ABB MEASUREMENT & ANALYTICS | OPERATING INSTRUCTION

CL3020

CLD NOx analyzer

Measurement made easy

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Important precautions

Use dry, oil-free instrument air only

Caution:	**This instrument will be damaged if used with instrument air that is not completely dry and oil-free. Ensure instrument air has −40 °C dew point and has been filtered to remove all oil and particulates.**

Safety notice

This instrument operates from potentially lethal line voltage. In addition, some internal components operate at high temperature and can cause serious burns. Observe all precautions when using this device, and particularly be sure that all devices connected to the instrument are safely wired and properly grounded. Always disconnect power to the instrument before opening the enclosure or servicing.

Caution:	**The analyzer should not be operated without the cover in place and the cooling fan fully operational.** **The exterior surface of the converter furnace and tubes will rise to nearly 80 °C if operated without the cover in place. Serious burns can result if the proper precautions are not taken.**

Model CL3020 specifications

Performance specifications

	NO_x	O_2
Measurement technology	Chemiluminescence using all solid-state detection	Amperometric Zirconium oxide cell
Measurement range	0 to 1000 ppm	0 to 25 % O_2
Full scale range	Continuously adjustable from 5 to 1000 ppm	Continuously adjustable from 5 to 25 % O_2
Zero noise	< 0.04 PPM	< 0.02 % O_2
Zero calibration drift	Better than ± 0.1 PPM	Better than ± 0.1 % O_2
Span noise	< 0.25% of reading	< 0.02 %O_2
Span calibration drift	Better than ± 1% of reading	Better than ± 0.1 % O_2
Linearity error	< 2% of high calibration value across range from zero to full scale[1]	< 1% of high calibration gas value across range from zero to full scale[1]
Response time	T95 < 10 seconds	T95 < 10 seconds
NO_2 converter efficiency	> 95%	

Features

- **Touch-screen interface:** All diagnostics and controls are accessible through an advanced, full-color 5” touch screen interface.
- **One-touch calibration:** Once target gas values (e.g. bottle concentrations) have been entered, span and zero responses may be captured, and hence the analyzer calibrated, at the touch of the screen.
- **Trend-screen:** Gas concentrations are plotted in a chart-recorder style trend with user settable scales for in-depth data analysis at a glance.
- **Diagnostics and alarms:** Critical component temperatures and gas flows are measured within the analyzer and reported on the diagnostic screen. Target values and alarmable deviations are user-settable. These alarms are displayed on the home screen, as well as warning messages for internal communication errors or if the converter or ozonator has been disabled.
- **Analog outputs:** Each measurement, including dual ranges for NO_x, is output as either 4-20mA or 0-10V (user selectable). Analog outputs can be forced to low (4mA/0V) or high (20mA/10V) for troubleshooting. Further, the gain and offset of these analog outputs may be trimmed within

[1] Provided the calibration value is 80 to 100% of the full scale.

approximately +/-5% of full scale to compensate for offsets or other issues with an external the data acquisition system, independent of analyzer calibration.

- **QR code (2D barcode):** Analyzer configuration and operating parameters, including calibration settings, can be sent via any mobile device that has a QR code / barcode scanning app for ease in remote troubleshooting and support.
- **Digital communications:** MODBUS over TCP/IP included, allowing access to gas concentrations, diagnostics, alarms, and other instrument parameters. The analyzer is also equipped with a VNC server that allows full remote operation from any device with a VNC viewer connected to the network. Using a locally connected PC or mobile device, factory personnel may remotely inspect and diagnose analyzer problems as if they were standing in front of the analyzer.

Mechanical specifications

- EIA 19-inch rack mount enclosure, 11 in. deep, 3 rack units tall (5.25 inches).
- Weight: 24 lbs.
- Power: 120VAC, 4 Amps max.
- Sample flow rate: Requires approximately 0.1 SLPM at atmospheric pressure (e.g. from a vented sample manifold) per NO_x measurement channel
- Instrument air: Requires approximately 0.2 SLPM dry, instrument-quality, oil-free air at atmospheric pressure (e.g. from a vented manifold), per NOx measurement channel

Overview

The Model CL3020 CLD NO_x analyzer is designed specifically for use in low-NO_x CEMS applications. NO_x and NO (if dual-channel) are measured using chemiluminescence and a molybdenum-based NO_2 converter for total NO_x.

The Model CL3020 meets or exceeds 40CFR60 and 40CFR75 demands for relative accuracy, linearity, and calibration drift in low and ultra-low NO_x gas-fired turbine applications.

Caution: The CL3020 is designed to analyze a clean, dry sample, as is typical of a conventional extractive CEMS. The sample dew point should be less than 5 C, and without any appreciable particulates or other condensable or reactive gases. As with all NO_x analyzers, care should be taken in SCR applications to scrub any residual ammonia from the sample to avoid contamination of internal components.

Measurement configurations

The Model CL3020 has several different configurations:

1. Dual-ranging NO_x, with or without O_2. In this configuration, total NO_x is measured using a molybdenum-based converter to convert any NO_2 in the gas stream to NO_x. Two separately calibratable NO_x ranges are available, e.g full scales of. 100 PPM and 25 PPM, in addition to a single range output for O_2.
2. Dual NO_x (speciating), with or without O_2. In this configuration, two independent chemiluminescence cells are used to simultaneously measure one converted stream (total NO_x) and one unconverted stream (NO). The difference of these two is reported as NO_2. This configuration may also be used with an external NH_3 converter to measure total NO_x plus NH_3 on one channel, total NO_x on the other channel, with the difference being NH_3. A variety of analog output options are available in this configuration.
3. Enhanced performance for low range NO_x, with or without O_2. For full scales less than 200 PPM, greater sensitivity may be achieved with modified flows. Flows given in this manual are for standard configuration; consult factory for more information about flows in this configuration.

Theory of operation

The Model CL3020 CLD NO_x analyzer uses chemiluminescence as the fundamental detection mechanism for NO_x measurement and a pumped (amperometric) zirconium oxide cell for the O_2 measurement. A brief description of these mechanisms and their implementation in the analyzer are given below.

Chemiluminescence measurement of NO_x

Chemiluminescence is defined as a chemical reaction that gives off light. Nitric oxide (NO) emits infrared light when it reacts with ozone (O_3) to form NO_2. By introducing a sample containing NO into a reaction cell and mixing it with ozone, one can measure the amount of light emitted by the ensuing reaction and can infer the amount of nitric oxide present in the original sample.

It is important to note that only NO is the only species directly measured. NO_x, defined as the sum of NO and NO_2 in a sample, is measured by first converting any NO_2 to NO before it enters the measurement cell using a molybdenum-based converter. If so equipped, NO only is measured in a second chemiluminescence cell from a sample that does not visit the converter.

Zirconium oxide measurement of O_2

The oxygen measurement makes use of the fact that zirconium oxide conducts oxygen ions when heated above approximately 600 °C. Platinum electrodes on the interior and exterior of a zirconium oxide tube provide a catalytic surface for the exchange of oxygen molecules and oxygen ions. As molecules encounter the platinum electrodes, they become ionized and are transported through the body of the zirconium oxide. This charge transport ultimately establishes an electric potential across the electrodes that is proportional to the log of the ratio of oxygen concentrations on each side of the oxide (The Nernst Equation). Thus, if a reference gas (usually instrument air at 20.9 % O_2) flows across the inner electrode, the concentration of sample gas flowing across the outer electrode can be determined. In a conventional zirconium-oxide oxygen analyzer, this voltage is exponentiated to determine the concentration.

In the Model CL3020, a second zirconium-oxide cell is ganged together to pump oxygen into the first cell, which is maintained at a constant voltage. The amount of oxygen needed to maintain the primary cell at the operating point is a more sensitive measurement of sample concentration, and allows for measurement at zero oxygen. This pump signal is carefully measured and related back to the sample concentration.

Pneumatic design

Although the chemiluminescence technique is extraordinarily sensitive, specific to NO_x, and inherently linear, there are many subtle effects involving pressures, flows, cell geometry, etc. that must be carefully engineered to produce a properly functioning analyzer. The pneumatic design of the Model CL3020 is shown in figure 1; the flow scheme is substantially different than other gas analyzers. To properly operate and service the analyzer, it is important that the flow scheme be well-understood.

Starting on the upper left side of the diagram, instrument air is drawn into the analyzer from a manifold vented to atmospheric pressure. Excess air flow should be available at this manifold to ensure integrity of instrument air to the analyzer. It is important that the air be free of oil and particulates. Ozone for the chemiluminescence reaction is produced in the ozonator, and is drawn into the cell where it mixes with the sample stream as described earlier. A flow-control orifice is embedded in the fitting on the ozone inlet(s) of the reaction cell(s), and the instrument vacuum pulls the proper flow through the ozonator.

Two sample channels, if so equipped, may be present on the analyzer. Excess sample flow should be available to each to ensure good sample integrity to the analyzer. A sample pump configured to deliver 1 SLPM under slight positive pressure to a 1/4" Swagelok™ tee connected to the analyzer, with a vent tube at least three feet long on each branch is an ideal connection.

Note:	Under no circumstances should the sample inputs or ozone feed air be pressurized.

For the total NO_x channel, the sample first flows through the converter where any NO_2 is converted to NO, while any NO present is unaltered. The furnace temperature is displayed on the front panel of the analyzer. Next, this sample flows though the oxygen sensor (if so equipped), and then through the sample flow meter. This flow rate should approximately 70 SCCM. The sample then flows on to the reaction cell where it mixes with the ozone stream and the NO_x measurement is performed. The reaction cell is kept at 40 °C.

The exhaust port of the reaction cell contains a critical flow orifice, which when backed by a sufficiently strong vacuum, controls the *total flow* drawn through the analyzer. Exhaust from the cell is routed through the high temperature furnace to destroy all the ozone in the exhaust stream to preserve the integrity of downstream components. Unlike carbon filters or other designs, this ozone destruction technique is very safe and effective. No measurable ozone is left in the exhaust. The analyzer is normally configured for an external pump to provide critical vacuum to pull the exhaust from the reaction cell. The flow through the analyzer is independent of this vacuum, provided it is low enough to meet the conditions for critical flow. The pressure on the downstream side of the critical flow orifice (measured under conditions of full analyzer flow) should be no more than 30% of atmospheric pressure.

If equipped, a second sample channel is present which does not flow through the converter, therefore measuring only NO. The difference between these two channels represents the NO_2 concentration in the original sample, or any such other speciation (e.g. NH_3) depending upon external system configuration.

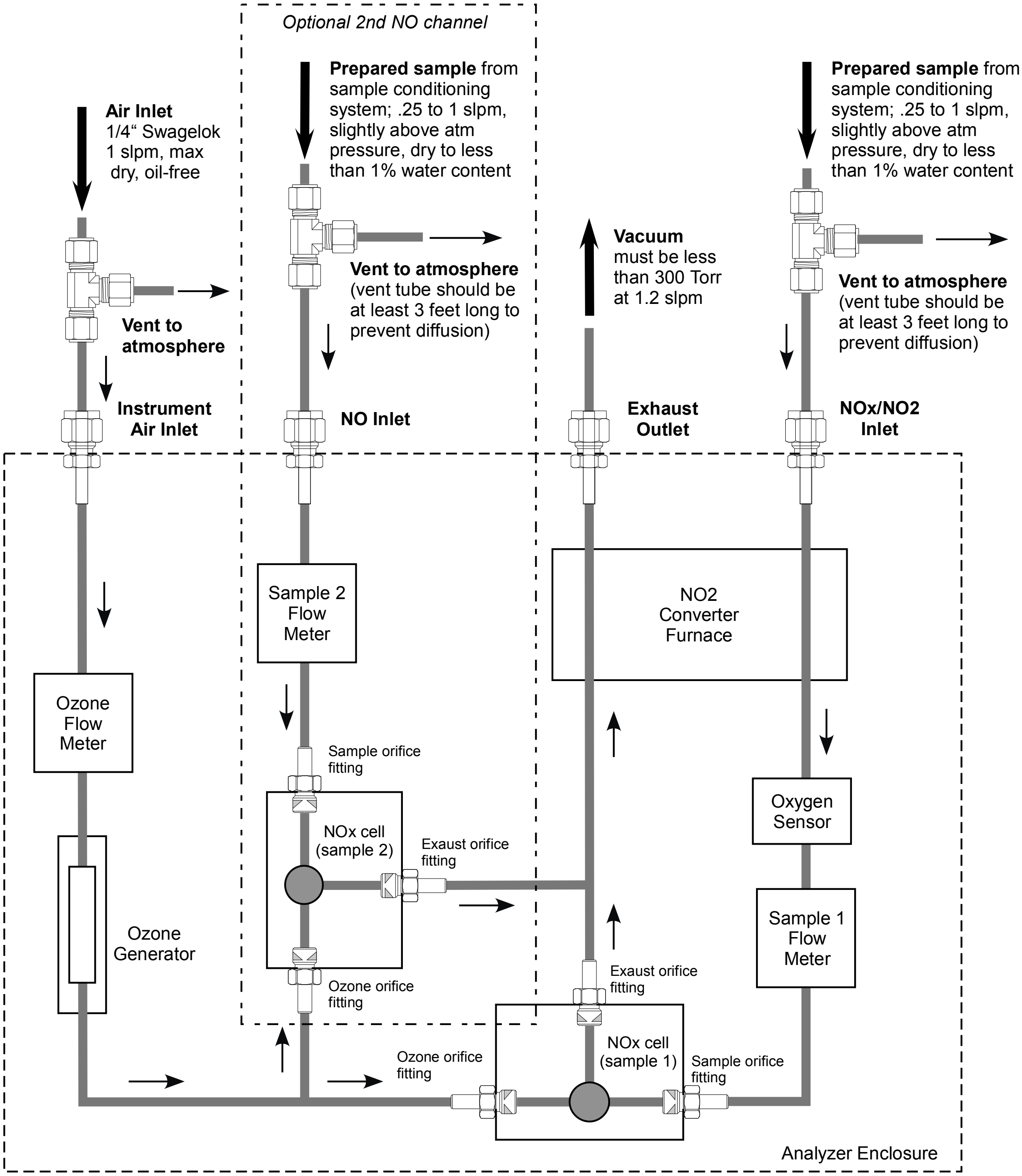

Figure 1 Functional pneumatics diagram

Analyzer setup and quick start procedure

For experienced users already acquainted with gas monitoring techniques and equipment, the following is a summary of installation and startup steps for a typical CEMS installation; consult factory for other applications. Analyzer menus and operation are described in more detail in the next section of the manual. **To ensure the quickest and most reliable startup, please follow the five steps below in the order shown.**

Connect the analyzer

1. Connect instrument air and sample to inlets via 1/4" Swagelok™ fittings.
   a. Instrument air: 1 SLPM of dry, oil-free air, vented to ambient conditions. The instrument draws approximately 0.2 SLPM of air per NO_x channel, and a sufficient excess should be supplied to the analyzer to ensure the analyzer only pulls instrument air, not ambient air, from the vented connection (see figure 1).
   b. Sample #1 (NO_x): 0.2 SLPM of sample from a sample manifold vented to atmospheric pressure. The instrument draws approximately 60 SCCM of sample per NO_x channel, and a sufficient excess should be supplied to the analyzer to ensure the analyzer only pulls sample gas, not ambient air from the vented connection (see figure 1).
   c. Sample #2 (NO), if equipped: 0.2 SLPM of sample from a sample manifold vented to atmospheric pressure. The instrument draws approximately 70 SCCM of sample per NO_x channel, and a sufficient excess should be supplied to the analyzer to ensure the analyzer only pulls sample gas, not ambient air from the vented connection (see figure 1)
2. Connect 1/4" diameter exhaust line (to pump or eductor) to 1/4" Swagelok™ exhaust port. The vacuum source should be able of maintain an absolute pressure of less than 200 Torr at 1 SLPM flow. For example, a Thomas/Gardner model 2688VE44 mechanical pump or Air-Vac Engineering AVR-038H air driven eductor.
3. Connect analog output signals via 8-pin Phoenix Contact connector (provided) per the pin assignments listed in Table 1, and/or Ethernet connection if using digital communications.

Warning: This instrument is designed for use with 120V AC input power only. Serious equipment damage and/or injury will occur if it is connected to improper power.

Analog Outputs: The CL3020 analyzer has four analog outputs, assignable to various measurements, depending upon configuration. Below are analog output assignments typical of a dual-range non-speciating NO_x-O_2 analyzer. Refer to analog output section of this manual for more information.

NO_x output (primary range): 4-20 mA or 0-10V → 0 to full-scale ppm	Pin 1: low Pin 2: high
NO_x output (secondary range): 4-20 mA or 0-10V → 0 to full-scale ppm	Pin 3: low Pin 4: high
O_2 output: 4-20 mA or 0-10V → 0 to full-scale % O_2	Pin 5: low Pin 6: high
Reserved	Pin 7: low Pin 8: high

Table 1 I/O Analog output pin assignments (typical)

Apply power to the analyzer and check diagnostics

Caution: **The analyzer should not be operated without the cover in place. The exterior surface of the converter furnace and tubes will rise to nearly 80°C if operated without the cover in place. Serious burns can result if the proper precautions are not taken.**

1. Apply power by connecting the instrument power cord (provided). Verify that the fan is operating by feeling for air flow at the back of the instrument. If inadequate flow is suspected, shut down power.

Caution: **The analyzer should not be operated without the cover in place and the cooling fan fully functional.**

Care should be taken to avoid blocking the air vents in the side panel. Standard EIA rack mounting should provide enough space for adequate cooling.

2. After approximately one minute the touchscreen will complete its startup cycle and be at the home screen. Navigate to the diagnostic screen and verify the following as summarized in Table 2:

a. Verify that the sample-flow (on the diagnostic screen) indicates approximately 70 SCCM per channel and the ozone-flow (diagnostic screen) indicates approximately 230 SCCM for single channel NO_x or 460 SCCM for dual channel configuration. If flows are not correct, check pneumatic connections and external system components (e.g. pump).

b. Verify the furnace temperature is rising. The furnace temperature should reach 400°C in about 30 minutes.

c. Verify the ozonator temperature is rising. The ozonator temperature should reach 40°C in about 15 minutes. It may be necessary to adjust the ozonator setpoint temperature for operation in unusually cool or warm environments. The operating temperature is not important, it is only necessary that the ozonator temperature remains constant.

d. Verify the NO_x reaction cell(s) temperatures is rising. The NO_x cell temperature(s) should reach 40°C in about 15 minutes.

Parameter	**Value**
Sample flow	70 SCCM
Ozone flow	230 SCCM single NO_x, 460 SCCM dual NO_x
Converter temperature	400 °C
Ozonator temperature	50 °C (user settable)
NO_x cell #1 temperature	40 °C
NO_x cell #2 temperature (if equipped)	40 °C

Table 2 Expected flows and temperatures during normal analyzer operation

Set analog outputs of the analyzer

From the analog output screen located within the Config menu, set full scale to desired values for each output channel, per configuration. Refer to analog output section of this manual for more information.

Calibrate the analyzer

After installation and temperatures have reached their setpoints above, the NO_x and O_2 channels can each be calibrated via the following procedure:

1. Low calibration:
   a. Flow low calibration gas through the sample handling system and analyzer. Dry nitrogen, EPA protocol zero gas, or well-scrubbed instrument air is recommended as a low calibration gas for NO_x. O_2 may be zeroed on NO span gas.

   b. Wait approximately two minutes or until reading settles. It may be helpful to monitor the trend screen to evaluate when the reading has reached final value.

   c. Enter the value of the low calibration gas, typically 0.

   d. Press “Low Capture” soft button on the calibration screen.
2. High calibration:
   a. Flow high calibration gas through the sample handling system and analyzer.

   b. Wait approximately two minutes or until reading settles. It may be helpful to monitor the trend screen to evaluate when the reading has reached final value.

   c. Enter the value of the high calibration gas, typically from the reported bottle value from the calibration gas supplier.

   d. Press “High Capture” soft button on the calibration screen.

Display screens and details of operation

Home screen, warnings, and alarms

The analyzer home screen analyzer is shown in Figure 2 below. In this view, only gas concentrations are displayed. Gas concentrations displayed will vary by configuration.

Figure 2 Home screen

If active alarms are present (any diagnostic variable out of range, see section on Alarm screen), a red triangle with an exclamation point will appear in the lower right-hand corner of the display as shown in Figure 3. Touching this icon will bring up the Alarm screen as described later.

Figure 3 Home screen showing active alarm

If there are active warnings, these descriptors will be annunciated in a banner at the bottom of the screen as shown in Figure 4. Possible warnings include:

- Communications error between display and main analyzer board, warning the display may not be updating thus readings or statuses may be invalid.
- Ozonator and/or furnace disabled (see Configuration screen)
- Analog outputs forced high or low (see Analog Output Trim screen)

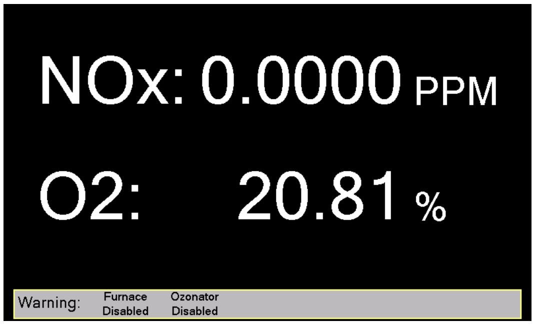

Figure 4 Home screen showing furnace and ozonator warnings

Analyzer menus may be accessed by touching the screen anywhere, causing the menu bar to become available at the bottom of the screen for about five seconds as shown in Figure 5. When the menu is visible, any of the main screens (Calibrate, Diagnostics, Trend, Config, of Alarm) may be selected.

Note: The menu bar will appear from any of the main screens by touching the screen anywhere there is not an active input box or button, enabling to return to the Home screen from any other main screen.

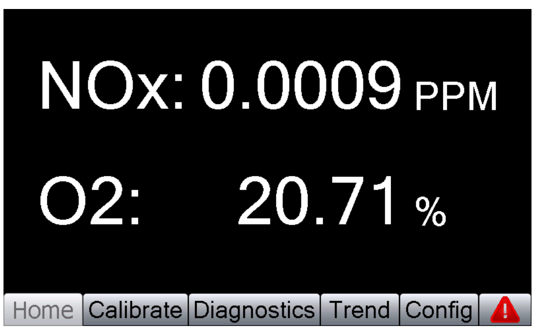

Figure 5 Home screen showing main menu choices

Calibration menu

Figure 6 shows an example calibration screen, in this case NOx1. Each gas has its own calibration screen selectable by touching the corresponding rectangle from the column of choices on the right of the screen.

In this screen the raw value displayed corresponds to the percentage of analog input from the sensor. When troubleshooting, the raw value is often more important to examine than the calculated concentration. This is because the calculated value may be corrupted by erroneous calibration, but the raw value represents the underlying sensor response. The gain is the calculated correspondence between gas concentration and raw value captured during calibration, as described below.

The analyzer is calibrated by assigning sensor responses to gas concentrations. Any two points may be used for calibration, but typically zero and span are chosen. Bottle values for calibration may be entered by selecting the appropriate field and entering numeric values form the pop-up touch keypad, as shown in Figure 7. This same keypad is available for all numeric entries throughout the interface.

Stored raw values corresponding to gas bottle values (or known process values) may be "captured" by pressing the high or low capture buttons when high or low concentration gas, respectively, is flowed to the analyzer. These response values may be entered manually by entering raw values in these fields using a numeric pop-up touch keypad.

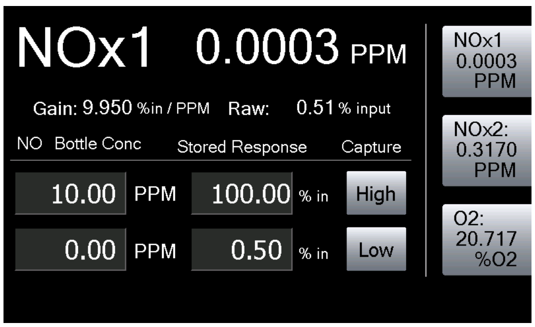

Figure 6 Calibration menu, for NOx1 gas

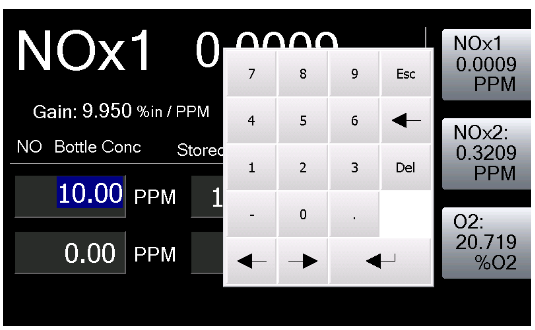

Figure 7 Numeric entry of calibration bottle value using pop-up keypad

Diagnostic screen

Table 2 shows typical values for expected flows and temperatures during normal operation. These diagnostics are displayed in the main diagnostic screen, and shown in Figure 8. Refer to the Alarms screen for setting limits on these parameters, and the troubleshooting section of this manual of if these values are out of range.

The 32-bit Fault Register is defined in more detail in the digital communications section. Bit 0 is on the far right, bit 15 is on the far left. Bits are one (TRUE) if in alarm condition, zero if not alarmed.

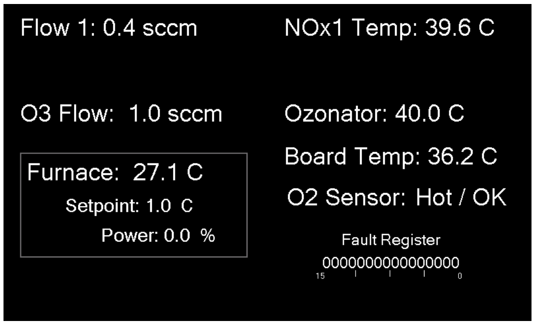

Figure 8 Diagnostic screen

Trend screen

The trend screen is shown in Figure 9. Note that the scale for Oxygen (on the left) and NO_x reading(s) on the right is adjustable by selecting the top and bottom numbers and rescaling with the pop-up keypad. The trend screen displays ten minutes of data, refreshing once a second.

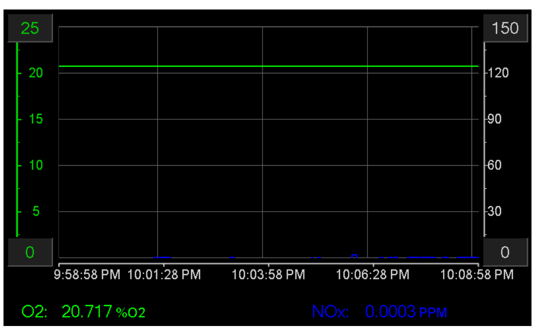

Figure 9 Trend screen

Config screen

The configuration screen is shown in Figure 10.

Furnace power and ozonator output may be toggled by tapping the appropriate buttons. Ozonator temperature will be maintained if disabled, only the ozonator discharge itself is disabled. Warnings messages will be displayed on other screens when either of these components is disabled.

The furnace temperature setpoint may be adjusted from this screen. During steady state operation at room temperature, the power duty cycle should be approximately 35%.

Averaging time for signals may be set to any value between 3 and 60 seconds. 15 seconds is the default,

Sub-screens for Analog outputs, IP address, QRC, and About may be accessed from this screen and are described below.

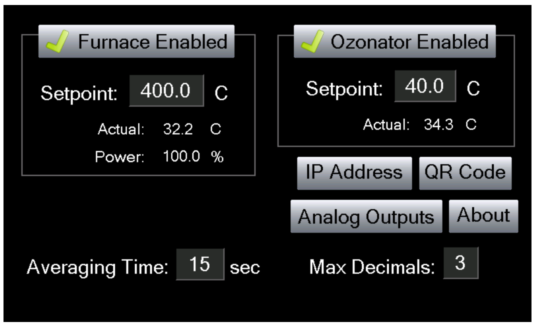

Figure 10 Config screen: Sub-screens for further configuration

Analog output scaling screen

The analog output screen is shown in Figure 11, in the case of dual-ranging NO_x with O_2. Other gas configurations are similar and self-explanatory. Concentrations corresponding to low and high analog outputs may be set using the numeric pop-up keypad as shown in Figure 7.

Current (4-20 mA) or voltage (0-10V) output is selectable from the Type menu box in the upper right-hand corner. Note the voltage output is intended for use only with high impedance (>1000 kOhm) devices.

Actual live outputs are shown for reference

Note the “gear” icon to the left of each channel. Selecting this icon brings up the Analog output trim screen for each channel, as described below.

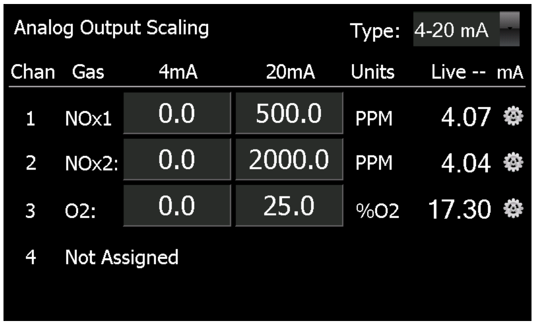

Figure 11 Analog output scaling screen

Analog output trim screen

Each analog output channel may be trimmed independently from its own screen, as shown in Figure 12. Under normal operation, the output is in “live” mode, but it may be forced to either the high or low limits by selecting the corresponding box. When the output is so forced, the corresponding trim field is active and may be used to adjust the actual output up or down to make up for any system discrepancies. In this manner, the analog loops and any external data acquisition system may be calibrated independent of gas concentration readings. This may also be used for troubleshooting external connections.

Note that when any outputs are forced high or low, a warning is displayed to the user in the warning banner in the lower portion of any main screen.

The “Next” and “Return” buttons allow the user to cycle through other analog channels and/or return to the main analog output screen.

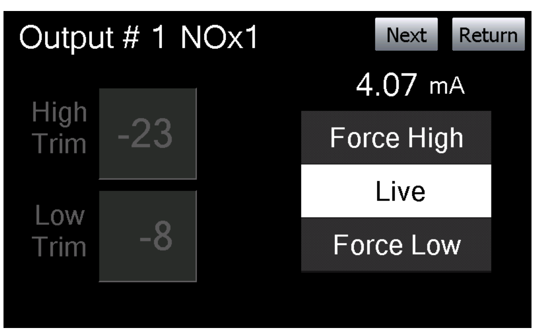

Figure 12 Analog output trim screen

IP address screen

The IP address screen is available from the Config screen. Either a static or dynamic IP address screen may be specified.

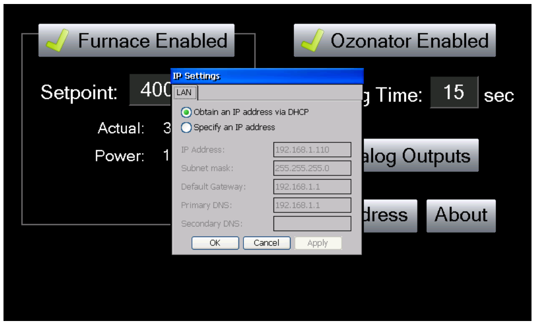

Figure 13 IP address screen

QR code

A standard QR code (2D barcode) image, as shown in Figure 14, may be displayed for capture and analysis by any mobile device with barcode scanning capability. Scanning with a mobile device will provide a text description of the analyzer configuration, status, and current readings that can be sent to support personnel for troubleshooting assistance.

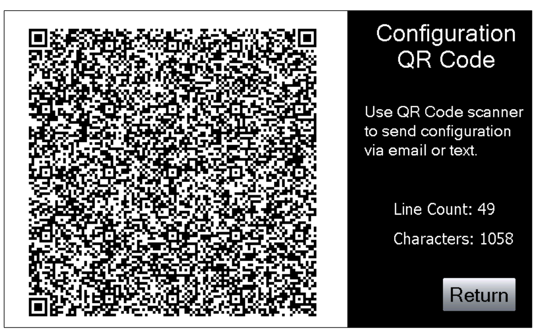

Figure 14 QR code snapshot screen

About screen

The About screen, as shown in Figure 15, shows the current software versions for the system.

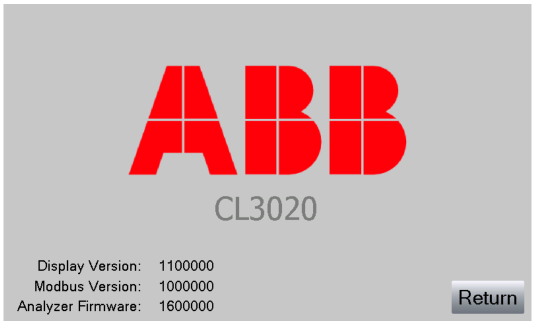

Figure 15 About screen

Alarm screen

The alarm screen is shown in Figure 16, accessible from the home screen by touching the red triangle. An active, or historical but uncleared, alarm sets the corresponding bit in the fault register, and causes the red alarm icon to flash on any main screen. If an alarm condition is still being met (causing the alarm), the alarm listing will be highlighted red. If the alarm condition is no longer being met (not alarmed), the text will no longer be highlighted in red, but still visible in the alarm history. The history can be cleared by tapping the “Clear” button. Only alarms that are no longer active may be cleared; if an alarm condition is still occurring it will reactivate and not remain cleared.

To access the sub-menus allowing configuration of each alarm, touch the Config Alarms button on this screen.

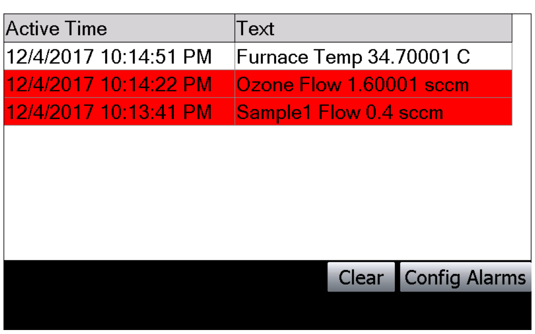

Figure 16 Alarm screen, with one alarm cleared and two others active

Config alarms screen

Each alarmable temperature and flow is configurable, as shown in Figure 17, in this case for the furnace temperature. While factory defaults settings should normally not require modification, allowing these to be configurable enables the user to operate the analyzer in custom configurations for unique applications or for testing purposes, while still having meaningful alarm conditions. A target value and deviation from the target may be set in the corresponding boxes. Note in the case of a control loop, like furnace temperature, this is only the target for the alarm, not the control setpoint temperature.

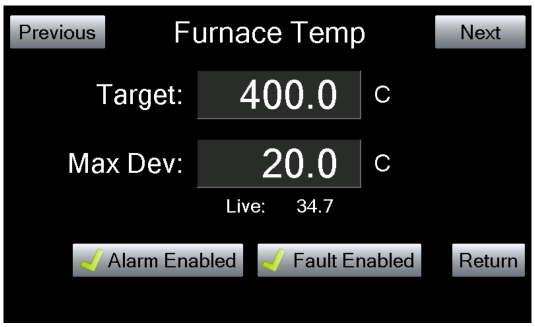

Figure 17 Config alarm screen

Troubleshooting

Below is troubleshooting information on the analyzer, as well as information on many of the sub-assemblies within the unit. Before troubleshooting the analyzer, read through the diagnostic and operating parameters explanations to help narrow down any problems.

> **Warning:** **Potentially lethal line voltage, lethal high voltage (within the ozone generator), and dangerously hot tubing and subassemblies are present within the analyzer. Service within the analyzer should be performed only by qualified, trained personnel, and only after the unit has been unplugged and allowed to cool for at least one hour with the cover off.**

Diagnostics and operating parameters

The diagnostics on the analyzer display much instrument status information (see diagnostics screen). From these readings, it is usually possible to narrow down the source of any problems:

Warnings and alarms

The Home screen of the display will display the presence of any warnings or alarms. Carefully check this information to troubleshoot any problems, for example if NO_x is not responding it may be the case that the ozonator has been left disabled.

Sample and ozone flow

Because these two flow rates are intimately related, it is important to consider them together. Sample flow is the amount of flow drawn through the sample inlet through the analyzer. Ozone flow is the amount of feed air pulled through the ozonator.

A critical flow orifice located in the exhaust fitting of the NO_x cell determines the total flow (sample and ozone flow combined). This total flow rate should be approximately 230 SCCM per channel.

One may determine several things by inspecting the NO_x sample and ozone flow meters:

- If the both flows are correct, it is very unlikely that there are pneumatic problems within the analyzer.

- If the both flow are low, there may leaks in the analyzer, the critical flow exhaust orifice may blocked, the sample inlet may be blocked, the exhaust may be blocked or not vented properly, or the vacuum at the rear of the analyzer may be inadequate.
- If the ozone flow is too low, the ozone air feed orifice may be blocked, there may be a leak in the ozone supply tubing, or the compressed air supply to the instrument may be faulty.
- If the sample flow is too low, the sample orifice may be blocked, there may be a leak in the sample tubing, or the sample supply to to the instrument may be blocked
- If either or both flows are too high, check for pressurization of sample or instrument air (inadequate or blocked vents), or other blockages. For example, if the ozone flow is restricted, one indication may be higher than normal sample flow, and vice versa.

Converter temperature

The converter furnace temperature is maintained at 400 °C. The temperature should not vary by more than two degrees. If it is not at the proper value, the furnace heater, thermocouple, or relay could be at fault.

Gas concentration readings

The O_2 value should be stable to approximately 0.02% (absolute). Instability or inaccurate readings could be caused by leaks or a faulty O_2 sensor module. The NO_x reading should be stable to better than 0.25% or reading, or 0.02 PPM, whichever is greater. Instability or inaccurate readings could be caused be leaks, a faulty ozonator, or a faulty NO_x sensor or sensor board.

System checks

Component failures within the analyzer are relatively uncommon. Most performance or reliability problems are due to improper system connections, leaks, faulty electrical connections, or improper configuration, in that order. Before opening the analyzer enclosure, double-check that the external connections and supply of conditioned sample gas, compressed air, and line voltage are correct. The following may aid in troubleshooting if the analyzer is not functioning properly and no faults are apparent form the diagnostic information.

Electrical connections and fuse

Be sure all connectors on the main board are firmly seated and that all wires within these connectors are firmly attached. There is a fuse holder on the main power inlet of the analyzer, serviceable from the analyzer back panel.

Leak checking

Leaks may cause many non-obvious problems, a leak check is highly recommended when servicing or troubleshooting gas analyzers for any reason. Leak checking should be done under vacuum, never pressure with the following procedure:

1. Seal the sample and instrument air inlet(s) on the back of the analyzer.
2. Connect a vacuum pump to the exhaust port, with an isolation valve in between the pump and the analyzer, and a vacuum gauge on the analyzer side of the isolation valve.
3. Open the isolation valve, pump the analyzer down, and record the vacuum reading.
4. Close the isolation valve. The isolated analyzer pressure should not increase more than 2 Torr/second.

If leaks are found, check all fittings for tightness, and locate the leak by progressively isolating parts of the analyzer. In general, if a leak is present it will be very noticeable, not subtle. A slight apparent leak within the ozonator is acceptable; a metered sweep of the ozonator assembly is designed to minimize stray ozone within the analyzer enclosure.

Component information

Information on service replacement of many of the analyzer components is given below. Only proceed to investigation of components after thoroughly checking pneumatic and electrical connections both inside and external to the analyzer as noted above. **"Part-swapping" without clear indication of component failure is not a recommended troubleshooting or repair technique.**

Oxygen sensor module

This is serviced as a unit. If approximately 9VDC is present on pins 1 and 2 of the five-pin connector, and oxygen readings are unstable, nonlinear, or inaccurate, replace this module. If 9VDC is not present, examine connections.

Ozonator

Lethal voltage is present with the ozonator: Do not attempt to service the ozone generator, and never open its enclosure or allow tools to come near it when the analyzer is energized. The ozonator hums audibly when operating, if power is being supplied to this unit (24VDC) and there is no hum, the ozonator should be replaced.

NO_x reaction cell

The NO_x reaction cell has several fittings and the NO_x sensor mounted on it.

The exhaust fitting on the back of the cell houses the critical flow orifice. It may be changed by disconnecting the tube leading into the furnace and unscrewing the fitting. The orifice and fitting are replaced as an assembly.

If the readings have dropped, or if the analyzer has been subjected to ammonia, it may be necessary to clean the window on the sensor:

1. Turn off power to the analyzer and remove vacuum from the exhaust port.
2. Remove the two screws holding the detector assembly to the reaction cell and remove the detector assembly.
3. Wipe off the optical window of the sensor through this port with deionized water or rubbing alcohol to remove any film or deposits. Do not use harsh solvents or abrasive materials.
4. Reinstall the detector assembly.
5. Energize analyzer, and apply vacuum. Leak check if readings unstable.

Converter

The converter has a cartridge heater and a thermocouple. The heater element and thermocouple connect to the main board near the back of the analyzer. The converter is typically replaced as an assembly, although the thermocouple and heater may be field replaced by experienced service personnel. The heater assembly should be replaced if either side of the heater shows less than 1 MΩ resistance to the shell or if the heater resistance is not approximately 70 Ω.

The power control relay for the heater is socketed near the rear of the board and may require replacement if the converter power supply has been short-circuited. The molybdenum charge may be replaced, consult factory for details.

Main board

If the main board must be replaced, the analyzer should be de-energized and all connections removed before attempting to remove the board.

Digital communications

The model CL3020 analyzer can act as a MODBUS server (slave) and may also be operated remotely via any standard PC or mobile VNC viewer. Additionally, a QR-code, i.e. 2D barcode, may be scanned by a mobile device to capture a complete snapshot of instrument status that can easily be sent to remote troubleshooting personnel.

Setting the IP address

The IP address for the analyzer is normally set to a static value of 192.168.1.50, and can be changed by tapping the IP Address button on the Config Screen. Either a static or dynamically assigned (DHCP) address can be specified.

Modbus over TCP/IP

The CL3020 can serve as a MODBUS slave over TCP/IP. The MODBUS register map is shown in Table 4.

Analyzer fault register

The 32-bit analyzer fault register reflects the alarm status of the analyzer, whereas any non-zero value represents an alarm condition. The fault register bit assignments are listed in Table 3. The lowest bit (0) is set to true if any alarm is present allowing for quick reading of a single bit for overall alarm status. The fault register is also available in float data-type representation of the 32-bit value to allow it to be read along with many other input registers using a single read command.

Bit	**Parameter**	**True (1) if**
0	Instrument Fault	Any alarm
1…5	Reserved	
6	O_2 Heater	Alarm
7	Sample Flow 1	Alarm
8	Sample Flow 2	Alarm
9	Ozonator Flow	Alarm
10	NOx1 Temp	Alarm
11	NOx2 Temp	Alarm
12	Ozonator Temp	Alarm
13	Furnace Temp	Alarm
14	Analyzer Temp	Alarm
15	Comms Error	Alarm
16…31	Reserved	

Modbus server version 1.00100

Table 3 Analyzer fault register bit assignments

Parameter	Register Num*	Data Type	Notes
Modbus Slave Version	30001	Int32	
System Board Firmware Version	30003	Int32	
Display Software Version	30005	Int32	
Status (integer)	30007	Int32	
Status (float)	30021	Float	Float of (Int32 Status) to allow all float reads
Concentration Gas NOx 1	30023	Float	Live concentration in gas-units
Concentration Gas NOx 2	30025	Float	Live concentration in gas-units
Concentration Gas O_2	30027	Float	Live concentration in gas-units
Reserved	30029		
Raw Response Gas NOx 1	30031	Float	Live signal response in % of available input
Raw Response Gas NOx 2	30033	Float	Live signal response in % of available input
Raw Response Gas O_2	30035	Float	Live signal response in % of available input
Reserved	30037		
Temperature Analyzer	30039	Float	degrees C
Temperature NOx 1 Cell	30041	Float	degrees C
Temperature NOx2 Cell	30043	Float	degrees C
Temperature Ozonator	30045	Float	degrees C
Temperature Furnace	30047	Float	degrees C
Heater Power Furnace	30049	Float	Live furnace power in %
Flow Sample 1	30051	Float	Live sample 1 flow in cm^3
Flow Sample 2	30053	Float	Live sample 2 flow in cm^3
Flow Ozone	30055	Float	Live ozone flow in cm^3
Stored Span Response NOx 1	40101	Float	Stored response in % of available input
Stored Zero Response NOx 1	40103	Float	Stored response in % of available input
Stored Span Response NOx 2	40105	Float	Stored response in % of available input
Stored Zero Response NOx 2	40107	Float	Stored response in % of available input
Stored Span Response O_2	40109	Float	Stored response in % of available input
Stored Zero Response O_2	40111	Float	Stored response in % of available input
Span Bottle Concentration Gas 1	40113	Float	Bottle concentration in gas-units
Zero Bottle Concentration Gas 1	40115	Float	Bottle concentration in gas-units
Span Bottle Concentration Gas 2	40117	Float	Bottle concentration in gas-units
Zero Bottle Concentration Gas 2	40119	Float	Bottle concentration in gas-units
Span Bottle Concentration Gas 3	40121	Float	Bottle concentration in gas-units
Zero Bottle Concentration Gas 3	40123	Float	Bottle concentration in gas-units
Converter Furnace Enabled	1	Bool	True (1) enables furnace power
Ozonator Enabled	2	Bool	True (1) enables ozonator power

* Register numbers 30xxx are input registers, 40xxx are holding registers, x are output coils. Modbus server version 1.00100

Table 4 Modbus register map

Remote operation via VNC

It is possible to operate the CL3020 remotely by any VNC viewer connected via TCP/IP. Every display and every action that is available from the analyzer display is duplicated on the remote device, with a mouse click or screen touch on the remote device serving as the same input as front screen touch commands.

Any VNC viewer may be used, once the IP address of the analyzer is known. The VNC connection password is CL3020 (case sensitive) and cannot be changed. TCP port 5900 is used for the VNC connection and must not be blocked by any routers or firewalls between the analyzer and the remote device.

Spare parts

Part description	Part number	Recommended on-site quantity
Exhaust orifice fitting	1000-1020	2
Sample orifice fitting	1000-1030	2
Ozone orifice fitting	1000-1031	2
NOx detector O-ring	1000-1032	2
Fuse	1000-1033	2
Oxygen sensor	1000-1034	1 (if configured)
Ozone generator	1000-1035	Optional
NO_2 furnace assembly	1000-1036	None
Furnace media recharge	1000-1037	None
NOx Detector	1000-1038	None
Flowmeter	1000-1039	None
Furnace relay	1000-1040	None
Furnace heater	1000-1041	None
Furnace thermocouple	1000-1042	None
Furnace sample fittings	1000-1043	None
Display	1000-1044	None
Electronics board	1000-1045	None
Fan	1000-1046	None
Sample tubing, 5 ft	1000-1047	None
Exhaust tubing, 2 ft	1000-1048	None
Tubing tee	1000-1049	None

Table 5 Analyzer spare parts list

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ABB Automation GmbH
Measurement & Analytics
Stierstädter Str. 5
60488 Frankfurt am Main
Germany
Fax: +49 69 7930-4566
Mail: cga@de.abb.com

abb.com/analytical

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