SECTION 230923.16 - GAS INSTRUMENTS

Revise this Section by deleting and inserting text to meet Project-specific requirements.

Verify that Section titles referenced in this Section are correct for this Project's Specifications; Section titles may have changed.

1. GENERAL
   * + 1. RELATED DOCUMENTS

Retain or delete this article in all Sections of Project Manual.

* + - * 1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
      1. SUMMARY
         1. Section Includes the Following Gas Instruments:

Carbon-dioxide sensors and transmitters.

Combination carbon-dioxide and VOC sensors and transmitters.

Single-point oxygen monitoring system.

Multipoint carbon-monoxide monitoring system.

VOC sensors and transmitters.

* + - * 1. Related Requirements:

Retain subparagraphs below to cross-reference requirements Contractor might expect to find in this Section but are specified in other Sections.

Section 230923 "Direct-Digital Control System for HVAC" for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, and cable.

Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 230923.16.

* + - 1. DEFINITIONS
         1. NDIR: Nondispersive infrared.
      2. SUBMITTALS
         1. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.
         2. Manufacturer’s installation instructions shall be provided along with product data.
         3. Submittals shall be provided in the order in which they are specified and tabbed (for combined submittals).
         4. Product Data: For each type of product, including the following:

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.

Installation instructions, including factor affecting performance.

Product description with complete technical data, performance curves, product specification sheets.

* + - * 1. Sustainable Design Submittals:
        2. Shop Drawings:

Include plans, elevations, sections, and [**mounting**]details.

Include diagrams for power, signal, and control wiring.

Number-coded identification system for unique identification of wiring, cable, and tubing ends.

Retain "Samples" paragraph below for single-stage Samples, with a subordinate list if applicable.

* + - * 1. Samples: For each exposed product installed in finished space.

Retain "Coordination Drawings" paragraph below for situations where limited space necessitates maximum utilization for efficient installation of different components or if coordination is required for installation of products and materials by separate installers. Coordinate paragraph with other Sections specifying products listed below. Preparation of coordination drawings requires the participation of each trade involved in installations within the limited space.

* + - * 1. 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.
        2. Product Test Reports: For each product, for tests performed by [**manufacturer and witnessed by a qualified testing agency**] [**a qualified testing agency**].
      1. CLOSEOUT SUBMITTALS
         1. Operation and Maintenance Data: For gas instruments to include in operation and maintenance manuals.

1. PRODUCTS

See Editing Instruction No. 1 in the Evaluations for cautions about named manufacturers and products. For an explanation of options and Contractor's product selection procedures, see Section 016000 "Product Requirements."

* + - 1. CARBON-DIOXIDE SENSORS AND TRANSMITTERS

* + - * 1. [Manufacturers:](http://www.specagent.com/Lookup?ulid=9874) Subject to compliance with requirements, provide products by one of the following:

[Building Automation Products Inc.; BAPI](http://www.specagent.com/Lookup?uid=123457048773).

[Telaire; a brand of Amphenol Thermometrics Inc](http://www.specagent.com/Lookup?uid=123457048772).

[Vaisala](http://www.specagent.com/Lookup?uid=123457048770).

[Veris Industries](http://www.specagent.com/Lookup?uid=123457048771).

Approved equivalent.

Requirements in remaining paragraphs below are based on Vaisala's "GMW 20 series" for wall-mounted space applications and its "GMD 20 series" for duct-mounted applications.

* + - * 1. Description:

NDIR technology or equivalent technology providing long-term stability and reliability.

Two-wire, 4-20 mA output signal, linearized to carbon-dioxide concentration in ppm.

* + - * 1. Construction:

House electronics in an ABS plastic enclosure. Provide equivalent of NEMA 250, Type 1 enclosure for wall-mounted space applications and NEMA 250, Type 4 for duct-mounted applications.

Equip with digital display for continuous indication of carbon-dioxide concentration.

* + - * 1. Performance:

Measurement Range: Zero to 2000 ppm.

Accuracy: Within 2 percent of reading, plus or minus 30 ppm.

Repeatability: Within 1 percent of full scale.

Temperature Dependence: Within 0.05 percent of full scale over an operating range of 25 to 110 deg F (minus 4 to 43 deg C).

Long-Term Stability: Within 5 percent of full scale after more than five years.

Response Time: Within 60 seconds.

Warm-up Time: Within five minutes.

* + - * 1. Provide calibration kit. Turn over to Director’s Representative at start of warranty period.
      1. COMBINATION CARBON-DIOXIDE AND VOC SENSORS AND TRANSMITTERS

* + - * 1. [Manufacturers:](http://www.specagent.com/Lookup?ulid=9875) Subject to compliance with requirements, provide products by the following:

Honeywell

Johnson Controls

[Siemens Industry, Inc., Building Technologies Division](http://www.specagent.com/Lookup?uid=123457048775).

Approved equivalent.

Requirements in remaining paragraphs below are based on Siemens' "QPA20 series."

* + - * 1. Description:

NDIR technology or equivalent technology that provides long-term stability and reliability.

Senses and responds to combined concentration of more than 30 contaminates commonly found in indoor environments.

* + - * 1. Output Signal: Zero to 10-V dc.
        2. Performance:

Carbon-Dioxide Range: Zero to 2000 ppm.

Carbon-Dioxide Accuracy: Within 50 ppm, plus 2 percent measured value.

VOC Range: Zero to 2000 ppm.

VOC Sensitivity Ranges: Field selectable, low, normal, high.

Ambient Temperature: 32 to 122 degrees F.

Ambient Relative Humidity: 5 to 95 percent non-condensing.

* + - * 1. Enclosure: White plastic.
        2. Electrical Connections: Screw terminals.

Retain "Display" paragraph below for display.

* + - * 1. Display: Digital, LCD.
      1. SINGLE-POINT OXYGEN MONITORING SYSTEM

This article is intended for single-point continuous monitoring and can be used as a guide for other gases. See manufacturers' product literature. Where monitoring of multiple sample points of same gas is required, consider a centralized system capable of monitoring multiple points from a single sensor suite. See "Multipoint Carbon-Monoxide Monitoring System" Article.

* + - * 1. [Manufacturers:](http://www.specagent.com/Lookup?ulid=9876) Subject to compliance with requirements, provide products by the following:

Johnson Controls

[MSA Instrument Division](http://www.specagent.com/Lookup?uid=123457048777).

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in remaining paragraphs below are based on MSA's "Toxgard II Monitor System."

* + - * 1. Description:

System shall 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.

System shall require no periodic maintenance other than periodic checking of sensor response to a known concentration of gas.

System shall be designed to provide for installation, setup, and start-up from outside of unit enclosure without need to open the enclosure door.

System shall be factory calibrated and ready for operation after installation.

Monitor shall be internally wired to accommodate a single-point field power connection.

* + - * 1. Performance:

Range: Full scale, zero to 25 percent oxygen.

Zero Drift: Within 1 percent per year.

Span Drift: Within 10 percent per year.

Repeatability: Within 1 percent of full scale.

Linearity: Within 2 percent of full scale.

Step Change Response Time: Within 12 seconds.

* + - * 1. Enclosure:

NEMA 250, Type 4X.

Access to the inside of enclosure, as well as to controller, display, and wiring connections, shall be through full-length door on front of enclosure.

Door with shatterproof window sized to provide viewing of visual display and indicator lights.

Equip enclosure with mounting brackets for the purpose of attaching the unit to a flat surface.

Provide door with key lock access to inside enclosure.

* + - * 1. Controller:

Password-protected access through full-function keypad.

Set:

Real-time clock.

Alarm levels.

Change span-gas values.

Display date of last calibration.

Display minimum, maximum, and average gas values.

Change address, future calibration time, and date.

Automatic return-to-normal-operation feature after calibration.

Date stamps last successful calibration.

Time and date stamps events.

Selectable lockout of output signals during calibration.

Logs minimum, maximum, and average gas concentrations over selected time intervals.

* + - * 1. Visual Display:

Four-digit LED or backlight LCD display visible from front face of enclosure.

Value displayed shall be a direct reading of gas concentration.

Displays system status indicators.

Visual Alarm Indication:

Three separate alarm levels: Caution, Warning, and Alarm.

Separate strobes for Warning and Alarm conditions. Externally mount the two strobes on top of enclosure.

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

Displays average, minimum, and maximum gas concentrations of the sensor over selected time.

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.

* + - * 1. Audible Alarm:

Provides an audible horn when an alarm condition occurs.

Horn shall be rated for 95 dB with selectable output tones.

Mount horn inside or on exterior of enclosure.

Activate horn through a horn relay. Horn relay shall be form "A" contacts and set as normally open and common.

* + - * 1. Operator Interface:

Door Audible Alarm Acknowledge Switch:

Push-button switch located on front door shall silence audible alarm.

Switch shall reset latched alarms if normal gas conditions exist. Visual alarms shall remain on as long as alarms are exceeded.

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

Display range value.

Latching or nonlatching mode for the alarm set points.

Upscale or downscale acting alarms.

* + - * 1. Output Signal:

Relays:

Provide one relay for each set-point level for each of the three alarm levels.

Provide one relay for fault conditions.

Alarm and fault relays shall be form "C," SPDT. Contacts shall be rated for 5 A resistive at 250-V ac or 30-V dc.

Contacts shall be capable of being selected normally open or normally closed.

Alarm relays shall be normally de-energized. The fault relay shall be normally energized.

Retain "Analog Output" or "Digital Communication" Subparagraph below. "Analog Output" Subparagraph is intended for minimal interface.

Analog Output:

Two-wire, 4- to 20-mA, [**isolated**] [**nonisolated**] [**isolated or nonisolated**] current source.

Signal capable of operating into a 600-ohm load.

Retain "Digital Communication" Subparagraph below for full interface through serial communication. Coordinate with control system.

Digital Communication:

Bidirectional sending and receiving of digital signals.

Digital signals shall comply with FTT-10-based communication.

Protocol shall be LonTalk supported by Lon Works.

Signal speed shall be no greater than 78.1 kBs per second.

* + - * 1. Sensor:

Electrochemical fuel-cell type does not require periodic addition of reagents.

Sensor shall be replaceable without the need for tools.

Sensors shall have a minimum useful life of one year. Replace failed sensors at no charge within first year.

Mount sensor externally on the side or bottom of enclosure. Where indicated on Drawings, mount sensor remote from enclosure.

Remote Mounting:

Provide sensor in a separate enclosure. Enclosure shall be NEMA 250, Type 4X, except when sensor is installed in a hazardous location, then enclosure shall be an explosion-proof type suitable for the application.

Provide sensor with cable for connecting to monitor.

Provide sensor with mounting hardware suitable for application.

For duct-mounted applications, the sensor installation shall provide kit for calibration of the sensor without removing sensor from duct.

* + - * 1. Gas Sampling Pump:

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.

Signal to the sensor from the pump shall be in digital communication format to eliminate radio-frequency interference (RFI) and electromagnetic interference (EMI).

A flow sensor shall activate a relay when the gas sample falls below the acceptable flow rate to the sensor and shall indicate a loss of gas flow on the display.

Introduction of a calibration gas to the gas sensor shall be through an integral push-button valve. This push-button valve shall return to monitoring the sampled area when released.

Retain "Battery Backup" Paragraph below for battery backup. Below is an option and not generally needed.

* + - * 1. Battery Backup:

Provide battery backup power supply to continue normal operation if normal power source is interrupted.

Transfer to battery backup shall be automatic and shall be indicated on the display.

Mount battery backup power supply inside enclosure.

Battery backup shall be continuously charged during normal operation.

Battery life shall be at least 0.5 hours with strobes flashing, alarm conditions asserted, and horn sounding.

* + - * 1. Calibration:

Calibrate and adjust functions through nonintrusive hand-held wireless remote control without opening enclosure door.

Enter calibration mode through hand-held wireless remote control unit. The display of the monitor shall instruct the user on when to apply zero and span gas. The system shall automatically adjust its internal settings to the proper calibration values without further intervention by the user. On completion of a successful calibration, the system shall 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 shall show an unsuccessful calibration attempt and revert to its previous calibration settings.

Wireless method shall employ a digitally encoded infrared light beam.

Retain one of first two subparagraphs below.

Hand-held wireless remote control shall let the user perform sensor zeroing and calibration.

Hand-held wireless remote control shall let the user perform sensor zeroing and calibration, as well as activate all functions and features of the monitor.

The monitor infrared link shall not be affected by natural and man-made low-level ambient light.

Retain "Automatic Calibration System" Paragraph below for automatic calibration. Automatic calibration is an option. Coordinate with "Calibration" Paragraph above.

* + - * 1. Automatic Calibration System:

Provide automatic calibration of all oxygen monitors installed. Number of automatic calibration systems shall be determined by supplier based on location and quantity of oxygen monitors.

Automatic calibration system shall, without manual intervention, periodically perform a complete calibration of the sensor.

System shall exchange digital signals with sensor.

Automatic calibration shall be adjustable from as many as three times per day to only once every 30 days.

Sensor alarms shall be suppressed or disabled until the automatic calibration cycle is completed.

Manual calibration of the sensor shall be initiated at any time with a hand-held infrared remote control without the need to disable or turn off the automatic calibration system.

House the system in a separate NEMA 250, Type 4X enclosure from the oxygen monitoring system. Enclosure shall have provisions for wall mounting.

Digital displays shall indicate zero and when span gas is being applied to the sensor, the status, and any fault condition.

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 shall light the fault indicator.

* + - 1. MULTIPOINT CARBON-MONOXIDE MONITORING SYSTEM

This article can also be used as a guide for other gases. Refer to manufacturer product literature.

* + - * 1. [Manufacturers:](http://www.specagent.com/Lookup?ulid=9877) Subject to compliance with requirements, provide products by one of the following:

[Building Automation Products Inc.; BAPI](http://www.specagent.com/Lookup?uid=123457058437).

[MSA Instrument Division](http://www.specagent.com/Lookup?uid=123457048779).

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in remaining paragraphs below are based on MSA's "MultiGard."

* + - * 1. Description:

Each sampling point shall monitor any variation in the carbon-monoxide concentration level.

Each sampling point shall be individually piped to the monitoring system.

Provide [**each**]sampling point with a 0.3-micron filter.

Each sampling point shall be an alarm point.

A dual-head diaphragm pump shall 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.

Sample time shall be adjustable in 1 second increments from zero to 60 minutes.

Span and zero calibration gas shall be automatically initiated by the microprocessor. System shall also provide manual initiation of span and zero calibration gas.

Analyzer output shall be corrected by the microprocessor.

Monitoring system shall have [**8**] [**16**] [**24**] [**32**] sample points.

System shall operate on 120-V ac, single-phase, 60-Hz power.

Final adjustment; calibration, testing, and startup of the system shall be performed by a trained representative of company field advisor.

* + - * 1. Analyzer:

Analyzer shall operate using principle of nondispersive infrared absorption.

Sampling response time shall be within 10 seconds.

Zero drift and span drift shall be less than 1 percent of full scale within a 24-hour period.

Repeatability shall be within 1 percent of full scale.

Accuracy shall be within 1 percent of full scale.

Calibration range shall be zero to 500 ppm.

Digital display on analyzer face with scale shall be in ppm.

Temperature shall be compensated from 30 to 120 deg F (minus 1 to 49 deg C) ambient temperature.

* + - * 1. Control and Display:

Each sample shall send a 4-20 mA output signal proportional to the highest concentration.

Alphanumeric visual display of current analyzer concentration reading shall be in ppm or another industry-accepted measurement.

Visual indication for sample analyzing, sample high-concentration alarm, analyzer malfunction, and calibration.

Any number and configuration of sample points shall be capable of being bypassed.

Each sample point shall be capable of being manually sampled through an override feature.

System parameters shall be stored in nonvolatile memory.

Provide at least an eight-hour battery backup of current alarm status. Battery shall be rechargeable.

* + - * 1. Enclosure:

NEMA 250, [**Type 1**] [**or**] [**Type 12**].

Hinged and locking door, full size of face.

House all system components. Multiple adjoining enclosures are acceptable if joined to a common support structure.

* + - * 1. Calibration Equipment:

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

Regular assembly.

Zero cap.

Calibration cap.

Two cylinders filled with calibration gas.

Instruction book.

Carrying case.

* + - 1. VOC SENSORS AND TRANSMITTERS

* + - * 1. [Manufacturers:](http://www.specagent.com/Lookup?ulid=9878) Subject to compliance with requirements, provide products by the following:

[Building Automation Products Inc.; BAPI](http://www.specagent.com/Lookup?uid=123457048781).

Johnson Controls

Siemens Industry, Inc., Building Technologies Division

Approved equivalent.

Requirements in remaining paragraphs below are based on Building Automation's "BA/AQS."

* + - * 1. Description:

VOC sensor shall use an oxidizing element that varies resistance with contaminant gases.

Senses and responds to combined concentration of more than 30 contaminates commonly found in indoor environments.

* + - * 1. Output Signal: Zero to [**5**] [**or**] [**10**]-V dc with minimum load resistance of 4000 ohms.
        2. Performance:

Measurement Range: Zero to 100 percent.

Ambient Temperature: 32 to 140 deg F (zero to 60 deg C).

Ambient Relative Humidity: 5 to 95 percent non-condensing.

* + - * 1. Enclosure: Lexan.

1. EXECUTION
   * + 1. EXAMINATION
          1. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
          2. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
          3. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
          4. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
          5. Proceed with installation only after unsatisfactory conditions have been corrected.
       2. INSTALLATION, GENERAL
          1. Provide products required to satisfy more stringent of all requirements indicated.
          2. Install products level, plumb, parallel, and perpendicular with building construction.
          3. 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.
          4. Fastening Hardware:

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.

Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.

Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.

* + - * 1. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Director’s Representative's access, confirm unrestricted ladder placement is possible under occupied condition.
        2. Corrosive Environments:

Use products that are suitable for environment to which they are subjected.

If possible, avoid or limit use of materials in corrosive environments, including but not limited to, the following:

Laboratory exhaust airstreams.

Process exhaust airstreams.

<**Insert requirements**>.

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.

Where instruments are located in a corrosive environment and are not corrosive resistant from manufacturer, field install products in a NEMA 250, Type 4X enclosure constructed of Type 316L stainless steel.

* + - 1. ELECTRICAL POWER
         1. Provide electrical power to products requiring electrical connections.
         2. Provide circuit breakers. Comply with requirements in Section 262816 "Enclosed Switches and Circuit Breakers."
         3. Provide power wiring. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
         4. Provide raceways. Comply with requirements in Section 260533 "Raceways and Boxes for Electrical Systems."
      2. INSTRUMENTS, GENERAL INSTALLATION REQUIREMENTS
         1. Mounting Location:

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.

Install gas switches and transmitters for indoor applications in mechanical equipment rooms. Do not locate in user-occupied space unless indicated specifically on Drawings.

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.

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.

* + - * 1. Mounting Height:

Mount instruments in user-occupied space to match mounting height of light switches unless otherwise indicated on Drawings. Mounting height shall comply with codes and accessibility requirements.

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.

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

* + - * 1. 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.
      1. CARBON-MONOXIDE MONITORING SYSTEM

Indicate area to be monitored on Drawings.

* + - * 1. Install sample points in monitored area to provide accurate measurement of gas concentration.
        2. Install exposed sampling points with a finished appearance consistent with other materials in space. Submit proposed products to be installed for review and approval.
        3. Individually install each sample point to the carbon-monoxide monitoring system.
        4. Install tubing in a minimum size of NPS 3/8 (DN 10).
        5. Use compression fittings at connections to equipment.
        6. If not indicated on Drawings, locate carbon-monoxide monitoring system in a secured and serviceable location accessible to authorized personnel.
        7. Support carbon-monoxide monitoring system from floor or wall. Support floor-mounted systems using a structural channel frame. Provide mounting brackets.
      1. OXYGEN MONITORING SYSTEM

Indicate area to be monitored on Drawings.

* + - * 1. Install monitor in space to provide an accurate measurement of gas concentration.
        2. Support oxygen monitoring system from wall.
      1. IDENTIFICATION
         1. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
         2. Install engraved phenolic nameplate with instrument identification on face.
      2. CHECKOUT PROCEDURES
         1. Check out installed products before continuity tests, leak tests, and calibration.
         2. Check instruments for proper location and accessibility.
         3. Check instruments for proper installation on direction of flow, elevation, orientation, insertion depth, or other applicable considerations that impact performance.
         4. Check instrument tubing for proper isolation, fittings, slope, dirt legs, drains, material, and support.
      3. ADJUSTMENT, CALIBRATION, AND TESTING
         1. Description:

Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.

Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.

For each analog instrument, perform a three-point calibration test for both linearity and accuracy.

Equipment and procedures used for calibration shall comply with instrument manufacturer's written recommendations.

Provide diagnostic and test equipment for calibration and adjustment.

Field instruments and equipment used to test and calibrate installed instruments shall have an accuracy of at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.

Calibrate each instrument according to instrument instruction manual supplied by manufacturer.

If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.

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.

* + - * 1. Analog Signals:

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

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

Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.

* + - * 1. Digital Signals:

Check digital signals using a jumper wire.

Check digital signals using an ohmmeter to test for contact.

* + - * 1. Meters: Check sensors at zero, 50, and 100 percent of Project design values.
        2. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.
        3. Switches: Calibrate switches to make or break contact at set points indicated.
        4. Transmitters:

Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.

Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

* + - 1. MAINTENANCE SERVICE

Verify, with Owner, that maintenance service is required for Project.

* + - * 1. Maintenance Service: In addition to the contractors 1-year project warranty requirements, beginning at Substantial Completion, maintenance service shall 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 shall be manufacturer's authorized replacement parts and supplies.
      1. DEMONSTRATION
         1. [**Engage a factory-authorized service field advisor to train**] [**Train**] Director’s Representative's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.
         2. Coordinate gas instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Director’s Representative in operating, maintaining, and troubleshooting.
         3. Record videos on DVD disks.
         4. Director’s Representative shall have right to make additional copies of video for internal use without paying royalties.
         5. Director’s Representative shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 230923.16