OPAL 200 OPACITY & DUST MONITORING SYSTEM

OPERATION AND SERVICE MANUAL

PRODUCT REGISTRATION

Thank you for selecting the OPAL 200 opacity and dust monitoring system for your application. We look forward to the opportunity to be able to provide any service or operational support you may require. If at any time you require our services please do not hesitate to contact our factory, or your local authorised distributor – we will be most pleased to assist.

Because the majority of our instrumentation products are sold through a local area sales and service network, we may not be aware of who and where you are. The below form is your method of establishing contact with our factory to gain the benefit of technical service support for your current and future requirements. Please find time to fill out the requested information and attention it to our factory service department. This will ensure that you will be updated at all times on any of the following important subjects.

1. *Product updates and design changes – At some stage most products will undergo design changes to further develop product capabilities and operational reliability. Some features will be up-gradable into your system to offer more features or better performance.*

2. *Calibration and Service records – OPAL product will require planned maintenance and routine calibration testing. We can track the operational life of your systems and remind you of any service or calibration procedures that are recommended.*

3. *Service Notes – With all technical products there will be a history of valuable service information, gathered over years of field operation. We plan to provide this information to our customers in the form of Service Notes and a lot of this information can be valuable to your service personnel, often saving time and inconvenience and preventing system failures at inconvenient times.*

COMPANY DETAILS

- Company .....……..……..
- Installation Site ……..……..……
- Site Contact …… Title ……
- Telephone ……..……..… Fax…….…… Email ……..……..

PRODUCT DETAILS

- Purchased From …… Purchase Date …… System Serial No. ..…… ..…..
- Type of Industry ? (eg. petrochemical, power, cement, etc) ……..……..
- Purpose of Instrument? Process Control …… Combustion control ……..… EPA Compliance ……..
- Lens Protection Source? Plant air …… Air Blower ……..… Vented draft …….

WARRANTY AND SERVICE SUPPORT PROCEDURES

All OPAL products are warranted against operational faults and breakdowns for a period of not more than 36 months from date of factory shipment. The warranty covers 100% of all parts and labour costs for all repairs determined by our factory, or our authorized service center, to be under conditions of warranty. Not covered by warranty is any product failure attributed to installation or operational conditions that are in contravention to factory recommendations as stated in this service manual. The OPAL warranty is based on authorized service shop repair and all freight or transportation costs are the responsibility of the customer. On site warranty work may, at the discretion of OPAL service staff, be chargeable to the customer.

To provide regional customer support for customers, ***OPAL Service Centres*** *have been established. These centres have OPAL factory trained service personnel who can provide technical or diagnostics support and rapid spare parts support. For more information on your regional support, please refer to the OPAL website.*

We strive to provide efficient and expedient service when an instrument or component is returned for either warranty or normal service repair, and your assistance can help us to better provide the service you need. To assure that we process your factory repairs and returned goods efficiently and expeditiously, we need your help. Before you ship any equipment to our factory please contact our office. When you call please be prepared to provide the following information:

- ***Contact name***
- ***Contact details***
- ***Company name and shipping address.***
- ***Details of items returned (Part #'s and Quantities).***
- ***The Serial number or a description of each item.***
- ***The reason for the return action.***

In addition to the above information we will require an official company purchase order before any repairs can be started. The final invoice repair may be a no charge service (or warranty repair) but there will be a requirement to cover for any additional service costs, such as freight, etc.

When you call in, our Service Department will assign a Service Reference Number (SRN) to your shipment and initiate the necessary paperwork to process your equipment as soon as it reaches us. Please include the SRN details with the equipment that you return, preferably both inside and outside the shipping container. This will assure that your equipment receives the fastest attention possible.

Your assistance in this matter will enable us to serve you better. We appreciate your cooperation and support of our products and services.

All Goods to be shipped to:

Goyen Valve Corp
1195 Airport Rd
Lakewood, NJ 08701
Ph: 732-365-7800
Fax: 732-364-14356
Email: ecollins@goyen.com

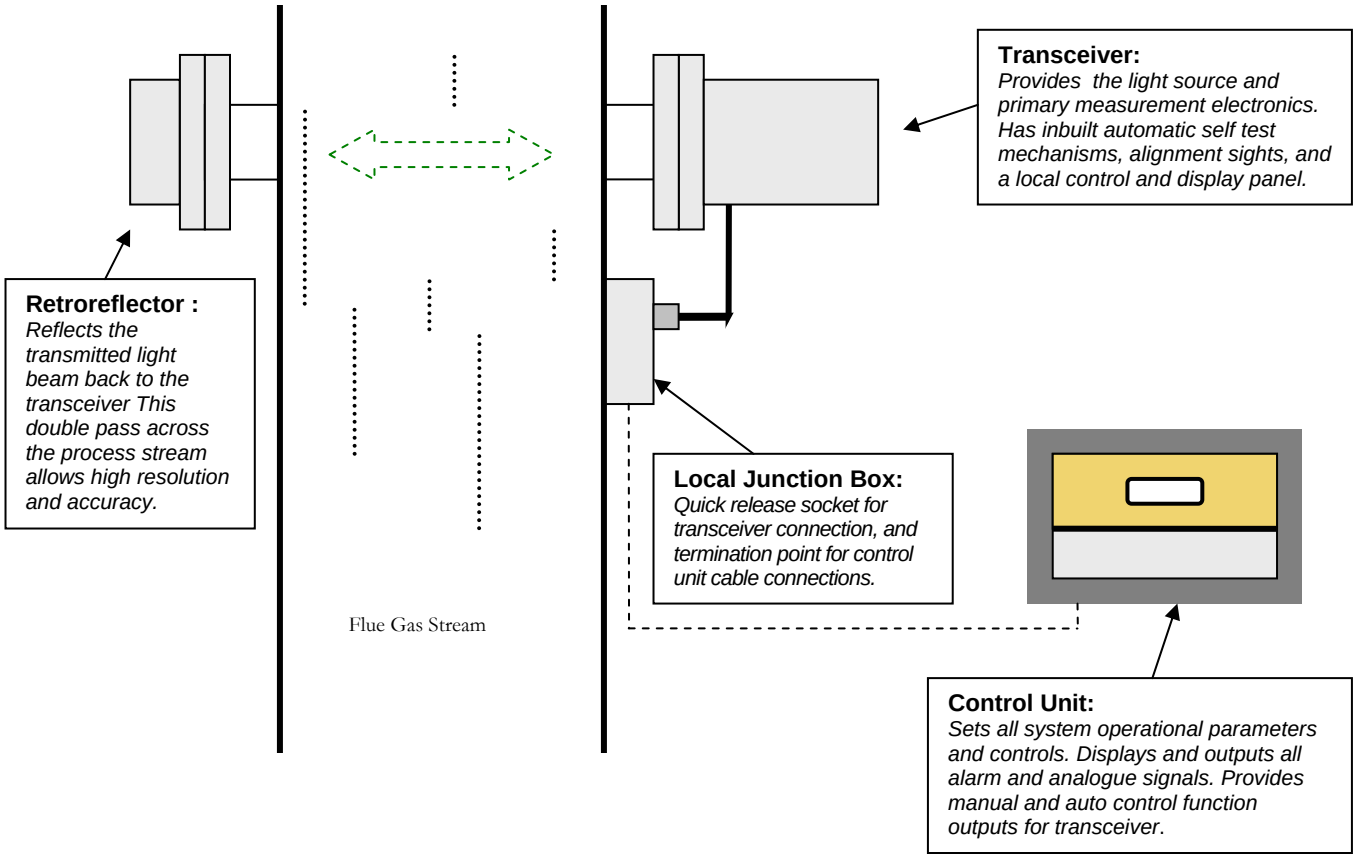
International customers, please refer to our website for your nearest authorized OPAL Service Centre.

SECTION 1 OPAL 200 OPTICAL SYSTEM

1.1 General Description

The OPAL 200 opacity and dust monitoring system provides continuous, precision measurement of flue gas particulate emissions in industrial applications. These emissions are usually the result of waste particulate matter in flue gas exhaust streams, and can be monitored as either visible emissions or as mass dust concentrations. The OPAL 200 opacity and dust monitor is a high performance system that provides dual outputs for Opacity (visible emissions, expressed as %), and Optical Density (directly proportional to mass concentrations), making the system ideal for control and monitoring of process emissions and arrestment plant performance.

The OPAL 200 opacity monitor system is a low maintenance, double-pass, dual beam transmissometer that consists of a transceiver (transmitter / receiver) mounted on one side of a stack or duct, and a passive retroreflector module mounted on the opposite side of the duct. These stack mounted components are then interfaced with the control unit, which is usually located in a more accessible location.



OPAL 200A Opacity & Dust Monitoring System Components.

1.2 Principle of Operation

Normal mode of operation

The OPAL 200 optical system consists of an optical transceiver mounted on one side of the stack and a retro reflector mounted on the other. To avoid errors due to ambient light, the lamp (refer Figure 1) is electronically modulated and projects a collimated beam of light, which is split into a source beam, and a measurement beam by an optical beamsplitter. The source beam is directed to the source detector, **(S^D).** The measurement beam is projected across the stack to a retroreflector that returns the beam back across the stack to a beam splitter which directs the measurement beam to the measurement detector, **(M^D).** A portion of the returning light is also sent to the TTL (thru-the-lens) alignment sight, as viewed through a window provided at the rear of the transceiver. The alignment sight is used to correct changes in alignment and is unique in that no moving parts are used.

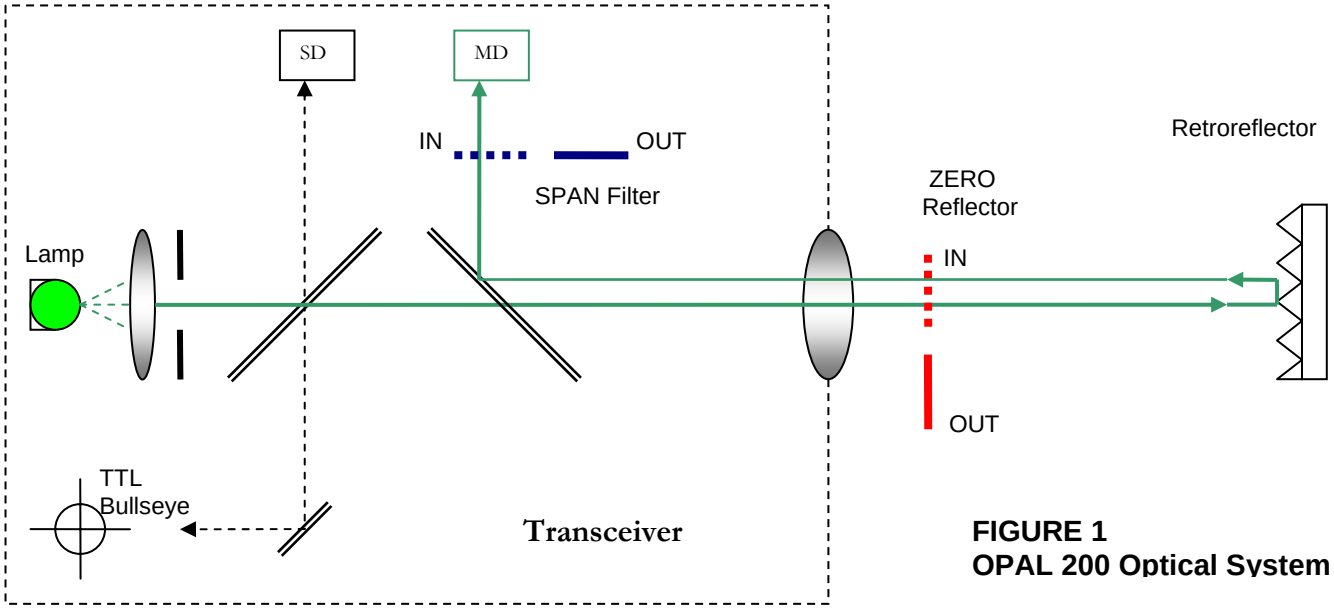


FIGURE 1
OPAL 200 Optical System

The measured transmittance (T) signal is the result of the measured value **(M^D)** ratioed against the original "clean stack" measurement value **(R^D)** that was established at the time of system calibration.

$$\text{Transmittance (T)} = M^D / R^D$$

The ratio of M^D / R^D represents a double pass value of the light transmittance **(T^2),** which is outputted in the form of a 4-20mA output signal to the main control unit where it is converted to a single pass value and used to calculate both linearised opacity and optical density values using the following formulae:

$$\text{Opacity} = 1 - T$$

$$\text{Optical Density} = \log_{10}(1/T)$$

Opacity Vs Optical Density Measurement

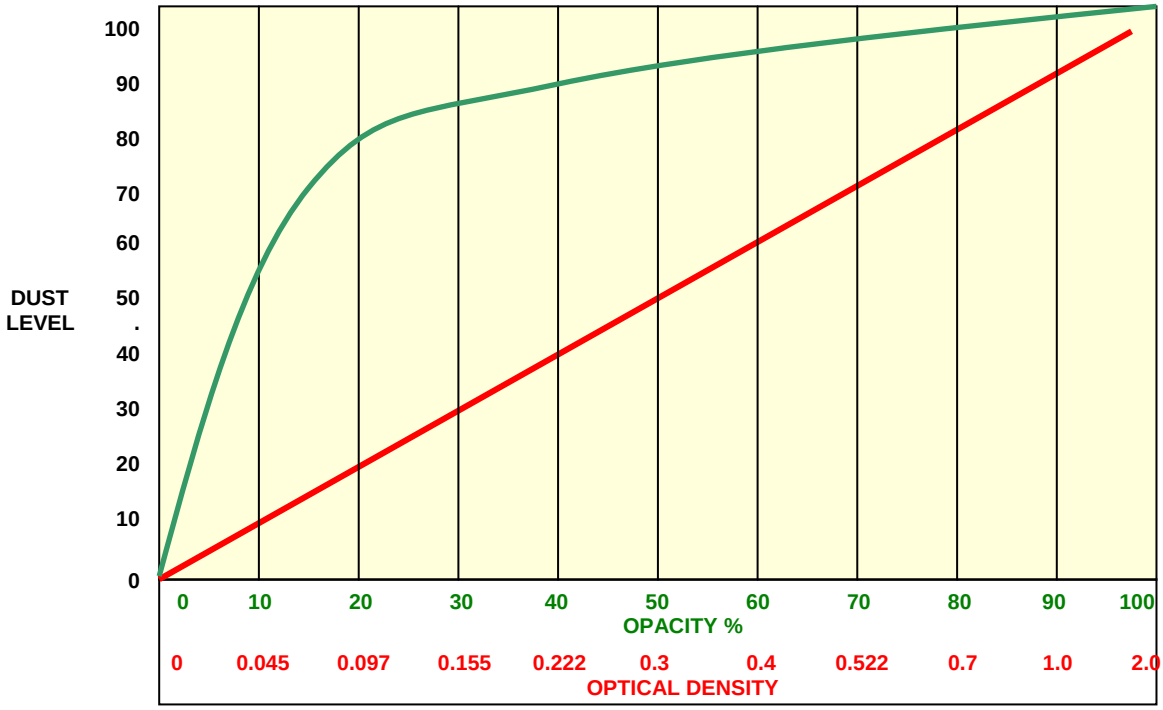
End user requirements for monitoring plant emissions will differ, subject to the process type and the conditions stated in site license for the environmental regulators. The OPAL 200S offers the ability to continuously monitor both formats for emissions - visible and quantitative measurement.

1. Opacity - is a measurement of visible emissions, as seen by the human eye, expressed in scales of opacity %, and calculated from basic measurement of light transmittance. This type of monitoring is more commonly required for combustion process emissions because of the changing nature of the particulate emissions when subjected to variations in combustion efficiencies and variable, or unburnt, fuel types. e.g. wood, coal, oil, etc

2. Optical Density - a calculation of the "rate of light loss" as the beam passes through the flue gas, based on the initial measurement of light transmittance. The optical density value will vary proportionally to variations in the actual mass concentration of the particulate in the flue gas. e.g. To double the particulate mass concentration will double the optical density measurement.

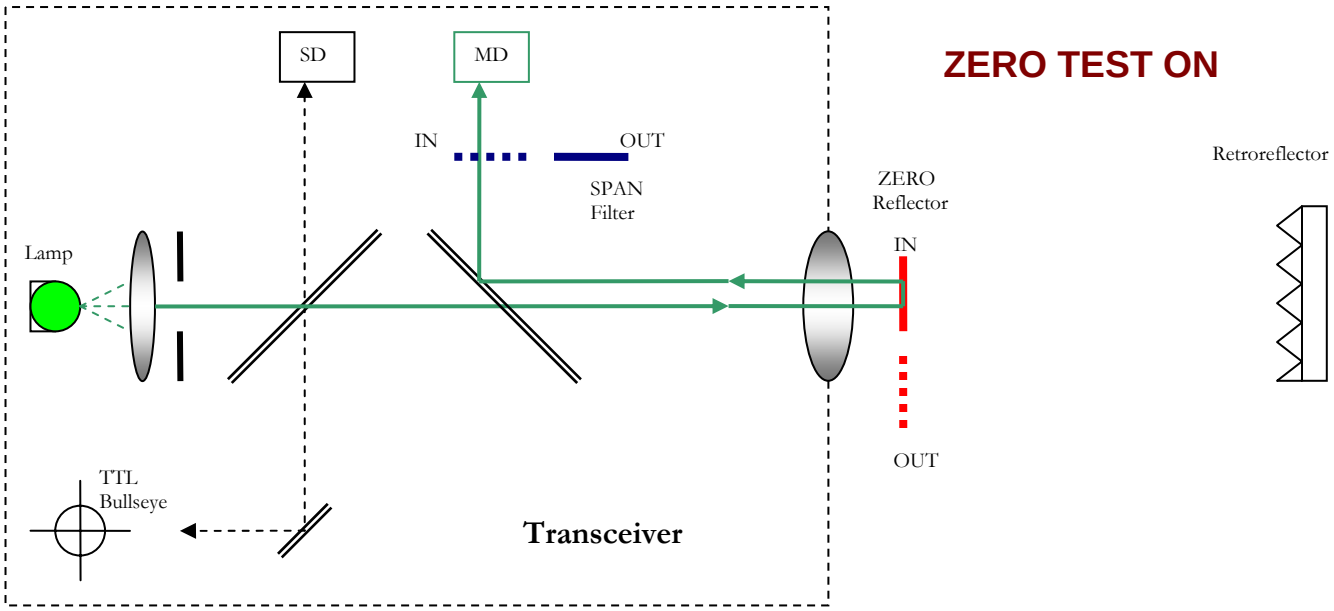
A linear correlation can be determined between optical density values and mass concentrations of particulate by means of an external gravimetric sample analysis, under isokinetic conditions. The accuracy of this correlation is based on the relative consistency of the particulate type (type, particle size and colour,etc.). In most continuous manufacturing process conditions, this would be the case. For more information on particulate variation, please contact our factory at info@opalenvironmental.com.au

The following graph shows the indicative relationship between mass concentrations, optical density and opacity changes including the non linearity of the opacity Vs dust level relationship.



Automatic Calibration Procedures

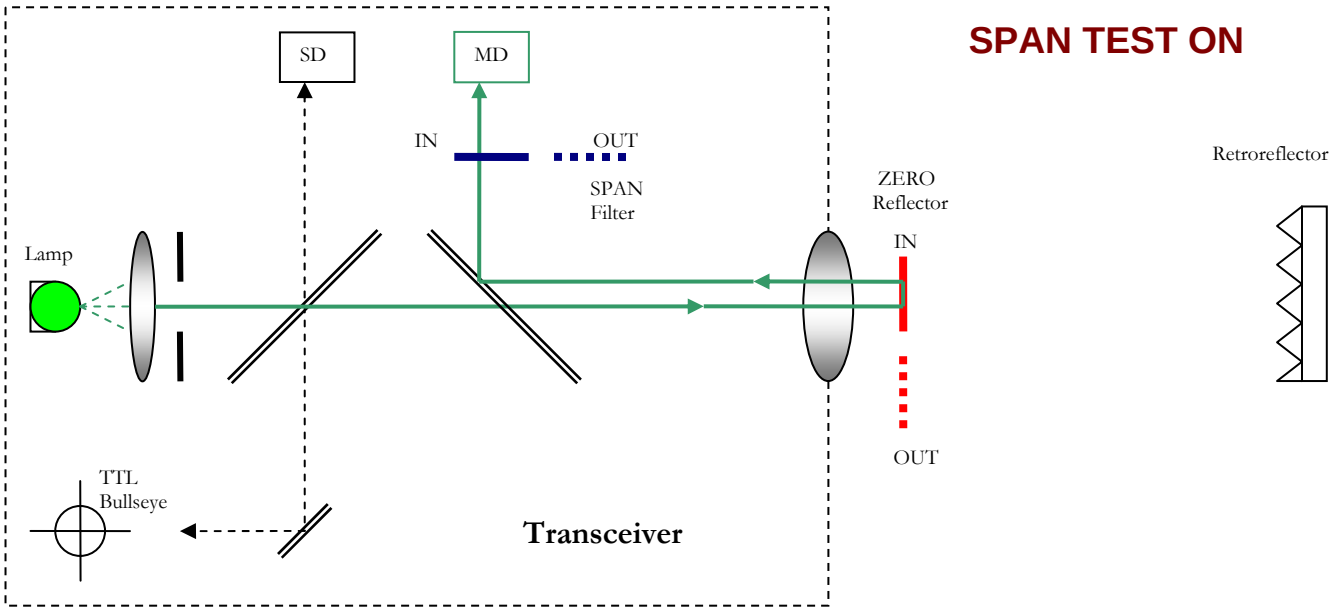
Despite the application of various lens purge protection techniques, it is still possible for contamination to occur at the system optical surfaces that are directly exposed to the flue gas contaminants. This contamination of lenses will incorrectly be included in the measurements of flue gas opacity and it is therefore necessary to regularly measure, and compensate for, any contamination buildup. The OPAL 200 system has an automatic procedure for measuring and compensating for accumulated lens dirt, and for validating the system accuracy against a fixed internal span filter value.



1. Autocal – ZERO Test

During the zero calibration period a calibrated zero reflector assembly is placed in front of the transceiver optical package. This zero reflector calibration is calibrated to provide the normal level of reflected light energy that the transceiver would normally receive in a clean stack condition, over the calibrated span distance. This zero test assembly will test all optical surfaces and electronic components to assure that the electronic zero level value has not changed.

Any variation from the calibrated zero value would normally be caused by dirt buildup on the exterior lens surface and any variation is electronically factored into normal measurements to prevent errors. The level of dirt buildup on lens surfaces is monitored and when a preset level is reached, a "*dirty lens*" alarm is triggered, indicating that service cleaning is required. Lens dirt is a lower line displayed item on the main control unit.



2. Autocal – SPAN Test

   In the span calibration mode the zero reflector remains in the test position and a span filter, of a known "neutral density" value, is placed in the beam path. This action produces a specific up scale reading that is monitored by the control unit. If the measured value is not within a set tolerance range, a *"cal filter fail*" alarm is triggered.

All system optical components, main lamp, photosensors, wiring, control unit and computation analysis are tested during the autocal test procedures.

Zero / Span Test Initiate

Because the system outputs will fluctuate outside normal measurements during the above test cycle it may cause plant operational problems. The system control unit can be programmed so that each of the two output signals can be live, or frozen at last measured value, during the test cycle.

An automatic zero and span test cycle can be initiated by:

1. Automatic pre-programmed cyclic start.
2. Manually via control unit or transceiver keypad control.
3. Manually via remote input signal to control unit.

A momentary Zero or Span test can also be initiated at the transceiver or control unit keypads by push button operation. The displayed value will be live, but the output signals are frozen during this service operational test.

1.3 General & Performance Specifications

General Specifications

Peak and Mean Spectral Response	515 to 585 nm, less than 10% of peak response outside 400 to 700 nm
Angle of View	< 4.0 °, *Meets or Exceeds PS-1 Revised and ASTM D6216-03*
Angle of Projection	< 4.0 °, *Meets or Exceeds PS-1 Revised and ASTM D6216-03*
Calibration Error/accuracy	<+/- 1.0% FSD, *Meets or Exceeds PS-1 Revised and ASTM D6216-03*
Response time	< 10 seconds, *Meets or Exceeds PS-1 Revised and ASTM D6216-03*3
Zero Drift	Nil drift *Exceeds PS-1 Revised and ASTM D6216-03*
Calibration Drift	Nil drift *Exceeds PS-1 Revised and ASTM D6216-03*
Output	Transmittance, squared signal (T^2) 4 - 20mA = 0 - 100%
Zero/Span Calibration	Timed automatic, or manual, span and zero tests, via servomotor control

Transceiver Control Panel

Display	2 line 16-digit LCD, backlit, selectable and scaleable display: Transceiver output: Transmittance - % and mA Transceiver input: i) Opacity - % and mA ii) Optical Density – value and mA
Local Zero/ Span test control	Automatic test - keypad initiation Manual test – span or zero
4-20 mA signal measurement (selectable on display)	1. 4-20mA (Opacity %) , from control unit 2. 4-20mA (Transmittance %) from transceiver
Status relay outputs	Dual relays for *optical system fault* or *local test mode*
Control functions	Local test, Transceiver setup and system calibration, diagnostics

Transceiver/ Reflector

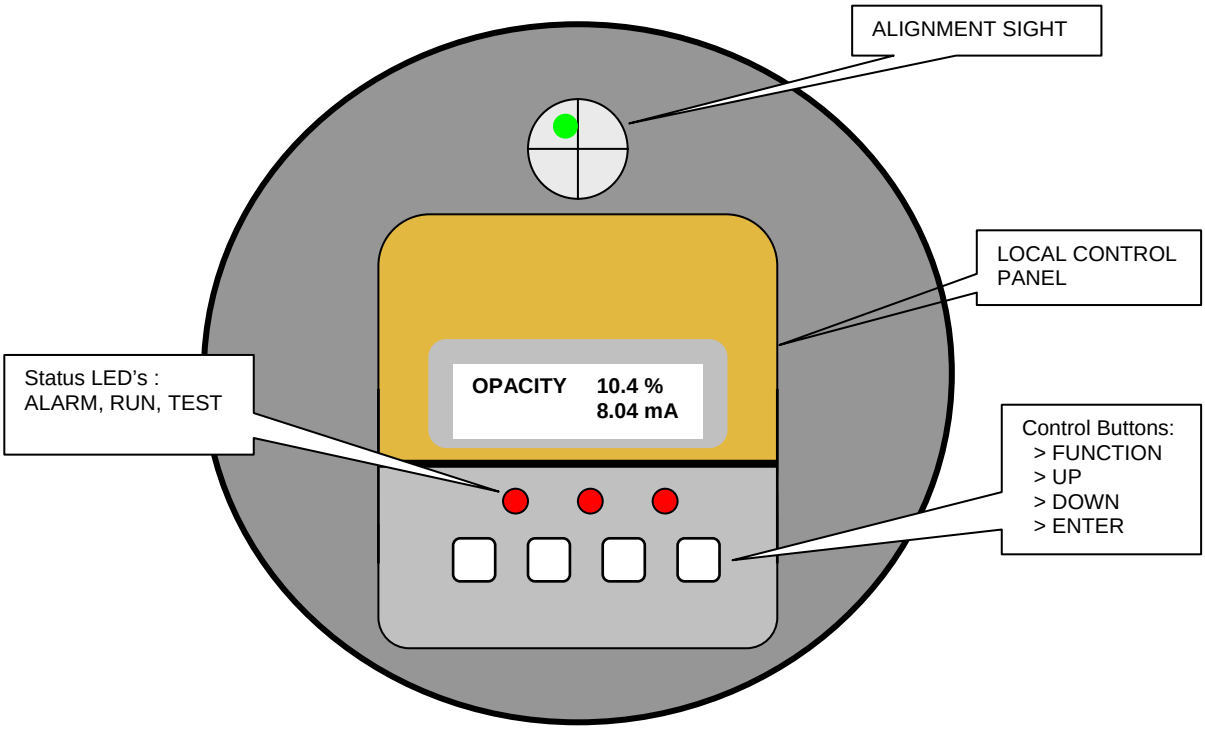
Enclosure	IP65 weatherproof enclosure
Path Length	0.5 to 15 metres.
Optical System	Double Pass
Light Source Aging Compensation	Automatic
Light Source Life	> 10 years
Ambient Temperature Limits	-20 ° to +50 ° C (Optional weather cover set and in-line purge heater for -40 O to +50 O C operation.)
Process Gas	Up to 250 ° C, standard. (higher available on factory request)
Alignment Verification	Passive, through-the-lens cross hair alignment verification – no moving parts. Adjustment via 4 point ball socket flange alignment flange +/- 4 degrees
Mounting Flanges	90NB flange - 205mm dia flange with 90NB and 4 x 18mm bolt holes on a 165pcd
Ambient Light Immunity	100% immunity - Solid-state LED with electronic light modulation

1.4 Transceiver Control Panel

The OPAL 200A transceiver has an inbuilt control panel on the rear cover of the transceiver. The digital display, status leds, and keypad are protected by a weatherproof membrane cover to allow easy access at any time during the operation of the system. The purpose of the control panel is:

- Display of system performance outputs.
- System calibration and set-up.
- Local service testing and diagnostics.
- System fault indication and operational status.

OPAL 200A TRANSCEIVER CONTROL PANEL



The transceiver control panel has a 2 line 16 digit alphanumeric backlit display and three status LED's to indicate the current operational status of the system:

- **ALARM LED -** A fault alarm relay is triggered and the LED will glow whenever the measured reference signal (lamp source) is too low or too high.

- **RUN LED -** This LED Indicates that the system is fully serviceable and in normal operation.

- **TEST LED -** A status alarm relay is triggered and the LED will glow whenever the system control programme is accessed. This provides remote indication that the instrument is under test or adjustment.

Programme Access and Operation

The OPAL 200A system programme is accessed via the four keypad push buttons as described below:

- **FUNCTION -** Allows operator to alternate between normal display window and other modes.
- **UP** - Used to step through various options and change set values in each mode.
- **DOWN** - Used to step through various options and change set values in each mode.
- **FUNCTION -** Allows the operator to store or initiate any selected function.

There are four main sections in the OPAL 200A programme:

- **DISPLAY MODE -** Allow continuous real time display of the system performance in scaling of opacity (or optional optical density) and transmittance, displayed as either % or actual measured milliamp values.
- **TEST MODE -** For local service convenience, this mode allows direct control of the span and zero test functions, and a manual test mode position where audit test filters can be used and responses displayed. Note:- OPLR correction will be suppressed whilst in test mode.
- **INSTALL MODE -** Use for initial set-up and calibration, as well as diagnostics displays of all transceiver performance features.
- **FACTORY MODE -** This mode is for factory use only and is accessed using a special key card entry. There are no operational parameters for customer use in this mode.

A transceiver programme MENU MAP, showing the location and facilities of each parameter within the software programme is available on the following page.

MODE	OPTIONS	DESCRIPTION
DISPLAY	1. Opacity or Optical Density) 2. Transmittance (display in value or milliamps)	Normal system operation with options for keypad display.
TEST	> ZERO Test > SPAN Test	Output signals are frozen while the keypad controls the servo drive operations for the SPAN & ZERO tests. Normal display options
	> MANUAL Test	Allows external audit filter tests with the outputs frozen. OPLR is auto set at 0.5 during tests.
	> AUTOCAL Start	Starts the main control unit autocal cycle. Useful for locally resetting lens dirt values after maintenance.
INSTALL	> ALIGNMENT	Starts high intensity lamp to assist the alignment procedure. Off after 60 seconds
	> CHECK OPTICS	Displays last calibration values for SPAN & ZERO (engineering units). Also displays current value.
	> CHECK REF	Displays last calibration value for Source Detector (engineering units) Also displays current value.
	> SERVO ALIGNMENT > ZERO TEST > ZERO REST > SPAN TEST > SPAN REST	Allows adjustment of the SPAN and ZERO servo motor TEST and REST positions. Displays current set position Step adjustment range is +/-30 digital units
	> AUTOZERO OFFSET	Displays the calibrated zero value and the ZERO module current value (engineering units) while it is adjusted mechanically. On completion a fine auto offset can be initiated. The % of automatic offset is displayed and is limited to <10% .
	> CALIBRATION	Allows system calibration for ZERO and SPAN measured conditions. Displays current stored values in engineering units. **IMPORTANT – INITIATING THIS FEATURE WILL CHANGE SYSTEM CALIBRATION**
	> DISPLAY	Allows the transceiver display to be set to match the Channel 1 output signal settings used in the main control unit.
FACTORY	(FACTORY ACCESS ONLY)	Used for factory calibration of displays and auto-temperature compensation, etc.

SECTION 2 OPAL 200 CONTROL UNIT

2.1 General Description

The OPAL 200 Series control unit provides digital display of all measured components (opacity, optical density, etc), system operational status, as well as providing re-transmission of analogue output signals and alarm status to plant control systems, where required. The control unit can be located up to 300 metres from the optical system installation point. We recommend a sheltered environment at normal ambient temperatures.

In normal operation the control unit is in the RUN mode and automatic time based functions, such as SPAN / ZERO calibration tests will be performed. In the SETUP mode, all operational settings, (times, alarm levels and output ranges, etc) can be entered and stored in the programme. The control unit has preset factory values and options entered for each function item. These values will be restored at any time that a “cold start” is initiated.

The analyser control unit also provides three different methods of control of the ZERO and SPAN calibration value testing, making the instrument very simple for service diagnostics:

1. Manual ZERO or SPAN TEST – push button individual tests, with live display and frozen outputs.
2. Manual AUTOCAL - starts the automatic calibration test cycle as programmed, on demand.
3. Programmed AUTOCAL - the automatic calibration test cycle is initiated at programmed time intervals.

2.2 General & Performance Specifications

General Specifications	
Ambient	-20 to 50°C
Power	240 or 110V, 50/60 Hz link selectable.
Weight	3 Kg (6.6 lbs)
Dimensions	285W x 180H x 100D (mm)
Mounting	IP65 - wall or surface mounting.
Display	Alphanumeric, 16 digit, 2 line, LCD backlit

Electrical Specifications	
Inputs	Analogue (Transmittance^2 signal: 4 - 20mA = 0 - 100% NC contacts – BLOWER FAIL NC contacts – SERVICE MODE NC contacts – HEAD FAULT NO contacts – Remote AUTOCAL command
Outputs	Dual 4-20mA signals. Programmable: i) Opacity % scaleable 0 – 10% to 0 – 100% ii) Optical Density scaleable 0 - 0.05 to 0 – 2.0 iii) Dust mg/m3 scaleable 0 – 10 to 0 - 500 Dual (2) alarm relays: SP- NC with selectable functions RS 232 / RS 485 / MODBUS

System Outputs

The OPAL 200 main control unit provides dual linearised and galvanically isolated 4-20mA signals for plant use. Each output can be programmed from the following options:

Opacity - A single pass opacity measurement derived from the double pass transmittance measurement. This output signal is subject to an OPLR (optical path length ratio) adjustment so that the measured signal is recalculated to be representative of the actual stack exit opacity. In the case of a parallel stack, the OPLR is 0.5. The output signal damping (averaging) is set between 1 and 20 seconds.

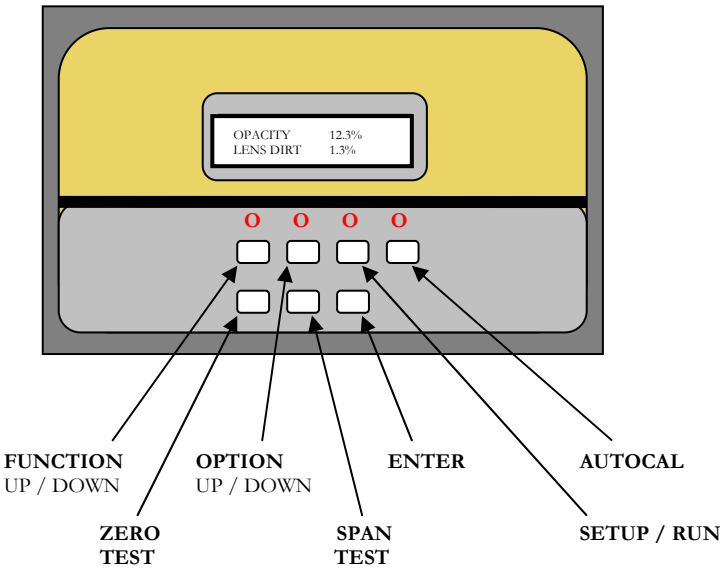
Optical Density – Optical density is also calculated from the transmittance signal. It is the measured rate at which the light intensity is reduced when it passes thru the flue gas. After correlation to a stack gravimetric test, this signal can be rescaled to display and report actual quantitative values of emissions. The output signal damping (averaging) is set between 1 and 20 seconds.

Quantitative – A dust concentration signal, auto-correlated in the control unit using the “Q-Test” function, can be available for quantitative reporting in milligrams per cubic metre. (mg/m3) The Q-Test function compares the internal data storage of optical density measurements, against an inputted value for a stack sample test.

EPA versions of Opacity and Optical Density – Available specifically for direct data storage and display for EPA license reporting. Same as the standard outputs except the signal damping (averaging) is set between 1 and 60 minutes.

2.3 Parameters and Settings

OPAL 200 Control Unit Keyboard Layout



SETUP Mode Access

For the SET-UP mode keyboard to operate, press the SET-UP/RUN button. The set-up light will come on when the set-up mode has been entered. Please note :

1. Set-up mode cannot be entered if the keyboard lock switch (SW1) on the inside of the control unit is in the UP position. The keyboard lock switch can be found on the door PCB (1630-1), on the lock side, at the top. If access is attempted while the keyboard is locked, the message **'Illegal Access'** will be displayed.

2. While the control unit is in set-up mode the outputs will be frozen. All of the keyboard button functions printed in BLUE will now operate. After 60 seconds without activity the control unit will automatically revert back to RUN mode.

3. While a timed, or manual, autocal test is underway the control unit buttons are frozen and SETUP cannot be accessed.

Extended Menu

An "extended menu" can be accessed if the SETUP button is pressed before power is applied to the control unit, and held until the display shows the words "Extended Menu". The extended menu contains additional functions that are not normally required by operators and service personnel. This menu would normally be accessed by qualified personnel. Extended menu items are identified in the summary below and are highlighted in Red print.

Cold Start

A “cold start” is used to update the control unit if any software changes are issued by the factory. This action is sometimes necessary if problems are experienced. It is important to log all site specific values and options in the page provided at the rear of this service manual so that they can be re-entered in the event of a “cold start” procedure. To initiate a cold start, remove power from the control unit, open the control unit, and remove the anodised circuit board cover plate on the inside of the door. Remove the link marked “c/s link” from the pcb and restore power. When the display advises, put the link back in position and replace the cover plate. The factory default values and options for all programme functions will now be restored.

Changing Functions, Options or Values

- Functions - To step through the function, press the ‘FUNCTION ⮝’ or ⮟’ buttons to increment up and down the function numbers. The OPAL 200 control unit is designed as a multifunction controller and various adjustable functions will not be displayed for the opacity monitor application
- Options - To step through the available options for each function press the ‘OPTION ⮝’ or ⮟’ buttons. When the required option is selected press the ‘ENTER’ button. An asterisk will then appear alongside the option selected. When viewing various set-up functions, the display will always first indicate the last options entered for each function. The ‘Lower Line Select’ (F 30) and ‘Data To Print’ (F 61) items are multiple options. One or more options may be selected for these functions.
- Values - To set a value for a particular function press the ‘OPTION ⮝’ or ⮟’ buttons to change the value. A momentary press will change the value one digit. Holding the button will change the value more quickly. Once the correct option or value is displayed it can be entered into the analyser's memory by pressing the ‘ENTER’ button. When a value has been entered an asterisk will appear at the right hand side of the lower line in the display.

Summary - Functions and Options

1. System Option
2. Calendar - year
3. Calendar - month
4. Calendar - day
5. Real time clock - hour
6. Real time clock - minutes
7. Reference voltage #1
8. Reference voltage #2
9. Reference voltage #3
10. Reference voltage #4
12. 4-20mA CH1 Cal
13. Cal 4mA CH1
14. Cal 20mA CH1
15. 4-20mA CH2 Cal
16. Cal 4mA CH2
17. Cal 20mA CH2
18. Enter Service Year
19. Enter Service Month
20. Enter Service Day
23. Channel 1 Output
25. CH1 Output Span
26. Channel 2 Output
28 Channel 2 Span
30. Temperature Units
31. Lower line Display
34. Opacity Autocal
35. Opacity Autocal, Start
36. Opacity, Autocal, Period
37. Opacity Autocal, Duration
38. Opacity Autocal, Filter Value
39. Opacity Autocal, Filter Error
40. Opacity Autocal, Output s
41. Q Test – Start
42. Q Test – Stop
43. Q Test – Value
49. Lens Dirt
50. Process Alarm Enable
51. High Opacity Alarm #1
52. High Opacity Delay #1
53. High Opacity Alarm #2
54. High Opacity Delay #2
61. Alarm Relay #2
64. Print Data
65. Print Log Period
66. Printer Baud Rate
70. Opacity Damping
71. EPA Averaging
72. FSS Fitted
73. MODBUS™ Address
76. SSR Fail
77. Maintenance Mode
78. Relay 2 REV
79. Extended menu ON

Details - Functions and Options

1. System Option
Options: Opal 100, Opal 200, Opal 300.

2. Calendar - year
Options: Select the current year for the real time clock/calendar.

3. Calendar - month
Options: Select the current month for the real time clock/calendar.

4. Calendar - day
Options: Select the current day for the real time clock/calendar.

5. Real time clock - hour
Options: Select the current hour for the real time clock. (24 hour format)

6. Real time clock - minutes
Options: Select the current minutes for the real time clock.

7. Reference voltage #1
Options: Set the value of the reference voltage as read on a 3 ½ digit multimeter. (about 27.5mV)

8. Reference voltage #2
Options: Set the value of the reference voltage as read on a 3 ½ digit multimeter. (about 193.60 mV)

9. Reference voltage #3
Options: Set the value of the reference voltage as read on a 3 ½ digit multimeter. (about 1202.00 mV)

10. Reference voltage #4
Options: Set the value of the reference voltage as read on a 3 ½ digit multimeter. (about 2479.00 mV)

Note: Set-up items 7 to 10 are used to calibrate the A/D of the instrument. This should be done 30 minutes or more after the instrument has been on, approximately once every year. The calibration constants are retained in battery backed memory unless a 'COLD START' is performed. Connect a 3 ½ digit multimeter negative lead to the test point marked 'C' to the right of the PCB on the inside of the door (labelled 'REF VOLTS'). Measure the four voltages on the test point marked 1 to 4 with the positive lead. Enter the measured values in set-up items 7 to 10.

12. 4-20mA CH1 Cal
Select the calibration method for the 4-20mA output channel #1. The output channels can be either calibrated by simply pressing the 'AUTO CAL' button, or can be trimmed at both the 4mA and 20mA ends of the scale using a multimeter.
Options:

1. Auto Calibration *
2. Manual Calibration
3. Set 4mA Trim
4. Set 20mA Trim

Note: If 'MAN CAL' is selected, it is necessary to trim both ends of the 4-20mA output range using the 4mA and 20mA trim options in this menu item. Selecting 'MAN CAL' inhibits the 'Auto Cal' process of this channel. Always do the 4mA trim first, and then the 20mA trim. After trimming both ends of the scale, return the 'CALIBRATION OPTIONS' menu option back to 'MAN CAL' (not 'AUTO CAL'), or the calibration will be over written by the next 'AUTO CAL'. The control unit will only stay in either '4mA TRIM' or '20mA TRIM' modes for 30 minutes before it automatically returns to 'MAN CAL'.

13. Cal 4mA CH1
This menu item only appears if 'Set 4mA Trim' is selected in Set-up 12.
Range: 0 to 25mA, (Default is 4.00 mA)

14. Cal 20mA CH1
This menu item only appears if 'Set 20mA Trim' is selected in Set-up 12.
Range: 0 to 25mA, (Default is 20.00 mA)

15. 4-20mA CH2 Cal
Select the calibration method for the 4-20mA output channel #2. The output channels can be either calibrated by simply pressing the 'AUTO CAL' button, or can be trimmed at both the 4mA and 20mA ends of the scale using a multimeter.
Options:

1. Auto Calibration *
2. Manual Calibration
3. Set 4mA Trim
4. Set 20mA Trim

Note: If 'MAN CAL' is selected, it is necessary to trim both ends of the 4-20mA output range using the 4mA and 20mA options in this menu item. Selecting 'MAN CAL' inhibits the 'Auto Cal' process of this channel. Always do the 4mA trim first, and then the 20mA trim. After trimming both ends of the scale, return the 'CALIBRATION OPTIONS' menu option back to 'MAN CAL' (not 'AUTO CAL'), or the calibration factors will be over written by the next 'AUTO CAL'.

16. Cal 4mA CH2
This menu item only appears if 'Set 4mA Trim' is selected in Set-up 15.
Range: 0 to 25mA, (Default is 4.00mA)

17. Cal 20mA CH2
This menu item only appears if 'Set 20mA Trim' is selected in Set-up 15.
Range: 0 to 25mA, (Default is 20.00mA)

18. Enter Service Year
For a new 'DATE OF LAST SERVICE', enter the service 'YEAR'. This can represent the last time the system was serviced. It is recommended that the system be programmed for service every two years.

19. Enter Service Month
Enter the current 'MONTH'.

20. Enter Service Day
Enter the current 'DAY' of the month. Altering these values will reset the 'RUN TIME'.

23. Channel 1 Output

Selects the measured component for output.

1. Opacity
2. EPA Opacity
3. Optical Density
4. EPA Optical Density
5. Dust – mg/m3
6. No Output

25. Channel 1 Output Span
Sets 20mA span of measurement.
Range: Varies depending on output selected.

26. Channel 2 Output
Selects the measured component for output.

1. Opacity
2. EPA Opacity
3. Optical Density
4. EPA Optical Density
5. Dust – mg/m3
6. No Output

28. Channel 2 Span
Sets 20mA span of measurement.
Range: Varies depending on output selected.

30. Temperature Units
Select displayed units scaling.
Options:

1. Celsius (Centigrade) *
2. Fahrenheit

31. Lower line Display Functions
In the run mode the upper line on the LCD display will always read % Opacity. The lower line can be set to read one or more of the following. Select as many as are required to be displayed by pressing the 'ENTER' button. Those selected will have an asterisk displayed alongside.
Options:

1. Ambient temperature
2. EPA Opacity
3. Optical density
4. Lens dirt, (%)
5. Duct ratio, (OPLR)
6. EPA Optical Density
7. Ambient RH %
8. Mg/m3
9. Transmittance (T^2) mA
10. Q-Test optical Density

34. Opacity Autocal
Selects if an automatic calibration test will be carried out on a timed basis. (Default is Yes)

35. Opacity Autocal, Start
Sets start hour for autocal operation (Default is 8 O'clock)

36. Opacity, Autocal, Period
Sets period between autocal operations.
Range is 4 – 48 hours (Default is 24 hours)

37. Opacity Autocal, Duration
Set period for total autocal operation. Stage 1 (Zero) and Stage 2 (Span) are each 50% of set duration. (Default is 6 minutes)

38. Opacity Autocal, Filter Value

Sets opacity % value of internal Span test filter. (Factory Set Value – default 50%)

39. Opacity Autocal, Filter Error
Sets opacity % value of tolerance (+/-) for Span filter test.
Range: 0 – 100%. (Default is 2%)

40. Opacity Autocal, Output Live
Selects the status of 4-20mA outputs during autocal cycle.
Options:

1. Freeze Channel 1
2. Freeze Channel 2
3. Both Frozen
4. Both Live

41. Q-Test Start
Select date and time for the planned start of the stack isokinetic sampling test period. (This start time should be co-ordinated with the stack sampling company.) Used to start the data logging period for determining averaged optical density value during the test period.
Range:Date, Hour, Minute in 5 minute steps

42. Q-Test Stop
Select date and time for the actual finish time of the stack isokinetic sampling test period. (This stop time should be recorded and advised by the stack sampling company.) Selects the period of data logging that is to be used to determine the averaged optical density value during the test period. Averaged O.D is displayed as an optional lower line item.
Range:Date, Hour, Minute in 5 minute steps

43. Q-Test Value
Enter stack isokinetic test results for the above selected test period. The test result value, in mg/m3, will be provided by the sampling company after analysis. The entered value will automatically determine the correlation factor for the measured (averaged) optical density value during the test period, to convert the response into mg/m3.
Note: Until a test value is entered, the lower line display of mg/m3 will display *CAL Required.*
Range:0 – 500 mg/m3

49. Lens Dirt
Selects the alarm trigger level of accumulated Lens Dirt as measured during autocalibration tests.
Range: 0 – 10%

50. Process Alarm Enable
If process alarms are not required, 'NO' can be selected. There will not be any process related alarms generated, and all process alarms will be cancelled, if 'NO' is selected.

51. High Opacity Alarm #1
Set the operating point for the high opacity alarm relay
Range: 1 – 100% opacity. (Default is 20% opacity)

52. High Opacity Delay #1
Sets time delay before alarm triggers.
Range: 1 – 300 seconds. (Default is 10 seconds)

53. High Opacity Alarm #2
Set the operating point for the high opacity alarm relay
Range: 1 – 100% opacity. (Default is 50% opacity.)

54. High Opacity Delay #2
Sets time delay before alarm triggers.
Range: 1 – 300 seconds. (Default is 10 seconds)

61. Alarm Relay #2
Any or all of the following alarm functions may be used to activate the alarm relay. They may be selected or de-selected using the 'ENTER' buttons.
Options:
1. High Opacity. 2.Service mode 3. Cal in Progress

64. Print Data
Any or all of the following values may be printed on a printer or computer connected to port 2. They may be selected or de-selected using the 'ENTER' buttons. The log period follows in set-up step 61. NOTE: If a MODBUS™ address (Function 68) other than zero is selected, the data log function will be disabled.
Options:

1. Opacity
2. EPA Opacity
3. Optical Density
4. EPA Optical Density
5. Lens dirt
6. Duct ratio, (OPLR)
7. Ambient temperature
8. Ambient RH %
9. Transmittance (T2)
10. Q Test O.D.
11. Mg/m3

65. Print Log Period
Select the time interval between data print outs on the printer.
Range: 2 - 120 minutes, 2 – 24 hours

66. Printer Baud Rate
Select the correct BAUD rate for data to be transmitted out of the port to the printer.
Options: 300, 1200, 2400, 4800, 9600 (Default is 9600)

70. Opacity Damping
Each time a new reading is read from the opacity monitor, the new reading is averaged with the last readings taken, before the new average is either displayed on the LCD, or sent to the 4 to 20mA output. The number of readings that are averaged together is adjustable with this function. A value of five for example, means that the new reading from the system and the previous four readings are averaged together before being displayed. The smoothing of the opacity signal is an exponential function. If a factor of 5 is used, a step change of input signal will take about 5 seconds to reach 63% of the change on the output/display.
Range: None to 20. (Default is 5.)

71. EPA Averaging
CH2 4-20mA output is available for EPA reporting to averaged periods of time. This function sets the period for averaging.
Range: 1 to 60 minutes

72. FSS Fitted
This function confirms the use of fail safe shutters in the system and allows the daily automatic calibration test cycle to include individual fail safe shutter testing.
Options: YES / NO

73. MODBUS™ Address
This function is used when networking of one or more analysers back to a master computer or data acquisition system is required. Any analyser with zero selected as the MODBUS™ address will have the MODBUS™ disabled, and the data log function enabled. If the MODBUS™ address is changed, the analyser must be turned off and back on for the address changes to take effect.
Range: 0 - 31. (Default is 0)

EXTENDED MENU ITEMS
(Access to extended menu items is by powering up the control unit with the SETUP button depressed)

76. SSR Fail (Extended Menu Item)
This function determines the number of loop tests to be completed before the solid state relay alarm is triggered.

77. Maintenance Mode (Extended Menu Item)
This function enables the top line of the control unit to display any negative measured values. This function is for service convenience and is not a normal display item. Displayed negative values will revert when the control unit power is turned off.
Options: YES / NO

78. Relay #2 Reverse (Extended Menu Item)
This function selects the operation mode for alarm relay #2. The relay can be set to function as either normally energized (fail safe), or normally de-energised.
Options: YES / NO (Fail safe condition)

79. Extended Menu Display (Extended Menu Item)
This function allows the extended menu items to be displayed at all times.
Options: ON / OFF

SECTION 3 SYSTEM INSTALLATION

3.1 General Installation

The primary considerations for selecting a suitable location for the installation of the OPAL 200 system are:

1. Distances for electrical and air services
2. Safe and convenient accessibility
3. Operational ambient conditions
4. Suitable and representative sampling conditions.

Local Power Services

The OPAL 200S main control unit is internally switch selectable for either 240 or 110 vac, single phase power supply. The load current is approximately 2 ampere at 110vac. The transceiver optical system is powered from the main control unit at 15vdc, 350mA.

The OPAL 200-AB air blower assemblies require an independent power supply to the main control unit and can be supplied with several versions of the blower motor:

1. **Single phase 110vac 60Hz 7.0 Amps 0.5 kW**
2. **Single phase 240vac 50Hz 3.1 Amps 0.4kW**
3. **Three phase 415vac 50Hz 1.4 Amps 0.4kW**

We also recommend that a standard 240vac GPO, 10 ampere minimum, be installed at the transceiver installation point for test and repair equipment.

Accessibility

Locate the instrument in a position that provides safe access for periodic maintenance and inspection. A platform or walkway is required for access to the sensors and weather covers. Wherever possible, allow for a working bench area to stand tools and audit test equipment. Wherever necessary, consider windy conditions and security of all system components.

The platform or walkway must be available to allow access to the weather covers. The optimum condition would have the mounting flanges and weather covers approximately 1500mm up from the floor level.

In the case of the air blower assemblies, allow a minimum of 300mm from the bottom of the blower assembly to the floor for air hoses and access to air filters. Railings and other obstructions should allow the weather cover removal for normal service access.

Ambient Conditions

Locate the stack-mounted units in an area where the ambient temperatures lie between -20 and 50 Deg C. Ensure weather covers are used to avoid direct sunlight. (Consult the factory for extreme temperature ranges.) Areas that are clean and dry are desirable. Avoid areas with condensation or excessive vibration.

Locate the control unit in an easily accessible area with ambient temperatures between -20 and 50 DegC. Avoid direct sunlight and extreme weather. To permit the operator to read and/or change controls, the control unit should be mounted between 1500 and 1800 millimetres from floor level.

Stack Sampling Position

To achieve a representative sample measurement of the flue gas stream, it is necessary that the flow path before and after the measuring point is without disturbances. As a general guideline it is desirable to achieve not less than 4 straight diameters of duct before, and not less than two straight diameters after, the measuring position. Generally all OPAL 200 installations will be required to meet the statutory guidelines of your local environmental regulators. Please consult with your EPA advisor prior to commencing the installation.

A review of the drawings and procedures provided will help to produce an error free installation. However, there are several important points that should be observed:

1. The beam of the instrument must be kept in the horizontal plane- the transceiver should be mounted on the horizontal plane.
2. The weather covers must be installed vertically plumb.
3. Installation and wiring diagrams are found at the end of this manual.
4. Review all drawings prior to starting installation or wiring. If you have any questions please contact our service department for assistance.

Sampling point location

To achieve a representative sample of the flue gas stream, the accepted practice is to have the measurement path of the instrument directly in the centroidal area of a vertical stack, or in large horizontal flowing ducts, at a point that is at least 33% of the height of the duct. An area should be chosen where the particulate flow is not stratified in the stack or duct. For more details on this subject, contact our factory.

Where a bend is involved, the path should be chosen to be on the plane of the bend. Locations where significant levels of condensed water may be present should be avoided.

3.2 Installation – Mechanical

Installation procedure - stack flanges

Stack flange installation and alignment is the first step in successful installation. The final transceiver alignment adjustments are described in a later part of this section.

For an opacity monitor, the customer is required to install two suitable stub flanges at eye level directly across from each other. The flange faces, mounted on pipe stubs, should be approximately 150 – 200mm from the

stack or duct insulation to allow easy removal of securing bolts. On completion of the installation, the flanges must be aligned so that the total deviation of the transceiver and retroreflector flanges, relative to a common centerline, does not exceed +/- 2 degrees. Any deviation up to these specified limits can be adjusted out during the installation and alignment of the light source and retro reflector with the OPAL 200 flange alignment adjustments.

NOTE: The OPAL 200 alignment flange system has angular adjustment capability of +/- 4^0 which represents approximately +/- 1000mm adjustment over an 8 metre span distance.

For duct diameters less than 2000mm, successful and simple alignment of the stub flanges can be accomplished using an ***alignment pipe assembly***. The line pipe is inserted thru the holes that are cut in the duct wall and stub flange guides are slipped onto the line pipe. Securing guides will hold the stub flanges in exact position whilst the welding is completed.

For duct diameters greater than 2000mm, or where conditions do not permit the use of the alignment pipe assembly, a ***scope alignment tool*** can be purchased or hired from our factory. This device is attached to each stub flange to visually control position as the welding is completed.

Lens Purging System

Each OPAL 200 optical system incorporates a pair of flange mounting spools that have integral purge air inlets for the protection of optical lenses against the contamination and high temperatures of the process gases. In some applications negative duct pressures can ensure a flow of air into the air inlets without the need for an external air purge. If this is possible we recommend that filters be fitted on each air inlet to ensure clean, dry air enters the system.

If negative duct pressures cannot be guaranteed, the air supply should be provided by a suitable positive displacement blower source, at a flow rate suitable for the protection of optical components. Standard filtered blower assemblies are available from our factory, supplied with a standard 6 metre air hose. The air hose can be up to 6 metres long for a single side blower, or cut to 2 equal lengths for a dual side blower arrangement.

Single side blower assembly (see photo) is normally used in large duct installations where the total hose length required for a dual side blower arrangement would introduce airflow losses too great for reliable operation.

Integrated blower assembly – cover open

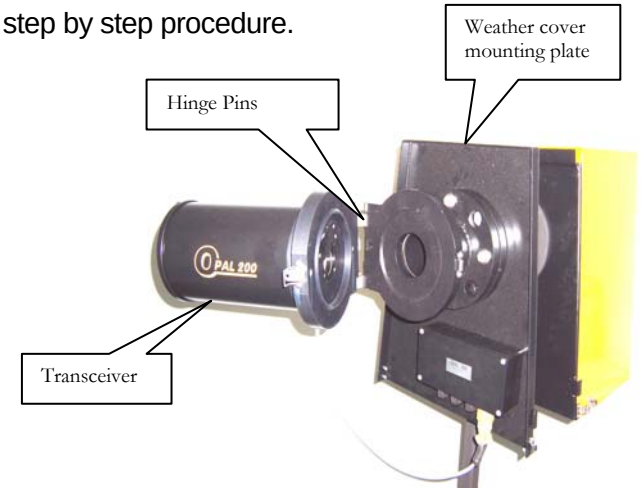
Installation procedure – Weather Covers and Flange Assemblies.

After the installation of stub flanges follow the below step by step procedure.

1. The transceiver and retro reflector have been shipped from the factory complete with a set of purge / alignment flanges and a set of weather covers.

   The transceiver purge / alignment flange is the unit with a double flange arrangement for alignment adjustment.

2. Check the supply of all items in the shipment .



3. The air purge assembly is attached to the stub flanges on the duct wall, using four 16mm x 60mm bolts. Working from the stub flange the correct assembly is;

Flange gasket > Weather cover mounting plate > Purge gasket > Purge module.

(Ref Drawing # 200 – 0104.)

4. Install the transceiver and retro reflector assembly by attaching the transceiver and retroreflector to the air purge assembly by placing them on the hinge pins. Close transceiver & retro and secure in place with the two hold down latches. The air-purge blowers should be powered up at this time to prevent stack particulate from accumulating in the air-purge housing.

Caution: If the installation is subject to positive duct pressure, the air-purge system must be used continuously during installation to prevent process gases from contaminating optical surfaces or over heating 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.

Weather Covers

The transceiver, retroreflector and blower assemblies are supplied with removable weather covers for normal operation to provide protection against direct sunlight and adverse weather conditions.

NOTE: FAILURE TO INSTALL THE WEATHER COVERS MAY VOID WARRANTY.

OPAL 200 weather covers are fairly compact to allow movement around the walkway or platform. They protect the stack-mounted components from direct sunlight, dirt, moisture, and radiant heat from high temperature stack conditions that may exceed the specified ambient temperatures limits of the system.

Installation procedure – Beam Alignment

It is important to ensure the optical light beam alignment is completed prior to starting any calibration testing, or startup. Power must be connected to the control unit to allow power to the transceiver before this can be done.

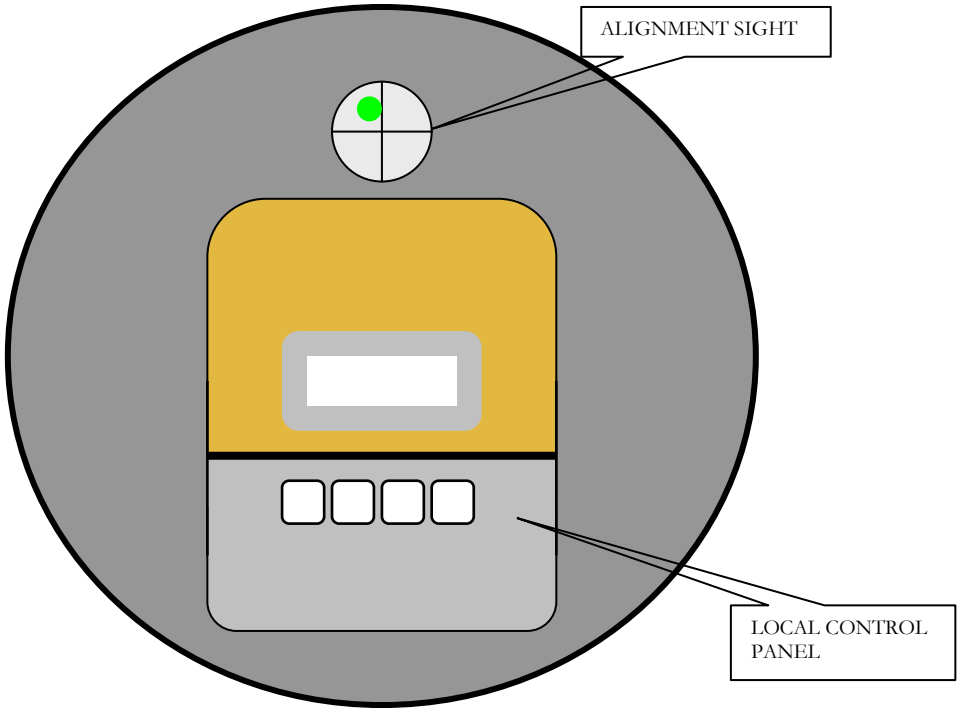
The stack should be at normal process temperature and the air purge blowers in operation.

To aid the alignment process the OPAL 200A offers two features:

1. High power alignment beam - In the OPAL 200A transceiver programme which is accessible at the keypad control panel on the rear of the transceiver, go to the *INSTALL MODE,* then *Alignment,* and press *ENTER.* This will activate a high power pulsing light from the transceiver which can be used to visually align the transceiver with the retroreflector position. The best technique is to remove the retroreflector module and observe the direction of the transceiver beam, whilst adjusting the alignment.

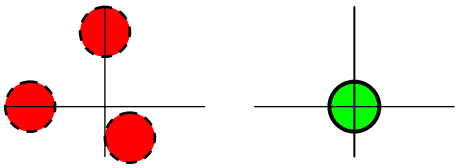
   The high power beam will turn off after two minutes and may need to be re-started.

REAR VIEW OF OPAL 200A TRANSCEIVER



2. Built in alignment sight – Once the basic alignment has been completed. Use the optical alignment sight at the rear of the transceiver. This sight indicates the exact direction of the normal beam and allows fine adjustment of the alignment flange.

   If the cross hairs are not illuminated by the return beam (spot), it is probably because the basic alignment is not satisfactory and may need to be re-done.



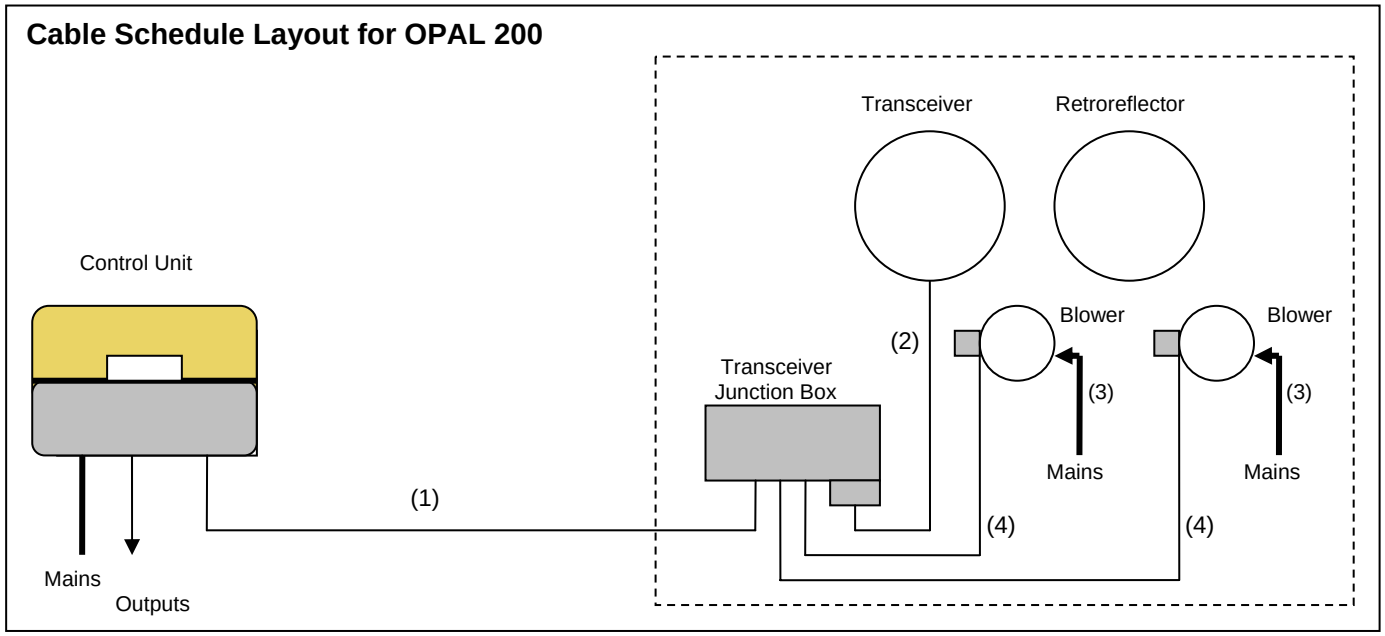
3. Another method of confirming the system optical alignment can be achieved if the process flow in the duct is shut down, and there is a clean stack condition.

   From the transceiver control panel, access *INSTALL*, then *Check Optics*. On this screen you will be able to observe the calibrated value of ZERO and SPAN opacity, expressed in engineering units. Above this value you will also observe the current stack measured value (also in engineering units) Under a clean stack condition, similar to when the system was factory calibrated, the values should be the same.

   By adjusting the alignment flange adjusting bolts– first vertical, then horizontal - and observing the live value, you will be able to make an “electronic alignment” of the system.

3.3 Installation – Electrical

All termination details are available in Drawing # 200-0103. The general information on the cable requirements are listed below:



(1) Control unit - Transceiver Junction Box. This is a customer supplied cable length not exceeding 300 metres. This cable should be a minimum of 6 twisted pair, overall shielded. (The shield should be grounded at the control unit end only. This cable is available for supply on request.

(2) Transceiver Junction Box - Transceiver This cable is factory fitted and includes a multi-pin connector plug for easy removal of the transceiver. There are 2 x M16 and a single M20 Cable glands fitted in the supplied junction box.

3) Air purge blowers Each air blower assembly requires an independently overload protected power supply. For circuit load requirements, refer to blower options below.

Single phase 110vac	60Hz	7.0 Amps	0.5 kW
Single phase 240vac	50Hz	3.1 Amps	0.4kW
Three phase 415vac	50Hz	1.4 Amps	0.4kW

4) Airflow switches If purge blowers are installed they can be fitted with in-line airflow switches to alarm in the event of failure of the air purge system. The AFS airflow switches are connected via the junction box and will trigger a control unit output alarm for BLOWER FAIL. The switch arrangements can be configured in the junction box for either NC (series) or NO (parallel) switches.

Maintenance GPO sockets Customer responsibility. We recommend the availability of a standard GPO, minimum 10 ampere, for service purposes. (Power tools, test equipment, etc)

SECTION 4 CALIBRATION AND STARTUP

4.1 General Information

IMPORTANT: COMPLETE THE FOLLOWING STEPS BEFORE START UP IS ATTEMPTED.

1. Measure and record flange-to-flange distance to verify that it is the same as the OPAL 200 calibration records sheet, as supplied with the instrument from the factory.

2. Read the instructions first to familiarise yourself with the instrument before attempting start up. Remember that the system was fully tested and calibrated prior to shipment.

3. The air purge assemblies, weather cover system, transceiver, retroreflector, and control unit must be installed and power applied. Do not attempt to install the optical head set on an operating duct until the air purge systems are operating

4. Beam alignment procedure has been completed.

Overview of the systems operation

The OPAL 200 monitoring system consists of the following components:

- Transceiver – provides a 4-20mA output signal that represents a measured double pass (squared) transmittance value expressed in terms of percentage (%). This $\mathbf{T^2}$ signal has a maximum output loop compliance of 800 Ohms. The transceiver also receives a processed 4-20mA signal from the control unit that is scaled 4-20mA = 0 – 100% opacity. This signal is the actual field signal for customer use with customer termination connections at the control unit.

- Retro reflector – has no electronic component and is simply a passive light beam reflective device.

- Control Unit – receives the 4-20mA transmittance signal ($\mathbf{T^2}$) from the transceiver and generates a corresponding linearised 4-20mA signal representing 0 -100% opacity. This signal can be re-ranged to a lower level if required for process data purposes. Prior to transmitting this signal as an output, it is routed via the transceiver for diagnostics purposes.

- Junction Box – This enclosure allows interconnection of the customer supplied cable between the control unit and the transceiver. The transceiver has a short cable with a quickrelease plug that is connected at the junction box. The junction box also allows for cable termination from air blower alarm switches if fitted.

IMPORTANT: ALL SYSTEM COMPONENTS ARE FACTORY INTEGRATED AND CALIBRATED PRIOR TO SHIPMENT. THE KEY COMPONENTS OF EACH SYSTEM ARE MARKED WITH A COMMON SERIAL NUMBER AFTER CALIBRATION. BY INTERCHANGING ANY OF THESE UNITS, THE SYSTEM MUST BE RE-CALIBRATED IN ORDER TO MEET THE USEPA PS-1 STANDARD. IN THE CASE OF MULTIPLE SYSTEM SHIPMENTS. PLEASE CHECK THE SYSTEM MAIN COMPONENTS ARE NOT ACCIDENTALLY INTERCHANGED.

4.2 Calibration Changes & Testing

Prior to shipment, each system is installed and aligned at the factory on a calibration and testing track using the same flange-to-flange dimensions as specified by the customer. At this stage, in accordance with the USEPA PS-1 requirements, a complete zero and span calibration is conducted. The total procedure takes less than 3 minutes and a series of ND test filters are then inserted into the optical path to validate the overall system accuracy.

If the situation arises, an in-situ calibration can be done as long as clean stack condition can be verified. The system can also be calibrated on a workshop bench, prior to installation using the following procedures.

IMPORTANT – TO ENSURE THE SYSTEMS ADVANCED TEMPERATURE STABILISATION IS EFFECTIVE, THE TRANSCEIVER MUST BE TEMPERATURE STABILISED BEFORE ANY CALIBRATION ADJUSTMENT IS CARRIED OUT. WE RECOMMEND THE SYSTEM BE POWERED FOR AT LEAST 60-120 MINUTES BEFORE ANY CALIBRATION PROCEDURES ARE STARTED.

In-situ Calibration

The benefit of in-situ calibration is that the span distance is absolutely correct and all that is required is to ensure the alignment is correct. But the in-situ calibration procedure also requires that the OPAL 200 light beam path is absolutely clear of flue gas contaminants for the ZERO calibration. If this condition cannot be provided it will not be possible to complete an in-situ calibration.

Please note that even though the plant process is shut down, and you believe a clean stack (zero) condition exists, flue gas contamination may still exist for up to 24 hours. It is also possible to have flue gas contamination being caused by cross connected flue gas ducts that are in operation.

The SPAN calibration requirement of 100% blockage of the light beam can be best achieved in-situ by releasing the transceiver and swinging it open to direct the light beam to open air, or at any non reflective surface in order to achieve absolutely zero return light to the transceiver. Remember that direct sunlight, or artificial light, has absolutely nil affect on the OPAL 200 measured signals.

Workshop Calibration

Successful workshop calibration can be easily achieved in a workshop area as long as the positioning of the transceiver and retroreflector modules is accurate and stable. To achieve this we recommend the use of a set of secured OPAL bench test brackets (see photo), which also have an inbuilt test filter holder for ongoing accuracy testing.

With an accurate span distance established, correct alignment, and a dust free environment, the ZERO calibration is easy to complete.

The SPAN calibration can be achieved by simply placing a non reflective blocking material in the light beam path. We would recommend a piece of matt black cardboard placed in the beam at an angle to ensure nil reflection.

The complete calibration procedure of the OPAL 200 system requires 4 distinct steps:

1. Calibrate the OPAL 200 transceiver / retro system
2. Adjust the Transceiver AUTOZERO MODULE
3. Calibrate the OPAL 200 control unit – Signal IN
4. Calibrate the OPAL 200 control unit – Signals OUT

STEP 1. Calibrate the OPAL 200 transceiver / retro system

Zero Calibration

The zero calibration of the system is based on the systems response to a totally clean gas stream in the stack, i.e. 100% light transmittance or 0% Opacity, when set up across the customer specified flange to flange distance for the application. This zero value is critical as it can offset all measurements, plus or minus, if not correctly set. To complete the zero calibration:

1. Set the transceiver and retroreflector at a span distance (flange to flange) as specified by the customers installation requirements. (Please note that our factory tests have shown that for every +/- 1% of error in the span distance, there will be a similar % error in the actual opacity measurement.)
2. Align the transceiver to dead center. (Once the system is installed at site the same alignment is required.)
3. Access the transceiver control: **> INSTALL > CALIBRATION > SET ZERO > ENTER**. The calibration will take approximately 10 seconds before the transceiver display will ask you to accept the calibration. When asked, press **> ENTER** to accept result.

Span Calibration

After the zero calibration is completed, the system can then be calibrated to the 100% opacity level. This condition is equivalent to total blockage of any return light signal into the transceiver and the simple procedure is as follows:

1. Block the transceiver light beam to prevent any return light being received. This can be achieved by releasing the transceiver and swinging it open to allow it to point into an open space or at a non-reflective

surface, by removing the retroreflector module to avoid any return light, or by placing a non reflective material into the beam path to prevent a reflected signal.

Please note that the first method is the easiest technique for an in-situ calibration, but is most likely to disturb the bench alignment during a workshop calibration. (Remember that natural or artificial light has no effect on any measured signal.)

2. Access the transceiver control: **> INSTALL > CALIBRATION > SET SPAN > ENTER**. The calibration will take approximately 10 seconds before the transceiver display will ask you to accept the calibration. When asked, press **> ENTER** to accept result.

3.

STEP 2. Adjust the Transceiver AUTOZERO MODULE

Once the above system calibration and validation procedures are completed, it is then necessary to set up the auto calibration and testing mechanisms of the system.

A servo driven zero test module is installed at the front of the transceiver and is used to routinely interrupt the transmitted light beam. This module effectively bypasses the normal retroreflector and light path through the flue gas to simulate the normal calibrated zero (clean stack) condition. When in place, this mechanism is able to identify any lens dirt contamination for auto-compensation purposes.

Assuming there has been no alignment shift, any drift in the zero level is considered to be an accumulation of dirt on the process lens surface. The % value of the error is registered and subsequently compensated out of all opacity measurements. The actual lens dirt value remains as a lower line display item on the control unit. When the accumulated value reaches the alarm limit (factory set at 4% in accordance with USEPA PS-1), an alarm is triggered and lens cleaning is required. The alarm set range is 1-10% but the actual system will continue to compensate for up to 20% lens contamination.

Before the test mechanism can be used, it is first necessary to adjust the internal reflector of the autozero module for the correct level of light intensity.

The autozero module on the front of the transceiver must be adjusted so that the reflected energy level produces the same transmittance value as the clean stack conditions of the system calibration.

FUNCTION UP DOWN ENTER

1. Swing open the transceiver to access the front plate area.
2. Loosen the three (3) securing screws on the autozero module until the iris can be easily adjusted.

3. At the transceiver keypad, access *AZ OFFSET* via the *INSTALL* menu. (Press *ENTER*)

   The display will show:

- *AZ CAL is the last adjusted value*
- *AZ NEW is the current value being adjusted*

(sample screen values only)

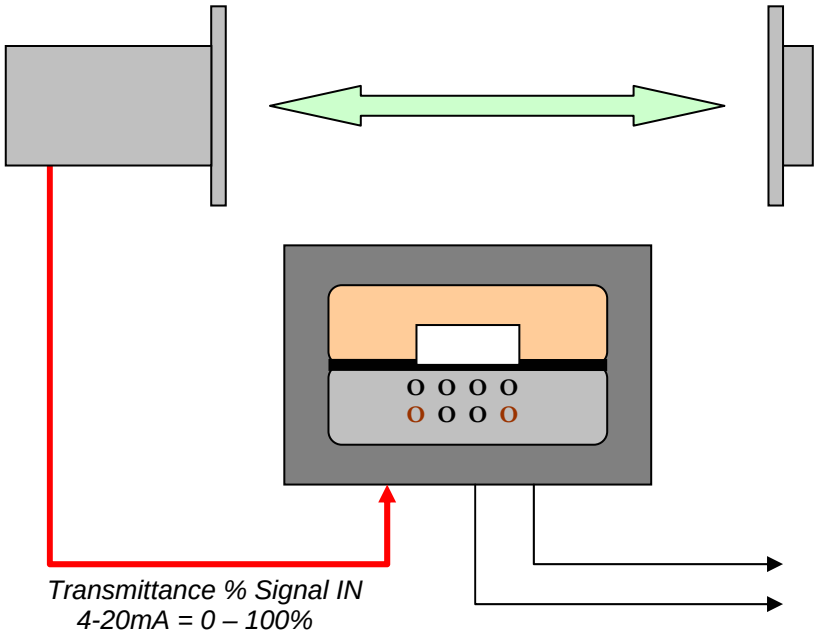
4. Adjust the iris to achieve *AZ NEW* value between 0.950 and 1.000 representing a measured light intensity from the autozero module that is within 5% of the actual clean stack condition of the installed system. Please note that the display will flash if the adjusted light intensity drops below 0.900 (too low) or above 1.050 (too high).
5. When a stable value is achieved that is between 0.950 and 1.000, re-tighten the securing screws.
6. Because the securing screw adjustment will slightly alter the setting, observe the *AZ NEW* value to ensure it is still within the acceptable range. Re-do if necessary.
7. Once the autozero module securing screws are tight, and the adjustment is within range, press *ENTER* to electronically offset the fine adjustment required to achieve a value of 1.00
8. Press *ENTER* again to confirm the new setting. The AZ offset adjustment is now complete.

Caution: During the adjustment of the autozero module, it is likely at many stages that the alignment of the module, to the center test position, may be accidentally moved. It is recommended to exit the AZ OFFSET programme (by pressing the FUNCTION button) and re-enter (by pressing the ENTER button) to correct this positional error.

STEP 3. Calibrate the OPAL 200 control unit – Signal IN

After the system has been calibrated the OPAL 200 transceiver provides a 4-20mA transmittance signal to the control unit. Complete system calibration requires that this input to the control unit must be correctly calibrated. To check the accuracy, compare the control unit lower line display of T2 current (mA) to the transceiver displayed value of the same current (T2 mA) under clean and blocked stack conditions.

- **Blocked stack condition: 0% transmittance = 4mA**
- **Clean stack condition: 100% transmittance = 20mA**

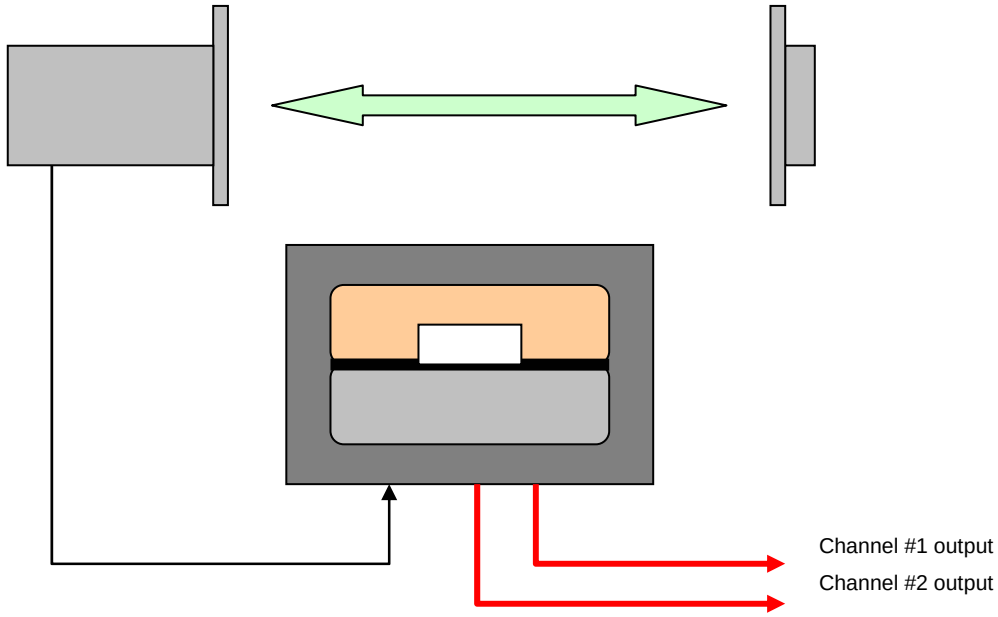


The transceiver displayed value of output signal is a precision calibrated measurement and it can be relied upon to be extremely accurate. If the control unit value differs to an unacceptable level (typically +/- 0.05mA) it may be necessary to calibrate the control unit measurement.

1. Power off control unit. Press firmly the two keypad button positions (marked **RED** in above schematic – the right hand button is not visible). Take care not to release either button.
2. Power up the control unit. Release buttons only after the display reads ***SET 4mA***
3. Create a 4mA transmittance (T2) signal by blocking the transceiver light beam. Wait until the transmittance (T2) mA signal value stabilises near 4.00mA on transceiver display.
4. Press any button on control unit. The display will now read ***SET 20mA***
5. Remove transceiver beam blockage to achieve a clean stack condition. Wait until the transmittance (T2) mA signal value stabilises near 20.00mA on transceiver display.
6. Press any button on control unit. The control unit will now fully initialise to begin operation, and the lower line display of T2 current will now correspond to the transceiver displayed value.

STEP 4. Calibrate the OPAL 200 control unit – Signals OUT

The last stage of complete system calibration may be necessary if the output signals (Channels #1 and #2) do not correspond to the transceiver displayed signal values for Opacity % and milliamps.



1. Connect a multimeter in the Channel #1 output terminals to measure the 4-20mA value.
2. Access control unit P#12 in SETUP menu. Select ***SET 4mA TRIM***
3. Exit SETUP and read multimeter value.
4. Re-enter SETUP, go to P#13 and adjust 4mA value up or down as necessary. **> ENTER**
5. Exit SETUP and read multimeter value.
6. Continue adjustments until the measured value at the multimeter is correct
7. Go to P#12 in SETUP menu. Select ***SET 20mA TRIM***
8. Exit SETUP and read multimeter value.
9. Re-enter SETUP, go to P#14 and adjust 20mA value up or down as necessary. **> ENTER**
10. Exit SETUP and read multimeter value.
11. Continue until the measured value at the multimeter is correct.
12. Go to P#12 and select ***MANUAL CALIBRATION***
13. Repeat procedure for Channel #2 using SETUP parameters P#15, P#16 and P#17.

Channel 1 and 2 outputs are now calibrated.

Validation of Calibration

Once the above zero and span calibration is completed, it is recommended to verify the accuracy of the system using a series of certified test filters, typically a minimum of 5 points across the opacity scale. Each filter is placed in the operation light beam path and the results are recorded. The USEPA PS-1 target accuracy required is better than +/- 2.0% but we would normally expect the calibration procedure to achieve better than +/- 1.0% opacity

Autocalibration – Testing Procedures

There are 3 methods of initiating the ZERO and / or SPAN calibration tests, without the tests being affected by the stack flue gas stream:

1. AUTOCAL (Timed) - During normal operation, the OPAL 200 transceiver, under programmed control from the control unit, will carry out automatic span and zero calibration testing using inbuilt zero mirror and test filter mechanisms. The start times, duration, and alarm tolerance levels are user set and the output signal(s) can be individually set live or frozen during the timed autocal procedure. The factory default setting is for the timed autocal to be carried out every 24 hours.

2. AUTOCAL (Manual) - At any time, the auto testing procedure can also be initiated by pressing the autocal button on the front of the control unit, or by the keypad on the transceiver. Once started, the autocal cycle cannot be interrupted unless the system is de-powered. During this manual autocal procedure, the output signals will be the same as for the timed autocal procedure.

3. SPAN and ZERO TEST - As a convenient service feature, the control unit and the transceiver both have the ability to conduct either a manual span or a manual zero test. The control unit has dedicated test buttons on the front keypad, and the transceiver operation is via the TEST MODE programme. If either operation is initiated, the local display will show the measured test results as the test is being carried out, with the output signals temporarily frozen at last value. This action will confirm the operational status of the automatic test mechanics, as well as the validity of the systems calibration.

4.3 Audit Testing

Environmental Regulator requirements for audit testing of opacity monitors will vary for each region and we recommend that you talk to your local EPA office for more information. We do however recommend that each system is audit tested annually as a minimum requirement. If you require this service carried out by our qualified service personnel, please contact our office for more details.

To complete the audit test procedure you will require access to an OPAL 200 on-line audit test kit with a set of 3 certified calibration test filters. In accordance with USEPA PS-1 requirements, these filters must have a certified test date validity not exceeding 12 months. The test filters provided are marked with single-pass opacity and optical density values as normally displayed on the system. The OPAL 200 on - line audit test module set may be used for:

- **Opacity audit testing**
- **Linearity checks and adjustments**
- **System accuracy verification**
- **Service work - on line or off stack**

OPAL 200 Audit Test Kit

Insertion of Test Filter

1. Swing both the retro and transceiver open and clean the process lenses. (A standard spectacles cleaning cloth is recommended for best results and to prevent damage.) Return both to the closed position.

2. Note that it is not necessary to clean the lenses prior to these audit tests, however if the lenses are cleaned it will be necessary to carry out an autocal procedure to cancel out the last recorded level of accumulated "Lens Dirt". To start the autocal test cycle **> TEST MODE > AUTOCAL > ENTER.**

3. On the transceiver control panel select **>TEST MODE > MANUAL TEST > ENTER.** The screen will now display either Transmittance or Opacity, expressed in milliamps and %. Alternate between the displayed values using the *UP / DOWN* buttons.

4. Attach the Audit test module to the front of the Transceiver and adjust the audit module adjustment screw to obtain 100% transmittance on the Transceiver display.

5. Insert each test filter and observe the displayed values. The system accuracy should be better than +/- 2% opacity, in accordance with USEPA PS-1 specifications.

NOTE: Normally the displayed value of opacity is based on the OPLR (Optical Path Length Ratio) and reflects the actual opacity value that is observed at the exit diameter of the stack. – in the case of a tapered stack the actual measured opacity would not be the same as the displayed exit opacity.) When the transceiver is in the *TEST MODE* the Opacity values are calculated and displayed as a parallel stack (with a 0.5 OPLR) and the readings will be in the form of a single pass value, as marked on each filter.

OPLR – Optical Path Length Ratio

Prior to an OPAL 200 system being shipped from our factory, it is necessary to programme an OPLR ratio into the control unit. This ratio is a factor calculated from the OPAL 200 measuring path length, and the diameter of the stack at the exit point. The ratio is used to calculate the actual opacity level at the exit point, based on a measurement at the measuring position. EPA regulations require the reporting to be based on the stack exit opacity.

The OPLR value programmed into the control unit is a factory setting and it cannot be altered by the end user, in accordance with the USEPA compliance regulations. Any re-location of the instrument may require a factory service change to the setting.

The OPLR factor is displayed as a lower line value on the control unit and is calculated by the formula:

OPLR = Stack Exit Diameter (mm) / 2 x Measuring Path Diameter (mm)

e.g. For a straight stack, diameter 1000mm:

OPLR = 1000 / 2 x 1000 = 1000 / 2000 = 0.5

Please note that the OPLR value representing a parallel stack in the OPAL systems is 0.5. This may differ to other brands where a value of 1.0 is common.

SECTION 5 MAINTENANCE PROCEDURES

5.1 Planned Maintenance Recommendations

Preventive maintenance consists of cleaning the instrument regularly and inspecting it occasionally for broken or damaged parts. Regular maintenance will improve the reliability of your instrument and prevent breakdowns. Important points to note are:

1. Optical surfaces must be cleaned using non wood based optical cleaning cloths, and acetone based glass cleaner fluids. Observe care and safety when using cleaning compounds in enclosed non ventilated areas.

2. Use OPAL certified spare parts only. Alternate component supply may void warranty.

Preventive/corrective maintenance schedule	WEEKLY	QUARTERLY	ANNUAL
Check manual Zero/Span tests are within specification	x	x	x
Check for fault conditions	x	x	x
Check lens dirt values (lower line display)	x	x	x
Check alignment, correct if necessary		x	x
Check air filters replace if necessary		x	x
Check all fittings for tightness and wear		X	x
Check weather covers for security			x
Check air blower motor operation			x
Remove transceiver and retro, clean air plenum			x
Internal inspection - Replace any worn seals or gaskets			x
Clean inner optics if necessary			x
Check all system operations			x
Carry out a clear stack zero calibration and span filter check			x

NOTE: Corrective and preventive maintenance schedules should be adjusted according to site specific conditions to ensure the maximum availability of accurate measurement data. Routine checks should be adhered to as a minimum level of maintenance.

5.2 Spare Part List – Recommendations

All spare parts for OPAL opacity monitoring systems are normal ex stock items from our Sydney factory and any delay would therefore be subject to final destination, and time of order processing. It is important for us to advise that it is possible at times for our stock availability to be subject to current demands.

For these reasons all customers should consider their own situations to determine the level, and variety, of spare parts held at plant. Levels should be based on the following criteria:

1. Number of systems installed at site, or in company area group.
2. Level of acceptance of downtime.
3. Operating environment and level of routine service.

Level 1	Level 2	Part No	Description
Nil required	1 per plant		Transceiver / Retro system, complete
Nil required	1 per plant		Main control unit
1 per plant	1 per 8 inst		Transceiver main window kit
1 per plant	1 per 8 inst		Retroreflector main window kit
1 per plant	1 per 8 inst.		Transceiver autozero module
Nil required	1 per plant		Main control unit , fascia cover
Nil required	1 per plant		Transceiver, fascia cover
Nil required	1 per plant		Air purge – ring Blower
Nil required	1 per 8 inst.		Air purge - filter assembly, complete
1 per inst.	1 per inst.		Air purge - filter cartridge
Nil required	1 per plant		Air purge - blower cover, retainer clip, set of 2
1 per plant	1 per plant		Transceiver, retainer clip, set of 2
Nil required	1 per plant		Transceiver, hinge set, set of 2

The above recommendations are based on system(s) being subject to a suitable maintenance routine by qualified personnel, with environmental and process conditions within specifications.

Level 1 - Acceptable downtime (72 hour parts or repair availability) and / or less than 4 systems at site

Level 2 - High priority availability and / or 8 or more systems at site.

SECTION 6 SYSTEM ACCESSORIES & OPTIONS

The successful and reliable operation of the OPAL systems will depend on careful consideration and planning for all aspects of the project. The installation conditions and operating details that are most important will include:

- Ambient conditions (location, climate, etc)
- Process conditions at site (flue gas effects, vibration, etc)
- EPA licence requirements (maintenance and validation)
- Technical capabilities at site (engineering skills, manpower, etc)

The following conditions may require system options or accessories that are not standard system components, or may involve special engineering conditions at site. For more information on these OPAL accessories and options to deal with the above conditions, please contact our OPAL factory service department or any authorised local OPAL distributor.

service@opalenvironmental.com.au

- **Ambient temperatures greater than 50 DegC** - the OPAL 200 transceiver is capable of continuous and drift free measurement with internal peak temperatures up to 50DegC but external sources can easily cause this temperature rise. The main cause is sunlight. OPAL 200 systems are supplied with a set of weather covers that shield the system from direct exposure to sunlight and other harsh weather conditions. In extreme ambient temperatures, we would recommend that the covers be modified to include side vents to improve air circulation.
- **Ambient temperatures lower than zero DegC** – The OPAL 200 is capable of continuous operation and drift free measurement with internal temperatures as low as -10DegC. Standard weather covers can protect the system in low temperatures, but for operation in ambients down -40DegC we recommend that the optional **OPAL - LTC** low temp covers be used. These covers include a fitted base cover plate and complete internal insulation against wind chill conditions.

  The system purge air, at subzero conditions, will condense as it makes contact with the optical surfaces that it is meant to protect. To prevent this happening **OPAL - ILH** in-line air heaters should be used. These heater units are powered from the purge blower motor supply and automatically cut in as the air temperature drops below 5 DegC. They allow successful system operation down to -40DegC ambient temperatures.

- **Process gas temperatures greater than 250 DegC -** radiant and conducted heat from the process may induce high temperatures into the transceiver. Radiant heat can be reduced by insulating the duct surface. As an alternative, the weather cover mounting plates can also be insulated at site to form a heat barrier. Conductive heat, transmitted along metal surfaces from the process, can be easily protected against by flanged pipe extensions to extend the separation distance. (Remember to include

the modified flange to flange dimensions in customer specs for system calibration at time of system order.) Factory designed high temp spools **OPAL-HTS** are suitable for applications up to 600DegC

OPAL – FSS fail safe shutter

Normally the purge air system, that protects the optical system against the flue gas contamination, creates a vital "air barrier" against high temperatures. If the purge air fails in applications where the process temperatures reaching the transceiver and retro optical surfaces can exceed 200DegC we recommend the use of **OPAL – FSS** fails safe shutters. These shutter systems are designed to provide a rapid and automatic mechanical isolation from flue gases. These units are installed in the stub flanged pipes between the process gas streams and the OPAL optical system and are powered by local mains supply, with auto daily test and control via the OPAL 200 system main control unit.

OPAL – AFS airflow switch

The detection of the purge air failure is done by using a set of **OPAL – AFS** airflow switches. These switches can be connected directly to the main control unit for alarm purposes, or to each local **OPAL – FSS** to activate the protection shutter operation.

SECTION 7 SYSTEM DRAWINGS & APPENDICES

APPENDIX 01 CONTROL UNIT – MODBUS CONFIGURATION

Communicating with the 1639 Analyser via Modbus

Digital networking as a method of exchanging information is rapidly overtaking its analogue predecessor within industry as a whole. The OPAL 200 control unit has the ability to work as a Modbus slave node on serial RS-232 or 3-wire multi-droppable RS-485 via RTU mode transmissions. Using holding register commands it is possible to access runtime variables and alarm conditions as well read and modify the device configuration.

The implementation of the Modbus protocol is limited to the few specific commands relevant to reading and writing holding register variables. Attempting to send unrecognised commands will result in appropriate error responses. It is advised you read this application note completely before attempting to integrate the analyser into a digital network.

Electrical Connections

To connect and initiate the OPAL 200 control unit for MODBUS operations:

Terminal 22	Network –ve connection
Terminal 23	Network +ve connection
Terminal 24	Network Common

Move link LK3 on the 1639-2 processor pcb (door pcb) to RS485 position. To access LK3, remove anodized shield plate from inside control unit door.

Serial Configuration

The OPAL 200 control unit is limited to communications of **9600 max. baud rate, 8 data bits, 1 stop bit, no parity**. Modbus slave address 1-31 is available and the analyser will not respond to broadcast mode requests. See operators' manual configuration menu 66 to set the baud rate and menu 72 to set the Modbus slave address. When enabling Modbus in menu 72 it is also important to reset the analyser in order to initialise the serial slave protocol.

Reading & Writing Holding Registers

Access to the contents of holding registers is provided to allow a Modbus master to read runtime variables and write back configuration. In the case of writing back configuration a special command is implemented which allows storing to non-volatile memory which will be retained after resetting. When writing configuration data via Modbus the onus is on the master to confirm the new values to be written are valid. Writing invalid configuration variables will result in unusual behaviour and may require the analyser to be factory reset using a cold start (see operators manual)

Modbus commands implemented in the 1639 slave are as follows:

- 0x03 Read Holding Registers
- 0x06 Write Single Register
- 0x42 Write Single Register (non-volatile)

To write to configuration variables stored in non-volatile memory, use the special Modbus command code 0x42 instead of the write single register 0x06 command code.

All holding register addresses contain a single 16 bit value, however some variables span multiple holding registers to yield a single 32 bit variable, or with the case of alarm condition arrays a single holding register contains two separate 8-bit values. The 1639 operates a big-endian memory system so when reading & writing 32-bit integers you may need to modify the word order.

Alarm Status Array

The alarm status array is comprised of 30 x 8bit status flags spanning 15 consecutive holding registers. Each holding register therefore holds the status flag for two alarms. Status flags contain a value 0-4:

- 0,1 – alarm condition clear
- 2 – alarm active
- 3 – alarm acknowledged via keypad, condition still exists
- 4 – alarm condition cleared, awaiting user acknowledgement

Read/Write Configuration Variables*

Reg (dec)	Description	Type	Valid Range	Comments
715	Probe Offset	SINT16	± 60	÷ 10 (mV)
718	Temperature Display Units	FLAG	[0,1]	0 - Celsius 1 - Fahrenheit
739	High Opacity Process Alarm 1 Threshold	UINT16	[1-100]	% Opacity
740	High Opacity Process Alarm 2 Threshold	UINT16	[1-100]	% Opacity
741	High Opacity Process Alarm 1 Delay	UINT16	[1,300]	Seconds
742	High Opacity Process Alarm 2 Delay	UINT16	[1,300]	Seconds
743	Dirty Lens Alarm Threshold	UINT16	[10-100]	÷ 10 (% Opacity)
746	EPA Damping Time	UINT16	[1-60]	Minutes
752	High Oxygen Process Alarm Trigger	UINT16	[1,300]	÷ 10 (% Oxygen)
753	High Oxygen Process Alarm Delay	UINT16	[1,900]	Seconds
754	Low Oxygen Process Alarm Trigger	UINT16	[1,300]	÷ 10 (% Oxygen)
755	Low Oxygen Process Alarm Delay	UINT16	[1,900]	Seconds
756	Very Low Oxygen Process Alarm Trigger	UINT16	[1,300]	÷ 100 (% Oxygen)
757	Very Low Oxygen Process Alarm Delay	UINT16	[1,900]	Seconds
762	Process Alarms Enabled	FLAG	[0,1]	0 - Disabled 1 - Enabled
764	Oxygen Damping Factor	UINT16	[0-20]	Readings Averaged
766	Opacity Damping Factor	UINT16	[0-20]	Readings Averaged
817	OPLR for OP-300 mode	UINT16	[25,400]	÷ 100 (Flue Ratio)

* To write values to non-volatile memory which will be retained after reset use the special modbus command $42 (write non-volatile register) command instead of the $06 (write holding register) command

Read Only Runtime Variables

Reg	Description	Type	Comments
744	Lens Dirt	UINT16	÷ 10 (%)
830	OPLR for OP-200 mode	UINT16	÷ 100 (Flue Ratio)
2048	Probe EMF	SINT32	÷ 1000 (mV)
2050	Oxygen %	UINT32	÷ 1,000,000 (%)
2052	Probe Impedance	SINT32	ohms (-1 indicates invalid)
2056	Probe Temperature	UINT32	÷ 10 (degrees C)
2190	Opacity	UINT32	÷ 1000 (%)
2192	EPA Opacity	UINT16	÷ 10 (%)
2193	Optical Density	UINT16	÷ 10,000
2194	EPA Optical Density	UINT16	÷ 10,000
2195	mg/m3	UINT32	÷ 10
2197	Transmittance T2	SINT16	÷ 100 (mA)
2058	Alarm Status Array	*see notes*	

Alarm Status Array

30 x 8bit registers in an array (15 holding registers)

- Each register holds 2 x 8bit configuration/status flags for 2 consecutive alarms

List of Alarms in Alarm Array

Index	Description	Index	Description
0	Oxygen Sensor High Impedance	15	ADC Calibration Fail
1	Oxygen Heater Fail	16	Burner Bypass Enabled
2	Oxygen Probe Thermocouple Open/Ct	17	High Opacity 1 Process Alarm
3	Opacity Head Fail	18	High Opacity 2 Process Alarm
4	BBRAM Error	19	Process Stop
5	Reference Air Pump Fail	20	Oxygen Probe Calibration Error
6	ADC Calibration Warning	21	DAC Output 1 Calibration Fail
7	Mains Frequency Error	22	Purge Fan Fail
8	Oxygen% Low (Process Alarm)	23	Opacity Span Calibration Fail
9	DAC Output 2 Calibration Fail	24	Oxygen Probe Temperature Low
10	Oxygen% Very Low (Process Alarm)	25	Service Mode
11	Oxygen% High (Process Alarm)	26	Oxygen Purge in Progress
12	Oxygen Heater SSR Fail	27	Opacity Cal in Progress
13	Opacity Lens Dirty (Process Alarm)	28	Oxygen Probe Temperature High
14	Opacity Head Fail	29	Alarm Horn (Relay 3 Only)

Types of Variables

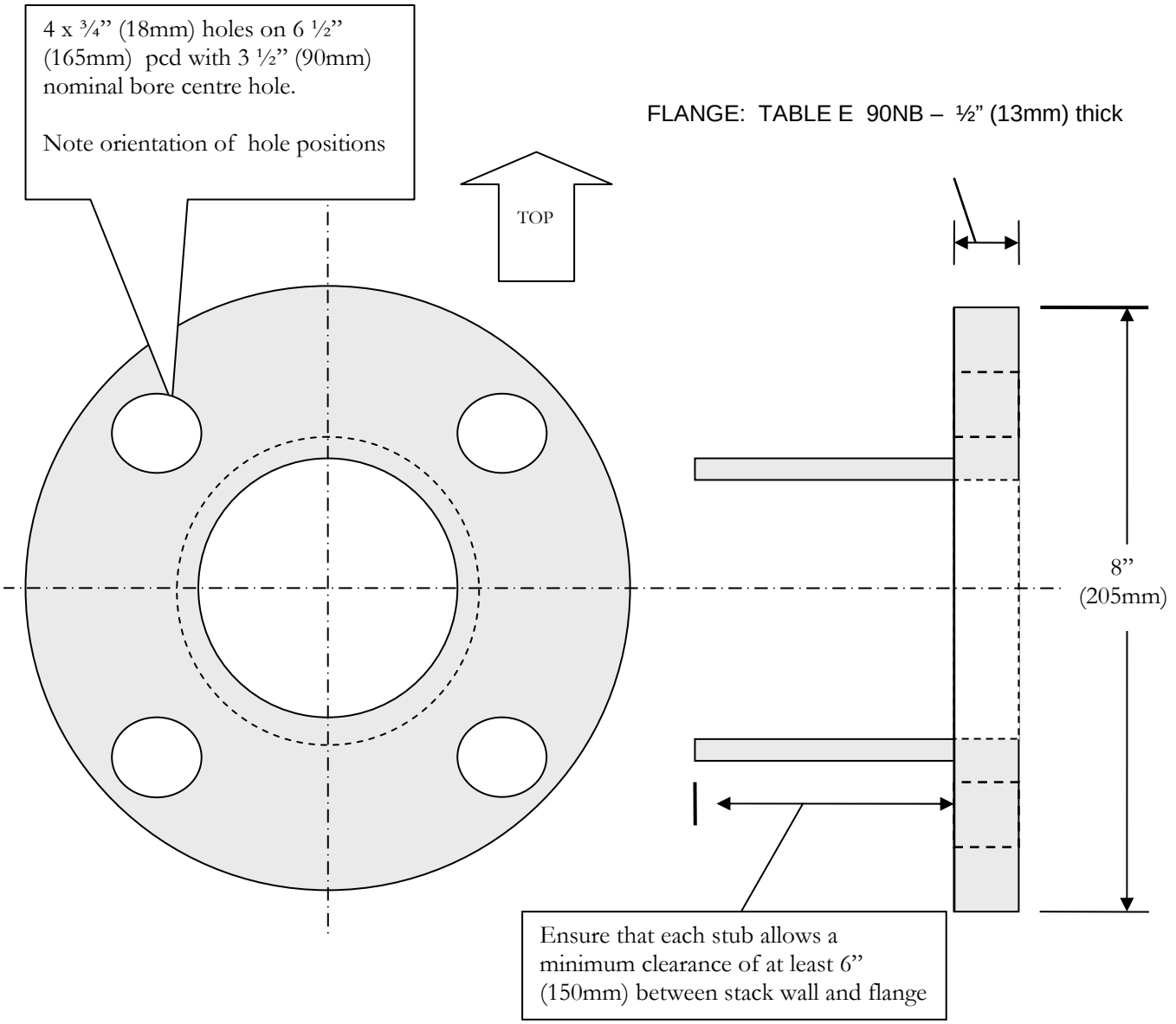
UINT16	16bit Unsigned Integer
SINT16	16bit Signed Inteter
UINT32	32bit Unsigned Integer
SINT32	32bit Signed Integer
FLAG	16bit Status Integer, refer to register comments

APPENDIX 02 CONTROL UNIT SETTINGS RECORD SHEET

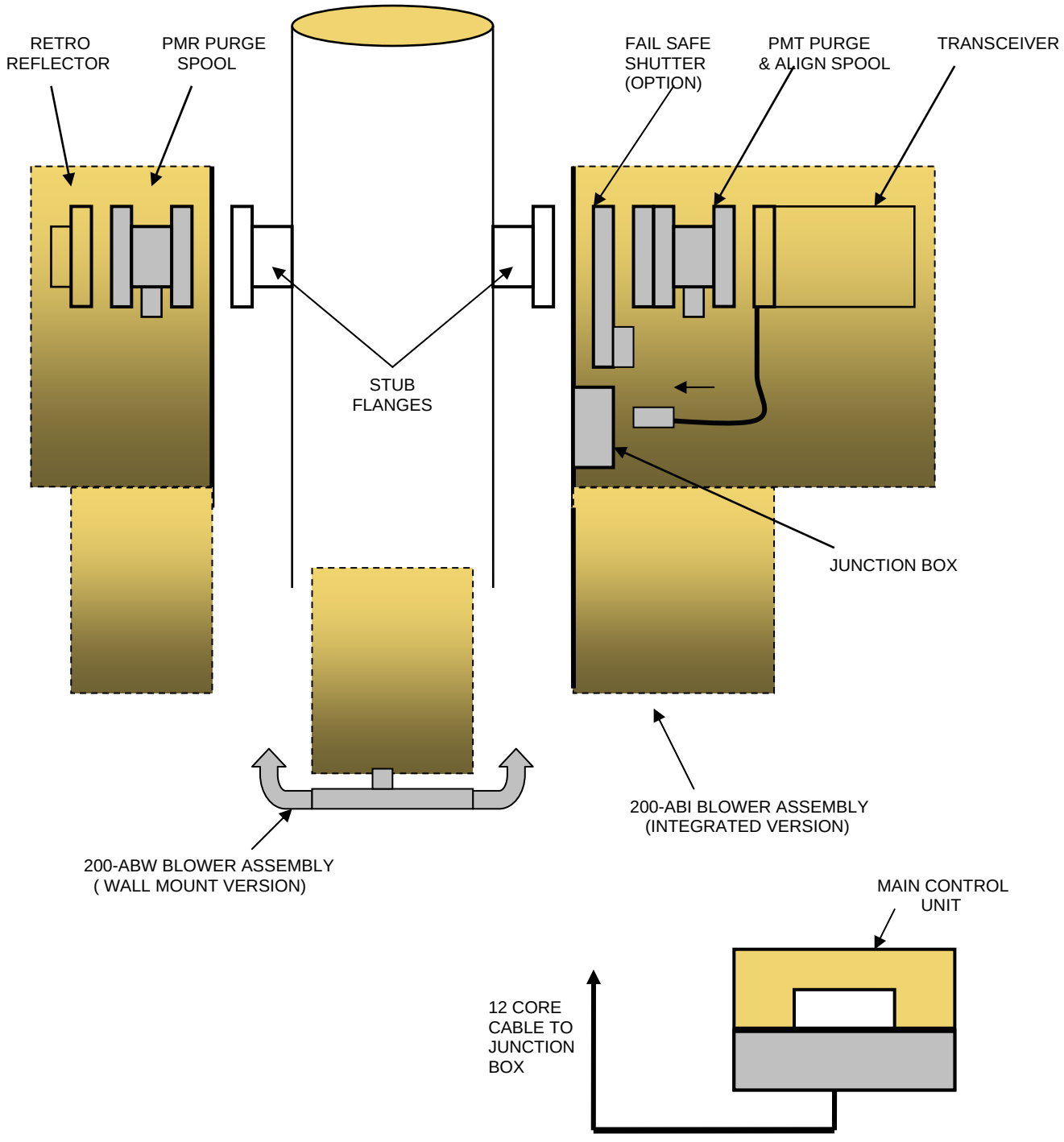
1. *The below list should be completed at time of commissioning and the records stored in a safe place. We recommend that a copy be forwarded to our factory for storage.*
2. *Please note that in the event of a "cold start" being required for the control unit, all stored settings will be lost and the functions will revert back to factory settings.*

F#	Setting	F#	Setting	F#	Setting
1		22		42	
2		23		43	
3		24		44	
4		25		45	
5		26		46	
6		27		47	
7		28		48	
8		29		49	
9		30		50	
10		31		57	
11		32		60	
13		33		61	
14		34		62	
15		35		63	
16		36		64	
17		37		65	
18		38		66	
19		39		67	
20		40		68	
21		41			

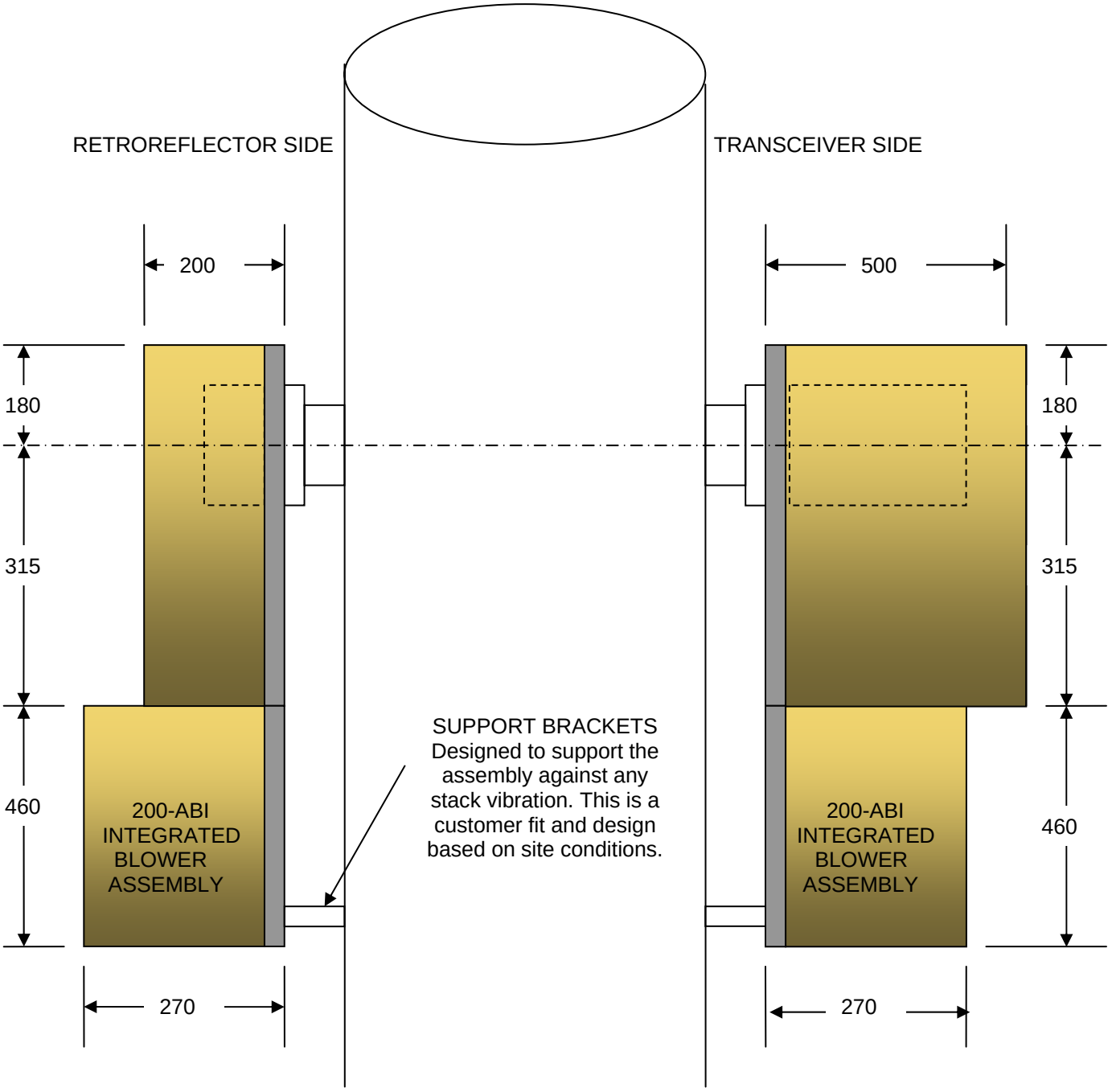
OPAL 200 Serial No…… **Date Recorded**…… **Record By**……



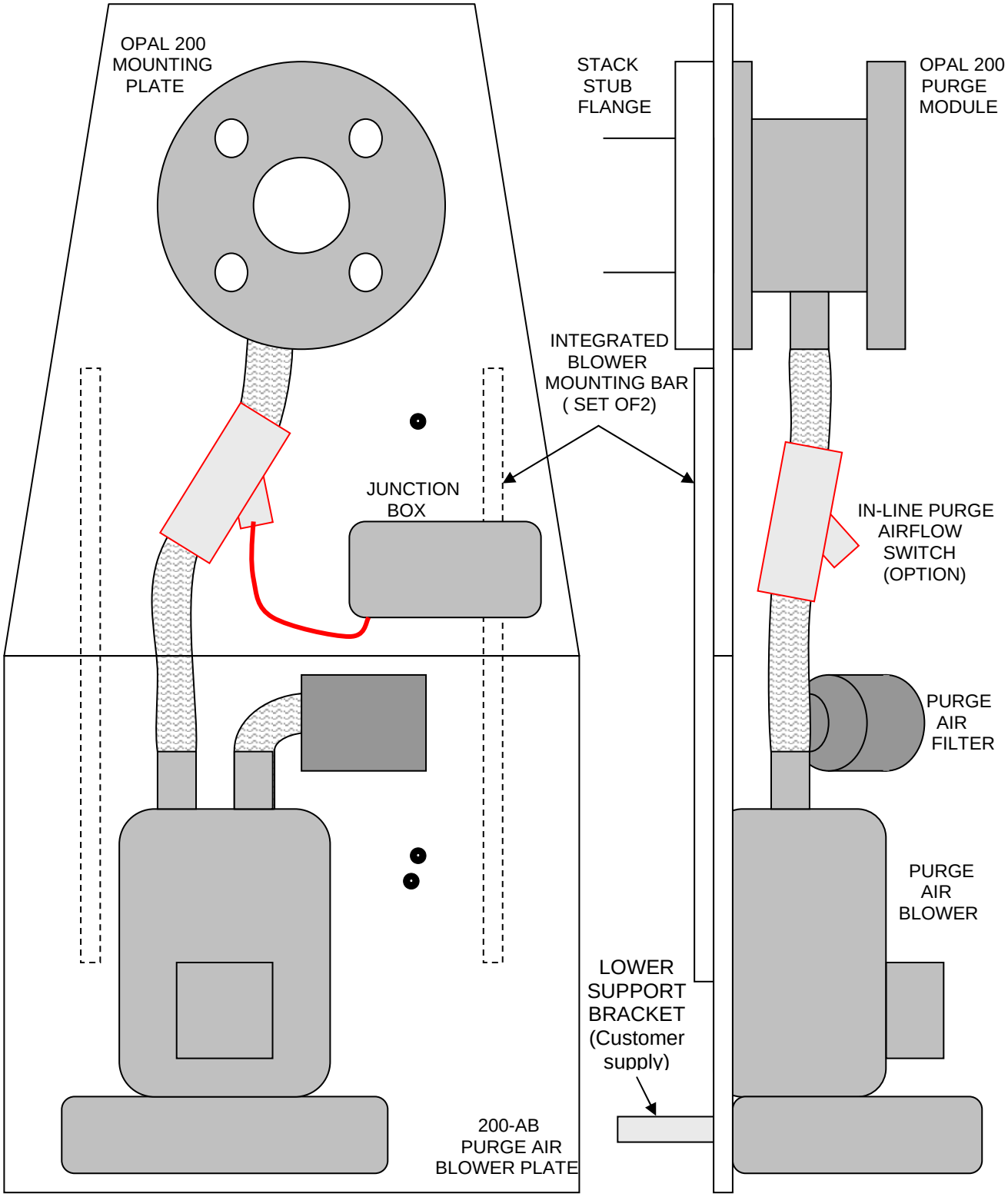
Drawing 200 - 0101 MOUNTING FLANGE SPECIFICATIONS



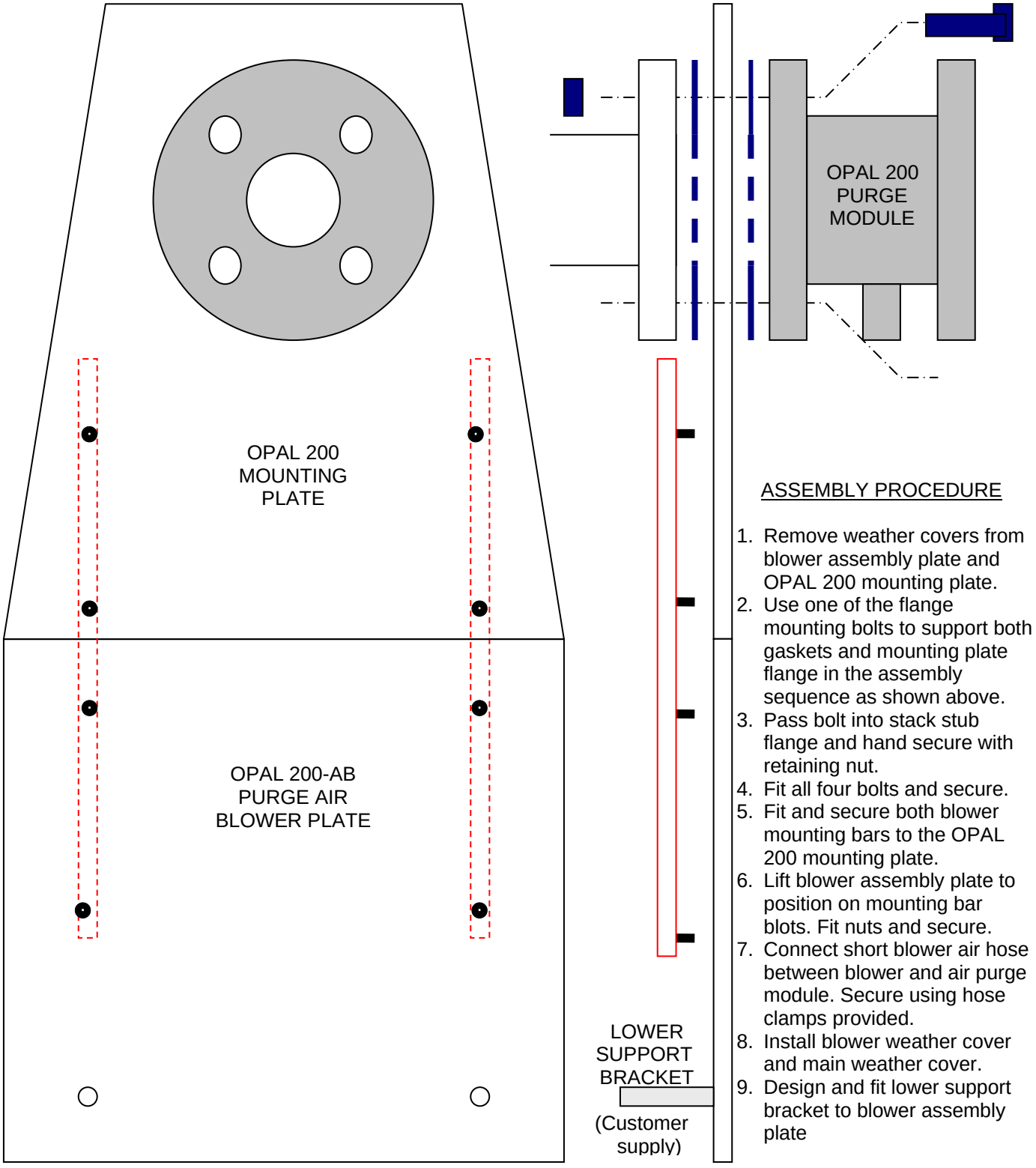
Drawing 200 - 0102 STACK ASSEMBLY SCHEMATIC



Drawing 200-0103 INTEGRATED PURGE BLOWER COVER DIMENSIONS



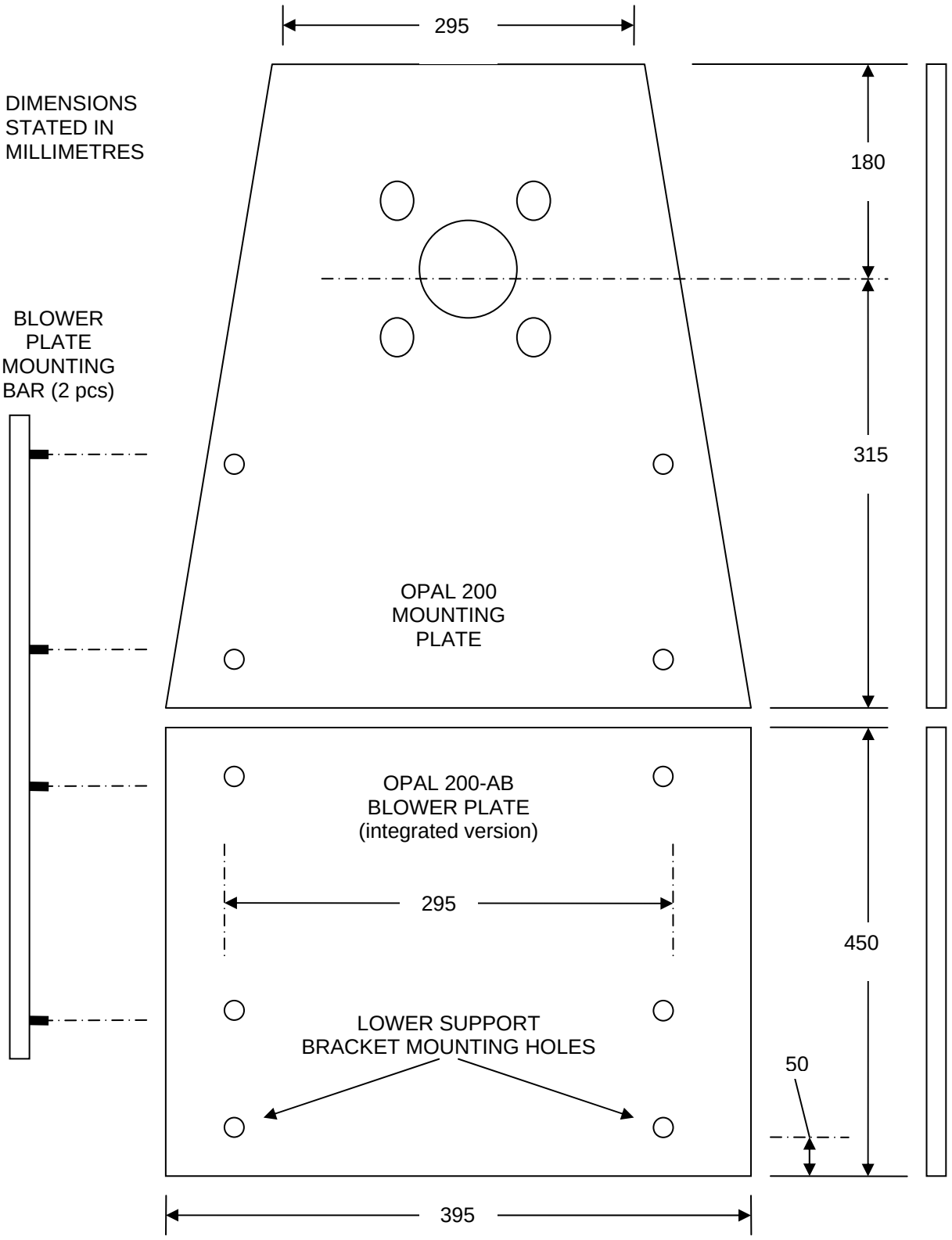
Drawing 200-0104 INTEGRATED PURGE BLOWER PLATE COMPONENT LAYOUT



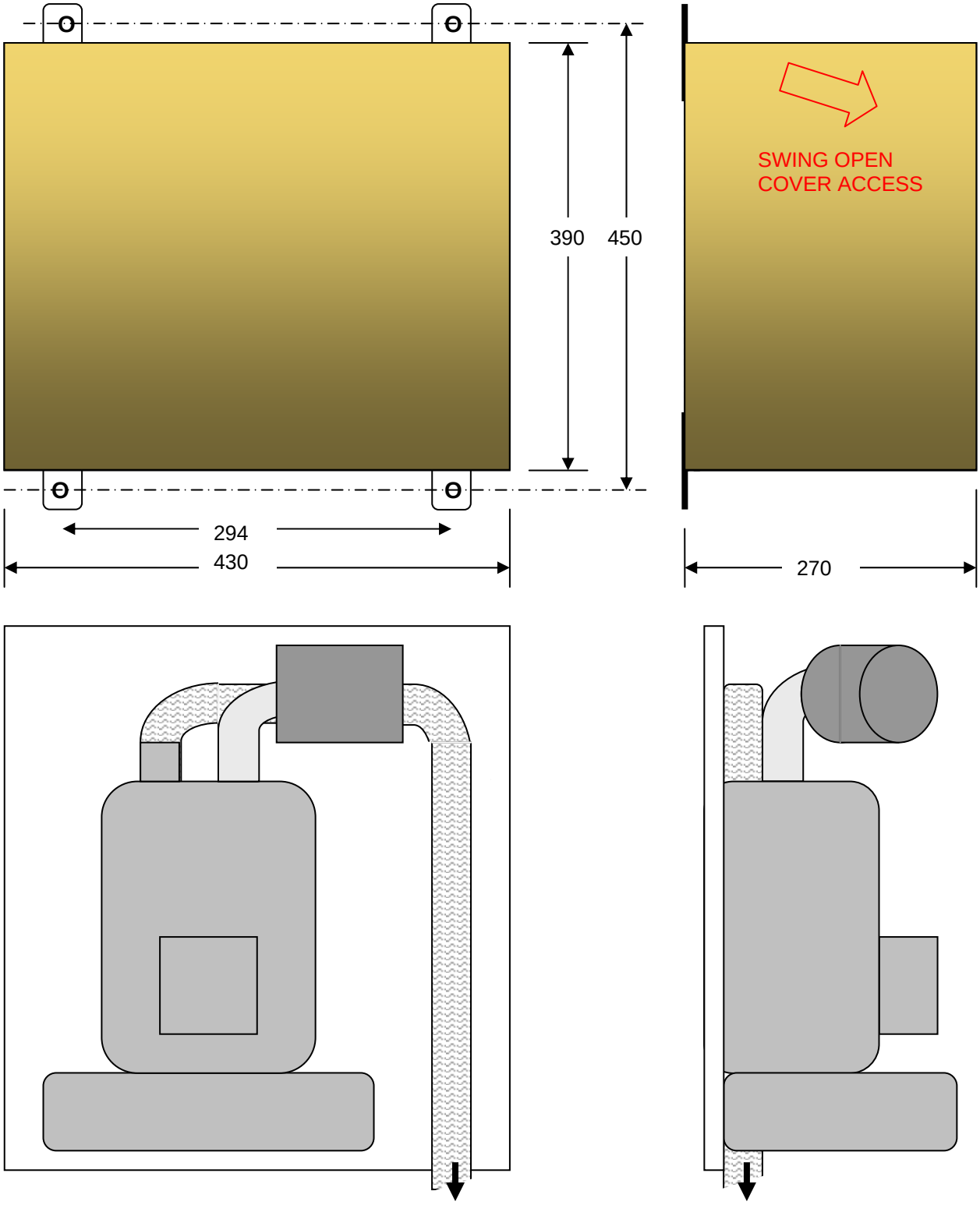
ASSEMBLY PROCEDURE

1. Remove weather covers from blower assembly plate and OPAL 200 mounting plate.
2. Use one of the flange mounting bolts to support both gaskets and mounting plate flange in the assembly sequence as shown above.
3. Pass bolt into stack stub flange and hand secure with retaining nut.
4. Fit all four bolts and secure.
5. Fit and secure both blower mounting bars to the OPAL 200 mounting plate.
6. Lift blower assembly plate to position on mounting bar blots. Fit nuts and secure.
7. Connect short blower air hose between blower and air purge module. Secure using hose clamps provided.
8. Install blower weather cover and main weather cover.
9. Design and fit lower support bracket to blower assembly plate

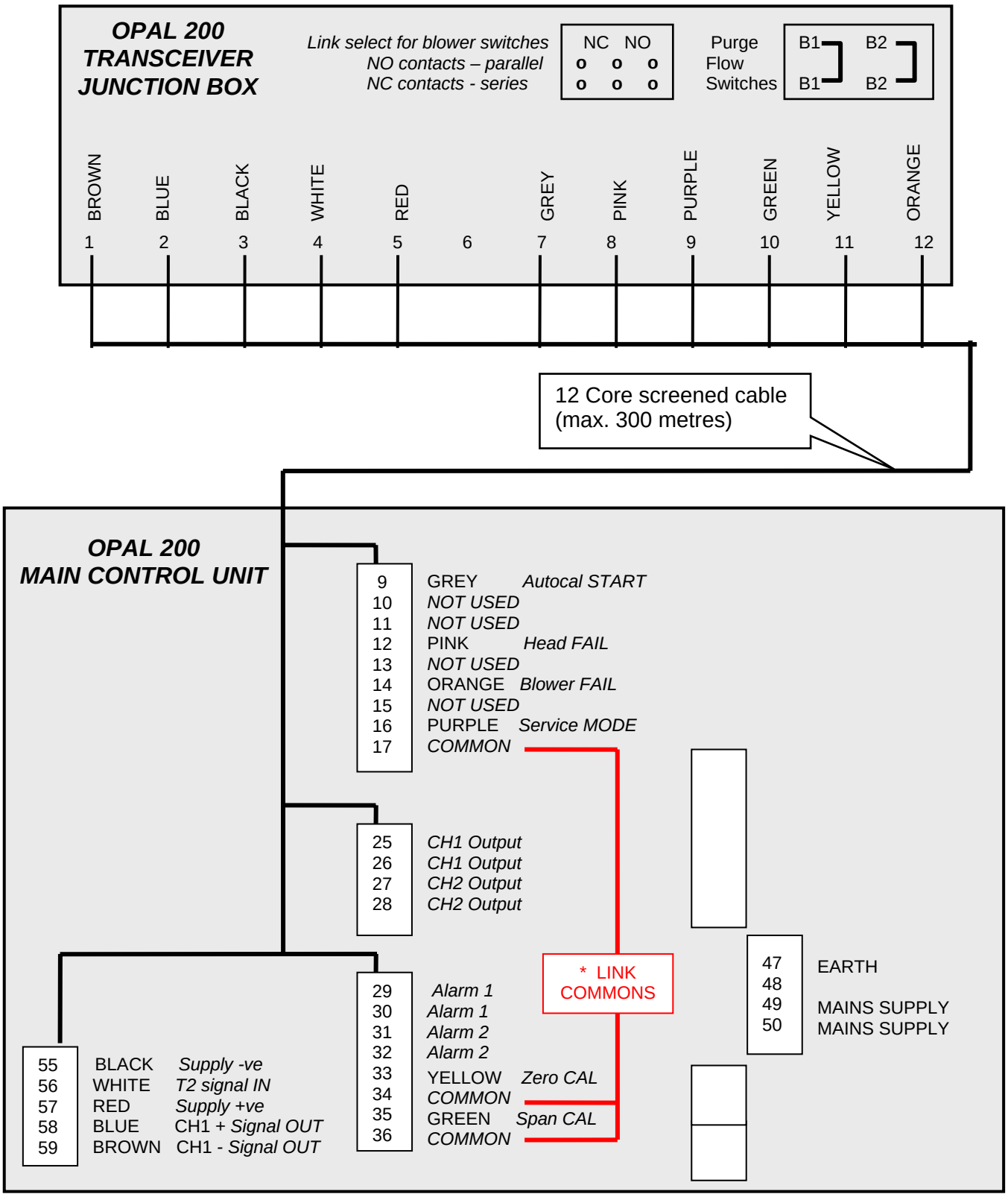
Drawing 200-0105 INTEGRATED PURGE BLOWER PLATE ASSEMBLY



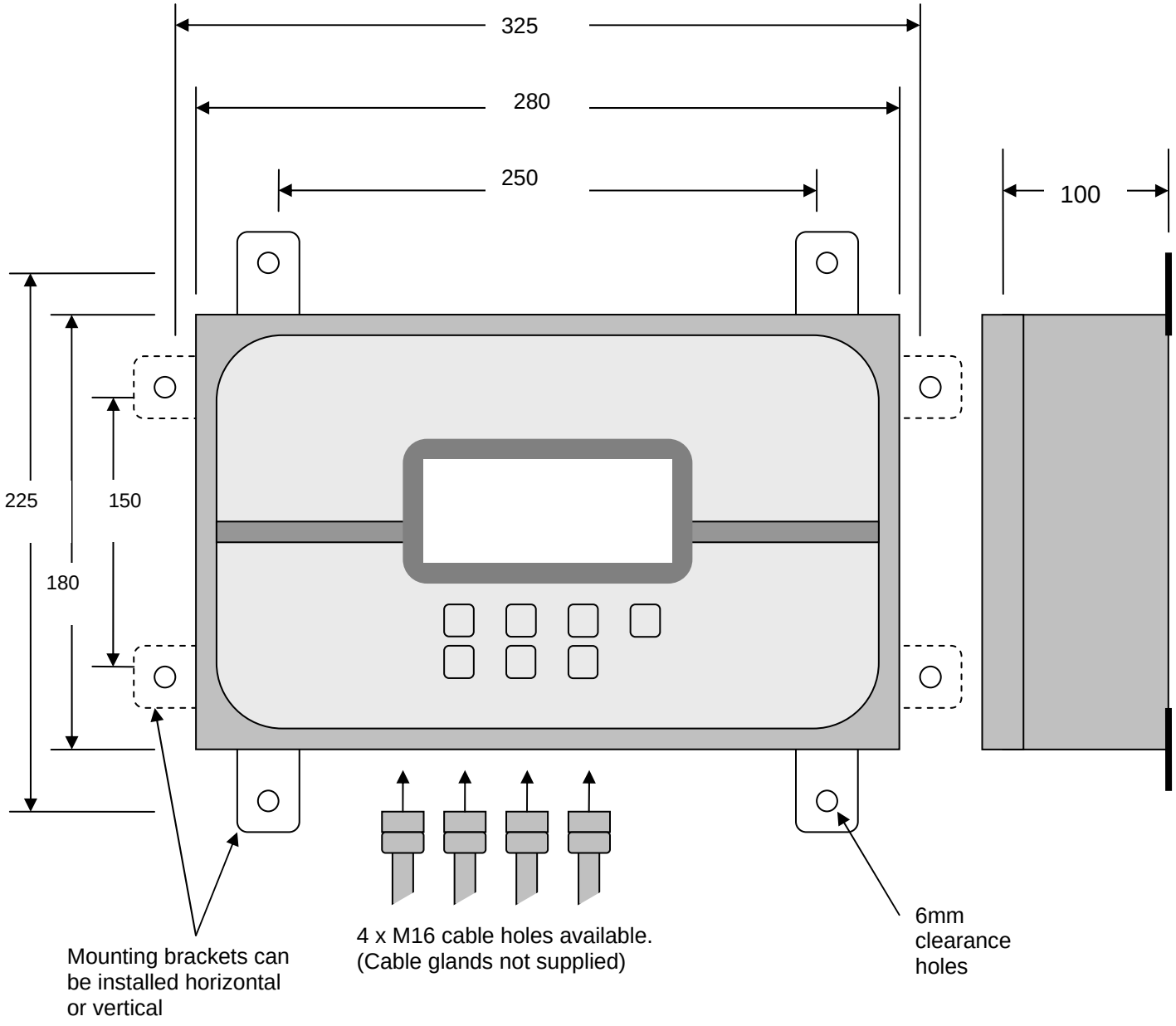
Drawing 200-0106 INTEGRATED MOUNTING PLATE DIMENSIONS



Drawing 200-0107 WALL MOUNT PURGE BLOWER ASSEMBLY



Drawing 200 - 0108 ELECTRICAL TERMINATION



Drawing 200 - 0109 MOUNTING SPECIFICATIONS - OPAL200 MAIN CONTROL UNIT

SYSTEM CALIBRATION HISTORY.

SYSTEM SERIAL # ……..

FOR FUTURE SERVICE GUIDANCE, PLEASE RECORD ANY SYSTEM CHANGES THAT MAY HAVE BEEN ACTIONED BY ON SITE PERSONNEL, INCLUDING AUDIT TEST RESULTS, RE-CALIBRATION DATA AND INSTALLATION CHANGES.

DATE **ACTIVITY** **RESULT**

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KEYWORD INDEX FOR PAGE LOCATIONS.

(FOR END USER CONVENIENCE)

KEYWORD	PAGE#	KEYWORD	PAGE#