean the optical windows on both the transceiver and retro reflector.

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.

2. CONTROL UNIT INSTALLATION

a. Mechanical Installation - NEMA 4 Surface Mount: The monitor 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: 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 DT109D has 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 DT109D is equipped with aserial port. This allows the Model DT109D 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 DT109D (See Table 3-1).

RELAY OUTPUT	DESCRIPTION	Comment
1	In Cal	(N.O.)
2	In Cal	(COM)
3	Excess Opacity Set Point	(N.O.)
4	Excess Opacity Set Point	(COM)
5	Pre Emission Set Point	(N.O.)
6	Pre Emission Set Point	(COM)
7	System Fault	(N.O.)
8	System Fault	(COM)

Table 3-1

3. ATTACHMENT OF OPTICAL TRANSCEIVER TO DUCT OR STACK WALL*:*
The following process connections are needed for installation and operation of the Opacity Transceiver and Retro reflector of the Model DT109D.

See drawing 04-3784 Negative Pressure Installation. Rigid optical bench is needed for proper operation.

4. RETROREFLECTOR:
The retro reflector included standard with the DT109D system can withstand temperatures up to 150℉ (66℃). 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 purchased from Datatest.

5. CABLE FROM TRANSCEIVER TO CONTROL UNIT
a. Transceiver Lamp Power Supply Wiring
Referring to Contractor Wiring Diagram 06-3830, use 2C-14 AWG insulated wire to run the transceiver lamp power supply from the Control Unit terminal block TB1-1 and 2 to the Optical Transceiver Junction Box. See drawing 06-3830 for details.

b. Transceiver Photocell Wiring
Referring to Contractor Wiring Diagram 06-3830, the Shielded cable for carrying the photocell current from the transceiver should be Belden #8777 or equivalent (6C-18 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 DT109D Control Unit for recording and logging purposes. Use a pair of #22 AWG (2C-18G) 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 0-3830 for analog signal output connections.

7. 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 translucent material in front of the hole.

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

c. Replace the Retro reflector.

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

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

The unit is now ready for use.

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	=	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 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

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 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

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 DT109D 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 DT109D 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 DT109D Opacity Monitor has been installed and the Parameters have been installed by accessing the Utilities Routine from the Main Menu, the Model DT109D is now ready to be calibrated. In order to calibrate the Model DT109D, a Clear Stack or Duct condition must be obtained to Zero Adjust the monitor. The Model DT109D 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 DT109D.

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 DT109D 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. TRANSIENT MODE (Future)

Transient mode allows only those emission levels or changes in emission levels to affect the opacity measurement. Only those levels or changes defined in the Transient Full Scale (See section 5.6) will affect the opacity measurement.

In this mode, only transients will be observed and the meter and analog outputs will be at 0% opacity until an event occurs. An event could be a rupture in the seam of a bag in a baghouse or a small sudden discharge.

Entering a '1' will turn Transient Mode ON and a '0' will turn the Transient Mode OFF.

6. TRANSIENT FULL SCALE (Future)

Transient Full Scale defines the opacity transient or level changes to affect the opacity measurement. Transient Full Scale is user selectable from 0 to 100 percent opacity.

In order for the define transient full scale level to be observed, the Transient Mode must be turned ON.

7. 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 DT109D. The Model DT109D should read the correct date at any time unless the memory is lost. Even when the Model DT109D is not powered, the date and time are updated and changed. Each month is corrected for the proper days.

8. 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 DT109D is turned off. The time will **not** correct for Daylight Savings Time.

9. RECORDER RANGE

The recorder range relates to the analog signal available on the Model DT109D. This analog signal is obtained from the digital output and is thus a calibrated signal directly proportional to the instantaneous opacity measurement the Model DT109D detector is seeing. This signal is a 4-20mA. The full scale value for 20mA is set by the Recorder Range parameter.

10. 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.

11. 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.

12. 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.

13. 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 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.

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 DT109D
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 DT109D Opacity Monitor, the optical transceiver must be properly aligned and measuring a clear stack or duct. It is important that the process be off-line and the model DT109D optical transceiver is measuring a clear stack or duct. These methods are discussed earlier in this manual.

2. CALIBRATION

To begin a Calibration of the Model DT109D, 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 Adustment**
>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 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.

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: Transceiver Lamp out. Replace if necessary.

TRANSIENT MODE ON: Model DT109D is in Transient Mode.

SECTION 9 - OPTICAL TRANSCEIVER AND AIR PURGE BLOWERS

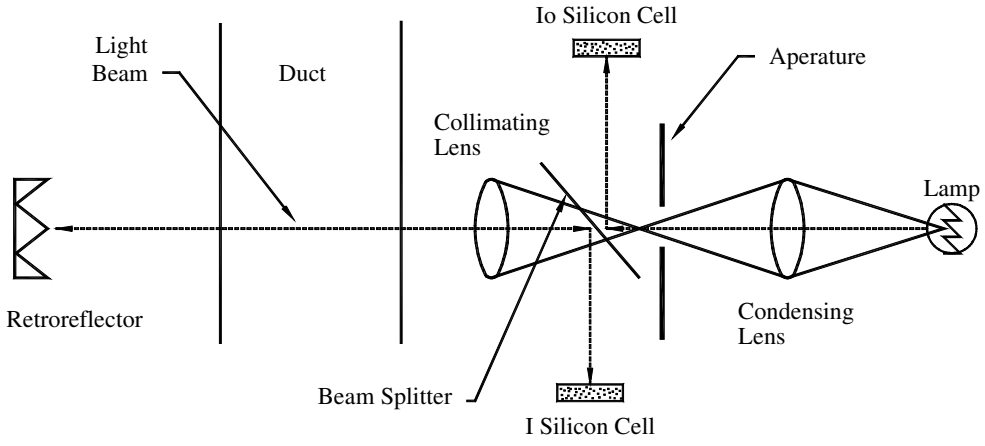
1. LAMP POWER SUPPLY BOARD

The Lamp Power Supply Board P2 (1485) is an DC-to-DC converter supplying up to 12 V DC to the Transceiver Lamp Emitter. The DC voltage is regulated by 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 lamp voltage should be reduced by adjusting R66 and the signals should fall to around 950. This is the normal operating range under a clear stack condition

2. OPTICAL TRANSCEIVER - GENERAL

The Optical Transceiver consists of a lamp, condensing lens, aperture, beam splitter, optical window lens and two silicon cells. The light from the lamp 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 lamp 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 lamp 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 opacity of the emission.

If the emission is 0% opacity, then there are no dust particles in the light path. 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)

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 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.

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 PC Board
System responds to opacity measurement changes but does not give correct reading.	Calibration error	System calibration	Recalibrate System
	Dirty optical window	Check transceiver and retro reflector optical window.	Clean transceiver and retro reflector optical window.
	Optical Alignment	Optical Alignment	Correct Optical Alignment
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 DT109D 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 DT109D 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 of the Model DT109D 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 DT109D has various Diagnostic Alarm features which may appear on the LCD display are listed in Table 10-2. 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

Table 10-2

SECTION 11 - 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. PRELIMINARY CHECKS

The following preliminary checks will help isolate problems in the analyzer. 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, Item 5.

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 toc.

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 DT109D Opacity Monitor should be calibrated when installed (Zero Adjust). Under normal operation, monitor will not require frequent calibration. When calibration is required, follow the procedures outlined earlier.

4. TRANSCEIVER REMOVAL AND INSTALLATION:

a. TRANSMISSOMETER REMOVAL:

This paragraph covers the Model DT109D Transceiver removal from the stack or duct. Use the following procedure to remove Transceiver from the Model DT109D 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 Transceiver assembly until it as cooled to a comfortable working temperature.

3. Disconnect signal cable wiring leading to Control Unit from Transceiver.

4. Disconnect Vane Switch wiring leading to Air Purge Blowers.

5. Disconnect flexible tubing leading to Air Purge Blowers.

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

b. TRANSCEIVER REPLACEMENT:

Use the following procedure to install Model DT109D Transceiver to the stack or duct.

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

2. Connect flexible tubing leading to Air Purge Blowers.

3. Connect Vane Switch wiring leading to Air Purge Blowers.

4. Connect signal cable wiring leading from Control Unit or Junction Box to Transceiver. See drawing C6109-1823 and drawing A07-3210 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 DT109D Control Unit removal. Use the following procedure to remove the Model DT109D Control Unit.

1. Turn the power OFF to the Model DT109D Control Unit.

2. Disconnect the wiring from the transceiver to the Control Unit.

3. Remove Control Unit.

b. **CONTROL UNIT REPLACEMENT:**
Use the following procedure to install Model DT109D Control Unit to the rack or wall.

1. Mount the Model DT109D Control Unit in its rack or to wall.

2. Reconnect the wiring to the Model DT109D Control Unit. See Datatest drawing 06-3830 and 06-3828 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 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.

7. TRANSMITTER LAMP REPLACEMENT

The lamp voltage at the transceiver can be adjusted up to 12 VDC. To determine the light output, read the Io signal on the Display Unit under Utilities. If the number is below 900, replace the lamp.

Normal lamp life is about 3 years. One factor affecting lamp life is the vibration at the duct. Using a slotted pipe 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.

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 lamp bracket.

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

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

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

g) Reconnect the Transceiver 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 in the Control Unit. This should be between 1 and 2 ohms, depending on the length of line between the control unit and the optical transceiver. After about 3 to 5 years, the bulb may darken due to tungsten deposits on the inside glass surface. In this case, replace.

9. SPARE PARTS

Recommended Spare Parts for Sensor

PART NUMBER	DESCRIPTION	QUANTITY
109-1142	Transmitter Lamp	1
DT109D-PCB	PC Board	1
109-78M	Lamp Power Supply - PC2	1
109-15M	Collimating Lens	1

Table 11-1

10. 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.
125 Stryker Lane Building 29 Unit 1
Hillsborough NJ 08844
TEL: (908) 874-5588
FAX: (908) 874-7994
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.

12. 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.