



WatchDog Instruction Manual

Installation, alignment, calibration, and operation



ENVIRONMENTAL MONITOR SERVICE, INC.

P.O. Box 4340, Yalesville, CT 06492

Sales@emsct.com

September 2026

Prepared by R. Zembruski

© Environmental Monitor Service, Inc.

Table of Contents

Safety and Electrical Installation	4
Warnings	4
Before Startup	5
Site Selection	5
Measurement Location	6
Access and Environmental Conditions	7
Installation Drawing Notes	8
Stack Exit Correlation Computations	9
Appendix B to Part 60 — Performance Specifications	10
Alternative Locations and Light Beam Paths	11
Section 1 — Transceiver to RCU Wiring	15
Section 2 — Communication Box and RCU	16
Communication Box Wiring at the RCU	16
Enhanced Controller System and RCU Description	17
RCU Analog Outputs, Relays, and Inputs	18
Section 3 — Installation and Alignment	19
Stack Flange Alignment	20
Flange to Stack Installation	21
Mounting Weather Covers	22
Mounting the Air Plenums and Weather Covers	23
Transceiver and Retro Reflector Installation	25
Section 4 — Beam Alignment Procedure	27
Section 5 — Field Calibration of the Clear Path	28
Clear Smoke Adjustment Procedure	28
Section 6 — WatchDog Cable Information	29
RS-485 Connections and Pinout	30
Control Unit Glossary	30
Section 7 — Control Unit Operation	31
RCU Buttons	31

About Pages	32
Operator Pages.....	34
Password Protected Tech Pages	37
Section 8 — Correlation with Particulate and Dust Density	43
Cement Kiln Calibration Curves	44
Boiler Calibration Curves	45
Correlation Accuracy and Error Levels.....	46
Comparison of Emission Sources	47
Sample Mg and Optical Density Calibration	48
Alarm Matrix	50
Automatic Reset Without Pressing Reset.....	50
Automatic Reset with Reset Pressed Before Returning to Zero	50
Manual Reset After Returning to Zero.....	51
Manual Reset Before Returning to Zero.....	51

Safety and Electrical Installation

This manual is intended to aid trained and competent personnel in the installation of this equipment. Only a technician or engineer trained in the local and national electrical standards should perform tasks associated with the electrical wiring of this device.

Warnings

- Under no circumstances will Environmental Monitor Service, Inc. be liable or responsible for any consequential damage that may arise because of the installation or use of this equipment.
- All examples and diagrams shown in the manual are intended to aid understanding. They do not guarantee operation.
- Environmental Monitor Service, Inc. accepts no responsibility for actual use of this product based on these examples.
- Due to the great variety of possible applications for this equipment, the user must assess the suitability of this product for specific applications.
- Make sure to have safety procedures in place to stop any connected equipment safely if the controller should malfunction or become damaged for any reason.
- Do not replace electrical parts or try to repair this product in any way.
- Only qualified, factory-trained service personnel familiar with the device's operation should open its housing or carry out repairs.
- The manufacturer is not responsible for problems resulting from improper or irresponsible use of this device.
- Ignoring these safety precautions may cause electric shock, fire, or equipment damage.

NOTE: If using a negative draft or plant air, disregard the blower and SW1 and SW2 information.

Before Startup

You must complete the following before attempting startup.

- Check that all parts have identical serial numbers.
- Measure and record the flange-to-flange distance to verify that it matches the final checkout sheet.
- If you are using a recorder, DAS, etc., **DO NOT CONNECT THEM NOW**. Outputs and inputs from other sources should be left off until the system has been thoroughly checked according to the following instructions. After system operation has been verified, connect and test external connections.
- Read the instructions first to familiarize yourself with the instrument before attempting to start up.
- The air-purge and weather-cover systems, transceiver, retro reflector, and service module must be installed, with power applied.
- The control unit must be installed and wired to the service module and the customer's equipment, as applicable.
- All wiring and mechanical installations must be completed per the drawings provided in this manual. All wiring must be checked, and power applied to both the control unit and the stack maintenance module.
- Complete the beam alignment procedure.

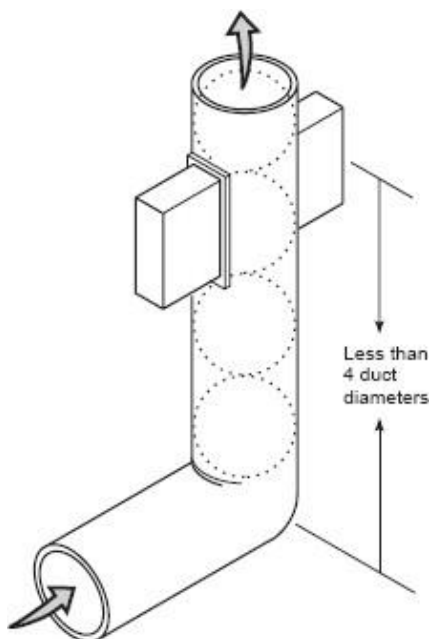
Site Selection

The primary considerations when choosing a site for the EMS WatchDog are accessibility, ambient environmental conditions, and a location that provides a representative sample of the process. Review the Federal Register excerpt under “Appendix B to Part 60 — Performance Specifications” before selecting an installation site. Also consider the following general guidelines.

Measurement Location

Ideally, locate the transmitter eight to ten stack diameters upstream from the stack exit and three to five diameters downstream from any bends, junctions, or other constrictions in the stack or duct. For best results, mount the transceiver and retro reflector modules so that the light beam is precisely perpendicular to the stack or duct and passes through its center.

Do not install the transmitter downstream of a wet scrubber. Water droplets introduced into the gas stream by such equipment will interfere with opacity readings. For an accurate measurement under these conditions, choose a location upstream from a wet scrubber or downstream from the scrubber where reheating of the gas vaporizes the water droplets. Verifying the stack exit correlation is especially important. If possible, verify all dimensions by actual measurement. Measure and record the inside stack dimensions at the measuring point and the stack exit, and compute the optical path length ratio (OPLR). Check that the calculated OPLR and the factory OPLR are within $\pm 2\%$.



Access and Environmental Conditions

Consider the height of the sensors above platforms, walkways, decks, and similar surfaces. A platform or walkway must be available for access to the weather covers. Ideally, the mounting flanges and weather covers should be approximately 5 feet above the floor. Railings and other obstructions should allow the weather cover to swing clear, as shown in the installation drawings.

Locate the stack-mounted units in an area with ambient temperatures between -4°F and $+130^{\circ}\text{F}$. Consult the factory for other temperature ranges. Clean, dry areas are desirable. Avoid areas with condensation.

Maintenance intervals are related to the installation environment. Intervals can vary from 2 to 3 months in clean environments to twice a month in dirty environments. Lens cleaning is a function of the ambient conditions and the cleanliness of the purge air.

Locate the instrument to avoid excessive vibration or shock.

Locate the control unit in an easily accessible area with temperatures between $+32^{\circ}\text{F}$ and $+122^{\circ}\text{F}$. To allow the operator to read and change the controls, mount the unit no higher than five feet above floor level.

Stack exit: Locate the transceiver more than two stack diameters down from the stack exit.



Installation Drawing Notes

Reviewing the drawings and procedures will help ensure an error-free installation. Observe these critical requirements: keep the instrument beam in the horizontal plane; do not rotate the transceiver more than $\pm 10^\circ$ from vertical; and install the weather covers vertically plumb.

Review all installation and wiring drawings in this manual before beginning work. For assistance, contact the service department at 203-935-0102, ext. 14, or techsupport@emsct.com.

Sensor Height Above Platforms and Walkways

A platform or walkway must be available for access to the weather covers. The optimum condition would have the mounting flanges and weather covers approximately 5 feet up from the floor. Railings and other obstructions should allow the weather cover to swing clear as shown in the installation drawings.

Alignment of Stack Flanges

Stack flange alignment is the first step in successful installation. The final beam alignment adjustments are described in the Beam Alignment Procedure.

Sample Area

To obtain a representative sample, the accepted practice is to locate the instrument's measurement path in the centroidal area of the stack. Choose a location where the gases are not stratified in the stack or duct. See the Federal Register excerpt under "Appendix B to Part 60 — Performance Specifications."

Where a bend is involved, the path should be chosen to be in the plane of the bend. Locations where large amounts of condensed water may be present should be avoided.

Stack Exit Correlation Computations

NOTE: Verifying the stack exit correlation is especially important. If possible, verify all dimensions by actual measurement. Use the instructions below to verify the values displayed on the About page. See the control unit operation section for details.

$Lx/(2 \times Lt)$ is the ratio of the inside diameter at the top of the stack to twice the inside diameter of the stack where the instrument is located. If the ratio is greater than 1.0, the exit opacity will be greater than the opacity at the instrument location. The controller uses this correction factor to calculate the stack exit opacity. It is not practical to have an $Lx/(2 \times Lt)$ factor much greater than 2.0 because the error of the instrument increases as $Lx/(2 \times Lt)$ becomes greater.

Lx = inside stack diameter at stack exit.

Lt = inside stack diameter at the transmitter location.

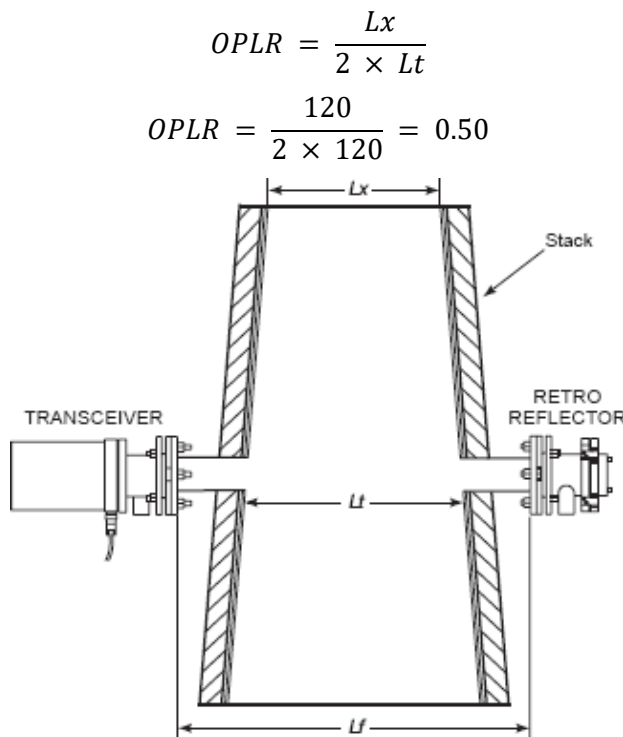
Lf = flange-to-flange distance between the transceiver and retro reflector unit.

Measure and record Lx and Lt , and compute the Optical Path Length Ratio (OPLR).

Check that the calculated value and the OPLR shown on the About page are within $\pm 2\%$.

Example: A stack with a 120 in. (3048 mm) stack exit ID and a 120 in. (3048 mm) path length.

OPLR cannot be changed in the field due to EPA regulations. If the difference between these values falls outside $\pm 2\%$, contact the EMS service department for instructions.



Appendix B to Part 60 — Performance Specifications

(2) You must install the opacity monitor at a location where the opacity measurements are representative of the total emissions from the affected facility. You must meet this requirement by choosing a measurement location and a light beam path as follows:

(i) Measurement Location. Select a measurement location that is (1) at least four duct diameters downstream from all particulate control equipment or flow disturbance, (2) at least two duct diameters upstream of a flow disturbance, (3) where condensed water vapor is not present, and (4) accessible to permit maintenance.

(ii) Light Beam Path. Select a light beam path that passes through the centroidal area of the stack or duct. Also, you must follow these additional requirements or modifications for these measurement locations:

If your measurement location is in a:	And is:	Then use a light beam path that is:
1. Straight vertical section of stack or duct	Less than four equivalent diameters downstream from a bend	In the plane defined by the upstream bend (see figure 1–1).
2. Straight vertical section of stack or duct	Less than four equivalent diameters upstream from a bend	In the plane defined by the downstream bend (see figure 1–2).
3. Straight vertical section of stack or duct	Less than four equivalent diameters downstream and is also less than one diameter upstream from a bend.	In the plane defined by the upstream bend (see figure 1–3).
4. Horizontal section of stack or duct	At least four equivalent diameters downstream from a vertical bend	In the horizontal plane that is between 1/3 and 1/2 the distance up the vertical axis from the bottom of the duct (see figure 1–4).
5. Horizontal section of duct	Less than four equivalent diameters downstream from a vertical bend	In the horizontal plane, that is between 1/2 and 2/3 the distance up the vertical axis from the bottom of the duct for upward flow in the vertical section, and is between 1/3 and 1/2 the distance up the vertical axis from the bottom of the duct for downward flow (Figure 1–5).

Alternative Locations and Light Beam Paths

(iii) Alternative Locations and Light Beam Paths. You may select locations and light beam paths, other than those cited above, if you demonstrate, to the satisfaction of the Administrator or delegated agent, that the average opacity measured at the alternative location or path is equivalent to the opacity as measured at a location meeting the criteria of sections 8.1(2)(i) and 8.1(2)(ii). The opacity at the alternative location is considered equivalent if (1) the average opacity value measured at the alternative location is within ± 10 percent of the average opacity value measured at the location meeting the installation criteria, and (2) the difference between any two average opacity values is less than 2 percent opacity (absolute). You use the following procedure to conduct this demonstration: simultaneously measure the opacities at the two locations or paths for a minimum period (e.g., 180 minutes) covering the range of normal operating conditions and compare the results. The opacities of the two locations or paths may be measured at different times, but must represent the same process operating conditions. You may use alternative procedures for determining acceptable locations if the Administrator approves those procedures.

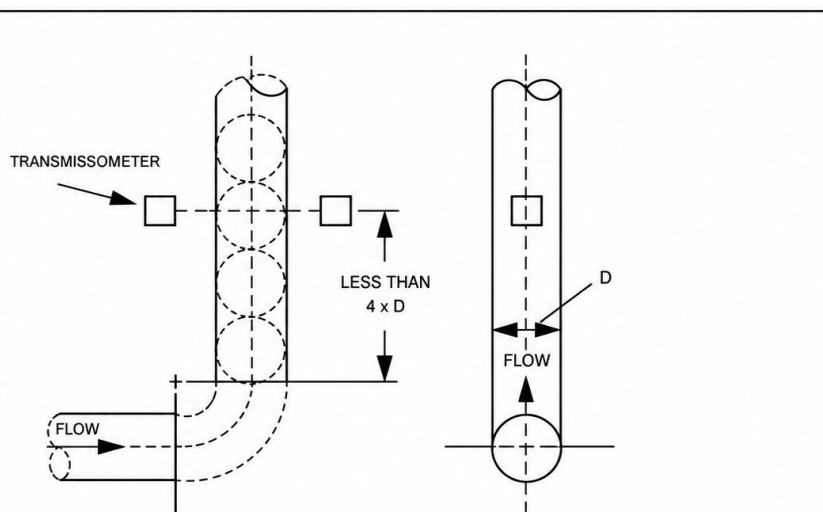


Figure 1-1 Transmissometer location downstream of a bend in a vertical stack.

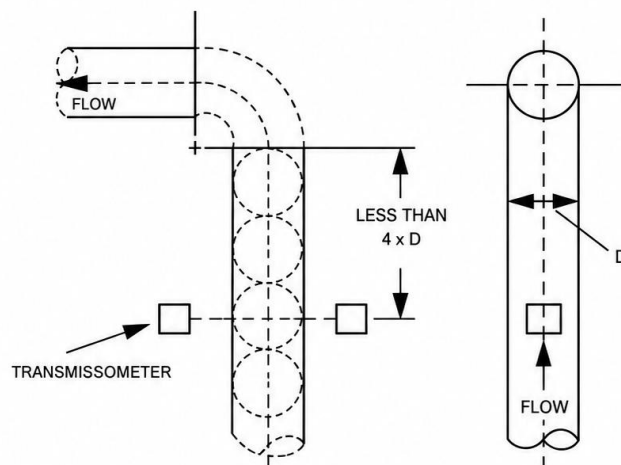


Figure 1-2 Transmissometer location upstream of a bend in a vertical stack.

Light Beam Path — Vertical Stack Bends

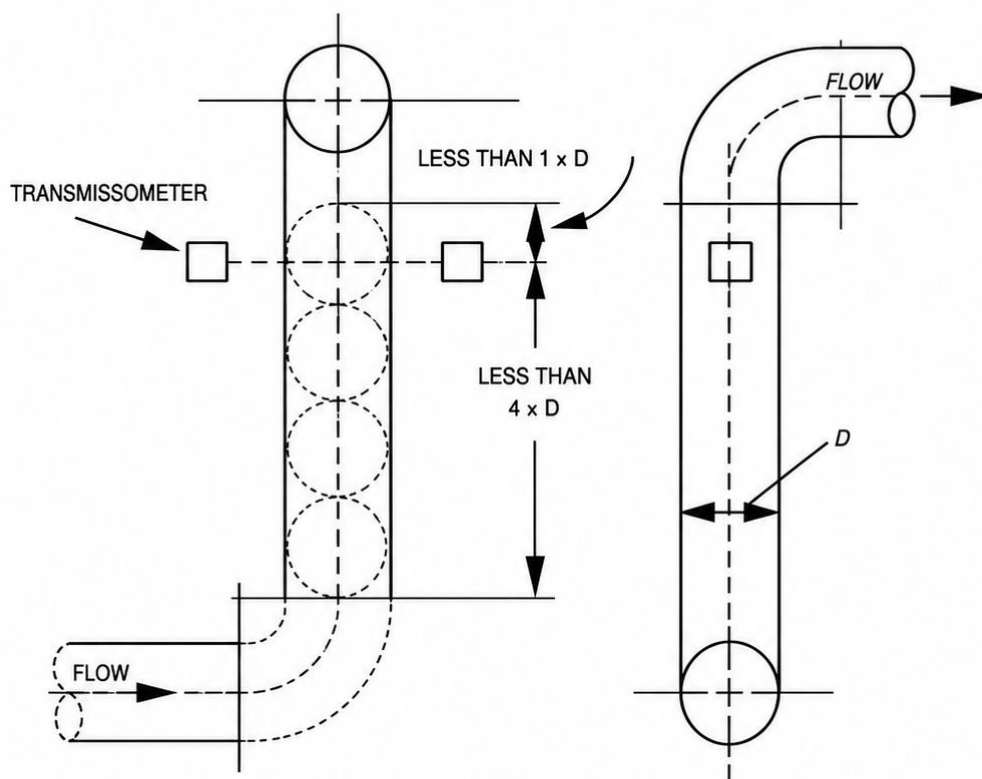


Figure 1-3 Transmissometer location between bends in a vertical stack.

Light Beam Path — Horizontal Duct After a Bend

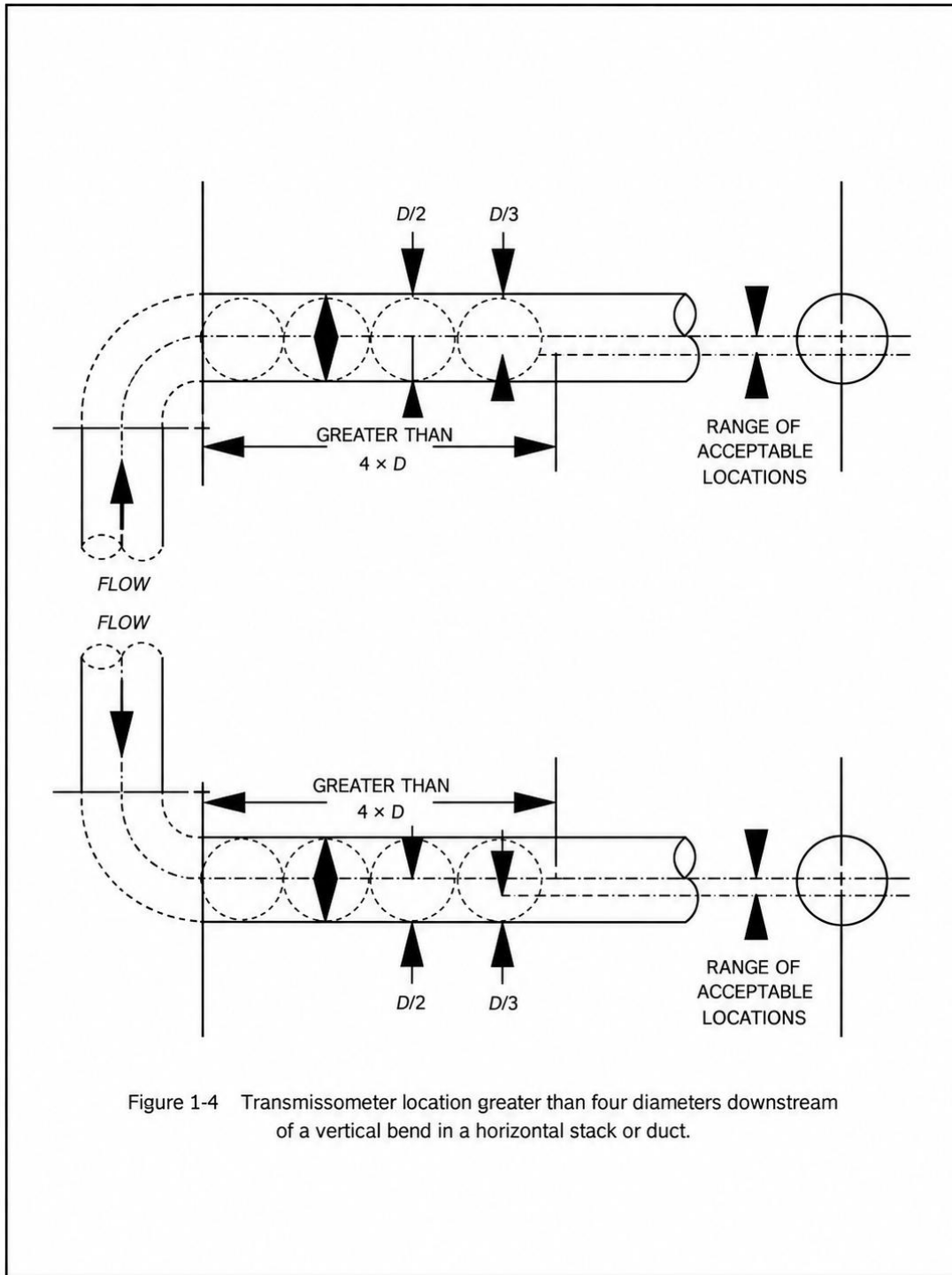


Figure 1-4 Transmissometer location greater than four diameters downstream of a vertical bend in a horizontal stack or duct.

Light Beam Path — Horizontal Duct Near a Bend

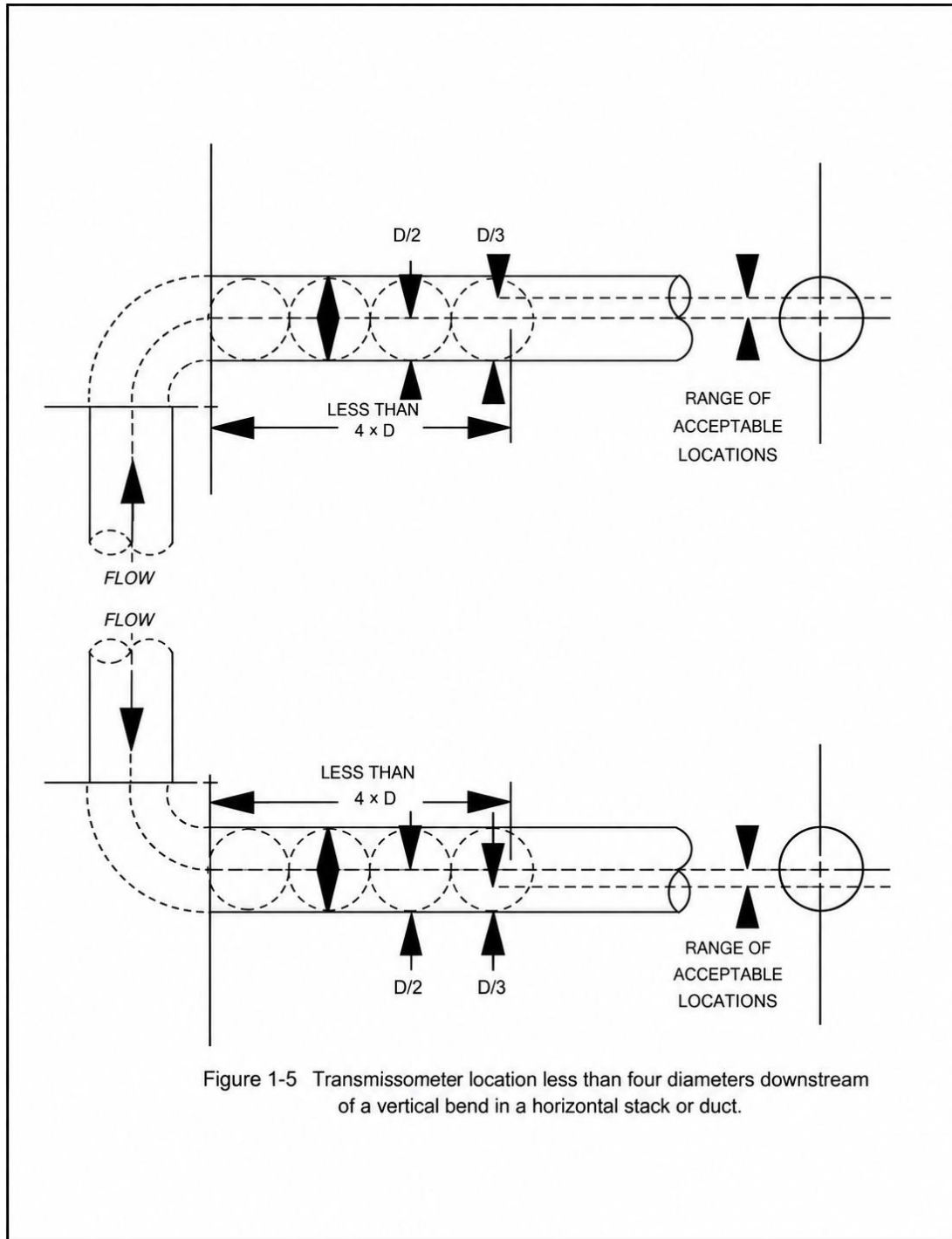
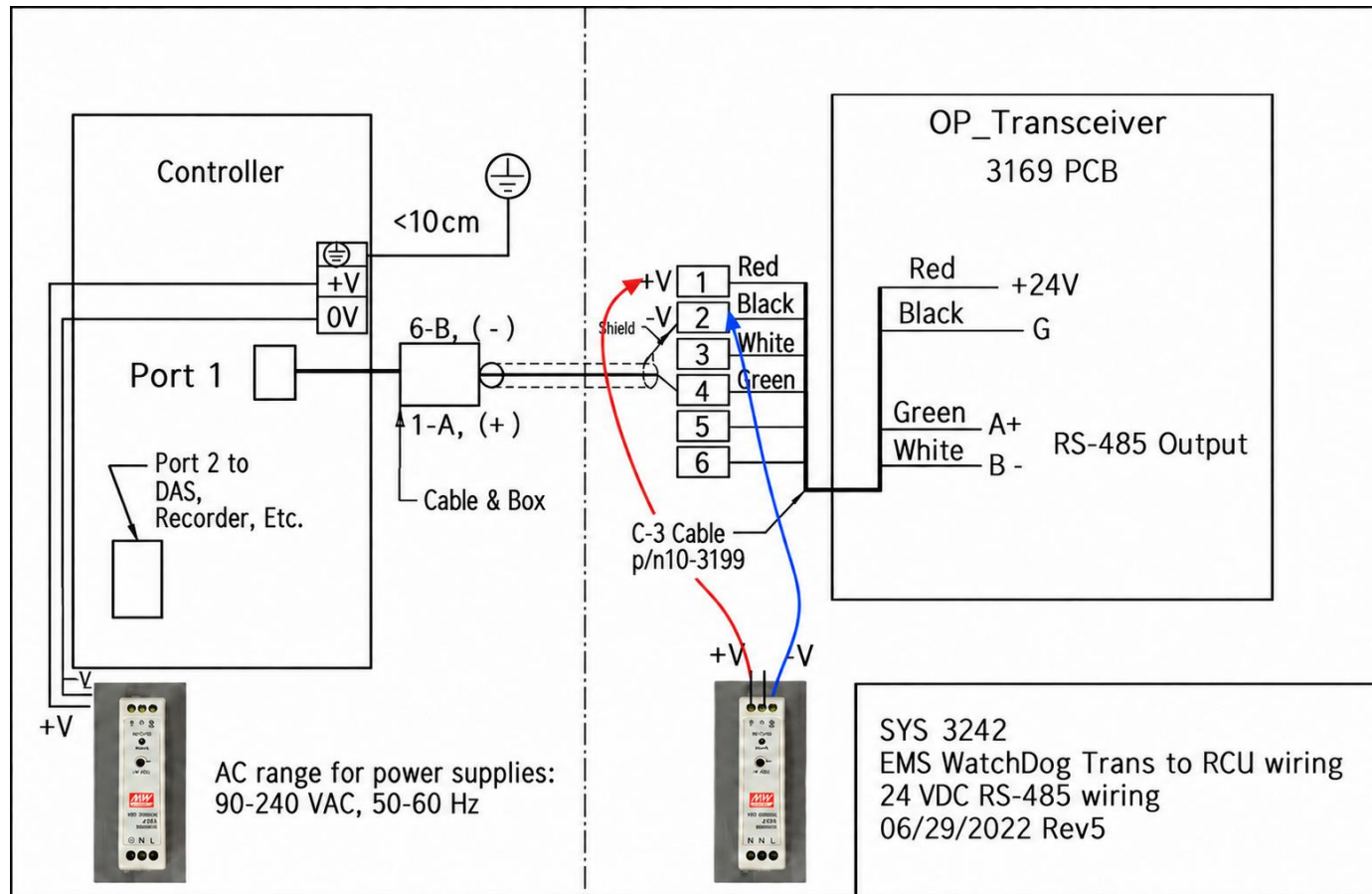


Figure 1-5 Transmissometer location less than four diameters downstream of a vertical bend in a horizontal stack or duct.

Section 1 — Transceiver to RCU Wiring

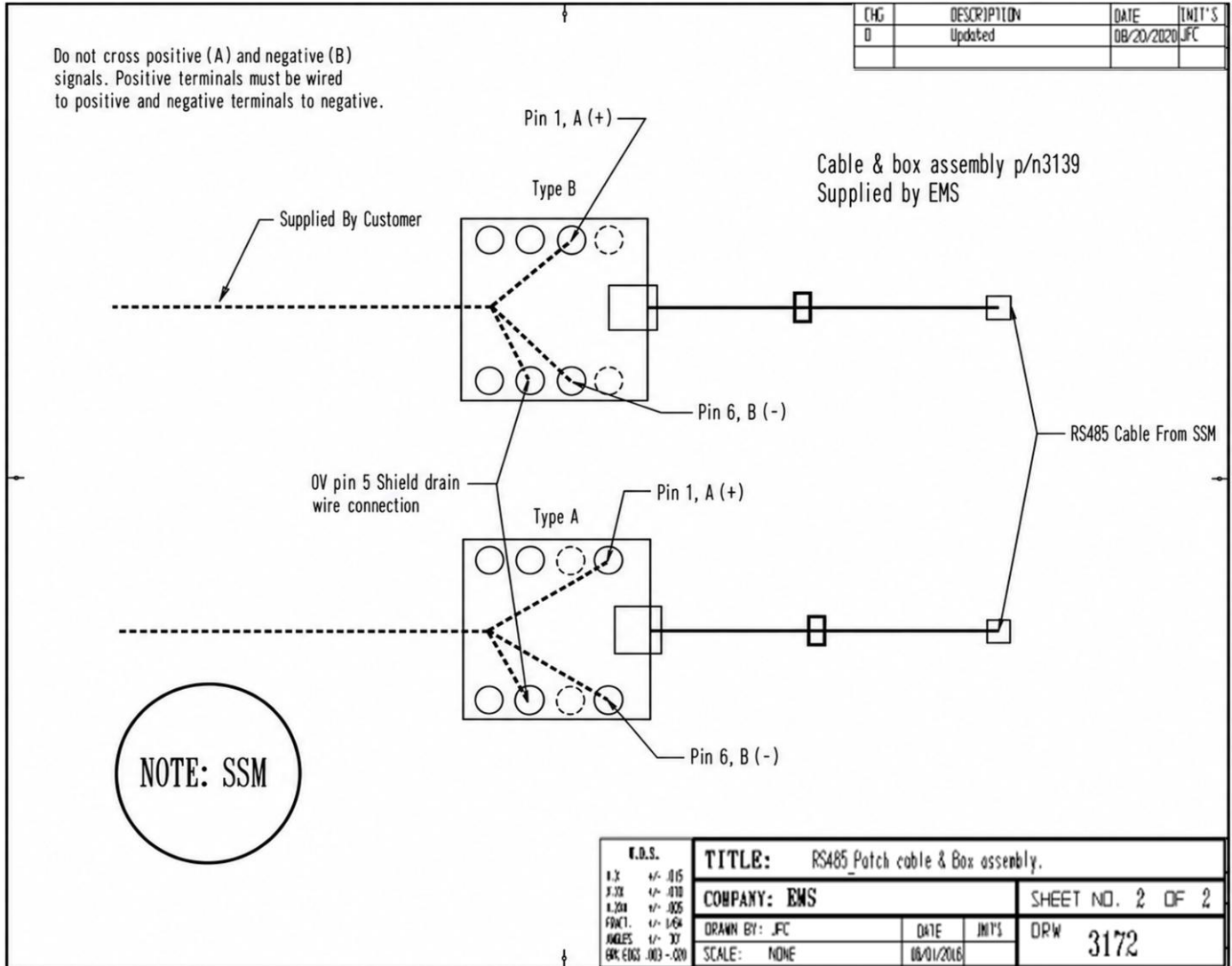
SYS 3242



Section 2 — Communication Box and RCU

Communication Box Wiring at the RCU

Important: Communication boxes may be configured differently. Identify your configuration using the drawing below. Use the correct pins; wire colors do not determine the connections.



Enhanced Controller System and RCU Description

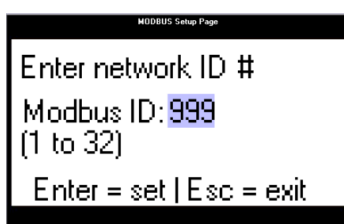
The Enhanced RCU provides instrument control functions, opacity readings, alarms, analog outputs, communication capabilities, system information, and more. It can be DIN rail-mounted or panel-mounted (3.7 × 3.7 in.; 93 × 93 mm) in a control room environment. The RCU is rated NEMA 4X/IP65 when panel-mounted. Battery backup for all memory is typically 7 years.

Mount the control unit in a clean, controlled environment with a temperature range of 0 °C to +50 °C (+32 °F to +122 °F). The EMS800 Enhanced control unit provides instrument control functions, opacity readings, alarm and fault indicators, analog outputs, and diagnostics with contact closures.

Modbus

To read the register number, use the register number plus 40,001. To read the relay, use the coil number.

MODBUS ID setup – Enter the desired node number (1 to 32).



800 Enhanced Controller Modbus Addresses for Port 2

MB = Modbus Poll Read Discrete Inputs (10001–20000).

MI = Modbus Poll Read Holding Registers (40001–50000).

Measurement or status	Address	Data or state
Instantaneous Opacity	MI 230	integer
O.D.	MI 232	integer
Mg	MI 233	integer
OPLR	MI 245	integer
High mg alarm	MB 235	No alarm = 0. Alarm = 1
High opacity alarm	MB 236	No alarm = 0. Alarm = 1
Early opacity warning alarm	MB 239	No alarm = 0. Alarm = 1
No Airflow	MB 247	No alarm = 0. Alarm = 1

RCU Analog Outputs, Relays, and Inputs

EMS WatchDog Analog outputs

Ch 1-2, Analog 4-20mA outputs Com -COM
Positive 4-20mA output CH1 - Aout0
Positive 4-20mA output CH2 - Aout1

4-20mA
Outputs

EMS WatchDog Relay Groups

Group 1 Relays

High mg ALARM - 00 (6)
Mg Early Warning) - 01 (7)
High Opacity ALARM - 02 (8)
Early Warning Opacity Alarm - 03 (9)
Com for Group 1 - na (10)

Group 2 Relays

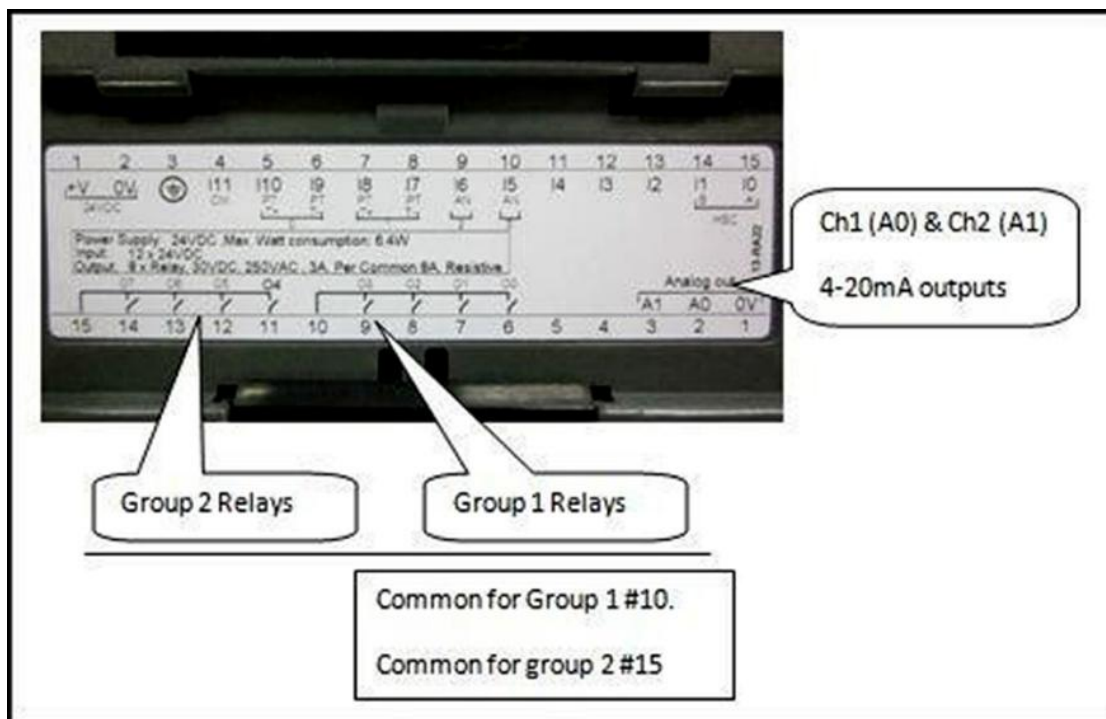
Boiler shut off - 04 (11)
NA -05 (12)
High Op Audable - 06 (13)
High Mg Audible - 07 (14)
Com for Group 2 - na (15)

xx = relay #
(xx) = Terminal #

Do not mix voltages in a group.
Relays are Normally Open.
Relays close when energized.
Rate Voltage 30Vdc or 250Vac.
Output current - 3A Max per output, 8A Max for Common
(resistive load).

WatchDog Digital Input wiring list

Remote Alarm Silence - I4



Section 3 — Installation and Alignment

For an opacity monitor, the customer must supply and install two 3 in. I.P.S. flanges at eye level, directly across from each other. The flange faces, mounted on pipe stubs, should be approximately 6 to 8 in. from the stack or insulation. After installation, align the flanges so that the total deviation from a common centerline does not exceed $+1^{\circ}$ for the light-source flange or $+3^{\circ}$ for the retro reflector flange.

Flanges should be mounted approximately 5 feet up from the deck of platforms, the roof, or the walkway.

Where conditions permit, suspend a piece of $2\frac{1}{2}$ in. pipe across the stack, protruding far enough to allow the 3 in. flange/pipe assemblies to slip over each end. Weld the assemblies in place as shown in the stack flange alignment drawing.

Any deviation up to the previously specified limits can be adjusted out during the installation and alignment of the light source and retro reflector with the system's alignment adjustments.

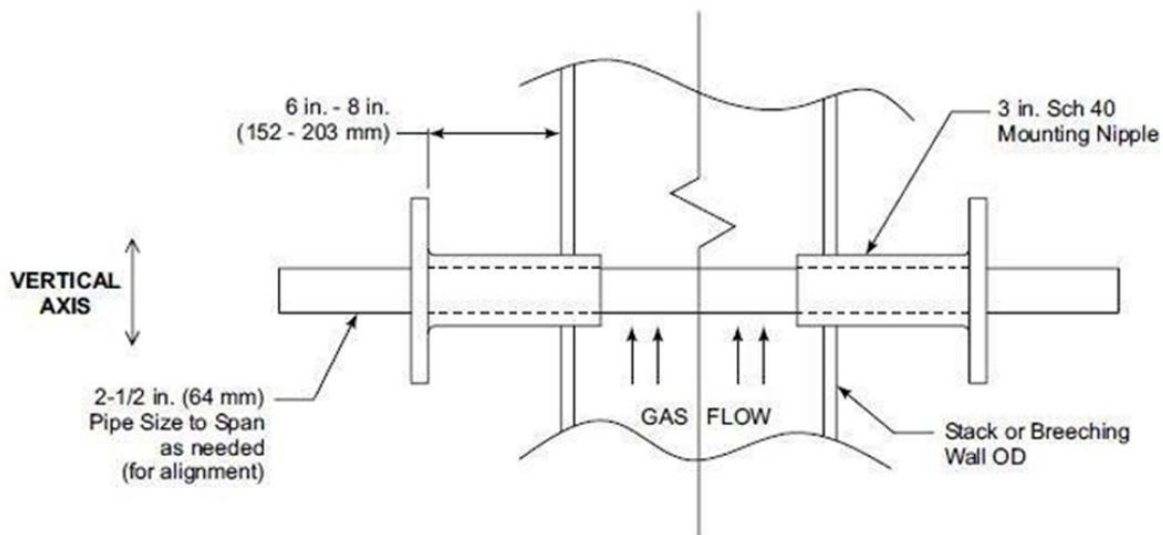
Where installations do not permit the use of the method above, the following procedure will accomplish the same results. An alignment tool can be purchased from the factory to ensure accurate alignment.

Accurately locate a $3\frac{1}{2}$ in. diameter hole, large enough to accept the 3 in. pipe, and a second hole approximately $\frac{1}{2}$ in. in diameter directly across from it. Attach the alignment tool to the flange/pipe assembly and insert the pipe into the $3\frac{1}{2}$ in. hole in the stack wall. Align the assembly with the $\frac{1}{2}$ in. hole on the opposite side by viewing through the alignment tool. Weld the pipe in place, taking care to maintain alignment.

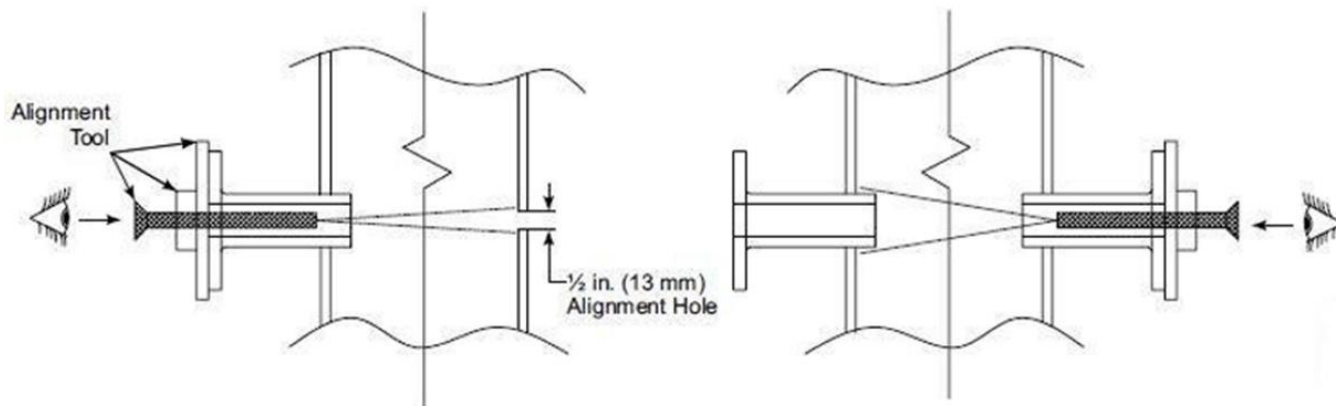
Enlarge the $\frac{1}{2}$ in. hole to approximately $3\frac{1}{2}$ in. to accept the other flange/pipe assembly. Install the assembly with the alignment tool attached and weld it in place, maintaining concentric alignment with the 3 in. pipe previously installed on the opposite wall.

Stack Flange Alignment

STACKS UNDER 6 FEET ACROSS



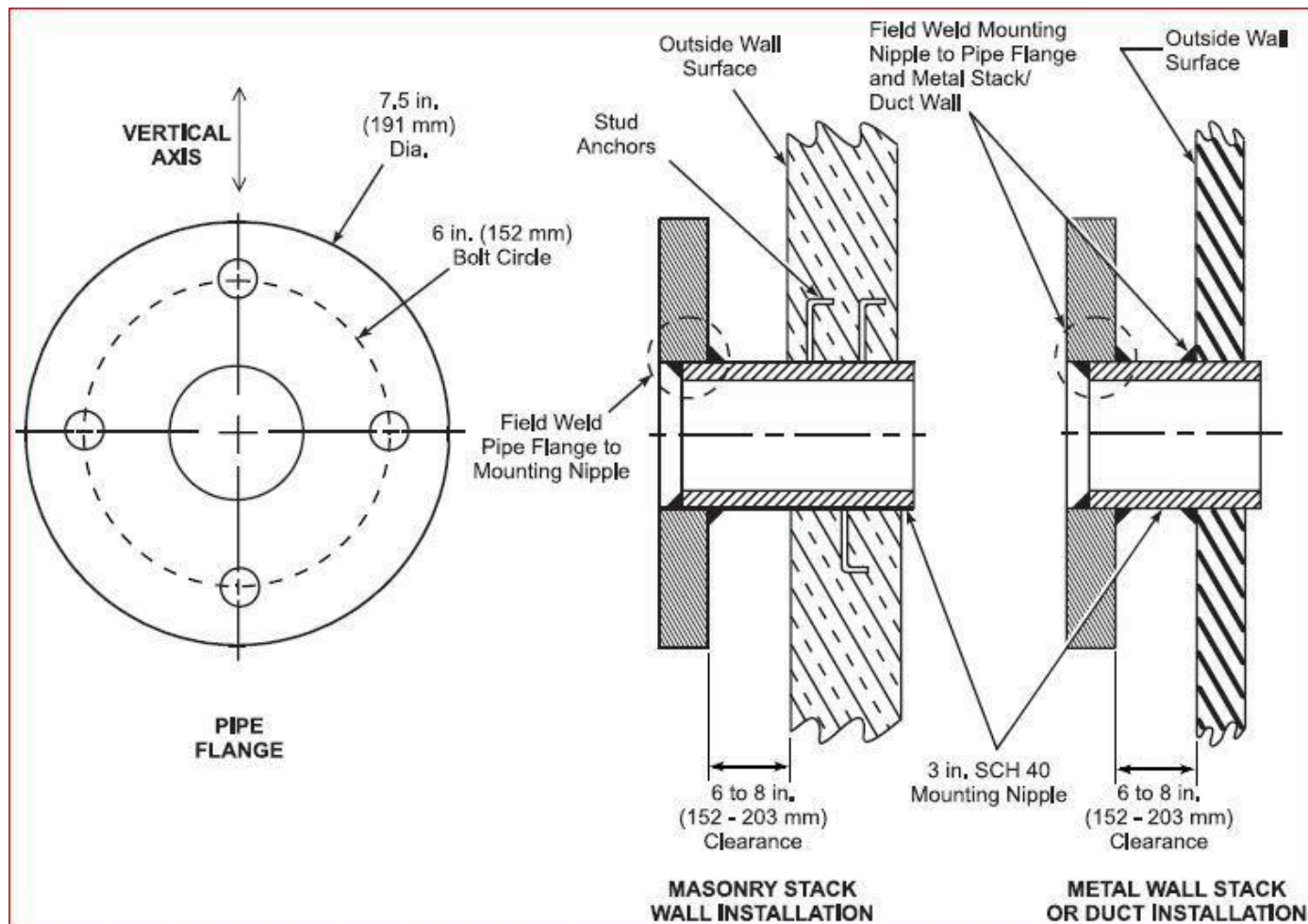
STACKS OVER 6 FEET ACROSS



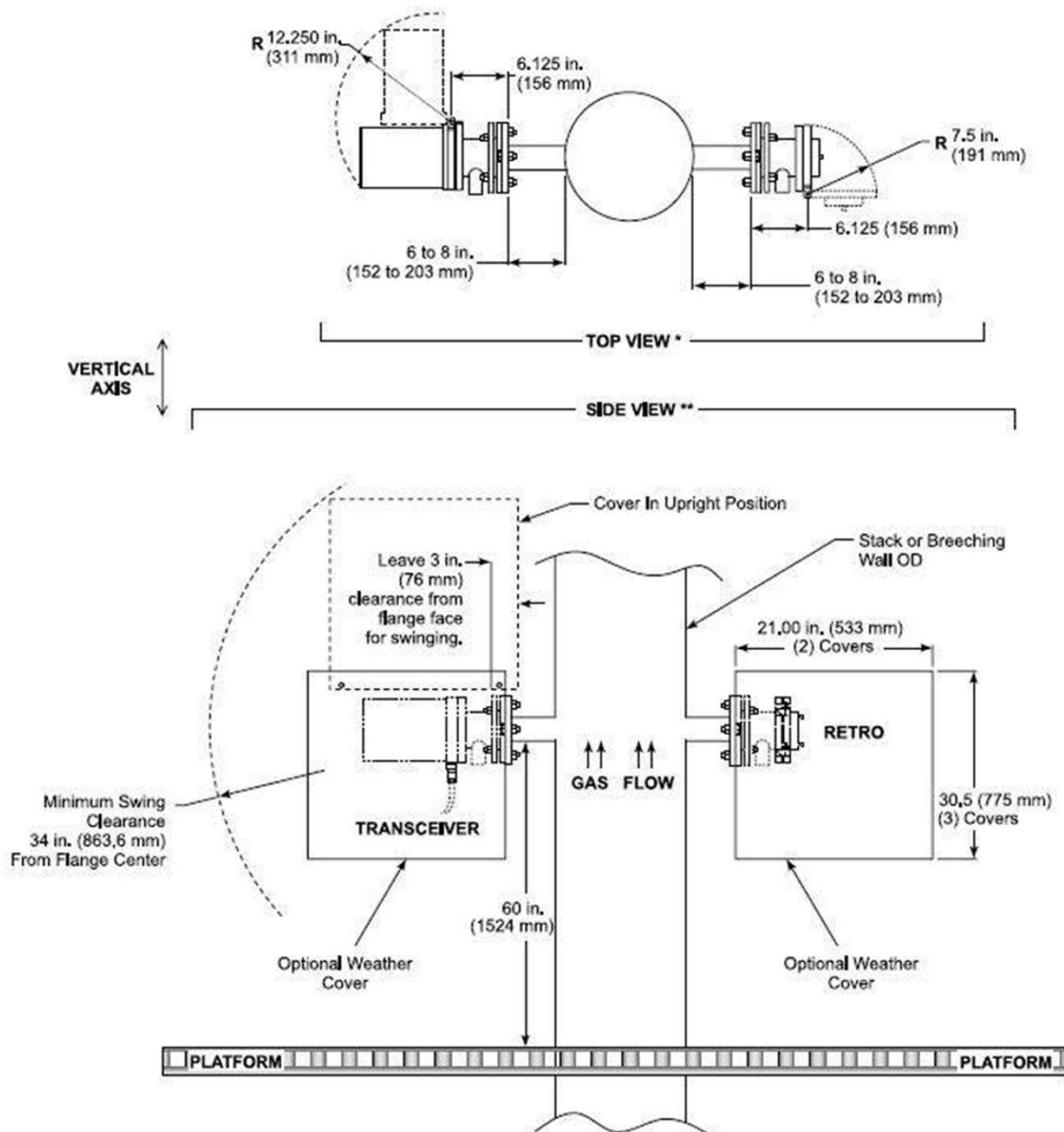
NOTE

If installed path length is not within 10% of the factory set path length, return the unit to the factory so the path length can be reset.

Flange to Stack Installation



Mounting Weather Covers



***Note 1:** The top view represents the transceiver and retro reflector assemblies with their swing clearances. Optional weather covers are not shown.

****Note 2:** The side view represents the installation and swing clearance dimensions for the optional weather covers.

Mounting the Air Plenums and Weather Covers

WARNING: The control unit, transceiver, and retro reflector serial numbers must match.

After selecting the installation site and meeting the platform requirements, install and align the mounting flanges as described in the preceding instructions. Install the flanges with the mounting faces in the vertical plane.

Before installing the transceiver, retro reflector, or any weather cover, remove the air plenum from both the transceiver and retro reflector. This makes installation easier and reduces the risk of damage while attaching the air plenums and optional weather covers.

If the transceiver and retro reflector were shipped with the air plenums attached, unclip both hold-down latches, swing the units open, and lift them off the hinge pins. Place the transceiver and retro reflector in a safe location.

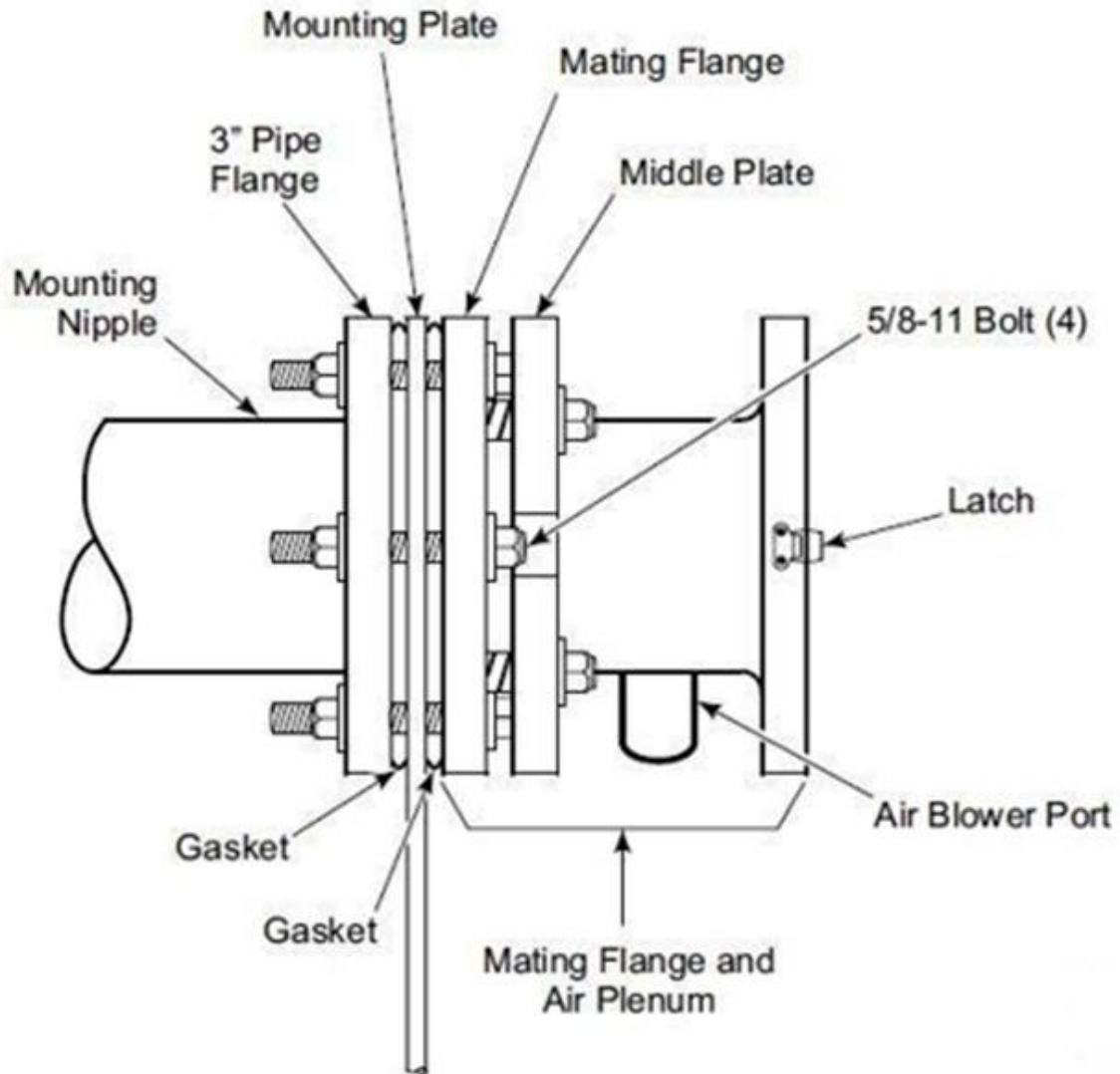
Attach the air plenum to the customer-supplied 3 in. pipe flange using four 2½ in. long, 5/8-11 bolts. Working outward from the 3 in. flange, the assembly order is gasket, then air plenum.

If weather covers are provided, remove the two hood hinge pins located at the lower right- and left-hand corners of the hood.

Attach the air plenum and weather cover to the 3 in. pipe flange using four 2½ in. long, 5/8-11 bolts. Working outward from the 3 in. flange, the assembly order is gasket, weather cover, mounting plate, gasket, mating flange, and air plenum. Place a 5/8-11 bolt through the top hole of the middle plate. Place a flat washer between the middle plate and mating flange, and pass the bolt through. Slip a split lock washer over the bolt and secure it with a nut. Repeat for the remaining three mounting bolts.

Connect any wiring or air hoses at this stage.

Air Plenum Mounting Details



Transceiver and Retro Reflector Installation

WARNING: The control unit, transceiver, and retro reflector serial numbers must match.

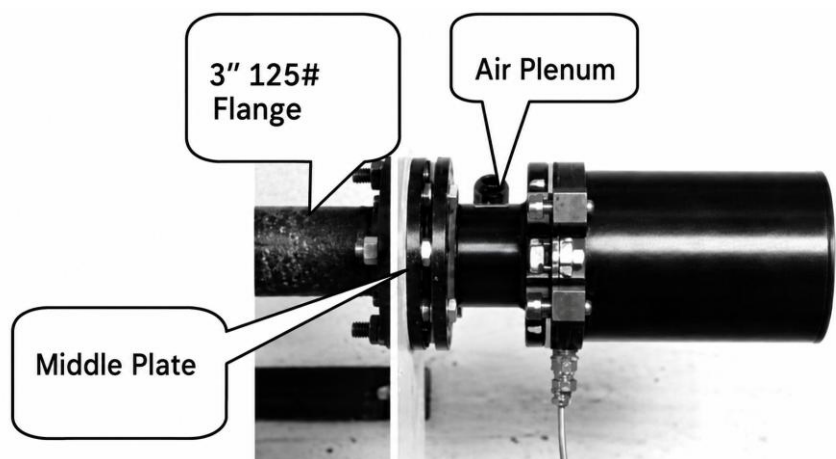
Before installing the transceiver, retro reflector, or any weather cover, remove the air plenum from both the transceiver and retro reflector. This makes installation easier and reduces the risk of damage when attaching the air plenums and optional weather covers.

If the transceiver and retro reflector were shipped with the air plenums attached, unclip both hold-down latches, swing the units open, and lift them off the hinge pins. Place the transceiver and retro reflector in a safe location.

Attach the air plenum to the customer-supplied 3 in. pipe flange using four 2½ in. long, 5/8-11 bolts. Working outward from the 3 in. flange, the assembly order is gasket, then air plenum.

If weather covers are provided, remove the two hood hinge pins located at the lower right- and left-hand corners of the hood. Attach the air plenum and weather cover to the 3 in. pipe flange using four 2½ in. long, 5/8-11 bolts. Working outward from the 3 in. flange, the assembly order is gasket, weather cover, mounting plate, gasket, mating flange, and air plenum. Place a 5/8-11 bolt through the top hole of the middle plate. Place a flat washer between the middle plate and mating flange, and pass the bolt through. Slip a split lock washer over the bolt and secure it with a nut. Repeat for the remaining three mounting bolts.

Any wiring or air hoses can be connected now.



Transceiver and Retro Reflector Assembly Continued

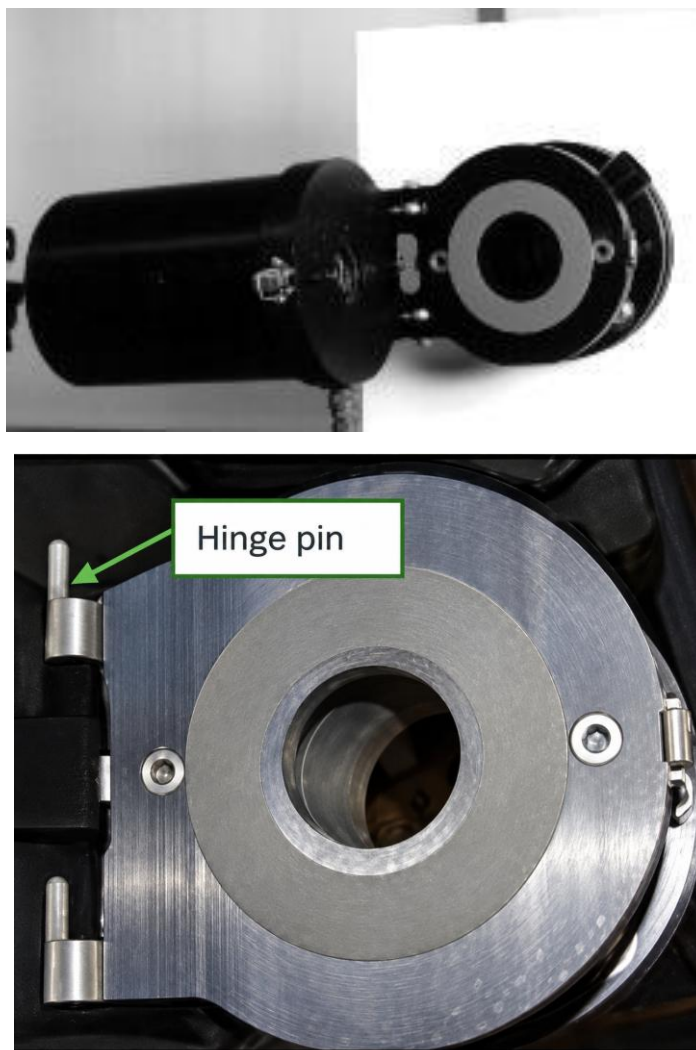
Attach the transceiver and retro reflector to the air plenum assemblies by placing them on the hinge pins. Close the transceiver and retro reflector, and secure each unit with its two hold-down latches.

The air-purge blowers should be powered up at this time to prevent stack particulate from accumulating in the nipple and air-purge housing.

Caution: If the installation location has positive pressure, use the air-purge system continuously during installation to prevent process gases from contaminating optical surfaces or overheating instrument electronics. If the system is shut off for more than momentary interruptions, the instrument may be damaged. Failure to provide continuous air purge may void the warranty.

All wiring from the control unit to the transceiver should be completed at this time.

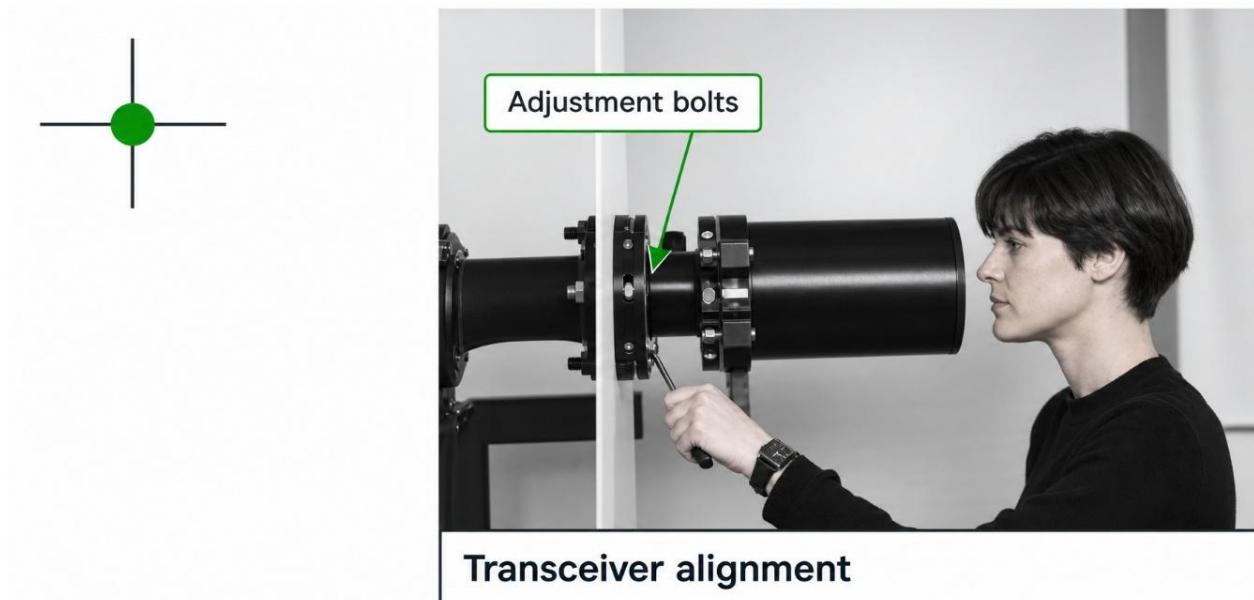
NOTE: Install the air plenum assemblies for both the transceiver and retro reflector with the pins on the left side pointing upward, as shown.



Section 4 — Beam Alignment Procedure

Note: Alignment requires power to the stack-mounted service module. The control unit does not need to be connected or powered. For accurate alignment, the stack should be at its normal operating temperature.

1. If not already on, turn on the power to all air purge systems and the service module.
2. Align the reflector mating flange so that it is plumb and parallel to the 3 in., 150# mounting flange.
Adjust the three nuts on the air-purge plenum flange as needed. The adjusting nuts have nylon locking inserts to prevent loosening from vibration.
3. At the transceiver, check monitor alignment by looking through the viewing port on the rear of the transceiver. Confirm that the beam image is centered in the crosshairs (bull's-eye).



Section 5 — Field Calibration of the Clear Path

After completing installation, adjust the system to a clear condition. Ensure that the measured path is free of smoke and that the sensors are properly aligned. Apply power for 15 minutes to allow the system to stabilize before making adjustments.

Clear Smoke Adjustment Procedure

1. A clear condition across the monitor path is required before adjustment.
2. With the path clear, navigate to “Setup,” scroll to “Tech,” and press ENTER. Enter password 1234, then press ENTER.
3. Scroll to “cal preset values” and press ENTER.
4. Press the right arrow to highlight the clear value and enter 0%. Press F1 to store the value.
5. Press ESC twice to return to the main display.
6. The clear smoke adjustment is complete, and the system is ready.
7. If the clear smoke condition changes, repeat the procedure beginning at step 2.

Section 6 — WatchDog Cable Information

The EMS WatchDog RCU provides instrument control functions, opacity readings, alarms, analog outputs, communications, system information, and more. The color screen is visible in both low-light and bright conditions. The RCU is rated NEMA 4X/IP65 when panel-mounted. Battery backup for all memory is typically 7 years.

Mount the control unit in a clean control room environment with temperatures between 0 °C and +50 °C (+32 °F and +122 °F). The control unit provides instrument control functions, displayed values, alarm and fault indicators, and analog outputs.

Belden P/N 89841 cable is recommended for the sensor and Port 1.

Port 1: 6-pin RJ-25 connector; pin 1 (+), pin 6 (-). RS-485 cabling to the sensor may be up to 2,000 feet long.

Port 2: 6-pin RJ-25 connector; pin 1 (+), pin 6 (-). RS-485 cabling to the customer's equipment may be up to 2,000 feet long.

Use network cables that meet the specifications of Belden P/N 89841, multiconductor EIA Industrial RS-485 PLTC/CM cable, or equivalent:

- 24 AWG stranded (7 × 32) tinned copper conductors; FEP insulation; twisted pairs; an overall Beldfoil shield (100% coverage) plus a tinned copper braid shield (90% coverage); a 24 AWG drain wire; and an FEP jacket.
- Impedance of 120 ohms
- Network cables must not exceed 1,219 meters (4,000 ft).
- If a longer distance is required, consider a wireless option. Contact the factory.

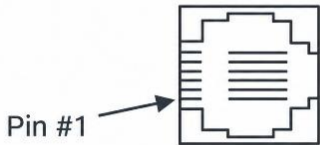
RS-485 Connections and Pinout

- Port 2: RS-485 connection to the customer's DAS, recorder, or other equipment.
- Port 1: For factory sensor use only.

Use RS-485 to create a multidrop network containing up to 32 devices. Ports 1 and 2 are set to RS-485.

- The ports are not isolated. If you use the controller with a non-isolated external device, avoid voltages exceeding ± 10 V. To avoid damaging the system, connect all non-isolated device ports to the same ground signal.
- Use shielded, twisted-pair cables.
- Minimize the stub (drop) length leading from each device to the bus.
- Ideally, the main cable should be run in and out of the network device.

Do not cross positive (A) and negative (B) signals. Wire positive terminals to positive terminals and negative terminals to negative terminals.

Diagram	Pin Number	Function
	1	A signal (+)
	2	(RS232 signal)
	3	(RS232 signal)
	4	(RS232 signal)
	5	(RS232 signal)
	6	B signal (-)

Control Unit Glossary

OUTPUT TYPE SETUP: “Output type” refers to the 4–20 mA outputs.

Instantaneous opacity, optical density (O.D.), and/or particulate concentration (Mg).

ALARM AUTO/MANUAL SETUP: Press the Return/Enter button to enter. Select 1 for automatic or 2 for manual.

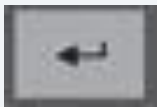
Automatic reset: After the high alarm has activated, the alarm contacts and icon reset automatically when the smoke level drops below the alarm setpoint.

Manual reset: After the high alarm has activated, press Return/Enter to de-energize the contact. Outputs 02 and 00 remain energized. When the smoke level drops below the alarm setpoint, press Return/Enter again.

MODBUS ID SETUP: In Tech Setup Menu 2, press Return/Enter and enter the desired node number (1 to 32). Press Return/Enter to set the value, then press ESC to exit. The default is 1.

Section 7 — Control Unit Operation

RCU Buttons

Control	Function
Arrow keys 	Move left, right, up, or down to move the display cursor or navigate between pages.
ESC 	Return to the previous page.
Enter or Return 	Select a variable. When the value changes from steady to blinking, enter the new value and follow the screen tip to complete the operation.
Info 	Set the PLC time, date, backup, and related functions. These functions are not used during normal operation; instructions are provided when required.
Keypad 	Enter values.
+/- 	Enter a negative sign when required.
F1 and F2 	Use these buttons as directed by the on-screen prompts and the procedures in this manual.

About Pages

When power is first applied, press ESC to display the main page shown here.



On the main page, use the UP or DOWN arrow to select the EMS WatchDog Display, Setup, or About page. Press Return/Enter to open the selected page.



To open the About pages, scroll to About and press the right arrow to enter the first About page.



About Pages Continued

Press the down arrow to open the second About page.
Note: Press ESC to return to the previous page.



Press the down arrow to open the third About page.



Operator Pages

Scroll to “Setup.” The operator menu contains two pages with 7 accessible setpoints. Press Return/Enter to open this page. 



Scroll down to display the second menu screen.



Select “Mode Select (Mg/OP)” from the operator menu and press Enter to display the “Operator Menu 1” setting. Choose Mg or Opacity mode.

Note: Alarm display settings reflect the selected opacity or Mg parameters.



Operator Alarm Settings

Select the alarm setpoint from Operator Menu 1 to enter the high opacity alarm setpoint.



Select Alarm Delay from the operator menu to set the delay. When opacity reaches the high alarm setpoint, the delay begins. The high opacity alarm activates after the delay expires.



The early warning contact closes when opacity reaches the selected setpoint, notifying the operator before the high opacity limit is reached.

Note: This contact cannot be higher than the alarm delay.



Operator Reset and Display Settings

Press Return/Enter and select 1 for automatic reset or 2 for manual reset.

Automatic reset: After the high opacity alarm has activated, the alarm contacts reset automatically when the smoke level drops below the alarm setpoint.

Manual reset: Press Return/Enter to de-energize the contact. The High Opacity Alarm, Opacity Early Warning, and Boiler Shut Off remain energized. After the smoke level drops below the alarm setpoint, press Return/Enter again to de-energize all alarm relays. The same applies to the respective Mg relays when Mg is selected as the Active Mode. See the alarm matrix.

NOTE: Before the audible alarm contact can energize again, the early warning and high opacity alarms must clear after the smoke level drops below the alarm setpoint.



Press F1 to toggle the display of tenths for opacity/Mg.



Use this page to increase or decrease the response speed of the main display readings.

Note: Only the display is affected.



Password Protected Tech Pages

To enter the “Tech” menu, press Enter and enter password 1234.
Note: “Active Mode” at the top of the screen shows the selection made on the first operator screen. OP = Opacity; Mg = milligrams.



After entering password 1234, press Return/Enter to display the first Tech menu.



Move the cursor down until the second Tech menu is displayed.



Tech Menus and Output Scaling

Continue moving the cursor down until the third Tech menu is displayed.



Select output scaling from the menu to enter the desired scale parameters for optical density, opacity, and Mg.



Select the O.D. output scale from the previous screen to enter the optical density 4–20 mA scale parameters.



Opacity and Mg Output Settings

Select the OP output scale from the previous screen to enter the opacity 4–20 mA scale parameters.



Select the Mg output scale from the previous screen to enter the Mg 4–20 mA scale parameters.



Use the output definition screen to select the desired output for CH1 only: opacity or optical density.



Dust Units and OPLR Settings

Select the desired dust measurement unit on the “active Unit” screen by choosing 1, 2, or 3.



The dust setup screen initially displays the factory defaults. See Section 8 for the dust correlation description and tables used to determine the required values.



The OPLR setup screen displays the stack exit inside diameter (ID) and measurement path length ID. These values can be selected to calculate OPLR.

NOTE: Contact the factory before making this adjustment.



Dimensions, Modbus ID, and Clear Smoke Preset Values

Enter the flange-to-flange dimensions here for reference.



Enter the Modbus network ID number on this screen.



1. Ensure that the monitor path is clear before making adjustments.
2. Navigate to "Setup," scroll to "Tech," and press ENTER. Enter password 1234 and press ENTER. Scroll to "cal preset values" and press ENTER.
3. Press the right arrow to highlight the clear value and enter 0%.
4. Press F1 to store the value.
5. Press ESC twice to return to the main display.
6. The clear smoke adjustment is complete, and the system is ready.
7. If the clear smoke condition changes, repeat the procedure beginning at step 2.



Transceiver Display Pages

NOTE: Refer to the clear smoke adjustment procedure in Section 5.

Transceiver Display A shows the unit's uncorrelated % opacity, the internal LED current parameters, and the gain value.



Transceiver Display B shows transmittance and uncorrelated % opacity.



Section 8 — Correlation with Particulate and Dust Density

According to Bouguer's law, the particulate or dust density within an optical path is directly proportional to the measured optical density of that path. The constant of proportionality varies with the gravimetric density of the particulate matter, its size distribution, and its optical properties. The constant can be calculated if all the data are known. In practice, it is usually easier to determine the proportionality constant and offsets experimentally for each installation. The data do not always correlate best with a line through the origin—that is, a line without an offset.

The correlation coefficient and offset of the linear relationship between optical density and particulate density, typically mg/Nm^3 , are determined by linear regression analysis of simultaneous optical density and dust density measurements. The data should cover as wide a range of operating variables as possible. Calibration in terms of dust loading remains valid as long as the particle size distribution and composition do not change significantly. This condition is generally met in emissions from sources with high-efficiency particulate control equipment.

To establish calibration accuracy over a range of emission rates and process conditions, obtain at least 12 to 15 calibration points using Method 5 or 17 isokinetic testing. The regression line and associated confidence limits can then be determined. Extensive data are available for correlating optical density with dust loading in various applications and can provide a starting point for characterizing a specific source. Figure 1 shows a calibration curve for a cement kiln equipped with an electrostatic precipitator, including the 95% tolerance intervals at the 95% confidence level. Figure 2 shows the same curve corrected to standard conditions (temperature and pressure on a dry basis). This corrected curve can be used when gas temperature, pressure, and water concentration are constant. Figure 3 shows a lignite-fired boiler calibration curve, and Figure 4 shows a bituminous coal-fired power station calibration curve.

Cement Kiln Calibration Curves

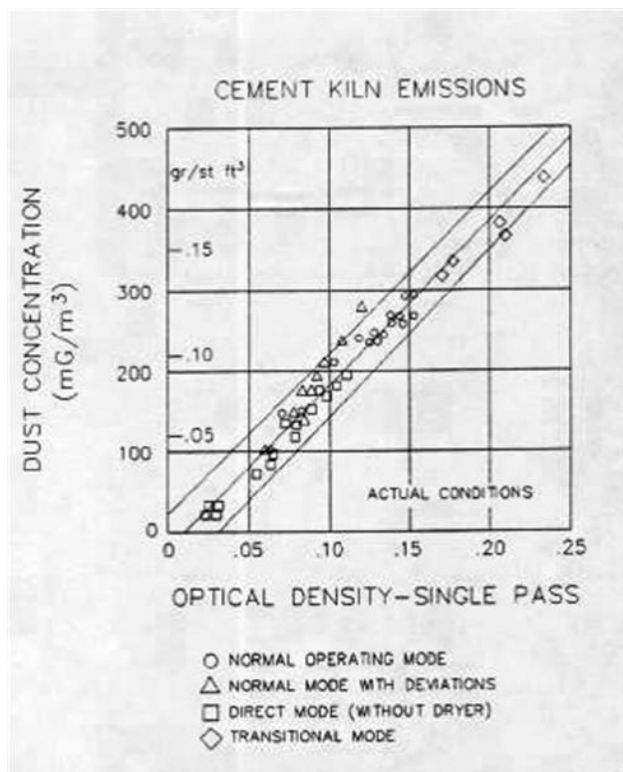


Figure 1 — Cement kiln emissions

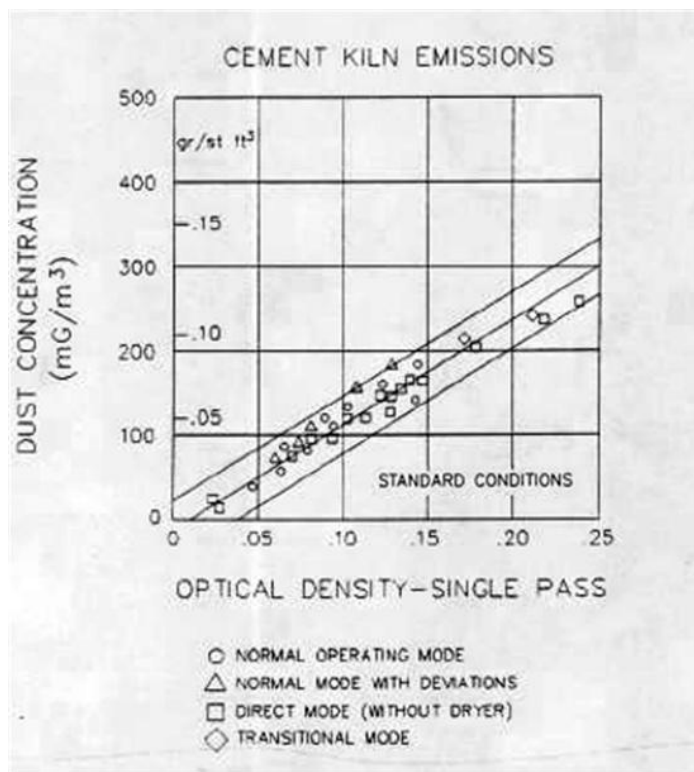


Figure 2 — Cement kiln emissions at standard conditions

Boiler Calibration Curves

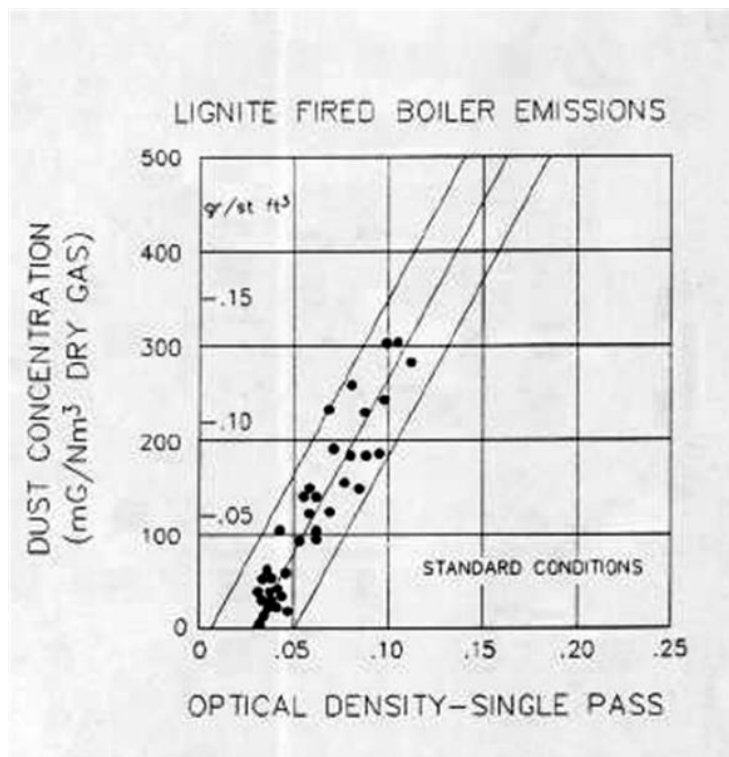


Figure 3 — Lignite-fired boiler emissions

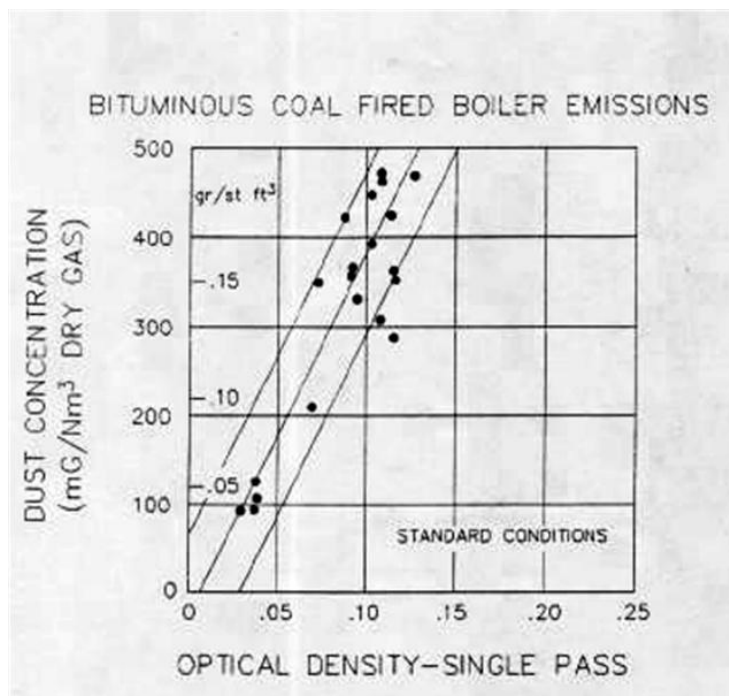


Figure 4 — Bituminous coal-fired boiler emissions

Correlation Accuracy and Error Levels

Transmissometers have been used in numerous installations throughout the world for continuous monitoring of both opacity and particulate concentration, based on the correlations established between the optical density measurement and dust loading. In the dust monitoring applications, the instrument calibration is typically checked by manual testing approximately once a year.

Table 1-1 summarizes the levels of error observed for different statistical analyses of several correlation lines for typical emission sources. Four different error definitions are shown. These error definitions are described more fully as follows:

- Standard deviation is the square root of the variance.
- Type 1 error is the 95% confidence level that the true mean of all observed optical data for a given particulate concentration will lie within the limit.
- Type 2 error is the 95% confidence level that the following observation will fall within the limit.
- Type 3 error is the 95% confidence level that 95% of all possible observations (95% tolerance) will fall within the limit.

Type 3 error specifications are typically applied in Europe, while the type 2 error definition is most common for US applications. The type 1 error yields the smallest errors, which range from 5 to 21% in the data.

Table 1-1. Particulate Concentration and Error Levels

Emission source	Observations	Correlation coefficient	Mean particulate concentration (mg/m ³)	Standard deviation (mg/m ³)	Error levels at mean particulate concentration (mg/m ³)		
					Type 1: 95% confidence — true mean	Type 2: 95% confidence — next single value	Type 3: 95% confidence — 95% of all possible values
Cement	39	0.985	179.9	±13.9	±9.0 (5.0%)	±54.2 (31.8%)	±68.6 (38.1%)
Bituminous coal	20	0.760	322.3	±85.5	±40.2 (12.2%)	±184.0 (57.1%)	±475.4 (147.5%)
Lignite	35	0.915	111.2	±31.4	±10.6 (9.5%)	±64.6 (58.1%)	±78.1 (70.2%)
Municipal incinerator	15	0.909	90.3	±29.5	±16.4 (18.2%)	±65.7 (72.7%)	±88.5 (98.0%)
Kraft recovery	12	0.957	76.4	±12.6	±16.1 (21.1%)	±57.9 (76.0%)	±81.6 (106.8%)
Hogged fuel	13	0.750	206.0	±61.8	±39.0 (18.9%)	±145.6 (70.7%)	±201.2 (97.6%)
Bituminous coal	11	0.974	252.3	±56.4	±38.4 (15.2%)	±133.2 (52.7%)	±379.5 (150.4%)

Comparison of Emission Sources

The following correlation data allow a comparison of stack opacities from different emission sources at equal particulate concentrations and stack diameters. Table 1-2 summarizes calculated opacities for a concentration of 150 mg/Nm³ and a stack exit diameter of 10.12 ft (3.085 m).

Table 1-2

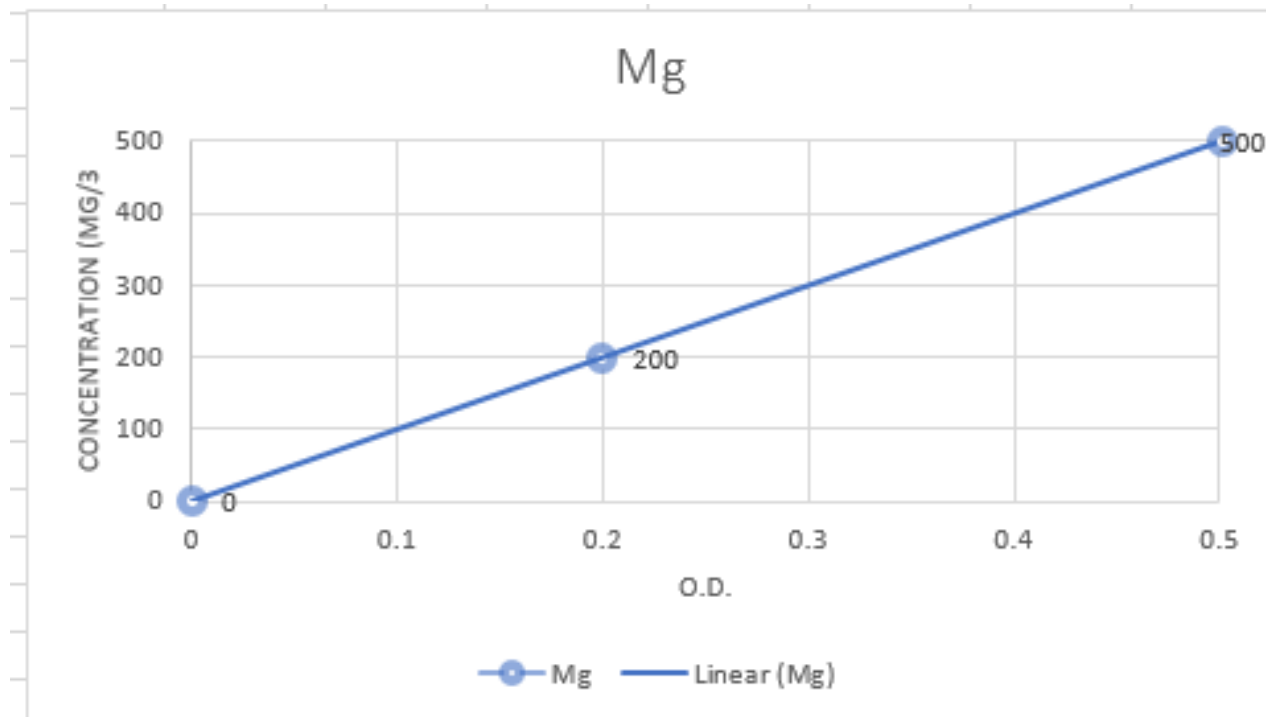
Particulate Concentration, Optical Density, and Opacity

Emission source	Mean particulate concentration (mg/m ³)	Single-pass optical density at mean particulate concentration	Diameter at measurement site (m)	Calculated at 150 mg/m ³ and a 10.12 ft stack diameter	
				Optical density	Opacity (%)
Cement	179.9	0.1029	1.95	0.1320	26.2
Lignite	111.2	0.0580	3.25	0.0722	15.3
Municipal incinerator	90.3	0.0235	4.00	0.0293	6.6
Kraft recovery	76.4	0.0746	3.66	0.1200	24.2
Hogged fuel	206.0	0.1290	1.52	0.1854	34.8
Bituminous coal	252.3	0.1432	4.88	0.0523	11.3

Sample Mg and Optical Density Calibration

Using the laboratory results from Method 5 or 17 isokinetic testing, draw a line from the origin (0.0) to the measured point (O.D., mg).

SAMPLE CHART: Use the chart to calibrate the monitor's mg/m^3 output. The calibration remains valid until the source characteristics change.



Use the laboratory particulate concentration and the corresponding monitor optical density (O.D.) reading to plot the graph. The origin is 0.0, and the graph is linear between the origin and the test result (O.D., mg).

EXAMPLE: Assume a concentration of $200 \text{ mg}/\text{m}^3$ and a corresponding O.D. of 0.2. Plot the graph and extend the line to approximately 2.5 times the typical stack dust level. In this example, the full scale is $2.5 \times 200 = 500 \text{ mg}/\text{m}^3$.

Sample Calibration Entry Screens

Enter the values from the chart:

Mg Lo = 0

OD Lo = 0

Mg Hi = 500

OD Hi = 0.5

Output values: 4 mA = 0; 20 mA = 500



CH1 O.D. output scale

Enter 4 mA = 0 from the chart.

Enter 20 mA = 5.0.



CH2 Mg output scale

Enter 4 mA = 0 from the chart.

Enter 20 mA = 500.



Alarm Matrix

Service reference. Contact state: 0 = open; 1 = closed.

Automatic Reset Without Pressing Reset

Test condition	High mg Alarm 00	High Op Alarm 02	mg/Op alarm silence 06 & 07	E.W. Op Alarm 03	E.W. mg Alarm 01
Start at 0%; use a test value above the high setpoints.	0	0	0	0	0
> High Mg, 150 mg setpoint, after the delay has elapsed (AL)	1	1	1	1	1
> High Op, 20% setpoint, after the delay has elapsed (AL)	1	1	1	1	1
Return to 0%	0	0	0	0	0

Automatic Reset with Reset Pressed Before Returning to Zero

Test condition	High mg Alarm 00	High Op Alarm 02	mg/Op alarm silence 06 & 07	E.W. Op Alarm 03	E.W. mg Alarm 01
Start at 0%; use a test value above the high setpoints.	0	0	0	0	0
> Setpoint after the delays have elapsed (AL)	1	1	1	1	1
> EW setpoint; reset button pressed	1	1	1	1	1
> Process alarm setpoint; reset button pressed	1	1	0	1	1
Return to 0%	0	0	0	0	0

Alarm Matrix Continued

Contact state: 0 = open; 1 = closed.

Manual Reset After Returning to Zero

Test condition	High mg Alarm 00	High Op Alarm 02	mg/Op alarm silence 06 & 07	E.W. Op Alarm 03	E.W. mg Alarm 01
Start at 0%; use a test value above the high setpoints.	0	0	0	0	0
> Setpoint after the delays have elapsed (AL)	1	1	1	1	1
Return to 0%	1	1	1	1	1
Process alarm reset button pressed	0	0	0	1	1
EW reset button pressed	0	0	0	0	0

Manual Reset Before Returning to Zero

Test condition	High mg Alarm 00	High Op Alarm 02	mg/Op alarm silence 06 & 07	E.W. Op Alarm 03	E.W. mg Alarm 01
Start at 0%; use a test value above the high setpoints.	0	0	0	0	0
> Setpoint after the delay has elapsed (AL)	1	1	1	1	1
Process alarm reset button pressed	1	1	0	1	1
EW reset button pressed	1	1	0	1	1
Return to 0%	1	1	0	1	1
Process alarm reset button pressed	0	0	0	1	1
EW reset button pressed	0	0	0	0	0