MODEL 80 MP
PORTABLE OPACITY PROBE
OPERATION & MAINTENANCE MANUAL

Serial No.: _____

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SECTION 1

SMOKE AND PARTICLE MONITOR OVERVIEW

a. Monitor Description

The Datatest Model 80MP Portable Monitor is a double-pass monitoring system designed for intermittent opacity measurement of smoke or particulate concentration in a stack or flue. The Model 80MP is ideal for measuring the efficiency of bag houses, electrostatic precipitators and other cleaning systems.

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

The electronic package incorporated within the 80MP features microprocessor technology that greatly expands the versatility and capabilities of the Smoke and Particle Monitor. Self-diagnostics, over emission alarm, and lamp out alarms are provided so that minimal operator attention is required.

Many other features included with the 80MP are a 4-line, 80 character LCD display and 16 element keypad which provides communication interface between operator and the Model 80MP. The display prompts the operator during the set parameter routine, displays Date and Time, Instant and Average opacity, Pre and Over opacity alarm set points, Exit Correction, Offset Adjust, and Recorder Range. An RS-232/422 communication port is also provided to allow two-way communication with other data acquisition systems.

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

b. Theory of Operation:

The measurement of opacity is accomplished by measuring the amount of optical attenuation of a transmitted light beam in a stack or duct. The Model 80MP 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 intensity loss in the LED lamp.

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:

$$OD = Log(Tr)$$

and

$$OD = Log(1-Op)$$

d. Electronic Controller.

The 80MP microprocessor controller electronically controls display measurements, calibrations, functions, and provides isolated analog outputs that are proportional to measured opacity concentrations.

The microprocessor accepts analog voltage signals (I, Io) generated by the sensing cells and differential amplifiers and converts this signal to an analog isolated 4-20mA 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. An RS-232 port is also provided to allow communication with other data acquisition systems.

4. Silk-screen mylar 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, selectable by the operator through the keypad.

7. Isolated current (4-20mA) outputs are available for instantaneous and average opacity.

8. Continuous monitoring of the transmitter LED source intensity.

SECTION 2

SPECIFICATIONS

MODEL 80MP OPACITY MONITOR

CONTROL UNIT

Standard Measurement Ranges ....……. Measures opacity from 0-100%

Analog Outputs .....…….. ……4-20 mA for instantaneous and average output

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 (115V/60Hz standard)

Power Consumption .....……. 25 Watts at 115 VAC, 60 Hz.

Enclosure .....……. Industrial rated fiberglass case

Alarm Set Points .....…… 0-100% Opacity user selectable

Self-Diagnostic .....……Alarms for 'Lamp Out', High and Over Emission.

TRANSCEIVER

Type .....……. Silicon Cells

Spectral Response .....…… 400 to 700 nanometers at the 10% points.

Environmental .....…… Severe environmental rated.

Optical Method .....…… Double Pass

TRANSCEIVER (continued)

Detector Type .....……. Light Sensitive Diodes

Lamp Source .....……. Green LED, average life 10 years.

Angle of view .....…… 2.5 deg max. (full angle)

Ambient Temperature.....…… -20°F to 150°F

Air Purge .....…… Recommended for sensor and retro reflector lens cleaning.

OUTPUTS

LCD Display .....……... 4-line, 80 character LCD

Analog .....…… 4-20mA for instantaneous and average output.

Serial Port .....…… RS-232/422 to a computer for two-way communication (optional)

CALIBRATION

Optical Audit Device .....……. Three optical filters for clear stack zero and span

ALARMS

High and Over Emission .....……. 0-100% Opacity, user selectable

Lamp Out .....…… Transmitter Lamp Out

Internal .....…… Audible 60 dB alarm

Alarm Condition .....…… Reported to Screen.

AIR PURGE BLOWERS (Optional)

Purge Air Flow Rate .....…… 25 CFM

PORTABLE PROBE

Overall length……... 44⅛″

Region exposed to the flue gas…… 20″

Opening required in duct or stack……. 4¼"

Mounting flange……3" ANSI

SECTION 3

INSTALLATION

3.1 CONNECTING THE PROBE TO THE CONTROL UNIT

Attach the cable between the control unit and the probe. Connect to AC power and switch the control unit on.

The optical alignment has been set at the Datatest factory. However, it is important to check the optical alignment in case it was mishandled in shipment.

With the probe out of the stack or duct the opacity should read 0%. If it does not, go to Section 3.4 Page 6 for zero adjustment instructions.

In a darkened area, place a piece of white paper at the hole adjacent to the retro reflector. The light beam should project at the center of the hole. If it does not, go to Section 10.4 Page 28 for alignment instructions.

3.2 ATTACHING THE PURGE BLOWER AND THE GROUND WIRE

The probe is now ready for insertion into the stack or duct. Before insertion, connect the hose from the blower to the probe.

Attach a ground wire from the probe body to earth ground.

It is important to ground the probe since a high static voltage (sometimes over 30,000 volts) from the gas flow can charge the probe.

3.3 INSERTING THE PROBE INTO THE STACK OR DUCT.

Insert the probe into the stack or duct. Make sure that the flue gas temperature does not exceed 600°F. Excessive temperature could damage the retro-reflector.

3.4 ZERO ADJUSTMENT (Clear Stack)

In order to adjust the Opacity probe to zero, it is necessary to have a clear stack or duct. The Model 80MP should be Zero adjusted periodically to ensure that the monitor is in calibration.

To calibrate the Model 80MP for zero opacity, access the Zero Adjust parameter in the Utilities Routine. 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:

1) ZERO ADJUST
2) OFFSET ADJUST
3) SIGNALS
4) LOGGING

3. Press < 1 >, Zero Adjust. The following prompt will be displayed:

ADJUSTING ZERO

After several seconds, the following prompt will be displayed:

ZERO ADJUSTED

The Model 80MP has now been calibrated for a zero stack condition.

3.5 SERIAL PORT CONNECTIONS

The serial port can be accessed at the DB connector on the front panel of the control unit. The connections are:

1	RXD-
2	RXD+
3	TXD+
4	TXD-
5	GND
6	RTS-
7	RTS+
8	CTS+
9	CTS-

3.6 INSTANTANEOUS AND AVERAGE SIGNAL OUTPUTS

There are 4-20 mA isolated outputs for these 2 signals. The connector terminal strip is on the front panel of the control unit.

1. instantaneous +
2. instantaneous -
3. average +
4. average -

SECTION 4

STARTUP AND OPERATION

4.1 INTRODUCTION

When the Model 80MP has been set up as described in Section 3, it is then ready for operation. This section describes what the Model 80MP does and what is needed from the operator. A detailed discussion of various parameters of operations, modes of information available, alarm operations and the like, will be given in other sections.

4.2 INITIAL STARTUP

Initially it is suggested that the Model 80MP 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.

4.3 SET UP PROCEDURE

Start Up

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 AC power switch to the Air Purge Blowers to the ON position.

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

3. The 80MP '**MAIN MENU**' display appears. By pressing <ENT>, you should hear a beep (a key click), which will verify the keyboard is active and you are ready to communicate with the instrument through the keypad.

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

4. When this is complete, press < 1 >. The Model 80MP will go into the RUN Mode and the run screen will appear as follows.

INSTANT = 0.0 PCT
AVERAGE = 0.0

OK 19:24

4.4 SETTING PARAMETERS

When the Model 80MP 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

Select parameters by pressing <2> from the Main Menu.

The display now appears as follows:

***** SET PARAMETERS *****

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:

OPAC PRE EMISSION

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

SET PNT= 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 80MP will be the value present when the Down Arrow < ↓ > is pressed to move to the next parameter.

OPAC OVER EMISSION

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

SET PNT = XXX.X pct

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

A parameter may be changed as many times as needed to get it right. The value retained by the Model 80MP will be the value present when the Down Arrow < ↓ > is pressed to move to the next parameter.

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 90 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 <ENTER>. Advance to the next parameter by pressing the Down Arrow key < ↓ >.

The display scrolls up with the bottom line reading:

DATE: MM/DD/YY

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

DATE IS

11/11/98

To edit the present Date, press <ENT>

NEW DATE

MM/DD/YY

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

The display scrolls up with the bottom line reading:

TIME: HH:MM

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

TIME IS

19:23

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

NEW TIME IS

HH:MM

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

The display scrolls up with the bottom line reading:

RECORDER RANGE

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

RECORDER RANGE

RANGE = 100 pct

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

The display scrolls up with the bottom line reading:

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 <ENTER>. The following prompt will be displayed:

AVERAGE TIME
TIME = XX min

Enter the new measured averaging time (From 0 to 60 minutes, for logging of data 1 to 6 minutes). Accept the value by pressing <ENTER>. Advance to the next parameter by pressing the Down Arrow Key <↓>.

The display scrolls up with the bottom line reading:

EXIT CORRECTION

This correction is required since the probe is usually shorter than the stack exit. The exit correction ratio is:

$$\frac{\text{Exit diameter in cm.}}{50.3}$$

To edit the Stack Exit Correction Ratio, press <ENTER>. 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 <ENTER>. The Stack Exit Correction Ration should be 1.0 if the stack diameter is equal or less than 50.3 cm. 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 <ENTER>. The following prompt will be displayed:

POSITIVE OFFSET

OFFSET = 0.0 pct

Edit the Positive Offset value (From 0 to 10.00 pct) and press <ENTER> 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 <ENTER>. The following prompt will be displayed:

NEGATIVE OFFSET
OFFSET = 0.0 pct

Edit the Negative Offset value (From 0 to 10.00 pct) and press <ENTER> 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.

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 80MP in automatic Run Mode.

The Model 80MP will continue running until it is stopped by one of the following:

1. Power cut off.

2. Accessing the Main Menu from the run mode without restarting.

During the course of running, if one leaves the Run Mode by pressing <CLR> to enter the Main Menu for parameters, to perform a Clear Stack Zero Adjustment, or to access anything in the Utility Menu, the operation is suspended until one returns to the Run Mode by pressing '1' from the Main Menu.

If the Model 80MP is out of the Run Mode but still in the report period, it is gathering data.

If an alarm occurs during this time, the external alarm closures will be activated the instant the alarm occurs. However, the alarm data will not be sent to the screen until the Model 80MP is returned to Run Mode.

4.5 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' or Run.

It should be noted here that when the Main Menu is displayed or the parameter routine is in progress, or the Utility Menu is displayed, then ten minutes after the last keyboard entry (the keyboard goes dead and needs to be accessed) the Model 80MP will revert to run mode and the display will show the Run screen.

4.6 CLEAR STACK CALIBRATION

After the Model 80MP Opacity Monitor has been installed and the Parameters have been installed by accessing the Utilities Routine from the Main Menu, the Model 80MP is now ready to be calibrated. In order to calibrate the Model 80MP, a Clear Stack or Duct condition must be obtained to Zero Adjust the monitor. This can be obtained by either removing the probe from the stack or a clear stack. The Model 80MP should be Zero Adjusted periodically to ensure that the monitor is in calibration. Follow the procedure outline below to Zero Adjust the Model 80MP.

ZERO ADJUST CLEAR STACK CALIBRATION

To Zero Adjust the monitor, the operator selects the Main Menu by pressing <CLR>. The display shows:

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

Select Utilities by pressing <3> from the Main Menu.

The display now appears as follows:

1) ZERO ADJUST
2) OFFSET ADJUST
3) SIGNALS
4) LOGGING

Press < 1 >, Zero Adjust. The following prompt will be displayed:

ADJUSTING ZERO

After several seconds the following prompt will be displayed:

ZERO ADJUSTED

The Model 80MP has now been calibrated for clear stack conditions (Zero Opacity) and is now ready for operation. After several seconds, the display will return to the Utilities Menu.

Press <CLR> to return to the MAIN Menu.

Press < 1 > to return to RUN Mode. The monitor is now calibrated and ready for operation.

4.7 INITIAL OFFSET ADJUST

To compensate for stray or ambient light conditions that may be introduced into the Model 80MP Transceiver due to sunlight reflections in the stack or duct, the Offset Adjust should be initiated in the Utilities Routine. Follow the procedure outline below to Offset Adjust the Model 80MP.

OFFSET ADJUST

To Zero Adjust the monitor, the operator selects the Main Menu by pressing <CLR>. The display shows:

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

Select Utilities by pressing <3> from the Main Menu.

The display now appears as follows:

1) ZERO ADJUST
2) OFFSET ADJUST
3) SIGNALS
4) LOGGING

Press < 2 >, Offset Adjust. The following prompt will be displayed:

ADJUSTING OFFSET

After several seconds the following prompt will be displayed:

OFFSET ADJUSTED

The Model 80MP has now been Offset for stray light conditions and is now ready for operation. After several seconds, the display will return to the Utilities Menu.

Press <CLR> to return to the MAIN Menu.

SECTION 5

PARAMETERS

5.1 INTRODUCTION

This section goes through each of the parameters that are needed by the Model 80MP for operation. The actual setting of these parameters was discussed in Section 4.4. 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.

5.2 PRE-EMISSION ALARM SETPOINT

Opacity Pre-Emission set point alarms can be set to provide alarm message for condition. If the opacity goes above the Pre-Emission set point value:

1. The display shows the statement 'PRE ALARM' at the bottom of the Run display.

2. The Pre-Emission alarm terminals on the front panel of the Model 80MP will have a contact closure between them. (Optional)

The display indication of an alarm condition alerts the operator to check the alarm status. The optional contact closure provides means for an external alarm such as a light, horn, siren, etc. The contact will handle up to 1 amp at 48V DC. 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.

5.3 OVER EMISSION ALARM SETPOINT

Over Emission alarms set points can be set to provide relay contacts and alarm messages for these conditions. If the concentration rises above the Over Emission set point value or goes below the Over Emission set point value, several things happen.

1. The display shows the statement 'OVER ALARM' at the bottom of the Run display.

2. The Over Emission alarm terminals on the front panel of the Model 80MP will have a contact closure between them. (optional)

The display indication of an alarm condition alerts the operator to check the alarm status. The optional contact closure provides means for an external alarm such as a light, horn, siren, etc. The contact will handle up to 1 amp at 48 V DC. If more current is needed, this contact closure can be used to activate an external relay that can handle a greater load.

When the concentration drops below the Over Emission set point the relay closure opens to remove the alarm and the alarm statement in the run report on the display is removed.

5.4 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 levels exceed the set point by the time specified by the alarm delay. This set point delay prevents opacity emission spikes from producing multiple false excess emission alarms that are of very short duration.

An alarm delay or buffer of up to 90 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.

5.5 DATE

The date is entered by using six digits. The first two digits (01/12/01) represent the month, the second two are for the day, and the final two 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 80MP. The Model 80MP should read the correct date at any time unless the memory is lost. Even when the Model 80MP is not powered, the date and time are updated and changed. Each month is corrected for the proper days. Even leap year (February 29) is taken into account in the right years.

5.6 TIME

The time is entered on the basis of a 24 hour clock. Four digits are entered, the first two for the hour (08:41) and the second two for the minutes. The battery backed RAM keeps the clock running even if the Model 80MP is turned off. The time will **not** correct for Daylight Savings Time.

5.7 RECORDER RANGE

The recorder range relates to the analog signal available at the recorder terminals on the rear of the Model 80MP. This analog signal is obtained from the digital output and is thus a calibrated signal directly proportional to the instantaneous opacity measurement the Model 80MP detector is seeing. This signal is 0-5 VDC or 4-20mA, if that option was obtained on the Model 80MP. The full scale value for 5V or 20mA is set by the Recorder Range parameter.

5.8 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. For logging of data an average time of 1 to 6 minutes must be selected (see Section 6.5 for Logging).

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

5.9 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 probe length. 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 portable probe, which is 50.3 cm.

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

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

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

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

5.10 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.

5.11 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.

5.12 CONCLUSION

After a parameter routine, the Model 80MP returns to the Main Menu. The operator must select the next operation from this menu. To return to Run Mode, press < 1 >.

SECTION 6

UTILITIES MENU

6.1 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

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

1) ZERO ADJUST
2) OFFSET ADJUST
3) SIGNALS
4) LOGGING

There are four different portions of the Utilities Menu. The Utilities Menu will be discussed in the order that it appears in the Utility Menu.

6.2 ZERO ADJUST

Zero Adjust properly calibrates your Model 80MP Opacity Monitor during clear stack conditions for zero opacity. During Zero Adjust, the measured light intensity signal 'I' is made equal to the Zero light intensity signal Io.

To perform a Zero Adjust Calibration for the Model 80MP, a clear stack or duct condition must be obtained. Once a Clear Stack/Duct condition exists for the Model 80MP, a Zero Adjust can be performed. The probe may be removed for a clear stack condition.

To begin a Zero Adjust, press < 1 >. The following prompt will be displayed:

ADJUSTING ZERO

After several seconds the following prompt will be displayed:

ZERO ADJUSTED

The Model 80MP has now been calibrated for Zero Opacity and is now ready for operation. After several seconds, the display will return to the Utilities Menu.

Press <CLR> to return to Main Menu.

6.3 OFFSET ADJUST

Offset Adjust allow the Model 80MP to compensate for stray light or abnormal lighting conditions that may be introduced into the Optical Transceiver. Stray light conditions may be introduced into the transceiver by reflections of sunlight due to stack/duct surface reflections or smoke particle surface reflections.

The sun position in the sky during certain times of the day or year may cause abnormal reflections in the stack that may be introduced into the transceiver. This can be compensated for when you press <2> while in the Utilities Menu.

When the Offset Adjust is selected, the Model 80MP turns off the Optical Transmitter lamp and measures the amount of ambient light or reflection that are being introduced into the transceiver. Through software, this stray light is subtracted from the measure light intensity signal 'I'.

To begin an Offset Adjust, press < 2 >. The following prompt will be displayed:

ADJUSTING OFFSET

After several seconds the following prompt will be displayed:

OFFSET ADJUSTED

The Model 80MP has now been adjusted for stray light conditions and is now ready for operation. After several seconds, the display will return to the Utilities Menu.

Press <CLR> to return to Main Menu.

6.4 SIGNALS

For diagnostic purposes, an operator may review the Model 80MP measured opacity signal values. These values include Instant (I), Zero (Io), I and Io Offset and Zero Offset.

To review the Model 80MP Signal values, press < 3 >. The following signals will be displayed:

I =XXXX.X X.X
Io=XXXX.X X.X

ZERO ADJ = XXX.X

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

Press <CLR> to return to Main Menu.

6.5 LOGGING

Logging allows for the collection and storage of 1 to 6 minute averaged opacity for up to 1 day. This data can then be transferred (print log) to a PC via RS232 serial port.

After selecting 1 to 6 minute average in Parameters – see Section 4.4 Average Time.

From Main Menu:

1) Run
2) Parameters
3) Utilities

Select <3> Utilities

1) Zero Adjust
2) Offset Adjust
3) Signals
4) Logging

Select <4> Logging

1) Logging Off/On
2) Print Log
3) Create New Log

If this is the first time or you have already transferred all data then select <3> Create New Log

Display will read New Log Created and will return to logging menu.

Now select <1> Logging Off/On

Display shows

Log Off = 0 Log On = 1
Logging = 0 or 1

Turn on by pressing <1> then push enter (ENT), push CLR twice to return to main menu. Push <1> for run. Display will show:

Instant = XX.X
Average = XX.X

Logging on HH:MM

Once desired data has been collected then turn off using same steps as were used to turn on except select <0> and push enter.

DO NOT push <3> Create New Log until stored data has transferred to a PC since creating a new log deletes stored data.

To Print Out (Download) connect RS-232 serial cable to the control unit and a PC. Open a terminal program such as Windows Hyper Terminal and select a file name to capture text. Turn on the control unit, go to Utilities <3> on Main Menu and select <4> Logging in Utilities Menu. Press <2> print out to start download.

The display will show how many records and the current record being sent.

The format of the data will be:

DATE (MM/DD/YYYY) TIME HH:MM OPACITY = XXX.XX

Model 80MP on the Processor board should have jumpers configured as follows for RS232 serial port operation: W29, W33, W35, W41, W43, W45, and W47.

Computer communications parameters are 9600 baud rate, 8 bits, no parity, 1 stop bit, no handshaking.

Terminal connection: 9 pin; 2 receive, 3 transmit, 5 signal ground on front panel of Model 80MP control unit.

SECTION 7

CALIBRATION

7.1 INTRODUCTION

In order to Zero Calibrate the Model 80MP 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 80MP optical transceiver is measuring a clear stack or duct. These methods are discussed in Section 4.6.

7.2 CALIBRATION

To begin a Calibration of the Model 80MP, 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-PARAMETERS
3-UTILITIES

From the Main Menu it is seen that the number 3 calls for Utilities. When this number is pressed the Utilities Menu appears on the display:

1) ZERO ADJUST
2) OFFSET ADJUST
3) SIGNALS
4) LOGGING

From here <1> is pressed for Zero Adjust. When Zero Adjust is selected from the Utilities Menu the following shows on the LCD display:

ADJUSTING ZERO

After several seconds the following prompt will be displayed:

ZERO ADJUSTED

The Model 80MP has now been calibrated for Zero Opacity and is now ready for operation. To return to the Main Menu, press <CLR>.

To return to Run Mode, press <1>.

SPAN CALIBRATION

To check the span calibration, there are 3 optical filters having nominal optical densities of 0.1, 0.2, and 0.4. Each filter may be placed in front of the hole adjacent to the retroreflector.

Each filter should be within ± 3% opacity (this is a US EPA requirement). There is no adjustment for this test.

SECTION 8

DIAGNOSTIC DISCUSSION

8.1 INTRODUCTION

During power up of the Model 80MP 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.

8.2 CANNOT ZERO

The processor receives a Zero Adjust signal from the Model 80MP 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 misalignment of the optical path.

8.3 STATUS ALARMS

During Run Mode, the Model 80MP 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

Pre-Emission Alarm
Over Emission Alarm
Lamp Out Alarm

Table 8-1

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

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

LAMP OUT ALARM: Transceiver Lamp out. Replace the LED if necessary.

8.4 SYSTEM RESET AND RAM RESET

There are 2 push buttons on the front panel of the control unit. If the computer locks up, press the push button next to the power switch. If this does not clear the problem, use the adjacent push button. This will reset the RAM. You must then put back the parameter settings.

SECTION 9

INSTRUMENT DESCRIPTION

9.1 INTRODUCTION

This section describes how the Model 80MP utilizes its various operating systems in order to function as a portable opacity probe.

The Model 80MP comes with a 4-line, 80 character LCD display and a 16-key membrane keypad. User interface is through the keypad and display which displays measurements, system status messages, and alarms. Monitor calibration is also initiated through the keypad.

The operating systems discussed are the electrical system, the optical transceiver system, and the purge air blower.

9.2 CONTROL UNIT

The Model 80MP control unit is housed in a rugged fiberglass Mil Spec type case, complete with quick snap latches and carrying handle.

9.3 ELECTRICAL SYSTEM

The electrical system is divided into four distinct parts that perform specific functions. Each of these functions relate to a particular printed circuit board or electrical wiring, internal or external to the Model 80MP. A listing of printed circuits boards and function circuit is as follows:

1. Mother Board with analog and digital I/O, relay outputs and D/A converter.
2. Microprocessor circuit board
3. Power Supply circuit board
4. Keyboard and display circuits

The majority of the electronics are mounted in a central location in the control unit.

9.4 MOTHER BOARD

The mother board PC1 (A02-3234) consists of amplifiers, 12 bit digital-to-analog converter (DAC), voltage-to-current converter (V/I), relay outputs, digital I/O, and drivers for solid state relays, and analog voltage outputs.

OPACITY ANALOG CIRCUIT

The Silicon Cells, located in the optical transceiver, provides a current output that is amplified by U1 to provide a voltage output to the microprocessor through a 12-bit Analog-to-Digital (A/D) converter.

D/A CONVERTER

The Digital-to-Analog (D/A) Converter (U3) is a serial 12-bit DAC for analog outputs. The DAC (U3) provides a 0-5 volt analog output to a non-inverting, unity gain, high impedance amplifiers U2. The output from the DAC is also sent to the V/I converters (U6 and U7), to provide an isolated 4-20mA output signal (optional).

V/I CONVERTER (Optional)

The V/I converters (U6 and U7) provide a 4-20mA isolated current analog output from a 0-5 volt analog signal from the D/A converter (U3). The V/I converters provide an instant (U6) and an average (U7) 4-20mA analog current output.

RELAY OUTPUTS (Optional)

The Model 80MP provides relay outputs (SPST) for Pre-Emission and Over Emission set point alarms, and System Fault. These relay contacts are rated at 1 Amp at 24 VDC. These relays can be used to drive 120 VAC relays or an audio alarm. All relay contacts are Normally Open (N.O.) and will provide a contact closure when energized.

9.5 MICROPROCESSOR BOARD

The microprocessor circuit board is based on a Motorola Z180, 8-bit microprocessor. The microprocessor has 32-Kbytes of RAM, 512-Kbytes of EPROM, watchdog timer, power-fail reset, and RAM battery backup. The circuit board also provides a RS-232 and RS-422 serial channels, an 8-channel 12-bit A/D converter, real time clock, keypad and printer port, LCD and VFD port and 48 lines of I/O.

The microprocessor connects to the mother board through headers. These headers bring out the usable I/O lines, analog inputs, and several other miscellaneous signals.

RS-422 SERIAL PORT

The serial port connector (DB9) is located on the front panel of the control unit. Refer to Section 3.5.

KEYPAD AND DISPLAY PORTS

The microprocessor board provides a keypad and display port for connecting a 4x4 element keypad and a 4-line, 80 character LCD display for operator interfacing with the Model 80MP microprocessor. The keypad is located inside the membrane keypad. The keyboard controls the liquid crystal display through a connection by an 8 wire ribbon cable. The LCD display is panel mounted and located on the front panel.

PRINTER PORT (Optional)

The microprocessor board also provides a printer port which can be connected to a printer for logging data and reports. Data sent to the printer is usually printed as a block average (ex 1-hour averages) for future reference or as a backup.

9.6 POWER SUPPLY BOARD

The power supply board PC3 (2969) is mounted inside, on the front panel plate. This power board acts as the power distribution point for the unit.

It provides rectified and filtered DC voltage at proper levels for the regulator also on the board. The regulator circuits are also located on this board to provide all DC regulated voltages used by the solid state devices in the Model 80MP. Several linear voltages regulators are on this board.

Other regulators supply positive and negative regulated voltages to devices such as operational amplifiers, DACS, ADC, etc.

9.7 KEYPAD

A 16-element (4x4) keypad is protected with a silk-screen mylar overlay that provides a completely sealed keypad to assure that its touch-sensitive contacts are not subject to dust retention. This keypad is connected directly to the microprocessor connector J8.

9.8 PROBE INTERFACE PCB (A02-3441)

This PC board is the interface between the TX/RC of the probe and the control unit. It is located at the underside of the front panel of the control unit. There are 2 adjustment trim pots. Located on the front panel are also 2 trim pots.

V → VR1 on front panel – I signal

VR2 on PCB = I Signal offset

VR3 on front panel – IO signal

VR4 on PCB = Io Signal offset

With the probe connected to the control unit and the power on make the following adjustments:

(a) With the light beam blocked with a black cloth, adjust VR2 such that the output at T1-9 is 0 millivolts.

(b) Remove the black cloth and adjust VR1 such that the output at T1-9 is 4.75V.

(c) Turn the LED light source off by connecting T1-8 to GND. Adjust VR4 such that the voltage at T1-10 is 0 millivolts.

(d) Lift the GND off T1-8 and adjust VR3 such that the voltage at T1-10 is 4.75 V.

SECTION 10

OPTICAL TRANSCEIVER AND AIR PURGE BLOWERS

10.1 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 retroreflector again strikes the beam splitter and is reflected to the 'I' cell.

The current outputs of both cells are amplified to produce 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.

10.2 OPTICAL RETROREFLECTOR

The retroreflector 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 retroreflector is a glass corner prism. It is cooled by the purge air blower.

10.3 AIR PURGE BLOWER

The Air Purge Blower provides clean air to keep the optical surfaces of the transceiver and reflector clean. It is necessary to maintain a column of clean air on these surfaces to insure that corrosive gases will not eat into the exposed metal and glass parts of the transmissometer and to keep the optical windows clean.

10.4 ALIGNING THE TRANSCEIVER

This should be done in a darkened room. Using a lens cleaning tissue paper; insert it at the mirror (retro reflector / corner prism) end of the probe – in front of the 1" hole.

The LED light beam should be in the middle of the hole. Also, the reflected beam should coincide with the transmitted beam. It may be easier to just use the edge of the tissue paper to get ½ the beam.

To adjust the beam, remove the 4 screws at the back of the trans/receiver and remove this plate.

The LED is mounted on a bracket with a ¾" washer. Loosen this screw a bit and move the LED housing such that the beam is in the center of the hole at the mirror. Make sure that the transmitted and reflected beam coincide.

This completes the alignment. Replace the back plate of the trans/receiver.

SECTION 11

TROUBLE SHOOTING

11.1 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.

11.2 SPECIAL TROUBLESHOOTING NOTES

a. Grounding: When the probe has been inserted in the stack or duct – make sure it is grounded.

b. Loose Integrated Circuits: The electronics uses a microprocessor and supporting integrated circuits. Should the electronics receive rough handling during shipping, 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 ensures he/she is at ground potential.

11.3 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 after Zero Adjust Calibration.

b. Fault Finding: Table 11-1 is a guide for finding faults of the above symptoms.

MALFUNCTION	FAULT	CHECK	REMEDY
No response to opacity concentration change.	Electronic Circuit malfunction	Op amp. U1	Replace U1 or PC1 Board
System responds to opacity measurements changes but does not give correct reading.	Calibration error.	System calibration.	Recalibrate System.
	Dirty optical window.	Check transceiver and retroreflector optical window.	Clean transceiver and retroreflector optical window.
	Optical alignment	Optical alignment.	Correct optical alignment.
System does not give accurate indication of opacity.	Dusted lenses.	Check lenses.	Clean lenses.

TABLE 11-1

11.4 ELECTRONICS TROUBLESHOOTING

The Model 80MP 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 80MP 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 80MP 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 >.

11.5 ALARM MESSAGES

The Model 80MP has various Diagnostic Alarm features which may appear on the LCD display are listed in Table 11-2. 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.
LAMPOUT... (4)	Transceiver Lamp Out.

Table 11-2

SECTION 12

SERVICE AND NORMAL MAINTENANCE

12.1 OVERVIEW

This section describes routine maintenance of the Model 80MP Portable opacity probe. Spare parts referred to are available from Datatest. Observe warning and caution labels.

12.2 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 Section 4, 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 11.

b. Run Zero Adjust Calibration Check: Run Zero Adjust Calibration check procedure according to paragraph 7.5.

If calibration is successful, no problem exists.

If calibration fails, shut off power and make sure that the cable is properly connected between the control unit and the probe.

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

c. Check I and Io Cell Output: Check I and Io mV output to microprocessor, J12-15/6 (I) and J12-13/8 (Io) on motherboard (PC1) and microprocessor board respectively. It should be between 0 and 5 volts.

12.3 MONITOR CALIBRATION:

The Datatest Model 80MP 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 in paragraph 7.2.

12.4 CLEANING THE LENS AND RETROREFLECTOR

1. Cleaning the retroreflector: Remove the 4 screws that hold the retroreflector on the probe and clean it.

2. Cleaning the lens on the transmitter/receiver: Use a clean cloth, wrapping it around the end of a ruler to reach in and clean lens. Don't remove transceiver from probe assembly. This will cause alignment problems when reassembled.

12.5 TRANSMITTER LAMP REPLACEMENT (LED)

The light source is a high intensity green LED. The normal life is about 100,000 hours or about 10 years. The LED is pulsed at approximately 200 hz. The pulse duration is 100 microseconds with a peak current of 150 mA. The average current is 3 mA.

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 2 set screws that hold the LED assembly in place.

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

f) Replace LED assembly.

g) Reconnect the Transceiver and turn the system ON. The LED should form an image on the front lens. Adjust the LED 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. Put a piece of paper in front of the retroreflector. The circle of light, about ¼" diameter should be in the center of the hole.

12.6 LAMP FAILURE

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

12.7 SPARE PARTS

Table 12-1 Recommended Spare Parts for Sensor

PART NUMBER	DESCRIPTION	QUANTITY
80-LED	Model 80MP Spares Kit which includes: (1) Lamp, Transmitter (LED)	1

Table 12-2 Spare Parts List

PART NUMBER	DESCRIPTION	QUANTITY
80-3441	PCB – Interface	1
109-75M	Datastar, PC Board	1
109-77M	Motherboard - PC1	1
109-79M	Logic Power Supply - PC3 (+/- 15V, 5V)	1
109-13M	80 Character LCD Display	1
109-12M	16 Element Membrane Keypad	1
109-15M	Collimating Lens	1
109-198	Silicon Photo Cell & Amplifier	2
80-5	Retroreflector	1

12.8 RETURNING EQUIPMENT TO THE FACTORY

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

a. Secure a return authorization from a Datatest Sales Office or Representative 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. 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 INDUSTRIES Inc.
125 Stryker Lane Bldg 29 Unit 1
Hillsborough NJ 08844
TEL: (908) 874-5588
FAX: (908) 874-7994
Website: http://www.datatest-inc.com
Email Address: karensurenko@datatest-inc.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.

12.9 WARRANTY

Datatest guarantees this system for a period of one (1) year from the date it was received, 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 pre-paid, 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.

Datatest personnel will not accept instruments returned under this warranty at the Datatest plant without prior authorization.

The user must prepay freight on returned equipment. Datatest will assume the cost of shipping the unit back to the user by common carrier. If the user wishes it returned by other means, 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.