SECTION 230923.16 - GAS INSTRUMENTS

TIPS:

To view non-printing **Editor's Notes** that provide guidance for editing, click on MasterWorks/Single-File Formatting/Toggle/Editor's Notes.

To read **detailed research, technical information about products and materials, and coordination checklists**, click on MasterWorks/Supporting Information.

Access Product MasterSpec Sections:

<Double click here to view the list of manufacturer Sections available at ProductMasterSpec.com.>

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Carbon-dioxide and temperature sensors and transmitters.
2. Combination carbon-dioxide and VOC sensors and transmitters.
3. Single-point oxygen monitoring system.
4. Multipoint carbon-monoxide monitoring system.
5. Toxic/combustible gas transmitter.
6. VOC sensors and transmitters.

B. Related Requirements:

1. Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.
2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to this Section.

1.2 DEFINITIONS

A. NDIR: Nondispersive infrared.

1.3 ACTION SUBMITTALS

A. Product Data:

1. Carbon-dioxide sensors and transmitters.
2. Carbon-dioxide, temperature, and relative humidity sensors and transmitters.
3. Carbon-dioxide and temperature transmitters with setpoint and override control.
4. Combination carbon-dioxide and VOC sensors and transmitters.
5. Single-point oxygen monitoring system.
6. Multipoint carbon-monoxide monitoring system.
7. Toxic/combustible gas transmitters.
8. VOC sensors and transmitters.

B. Product Data Submittals: For each product.

1. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
2. Installation instructions, including factor affecting performance.
3. Product description with complete technical data, performance curves, product specification sheets.

C. Sustainable Design Submittals:

1. Product data showing compliance with ASHRAE 62.1.

D. Shop Drawings:

1. Include plans, elevations, sections, and [**mounting**]details.
2. Include diagrams for power, signal, and control wiring.
3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

E. Samples: For each exposed product installed in finished space.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which wall-mounted instruments located in finished space are shown and coordinated with each other, showing relationship to light switches, fire alarm devices, and other installed devices using input from installers of the items involved.

B. Product Test Reports: For [**carbon-dioxide sensors and transmitters,**] [**combination carbon-dioxide and VOC sensors and transmitters,**] [**single-point oxygen monitoring system,**] [**multipoint carbon-monoxide monitoring system,**] [**toxic/combustible gas transmitters,**] [**VOC sensors and transmitters,**] for tests performed by [**manufacturer and witnessed by a qualified testing agency**] [**a qualified testing agency**].

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For gas instruments to include in operation and maintenance manuals.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Manufacturer's standard, but not less than five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CARBON-DIOXIDE SENSORS AND TRANSMITTERS

A. Room Carbon-Dioxide, Temperature, and Relative Humidity Sensors and Transmitters[**with LCD Display**]:

1. Basis-of-Design Product: Subject to compliance with requirements, provide ACI; Automation Components, Inc. model ESENSE Series; <**Insert drawing designation**> or comparable product by one of the following:

a. Building Automation Products Inc.; BAPI.
b. Telaire; a brand of Amphenol Thermometrics Inc.
c. Vaisala.
d. Veris Industries.
e. <**Insert manufacturer's name**>.

B. Description:

1. Carbon-dioxide NDIR technology or equivalent technology[**, with digital display for continuous indication of carbon-dioxide concentration**].
2. Analog Output: Provide one, two-wire analog output.

C. Construction:

1. ABS plastic, wall-mounted enclosure having UL 94 HB flame spread rating.
2. Display: 7-digit LCD type, with ppm indicator

D. Performance:

1. CO_2 Range: Zero to [**2000**] [**10,000**] <**Insert value**> ppm.
2. CO_2 Accuracy: Within [**3 percent of reading, plus or minus 40 ppm**] [**5 percent of reading, plus or minus 30 ppm**].
3. CO_2 Repeatability: Within 1 percent of measured value, plus or minus 20 ppm.
4. Zero Drift: Within 0.3 percent of span per year.
5. Analog Output: [**0-5 V dc**] [**0-10 V dc**] [**2-10 V dc**] [**4-20 mA dc**].
6. Ambient Temperature Range: 32 to 122 deg F (Zero to 50 deg C).
7. Ambient Relative Humidity: 0 to 95 percent.
8. Sensor Life: 15 years, minimum.
9. Calibration: Automatic Baseline Correction (ABC).
10. Response Time: 10 seconds, maximum.
11. Warm-up Time: 15 minutes, maximum.
12. Power: 24 V [**ac**] [**dc**], plus or minus 20 percent.
13. Maximum Power Consumption: 1.0 W.

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2.2 CARBON-DIOXIDE, TEMPERATURE, AND RELATIVE HUMIDITY SENSORS AND TRANSMITTERS

A. Room Carbon-Dioxide, Temperature, and Relative Humidity Sensors and Transmitters[**, with LCD Display**]:

1. Basis-of-Design Product: Subject to compliance with requirements, provide ACI; Automation Components, Inc. model TSENSE Series; <**Insert drawing designation**> or comparable product by one of the following:

   a. Building Automation Products Inc.; BAPI.
   b. Telaire; a brand of Amphenol Thermometrics Inc.
   c. Vaisala.
   d. Veris Industries.
   e. <**Insert manufacturer's name**>.

B. Description:

1. Carbon-dioxide NDIR technology or equivalent technology, with integral temperature sensor and relative humidity sensor[**, with digital display configurable for continuous indication of carbon-dioxide concentration, space temperature, or space relative humidity**].
2. Analog Output: Provide three, two-wire analog outputs.

3. Communications Protocol: [**Modbus RTU**] [**or**] [**BACnet MS/TP**].

   a. Baud Rate: [**9600**] [**19200**] [**38400**] [**57,600**] [**76,800**] [**115,200**].

4. Relay Output: One SPDT relay.

   a. Relay Output: Provide field configurable relay that changes state in response to [**CO_2**] [**Temperature**] [**Relative humidity**].
   b. Relay Set Point: [**1000 ppm CO_2**] <**Insert value for temperature or RH set point**>.
   c. Relay Contact Ratings: 1.0 A at 50 V ac or 24 V dc.
   d. Relay Mechanical Durability: Minimum 100,000 operations at 36,000 operations per hour.
   e. Relay Electrical Durability: Minimum 100,000 operations at [**1800 operations per hour at rated ac load**] [**1200 operations per hour at rated dc load**].

C. Construction:

1. ABS plastic, wall-mounted enclosure having UL 94 HB flame spread rating.
2. Display: 7-digit LCD type, with ppm indicator.

D. Performance:

1. CO2 Range: Zero to [**2000**] [**3000**] <**Insert value**> ppm.
2. CO_2 Accuracy: Within 3 percent of reading and plus or minus 30 ppm.
3. CO_2 Repeatability: Within 1 percent of span, plus or minus 20 ppm.
4. CO_2 Zero Drift: Within plus or minus 0.3 percent of span per year.
5. CO_2 Analog Output: 0-10 V dc.
6. CO_2 Response Time: 3 minutes, maximum.
7. Temperature Range: 32 to 122 deg F (Zero to 50 deg C).
8. Temperature Accuracy: Plus or minus 0.9 deg F (0.6 deg C) for ambient temperatures from 63 to 82 deg F (17 to 28 deg C).
9. Temperature Repeatability: Plus or minus 0.45 deg F (0.25 deg C) for ambient temperatures from 63 to 82 deg F (17 to 28 deg C).
10. Temperature Analog Output: 0-10 V dc.
11. Temperature Response Time: 6 minutes, maximum.
12. Relative Humidity Range: 0-100 percent RH.
13. Relative Humidity Accuracy: Plus or minus 5 percent of span for ambient relative humidity from 20 to 80 percent.
14. Relative Humidity Hysteresis: Plus or minus 1 percent of span for ambient relative humidity from 20 to 80 percent.
15. Relative Humidity Repeatability: Plus or minus 0.25 percent of span for ambient temperatures from 63 to 82 deg F (17 to 28 deg C).
16. Relative Humidity Zero Drift: Plus or minus 0.5 percent of span per year.
17. Relative Humidity Analog Output: 0-10 V dc.
18. Relative Humidity Response Time: 6 minutes, maximum.
19. Sensor Life: 15 years, minimum.
20. Calibration: Automatic Baseline Correction (ABC).
21. Warm-up Time: 15 minutes, maximum.
22. Power Consumption: [**0.35 W**] [**0.60 W**], average; 2.0 W, maximum.

23. Ambient Relative Humidity: 0 to 95 percent, non-condensing.
24. Sensor Life: 15 years, minimum.
25. Calibration: Automatic Baseline Correction (ABC).
26. Response Time: 10 seconds, maximum.
27. Warm-up Time: 15 minutes, maximum.
28. Power: 24 V [**ac**] [**dc**], plus or minus 20 percent.

2.3 CARBON-DIOXIDE AND TEMPERATURE SENSORS AND TRANSMITTERS WITH SET POINT AND OVERRIDE CONTROL

A. Room Carbon-Dioxide and Temperature Sensors and Transmitters:

1. Basis-of-Design Product: Subject to compliance with requirements, provide ACI; Automation Components, Inc. model A/CO2-R2 Series; <**Insert drawing designation**> or comparable product by one of the following:

a. Building Automation Products Inc.; BAPI.
b. Telaire; a brand of Amphenol Thermometrics Inc.
c. Vaisala.
d. Veris Industries.
e. <**Insert manufacturer's name**>.

B. Description:

1. Carbon-dioxide NDIR technology or equivalent technology, with integral temperature sensor, setpoint adjustment, and occupancy override.

C. Construction:

1. Enclosure: White ABS plastic, wall-mounted enclosure having UL 94 HB flame spread rating.

D. Performance:

1. CO_2 Range: Zero to [**2000**] [**10000**] <**Insert value**> ppm.
2. CO_2 Accuracy: Plus or minus [**3 percent of reading, plus or minus 40 ppm**] [**5 percent of reading, plus or minus 30 ppm**].
3. CO_2 Repeatability: Within 1 percent of span, plus or minus 20 ppm.
4. CO_2 Zero Drift: Within 0.3 percent of span per year.
5. CO_2 Analog Output: [**0-5 V dc**] [**0-10 V dc**] [**and**] [**4-20 mA dc**].
6. CO_2 Response Time: 2 minutes, maximum.
7. Provide integral temperature sensor.

2.4 COMBINATION CARBON-DIOXIDE AND VOC SENSORS AND TRANSMITTERS

A. Manufacturers: Subject to compliance with requirements, provide products by the following:

1. Siemens Building Technologies, Inc.

2. <**Insert manufacturer's name**>.

B. Description:

1. NDIR technology or equivalent technology that provides long-term stability and reliability.
2. Senses and responds to combined concentration of more than 30 contaminants commonly found in indoor environments.

C. Output Signal: Zero to 10-V dc.

D. Performance:

1. Carbon-Dioxide Range: Zero to 2000 ppm.
2. Carbon-Dioxide Accuracy: Within 50 ppm, plus 2 percent measured value.
3. VOC Range: Zero to 2000 ppm.
4. VOC Sensitivity Ranges: Field selectable, low, normal, high.
5. Ambient Temperature: 32 to 122 deg F (Zero to 50 deg C).
6. Ambient Relative Humidity: 5 to 95 percent non-condensing.

E. Enclosure: White plastic.

F. Electrical Connections: Screw terminals.

G. Display: Digital, LCD.

2.5 SINGLE-POINT OXYGEN MONITORING SYSTEM

A. Basis-of-Design Product: Subject to compliance with requirements, provide ACI; Automation Components, Inc. model [**B5**] [**Q5**] Series; <**Insert drawing designation**> or comparable product by one of the following:

1. MSA Instrument Division.
2. <**Insert manufacturer's name**>.

B. Description:

1. System to measure and display a single gas concentration, provide local audio and visual alarms when preset limits are exceeded, and send output signals of gas concentration and detected alarms.
2. System to require no periodic maintenance other than periodic checking of sensor response to a known concentration of gas.
3. System to be designed to provide for installation, setup, and start-up from outside of unit enclosure without need to open the enclosure door.
4. System to be factory calibrated and ready for operation after installation.
5. Monitor to be internally wired to accommodate a single-point field power connection.

C. Performance:

1. Range: Full scale, zero to 25 percent oxygen.
2. Zero Drift: Within 1 percent per year.
3. Span Drift: Within 10 percent per year.
4. Repeatability: Within 1 percent of full scale.
5. Linearity: Within 2 percent of full scale.
6. Step Change Response Time: Within 12 seconds.

D. Enclosure:

1. UL 50E , Type 4X.
2. Access to the inside of enclosure, as well as to controller, display, and wiring connections, will be through full-length door on front of enclosure.
3. Door with shatterproof window sized to provide viewing of visual display and indicator lights.
4. Equip enclosure with mounting brackets for the purpose of attaching the unit to a flat surface.
5. Provide door with key lock access to inside enclosure.

E. Controller:

1. Password-protected access through full-function keypad.
2. Set:

    a. Real-time clock.
    b. Alarm levels.
    c. Change span-gas values.
    d. Display date of last calibration.
    e. Display minimum, maximum, and average gas values.
    f. Change address, future calibration time, and date.

3. Automatic return-to-normal-operation feature after calibration.
4. Date stamps last successful calibration.
5. Time and date stamps events.
6. Selectable lockout of output signals during calibration.
7. Logs minimum, maximum, and average gas concentrations over selected time intervals.

F. Visual Display:

1. Four-digit LED or backlight LCD display visible from front face of enclosure.
2. Value displayed to be a direct reading of gas concentration.
3. Displays system status indicators.
4. Visual Alarm Indication:

    a. Three separate alarm levels: Caution, Warning, and Alarm.
    b. Separate strobes for Warning and Alarm conditions. Externally mount the two strobes on top of enclosure.

5. Indication of sensor nearing end of its useful life based on the sensor output, not on the time the sensor was in service.

6. Displays average, minimum, and maximum gas concentrations of the sensor over selected time.
7. Malfunction Indication Alarm: Displays a separate unique character when an over-range or under-range condition exists, a sensor signal sensor is lost, or a set-point error or memory failure occurs.

G. Audible Alarm:

1. Provides an audible horn when an alarm condition occurs.
2. Horn to be rated for 95 dB with selectable output tones.
3. Mount horn inside or on exterior of enclosure.
4. Activate horn through a horn relay. Horn relay to be form "A" contacts and set as normally open and common.

H. Operator Interface:

1. Door Audible Alarm Acknowledge Switch:

a. Push-button switch located on front door will silence audible alarm.
b. Switch to reset latched alarms if normal gas conditions exist. Visual alarms to remain on as long as alarms are exceeded.

2. Operating Modes and Parameters Selection: Selections listed to be accomplished by the use of switches, jumpers, or remote control not involving the use of tools.

a. Display range value.
b. Latching or nonlatching mode for the alarm set points.
c. Upscale or downscale acting alarms.

I. Output Signal:

1. Relays:

a. Provide one relay for each set-point level for each of the three alarm levels.
b. Provide one relay for fault conditions.
c. Alarm and fault relays to be form "C," SPDT. Contacts to be rated for 5 A resistive at 250-V ac or 30-V dc.
d. Contacts will be capable of being selected normally open or normally closed.
e. Alarm relays to be normally de-energized. The fault relay to be normally energized.

2. Analog Output:

a. Two-wire, 4- to 20-mA, [**isolated**] [**nonisolated**] [**isolated or nonisolated**] current source.
b. Signal capable of operating into a 600-ohm load.

3. Digital Communication:

a. Bidirectional sending and receiving of digital signals via [**Modbus RTU**] [**or**] [**BACnet MS/TP**].

J. Sensor:

1. Electrochemical fuel-cell type does not require periodic addition of reagents.
2. Sensor to be replaceable without the need for tools.
3. Sensors to have a minimum useful life of one year. Replace failed sensors at no charge within first year.
4. Mount sensor externally on the side or bottom of enclosure. Where indicated on Drawings, mount sensor remote from enclosure.
5. Remote Mounting:

a. Provide sensor in a separate enclosure. Enclosure to be UL 50E, Type 4X, except when sensor is installed in a hazardous location, then enclosure to be an explosion-proof type suitable for the application.
b. Provide sensor with cable for connecting to monitor.
c. Provide sensor with mounting hardware suitable for application.
d. For duct-mounted applications, the sensor installation will provide kit for calibration of the sensor without removing sensor from duct.

K. Gas Sampling Pump:

1. Where required by application, provide a pump mounted inside the enclosure to provide a motive force to induce flow of gas sample across the sensor.
2. Signal to the sensor from the pump to be in digital communication format to eliminate radio-frequency interference (RFI) and electromagnetic interference (EMI).
3. A flow sensor to activate a relay when the gas sample falls below the acceptable flow rate to the sensor and will indicate a loss of gas flow on the display.
4. Introduction of a calibration gas to the gas sensor will be through an integral push-button valve. This push-button valve will return to monitoring the sampled area when released.

L. Battery Backup:

1. Provide battery backup power supply to continue normal operation if normal power source is interrupted.
2. Transfer to battery backup will be automatic and will be indicated on the display.
3. Mount battery backup power supply inside enclosure.
4. Battery backup to be continuously charged during normal operation.
5. Battery life to be at least 0.5 hours with strobes flashing, alarm conditions asserted, and horn sounding.

M. Remote Wireless Calibration:

1. Calibrate and adjust functions through nonintrusive hand-held wireless remote control without opening enclosure door.
2. Enter calibration mode through hand-held wireless remote control unit. The display of the monitor will instruct the user on when to apply zero and span gas. The system will automatically adjust its internal settings to the proper calibration values without further intervention by the user. On completion of a successful calibration, the system will exit

the calibration mode. Date stamp of last successful calibration is retained in the system internal memory, with capability to be indicated on display. If calibration is unsuccessful for any reason, the display will show an unsuccessful calibration attempt and revert to its previous calibration settings.

3. Wireless method to employ a digitally encoded infrared light beam.
4. Hand-held wireless remote control will let the user perform sensor zeroing and calibration.
5. Hand-held wireless remote control will let the user perform sensor zeroing and calibration, as well as activate all functions and features of the monitor.
6. The monitor infrared link will not be affected by natural and man-made low-level ambient light.

N. Automatic Calibration System:

1. Provide automatic calibration of all oxygen monitors installed. Number of automatic calibration systems to be determined by supplier based on location and quantity of oxygen monitors.
2. Automatic calibration system will, without manual intervention, periodically perform a complete calibration of the sensor.
3. System to exchange digital signals with sensor.
4. Automatic calibration to be adjustable from as many as three times per day to only once every 30 days.
5. Sensor alarms to be suppressed or disabled until the automatic calibration cycle is completed.
6. Manual calibration of the sensor to be initiated at any time with a hand-held infrared remote control without the need to disable or turn off the automatic calibration system.
7. House the system in a separate UL 50E, Type 4X enclosure from the oxygen monitoring system. Enclosure to have provisions for wall mounting.
8. Digital displays to indicate zero and when span gas is being applied to the sensor, the status, and any fault condition.
9. Provide with a separate valve condulet to monitor the condition of the calibration cylinders attached to the calibration system. Insufficient gas pressure to calibrate the sensor will light the fault indicator.

2.6 MULTIPOINT CARBON-MONOXIDE/NITROGEN DIOXIDE MONITORING SYSTEM

A. Basis-of-Design Product: Subject to compliance with requirements, provide **ACI; Automation Components, Inc**. model [**B5C**] [**Q5C**] Series; <**Insert drawing designation**> or comparable product by one of the following:

1. Building Automation Products Inc.; BAPI.
2. Honeywell.
3. MSA Instrument Division.
4. <**Insert manufacturer's name**>.

B. Description:

1. Each transmitter to monitor variation in the [**carbon-monoxide**] [**nitrogen-dioxide**] concentration level.

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2. Each sensor to be an alarm point.
3. System to operate on 24-V [**ac**] [**dc**] power, [**0.3 A**] [**8.4 VA**], maximum.
4. Final adjustment; calibration, testing, and startup of the system to be performed by a trained representative of manufacturer.
5. Provide three SPDT relays having dry contacts rated [**1.0 A at 30 V dc**] [**0.3 A at 125 V ac**], minimum.
6. Provide LED to indicate communication status, and one LED per relay to indicate relay status.
7. Provide alarm buzzer, minimum 80 dB.

C. Description:

1. Each sampling point to monitor any variation in the carbon-monoxide concentration level.
2. Each sampling point to be individually piped to the monitoring system.
3. Provide [**each**]sampling point with a 0.3-micron filter.
4. Each sampling point to be an alarm point.
5. A dual-head diaphragm pump will draw an air sample through piping system and through a microprocessor-controlled sequencer feeding an analyzer with a new sample every [**15**] <**Insert number**> seconds.
6. Sample time to be adjustable in 1 second increments from zero to 60 minutes.
7. Span and zero calibration gas to be automatically initiated by the microprocessor. System will also provide manual initiation of span and zero calibration gas.
8. Analyzer output to be corrected by the microprocessor.
9. Monitoring system to have [**8**] [**16**] [**24**] [**32**] sample points.
10. System to operate on 120-V ac, single-phase, 60-Hz power.
11. Final adjustment; calibration, testing, and startup of the system to be performed by a trained representative of manufacturer.

D. Analyzer:

1. Analyzer to operate using principle of nondispersive infrared absorption.
2. Sampling response time to be within 10 seconds.
3. Zero drift and span drift to be less than 1 percent of full scale within a 24-hour period.
4. Repeatability to be within 1 percent of full scale.
5. Accuracy to be within 1 percent of full scale.
6. Calibration range to be zero to 500 ppm.
7. Digital display on analyzer face with scale to be in ppm.
8. Temperature to be compensated from 30 to 120 deg F (minus 1 to 49 deg C) ambient temperature.

E. Control and Display:

1. Basis-of-Design Product: Subject to compliance with requirements, provide ACI; Automation Components, Inc. model **M-Controller**; <**Insert drawing designation**> or comparable product by one of the following:

   a. <**Insert manufacturer's name**>.

2. Agency Approvals: CSA NRTL/C, C22-205.

3. Supply Voltage: [**24 V ac, ungrounded**] [**24 V dc**].
4. Power Consumption:

    a. Standby: 1.0 A.
    b. Horn and Strobe: 0.6 A.
    c. Load per Channel: 2.0 A, maximum.
    d. Total Controller Load: 10.0 A.

5. Operating Temperature: Minus 4 to plus 122 deg F (Minus 20 to plus 50 deg C).
6. Operating Relative Humidity: 5 to 95 percent, non-condensing.
7. Programming: On-board keypad or manufacturer's configuration software.
8. Communication Protocol: Modbus Slave using Modbus RTU RS-422 port to host computer.
9. RJ-11 Telephone Jack: RS-232 interface for data transfer and communication with Building Automation System.
10. Digital Inputs: 4 parallel RS-485 ports serving up to 32 gas sensors and 99 relays.
11. Analog Inputs: 8 channels, 4 to 20 mA dc.
12. Analog Output: Eight analog outputs (4 to 20 mA dc).
13. Indicators: 5 red LEDs showing status of 3 relays, fault, and silence.
14. Display: 2 x 16 character LCD, with backlight.
15. Keypad: 4 x 4 tactile and audible.
16. Relays: 3 SPDT, dry contacts.

    a. Contact Ratings: 5.0 A, resistive at 240 V ac and 30 V dc.
    b. Contact Ratings: 3.7 A, inductive at 240 V ac and 30 V dc.

17. Time Delay: 0 to 60 minutes on-delay and off-delay, field-adjustable.
18. On-Board Buzzer: 90 dB at 12 inches 305 mm.
19. Horn/Strobe Connection: Two pairs of terminals, 24 V dc, 6 W each.
20. Enclosure: NEMA 250, Class 1.

21. Basis-of-Design Product: Subject to compliance with requirements, provide ACI; Automation Components, Inc. model Q-Controller; <**Insert drawing designation**> or comparable product by one of the following:

    a. <**Insert manufacturer's name**>.

22. Agency Approvals: UL 2017.
23. Supply Voltage: [**24 V ac, ungrounded**] [**24 V dc**].
24. Power Consumption:

    a. Standby: 0.75 A maximum, fuse protected.
    b. Horn and Strobe: 0.75 A, fuse protected.

25. Operating Temperature: Minus32 to 120 deg F (0 to 49 deg C).
26. Operating Relative Humidity, Maximum: 85 percent, up to 86 deg F (30 deg C) decreasing linearly to 50 percent at 104 deg F (40 deg C).
27. Altitude: 6561 ft (2000 m).
28. Communication Protocol: Modbus Slave using Modbus RTU RS-485, BACnet IP ports to host computer.

29. Digital Inputs: 4 parallel RS-485 ports serving up to 128 gas sensors.
30. Analog Inputs: 128 channels, 4 to 20 mA dc.
31. Relay Inputs: 128.
32. Analog Output: 128 analog outputs (4 to 20 mA dc).
33. Relay Outputs: 128.
34. Indicators:

    a. 15 LEDs showing status of power, USB and TX/RX.
    b. 4 RS-485 port TXD/RX status for sensor network.
    c. 1 RS-485 port TXD/RX status for Modbus.
    d. 1 RS-485 port TXD/RX status for BACnet Module.

35. Display: 7 inch (178 mm) LCD touchscreen, with 800 x 480 resolution.
36. Relays: 4 SPDT, plug-in, dry contacts.

    a. Contact Ratings: 10.0 A, resistive at 250 V ac and 30 V dc.
    b. Contact Ratings: 7.5 A, inductive at 250 V ac and 30 V dc.

37. Time Delay: 0 to 9999 seconds, on-delay and off-delay, field-adjustable.

    a. Set to 10 seconds at factory.

38. On-Board Buzzer: 100 dB at 4 inches 102 mm.
39. Switch Inputs: Four.
40. Horn/Strobe Connection: Two pairs of terminals, 24 V dc, 750 mA each, maximum.
41. Enclosure: NEMA 250, Class 4X.

F. Control and Display:

1. Each sample to send a 4-20 mA output signal proportional to the highest concentration.
2. Alphanumeric visual display of current analyzer concentration reading to be in ppm or another industry-accepted measurement.
3. Visual indication for sample analyzing, sample high-concentration alarm, analyzer malfunction, and calibration.
4. Any number and configuration of sample points to be capable of being bypassed.
5. Each sample point to be capable of being manually sampled through an override feature.
6. System parameters to be stored in nonvolatile memory.
7. Provide at least an eight-hour battery backup of current alarm status. Battery to be rechargeable.

G. Enclosure:

1. UL 50E, [**Type 1**] [**Type 4X**] [**or**] [**Type 12**].
2. Hinged and locking door, full size of face.
3. House all system components. Multiple adjoining enclosures are acceptable if joined to a common support structure.

H. Calibration Equipment:

1. Provide equipment necessary to automatically and manually calibrate the system, including, but not be limited to, the following:

    a. Regular assembly.
    b. Zero cap.
    c. Calibration cap.
    d. Two cylinders filled with calibration gas.
    e. Instruction book.
    f. Carrying case.

2.7 TOXIC/COMBUSTIBLE GAS TRANSMITTERS

A. Toxic/Combustible Gas Transmitters:

1. Basis-of-Design Product: Subject to compliance with requirements, provide ACI; Automation Components, Inc. model [**B5**] [**B5C**] [**Q5**] [**Q5C**] Series; <**Insert drawing designation**> or comparable product by one of the following:

1. Armstrong.
2. Honeywell.
3. MSA Instrument Division.
4. <**Insert manufacturer's name**>.

B. Description:

1. Toxic gas transmitters with [**electrochemical**] [**catalytic bead**] sensors[**, or equivalent technology**] [**, with digital display for continuous indication of current instrument reading**].

    a. Toxic Gas: [**Ammonia**] [**Arsine**] [**Carbon-dioxide**] [**Carbon-monoxide**] [**Chlorine**] [**Chlorine-dioxide**] [**Diborane**] [**Ethylene Oxide**] [**Germane**] [**Hydrogen**] [**Hydrogen bromide**] [**Hydrogen chloride**] [**Hydrogen cyanide**] [**Hydrogen sulphide**] [**Nitric oxide**] [**Nitrogen dioxide**] [**Oxygen**] [**Ozone**] [**Phosphine**] [**Silane**] [**Sulphur dioxide**].

2. Combustible gas transmitters with catalytic sensors[**, or equivalent technology**] [**, with digital display for continuous indication of current instrument reading**].

    a. Combustible Gas: [**Acetalaldehyde**] [**Acetone**] [**Acetylene**] [**Benzene**] [**Iso-Butane**] [**Butanol, n-Butane**] [**Carbon-Disulfide**] [**Diesel fuel**] [**Dioxane**] [**Ethane**] [**Ethanol**] [**Ethyl Acetate**] [**Ethylene**] [**Ethylbenzene**] [**Gasoline**] [**Heptane**] [**Hexane**] [**Hydrogen**] [**Iso-pentane**] [**Ipa**] [**Isopropanol**] [**Jet fuel**] [**Kerosene**] [**Methane**] [**Methanol**] [**Naptha**] [**Pentane**] [**Propane**] [**Propylene**] [**Styrene**] [**Toluene**] [**VOC**] [**Xylene**].

3. Analog Output: Provide one, four-wire analog output, [**4 to 20 mA dc, 600 Ohm, maximum**] [**1 to 5 V dc, 3000 Ohm, minimum**] [**2 to 10 V dc, 3000 Ohm, minimum**].
4. Agency Approval: [**UL 2075**] [**UL 61010-1**].
5. Communications Protocol: [**Modbus RTU**] [**or**] [**BACnet MS/TP**].

a. Baud Rate: [**9600**] [**19200**] [**38400**] [**76,800**].
b. Baud Rate: [**9600**] [**19200**] [**38400**] [**76,800**].

6. Relay Output: Three SPDT relays.

a. Relay Input: Provide field configurable relay that changes state in response to measured gas.
b. Relay Set Point, Toxic Gas Instruments: <**Insert value**> ppm.
c. Relay Setpoint, Combustible Gas Instruments: [**20**] [**40**] [**50**] <**Insert value**> percent LEL, with 5 percent LEL deadband.
d. Relay Contact Ratings: 1.0 A at 30 V dc or 0.3 A at 125 V ac.
e. Relay Mechanical Durability: Minimum 50,000,000 operations at 36,000 operations per hour.
f. Relay Electrical Durability: Minimum 200,000 operations at [**1800 operations per hour at rated ac load**] [**1200 operations per hour at rated dc load**].

C. Construction:

1. Polycarbonate plastic, wall-mounted enclosure; UL 50E, [**4**] [**4X**] [**12**] [**13**] [**IEC IP 66**].
2. Flame Spread: UL 94, V-0
3. Conduit Openings: Knockouts for 1/2 inch conduit fittings.
4. Display: Backlit, 7-digit LCD type, with [**Time Weighted Average (TWA)**] [**Short Term Exposure Limit (STEL)**] [**ppm**] indicator

D. Performance:

1. [**Toxic**] [**Combustible**] Gas:.

a. Toxic Gas/Range: [**Ammonia/0 to 100 ppm**] [**Ammonia/0 to 1000 ppm**] [**Arsine/0 to 1 ppm**] [**Carbon-dioxide/0 to 5000 ppm**] [**Carbon-dioxide/0 to 5 percent, by volume**] [**Carbon-dioxide/0 to 20 percent, by volume**] [**Carbon-dioxide/0 to 100 percent, by volume**] [**Carbon-monoxide/0 to 250 ppm**] [**Carbon-monoxide/0 to 1000 ppm**] [**Chlorine/0 to 5 ppm**] [**Chlorine-dioxide/0 to 2 ppm**] [**Diborane/0 to 2 ppm**] [**Ethylene Oxide/0 to 20 ppm**] [**Germane/0 to 2 ppm**] [**Hydrogen/0 to 1000 ppm**] [**Hydrogen/0 to 2000 ppm**] [**Hydrogen bromide/0 to 30 ppm**] [**Hydrogen chloride/0 to 30 ppm**] [**Hydrogen cyanide/0 to 50 ppm**] [**Hydrogen sulphide/0 to 25 ppm**] [**Hydrogen sulphide/0 to 100 ppm**] [**Nitric oxide/0 to 100 ppm**] [**Nitrogen dioxide/0 to 10 ppm**] [**Oxygen/0 to 25 percent, by volume**] [**Ozone/0 to 1 ppm**] [**Phosphine/0 to 1 ppm**] [**Phosphine/0 to 5 ppm**] [**Silane/0 to 50 ppm**] [**Sulphur dioxidee/0 to 6 ppm**].

b. Combustible Gas/Range: [**Acetone/0 to 100 percent LEL**] [**Benzene/0 to 100 percent LEL**] [**Iso-Butane/0 to 100 percent LEL**] [**Butanol, n-Butane/0 to 100 percent LEL**] [**Ethylene/0 to 100 percent LEL**] [**Hydrogen/0 to 100 percent LEL**] [**Methane/0 to 100 percent LEL**] [**Methanol/0 to 100 percent LEL**] [**Iso-Pentane/0 to 100 percent LEL**] [**Propane/0 to 100 percent LEL**] [**VOC/0 to 100 percent LEL**].

2. Ambient Temperature Range: [**14 to 122 deg F (Minus 10 to plus 50 deg C)**] [**Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C)**] [**Minus 4 to plus 104 deg F (Minus 20 to plus 40 deg C)**] <**Insert value**>.
3. Ambient Relative Humidity: 5 to 95 percent RH, non-condensing.
4. Ambient Pressure: 14.7 psig (1.0 bar), plus or minus 10 percent.
5. Altitude: 3000 ft. (914 m), maximum, without recalibration.
6. Coverage Area: [**5000 sq. ft. (465 sq. m)**] [**7500 sq. ft. (697 sq. m)**] <**Insert value**>.
7. Coverage Radius: [**40 ft. (12 m)**] [**49 ft. (15 m)**] <**Insert value**>.
8. Mounting Height: Manufacturer's recommended height, [**above finished floor**] [**below ceiling**].
9. Warm-up Time: 24 hours, minimum.
10. Power: 24 V [**ac**] [**dc**], plus or minus 20 percent.
11. Maximum Power Consumption: 8.4 VA.

E. Furnish calibration kit. Turn over to Owner at start of warranty period.

2.8 VOC SENSORS AND TRANSMITTERS

1. Basis-of-Design Product: Subject to compliance with requirements, provide ACI; Automation Components, Inc. model VOC-R Series; <**Insert drawing designation**> or comparable product by one of the following:

2. Armstrong.
3. Greystone.
4. Honeywell.
5. <**Insert manufacturer's name**>.

B. Description:

1. VOC sensor to use a metal oxide semiconductor element to sense for contaminant gases.
2. Senses and responds to combined concentration contaminants commonly found in indoor environments.

C. Output Signal, Analog: [**4 to 20 mA dc, with 500 Ohms maximum load impedance**] [**0 to 10 V dc, with 2000 Ohms minimum load impedance**].

D. Output Signal, Contact: Provide relay having [**SPDT**] [**N.O.**] dry contacts rated [**3.0 A at 30 V dc**] [**3 A at 250 V ac**], minimum. relay having dry contacts

E. Performance:

1. Measurement Range: 0 to 1000 ppb.
2. Ambient Temperature: 32 to 122 deg F (0 to 50 deg C).
3. Ambient Relative Humidity: 10 to 95 percent, non-condensing.

F. Enclosure: ABS plastic.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.

C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.

D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION, GENERAL

A. Furnish and install products required to satisfy more stringent of all requirements indicated.

B. Install products level, plumb, parallel, and perpendicular with building construction.

C. Properly support instruments, tubing, piping, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to seismic loads.

D. Fastening Hardware:

1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

E. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.

F. Corrosive Environments:

1. Use products that are suitable for environment to which they are subjected.
2. If possible, avoid or limit use of materials in corrosive environments, including but not limited to, the following:

a. Laboratory exhaust airstreams.
b. Process exhaust airstreams.
c. <**Insert requirements**>.

3. When conduit is in contact with a corrosive environment, use Type 316 stainless steel conduit and fittings or conduit and fittings that are coated with a corrosive-resistant coating that is suitable for environment.
4. Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a UL 50E, Type 4X enclosure constructed of Type 316L stainless steel.

3.3 ELECTRICAL CONNECTIONS

A. Furnish and install electrical power to products requiring electrical connections.

B. Furnish and install circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."

C. Furnish and install power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

D. Furnish and install raceways. Comply with requirements in Section 260533.13 "Conduits for Electrical Systems."

3.4 INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS

A. Mounting Location:

1. Install transmitters for gas associated with individual air-handling units and associated connected ductwork and piping near air-handlings units co-located in air-handling unit system control panel, to provide service personnel a single and convenient location for inspection and service.
2. Install gas switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.
3. Mount switches and transmitters not required to be mounted within system control panels on walls, floor-supported freestanding pipe stands, or floor-supported structural support frames. Use manufacturer's mounting brackets to accommodate field mounting. Securely support and brace products to prevent vibration and movement.
4. Install instruments in dry gas and non-condensable vapor piped services above their process connection point. Slope process connection lines up to instrument with a minimum slope of [**2**] [**3**] <**Insert number**> percent.

B. Mounting Height:

1. Mount instruments in user-occupied space to match mounting height [**of light switches unless otherwise indicated on Drawings**] [**in accordance with manufacturer's published mounting instructions**]. Mounting height to comply with codes and accessibility requirements.
2. Mount switches and transmitters located in mechanical equipment rooms and other similar space not subject to code, state, and federal accessibility requirements within a range of 42 to 72 inches (1.1 to 1.6 m) above the adjacent floor, grade, or service catwalk or platform.

a. Make every effort to mount at 60 inches (1.5 m).

C. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated, using neoprene gaskets or grommets.

3.5 INSTALLATION OF CARBON-DIOXIDE SENSORS

A. Install transmitters in monitored area to provide accurate measurement of CO_2 concentration.

B. Install transmitters with a finished appearance consistent with other materials in space. Submit product data for products to be installed.

C. Connect power and signal wiring in accordance with manufacturer's printed instructions and NFPA 70.

3.6 INSTALLATION OF CARBON-MONOXIDE MONITORING SYSTEM

A. Install sample points in monitored area to provide accurate measurement of gas concentration.

B. Install exposed sampling points with a finished appearance consistent with other materials in space. Submit proposed products to be installed for review and approval.

C. Individually install each sample point to the carbon-monoxide monitoring system.

D. Install tubing in a minimum size of NPS 3/8 (DN 10).

E. Use compression fittings at connections to equipment.

F. If not indicated on Drawings, locate carbon-monoxide monitoring system in a secured and serviceable location accessible to authorized personnel.

G. Support carbon-monoxide monitoring system from floor or wall. Support floor-mounted systems using a structural channel frame. Provide mounting brackets.

3.7 OXYGEN MONITORING SYSTEM

A. Install monitor in space to provide an accurate measurement of gas concentration.

B. Support oxygen-monitoring system from wall.

3.8 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Designate each piece of wire, cable, and tubing with same designation at each end. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

B. Install engraved phenolic nameplate with instrument identification on face.

3.9 CHECKOUT PROCEDURES

A. Check out installed products before continuity tests and calibration.

B. Check instruments for proper location and accessibility.

C. Comply with manufacturer's published installation and operating instructions.

D. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.

3.10 ADJUSTMENT, CALIBRATION, AND TESTING

A. Description:

1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
3. Calibrate each instrument in accordance with instrument instruction manual supplied by manufacturer.
4. Comply with field-testing requirements and procedures in ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

B. Analog Signals:

1. Check analog voltage signals using a precision voltage meter at zero.
2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.

C. Digital Signals:

1. Verify output(s) at building automation system.

D. Meters: Check sensors at zero, 50, and 100 percent of Project design values.

E. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.

F. Switches: Calibrate switches to make or break contact at set points indicated.

G. Transmitters:

1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.11 MAINTENANCE SERVICE

A. Maintenance Service: Beginning at Substantial Completion, maintenance service to include [**three**] [**six**] [**nine**] [**12**] months' full maintenance by [**skilled employees of gas system and equipment Installer**] [**manufacturer's authorized service representative**]. Include [**monthly**] [**quarterly**] [**semiannual**] [**annual**] preventive maintenance, repair or replacement of worn or defective components, cleaning, and adjusting as required for proper operation. Parts and supplies will be manufacturer's authorized replacement parts and supplies.

3.12 DEMONSTRATION

A. [**Engage a factory-authorized service representative to train**] [**Train**] Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.

B. Coordinate gas instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.

C. Record videos on DVD disks.

D. Certify Owner's right to make additional copies of video for internal use without paying royalties or other charges.

END OF SECTION 230923.16