

# Technical Information

## Raman Rxn5



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## Function and system design

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### Analyzer technology

The Raman Rxn5 analyzer is a turnkey laser-based Raman analyzer developed for applications in the petrochemical and other process markets. In these applications, the Raman Rxn5 analyzer produces spectra that resembles a chromatogram from a gas chromatography (GC) system, which can be analyzed using similar univariate methods commonly used in the analysis of chromatographic data. The Raman Rxn5 analyzer can be used to determine the composition of gas mixtures, but without the need for any valves, ovens, columns, or carrier gases that lead to the higher operational expense of GC systems.

Fiber-optic probes (for both gases and liquids) are used to interface the Raman Rxn5 analyzer to the process sample. The Raman Rxn5 features four independent probes operating simultaneously, replacing the need for mechanical stream switching often used in multi-stream analyses with a single instrument. In addition, the analyzer allows for the application of four independent software methods for analyzing different stream compositions. It is like having four analyzers in one unit.

The Raman Rxn5 analyzer can measure gas mixtures containing several components. Typical gases that can be analyzed include: H<sub>2</sub>, N<sub>2</sub>, O<sub>2</sub>, CO, CO<sub>2</sub>, H<sub>2</sub>S, CH<sub>4</sub>, C<sub>2</sub>H<sub>4</sub>, C<sub>2</sub>H<sub>6</sub>, Cl<sub>2</sub>, F<sub>2</sub>, HF, BF<sub>3</sub>, SO<sub>2</sub>, and NH<sub>3</sub>. In addition, the Raman Rxn5 has a wide linear dynamic range and can measure components at levels typically from 0.1 mol % up to 100 mol %.

The Raman Rxn5 analyzer incorporates a flat screen, touch-sensitive display that is utilized for all user interactions. A simple tap with a finger is the equivalent of a mouse click.

### Raman RunTime

Raman RunTime is the embedded control software installed on all the Raman Rxn5 analyzers. It is intended for easy integration with standard multivariate analysis and automation platforms to enable a real-time, in situ process monitoring and control solution. Raman RunTime presents a Modbus interface which provides clients with analyzer data as well as analyzer control functions. Refer to the *Raman RunTime Operating Instructions (BA02180C)* for complete instructions on configuring and using the Raman Rxn5 with Raman RunTime.

Front view

The front of the Raman Rxn5 analyzer is shown below.

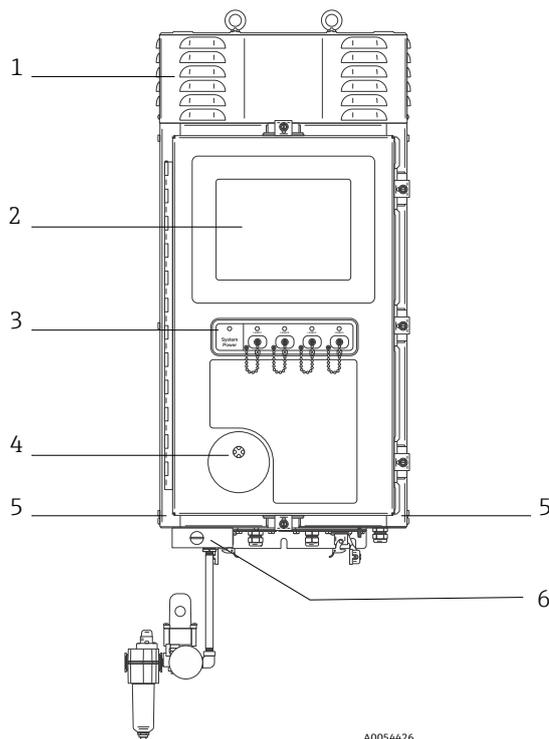


Figure 1. Raman Rxn5 analyzer front view

| # | Name   | Description  |
|---|--|--|
| 1 | Cooling exhaust vent shroud                  | Cooling air exhausts through the vents in this cover. Do not block.  |
| 2 | Touchscreen monitor                          | The built in Raman RunTime interface and touchscreen monitor.  |
| 3 | Switch indicator panel and laser on/off keys | <ul style="list-style-type: none"> <li>▪ <b>System power indicator.</b> Green and steady indicates system is powered and operating normally. Red and fast flashing indicates system is powered, but internal temperature is too warm. Red and slow flashing indicates that the system is too cold. Red and slow is normal upon startup in colder environments.</li> <li>• <b>Laser on/off keys and indicators.</b> Magnetically coupled switches control laser power for each channel. Switches are lockout/tagout compatible. Yellow indicators for each channel indicate if laser is on.</li> </ul>  |
| 4 | Purge indicator                              | A <b>Green</b> indicator light that indicates that the pressure inside the enclosure is above 5.1 mm (0.20 in) water column.   |
| 5 | Cooling air inlet                            | Cooling air enters in this location in both sides of enclosure. Do not block.  |
| 6 | Purge valve and purge air conditioning       | <p>The dilution and leakage compensation includes two modes:</p> <ul style="list-style-type: none"> <li>▪ <b>High flow dilution.</b> The dial on the valve should be turned so the slot in the dial is horizontal and lined up with the “ON” position. This position is used to purge enclosure of potentially hazardous gases prior to power-up. Dilution time is &gt; 9.5 minutes.</li> <li>▪ <b>Leakage compensation mode.</b> After manual dilution has been performed, the valve can be switched to this mode by turning the dial so the slot in the dial is vertical. This position is used to reduce purge air consumption after initial dilution.</li> </ul> |

**Interior view**

The interior of the Raman Rxn5 analyzer is shown below.

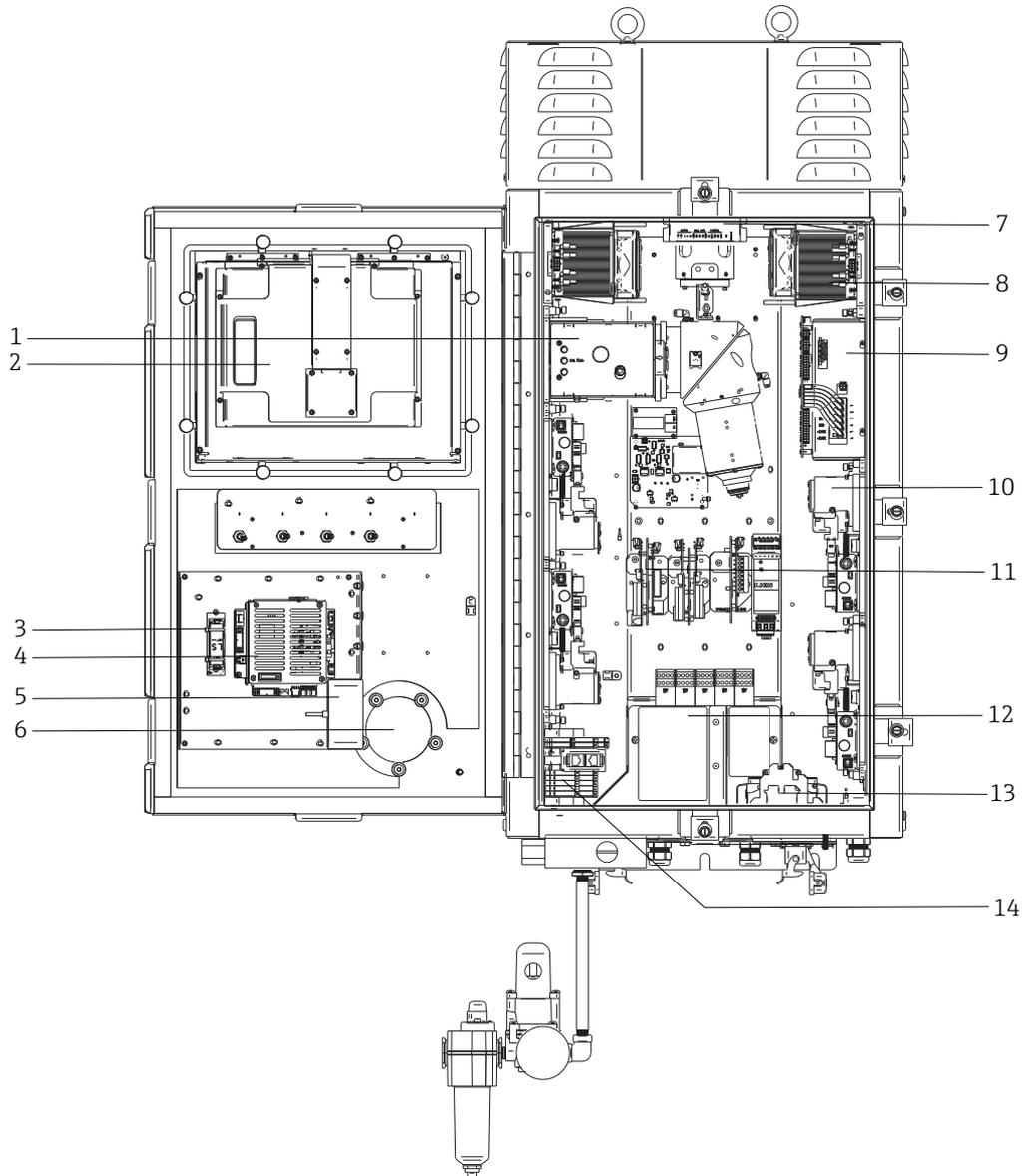


Figure 2. Raman Rxn5 analyzer interior view

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| #  | Name                           | Description   |
|----|--------------------------------|---|
| 1  | Detection module               | The location where collected Raman scattered light from the sample is analyzed. There are four analysis channels in the detection module.   |
| 2  | Touchscreen monitor            | Touchscreen monitor for Raman RunTime interface.  |
| 3  | Real time clock backup battery | <p>Backup battery for real time clock in the embedded controller.<br/>           Cell type: 3.6V AA sized Li-SOCI2</p> <p>The warning label on the front of the analyzer is in reference to this battery. Use only the manufacturer and type listed below for the Raman Rxn5.</p> <div style="border: 1px solid black; padding: 10px; text-align: center;"> <p>WARNING</p> <p>THIS ASSEMBLY CONTAINS A BATTERY</p> <p>MFR/TYPE: SAFT/LS 14500.</p> <p>REPLACEMENT BATTERIES MUST BE IDENTICAL.</p> <p>FAILURE TO OBSERVE THIS WARNING WILL INVALIDATE</p> <p>THE GOVERNING CERTIFICATES.</p> </div> |
| 4  | Embedded controller            | System controller with Raman RunTime.   |
| 5  | USB hub                        | USB ports for attachment of USB flash drive and input devices during service procedures.  |
| 6  | Purge indicator/relief valve   | Monitors internal enclosure purge pressure and provides enclosure over-pressure relief valve. A <b>Green</b> indicator light that indicates that the pressure inside the enclosure is above 5.1 mm (0.20 in) water column.  |
| 7  | Motor controller               | A device that regulates the speed and direction of the cooling fan motor.   |
| 8  | Coolers                        | Peltier cooling devices to remove waste heat from electronics inside the enclosure.   |
| 9  | Power supply                   | Main power supply which provides DC power for all electronics inside the enclosure.   |
| 10 | Lasers (4)                     | The Rxn5 includes up to 4 lasers, depending on the configuration ordered.   |
| 11 | Control electronics            | Analyzer internal sensor signal conditioning and digitization electronics. Thermal control electronics and intrinsically safe (IS) barrier power supply also reside here.   |
| 12 | IS input/output (I/O) area     | Probe fiber interlock and temperature/pressure sensor connection area.  |
| 13 | AC mains distribution          | Customer supplied mains power is connected here. Mains power is distributed to additional internal components via factory installed terminal blocks and wiring.   |
| 14 | Non-IS low voltage I/O area    | <p>Connection area for the following non-IS I/O:</p> <ul style="list-style-type: none"> <li>• (2) RS-485 Modbus RTU</li> <li>• (2) TCP/IP for Modbus TCP or remote control</li> <li>• (4) DC 24 V sampling valve driver</li> </ul>  |

**Bottom view**

The bottom view of the Raman Rxn5 is shown below. This is the location for all electro-optical and electrical I/O.

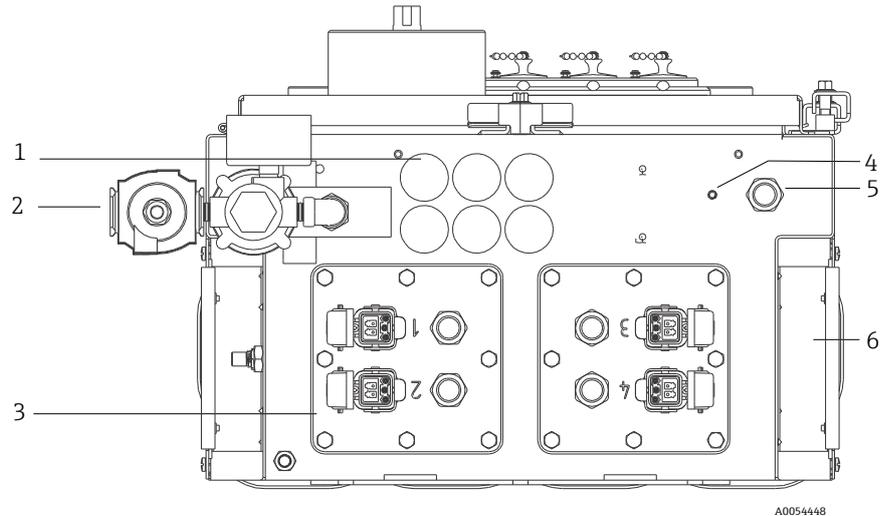
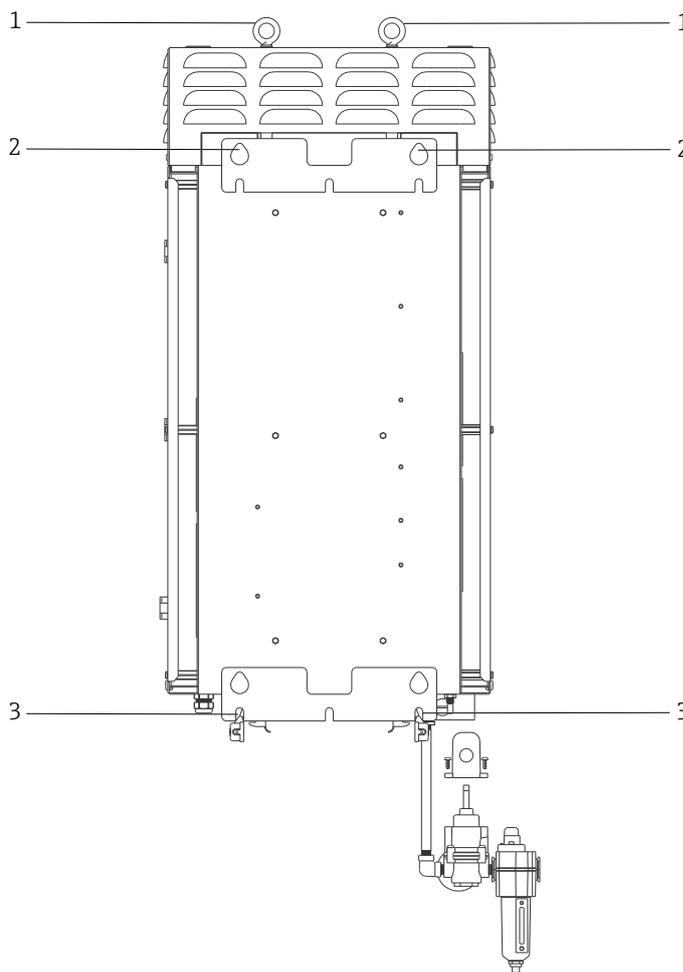


Figure 3. Raman Rxn5 analyzer bottom view

| # | Name                     | Description  |
|---|--------------------------|--|
| 1 | Low voltage I/O location | 6 holes for low voltage communications and process control wiring. Cord grips provided by customer and must meet local electrical and hazardous area safety standards. |
| 2 | Purge air inlet          | 1/4" NPT connection point for purge air supply   |
| 3 | IS I/O location          | I/O panels include up to four electro-optical connectors for sampling probes and cord grips for sample environmental sensors.  |
| 4 | Earth ground stud        | 1/4"-20 x 0.75" enclosure earth ground stud  |
| 5 | AC mains inlet           | Cord grip location for AC mains power connection   |
| 6 | Cooling air inlet        | A cooling air inlet is located on each side of the enclosure. Do not block.  |

**Rear view**

The rear view of the Raman Rxn5 is shown below.



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Figure 4. Raman Rxn5 analyzer rear view

| # | Name                  | Description  |
|---|-----------------------|--|
| 1 | Lift rings            | Two lifting rings for use when wall mounting the enclosure.                      |
| 2 | Upper mounting points | Two teardrop mounting points to hang the enclosure on supplied mounting bullets. |
| 3 | Lower mounting slots  | Two slots to secure enclosure to wall using standard hardware.                   |

## Installation

### Wall mounting framing

The Raman Rxn5 is wall mounted and includes the special hardware required for mounting to the Unistrut 1¼" width metal framing. The mounting structure must be constructed as shown below, with upper mounting bolts fully tightened and properly spaced. Nut plates for the lower mounting points should be pre-installed. The unit should be lifted so that the upper mounting bolts engage in the upper mounting features. Install lower spacer plates, washers, and bolts.

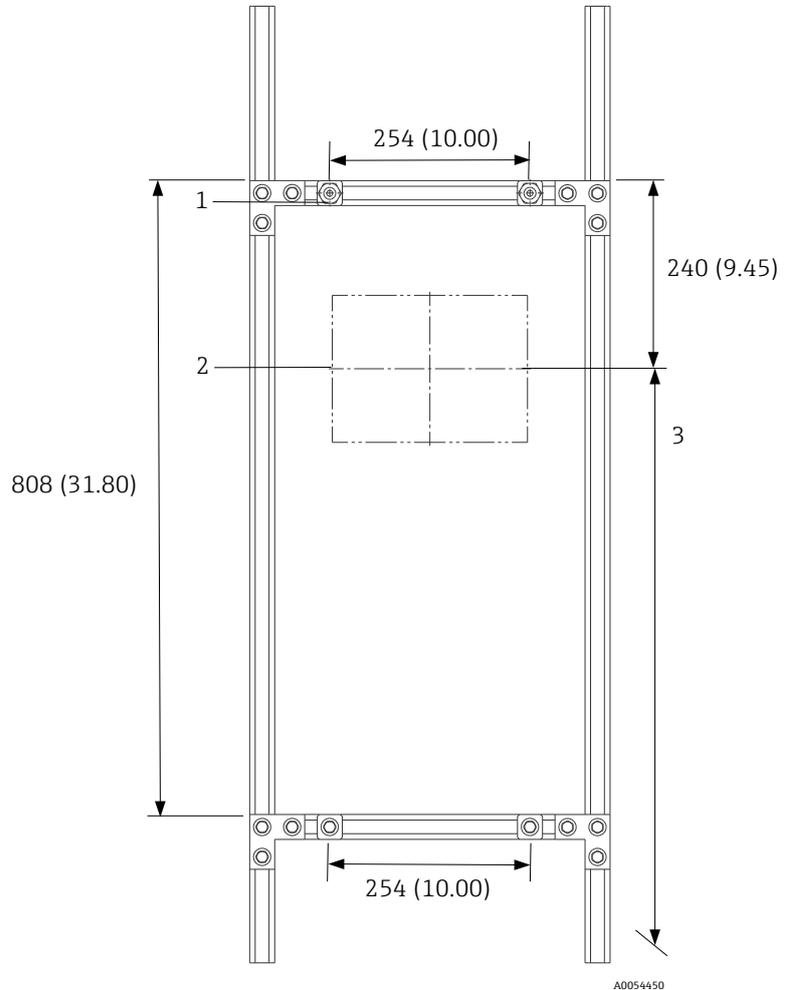


Figure 5. Hardware positioning for Raman Rxn5 mounting. Dimensions: mm (in)

| #   | Description   |
|---|---|
| 1   | Top mounting points should be fully tightened to allow unit to hang while bottom bolts are tightened. |
| 2   | Center line of monitor  |
| 3   | Position the monitor at standard viewing height.  |
| Note: The framing may be configured several ways to provide the 254 x 808 mm (10.00 x 31.80 in) spacing of the mounting points. |   |

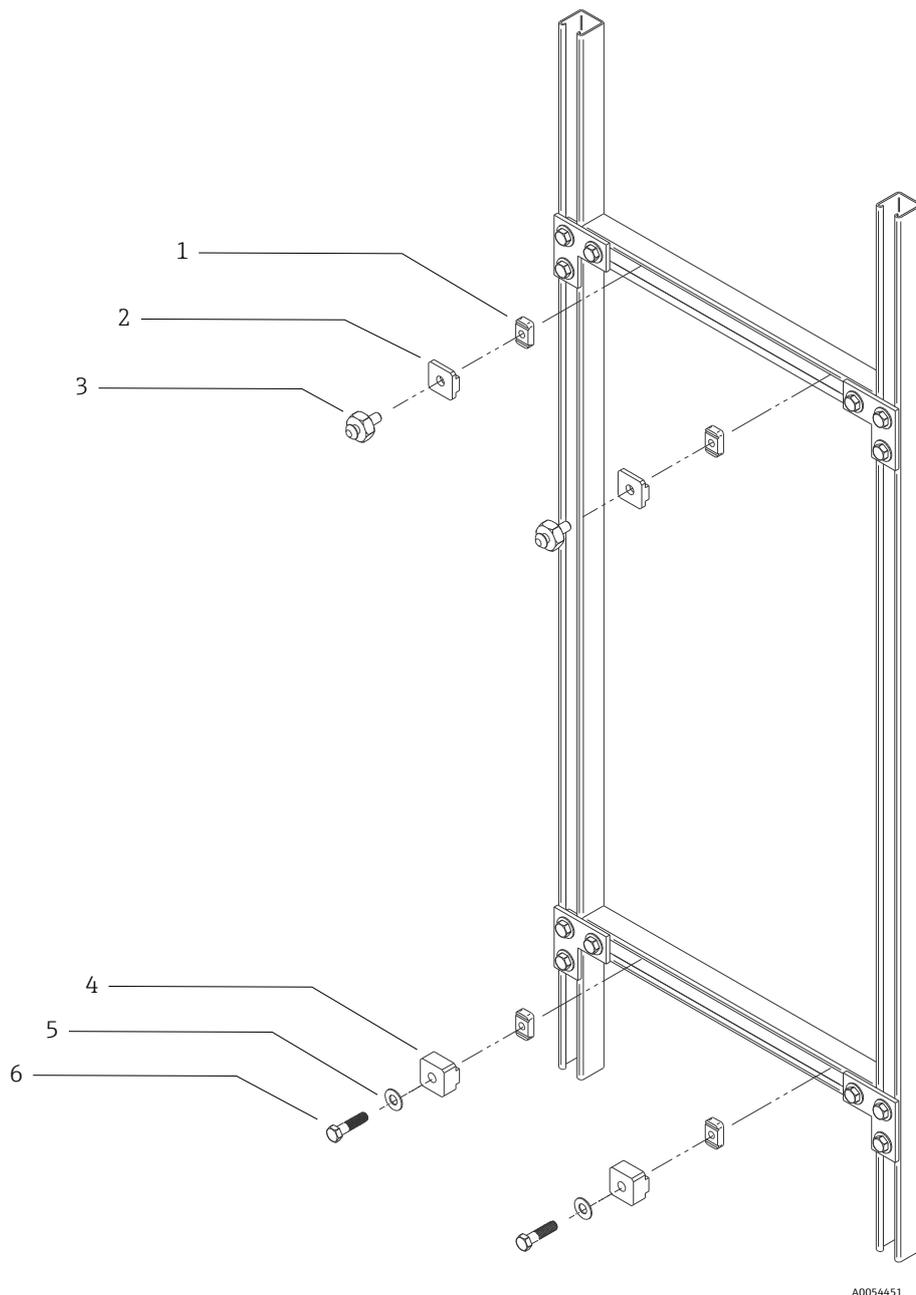


Figure 6. Mounting details

| #   | Description   |
|---|---|
| 1   | (4) 3/8" 16 channel nuts with springs (Unistrut p/n A1008-SS)         |
| 2   | (2) plates, Unistrut mount (supplied with Raman Rxn5 base unit)       |
| 3   | (2) mounting bolts (supplied with Raman Rxn5 base unit)               |
| 4   | (2) plates, Unistrut lower mount (supplied with Raman Rxn5 base unit) |
| 5   | (2) flat washers for 3/8" bolt diameter                               |
| 6   | (2) hex head cap screws 3/8" 16 x 1.50                                |
| Note: Mounting kit for Unistrut 1 1/4" width metal framing is shown in this drawing. A different kit is required for Unistrut P-Series (1 3/8" width) or 42 mm framing. |   |

**Sampling probe connection**

Two I/O panels on the Raman Rxn5 each provide sampling probe connections for two of the four channels available. The gray locking connector is the hybrid fiber-optic connector that contains both the excitation and collection fiber optics as well as the electrical laser interlock. Exercise appropriate care when making these connections to ensure clean fiber-optic connections.

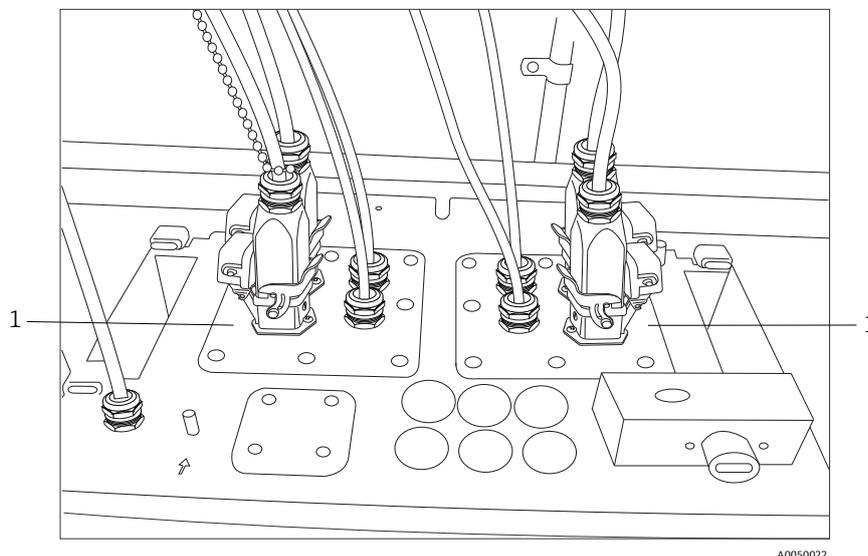


Figure 7. I/O panels provide sampling probe connections (1)

Endress+Hauser offers an optical service kit for the Raman Rxn5 (p/n 70208240), which is intended for diagnosing and servicing the major field-serviceable optical paths and components of the Raman Rxn5 system. It is also intended to diagnose and identify components that may require replacement or factory service.

**Temperature and pressure sensors**

In certain applications, each sampling probe is complemented with two environmental sensors: sample temperature and pressure sensors. These sensors are installed into the sampling system adjacent to each sampling probe. The sensors have 4–20 mA outputs and their ranges are configured to order.

The sensors are interfaced to the analyzer by up to 4 IS barriers with 1 per channel. One IS barrier interfaces to a temperature sensor and a pressure sensor. The IS barriers are installed on the lower DIN rail to the left of the electrical laser interlock IS barrier. Going from left to right, the IS barriers correspond with the sensors for channels 1 through 4. The electrical cables are installed through the appropriate cable gland.

**Solenoid valve driver**

The Raman Rxn5 is configured with an optional solenoid driver to drive up to four solenoids at the sampling system. One solenoid per stream can be driven, the timing of which is configured to order and set up at the factory. Each output provides DC 24 V at 0.5A maximum (12 W maximum). The maximum wire size the terminal blocks will accept is 18 American wire gauge (AWG). The channel number and polarity are labeled on the terminal blocks. It is the installer's responsibility to route solenoid power cables from the terminal blocks to the sampling solenoid valves through approved glands.

These outputs are not intrinsically safe and must terminate in nonhazardous areas.

**COM ports**

The Raman Rxn5 system can be configured at the factory to communicate with the customer's distributed control system (DCS) via Modbus RTU over RS-485. Endress+Hauser will provide the Modbus map. It is the installer's responsibility to route the communications cable from the computer to the DCS interface through an approved gland. The pinout for the Raman Rxn5 RS-485 COM port is labeled on the terminal blocks and referenced on the IS shield label.

**Ethernet ports**

Two Ethernet ports are provided. The Raman Rxn5 can also communicate with the customer's DCS via Modbus over TCP/IP. An RJ45 connector is provided on the terminal block DIN rail.

These outputs are not intrinsically safe and must terminate in nonhazardous areas.

**Purge alarm**

A purge alarm is provided to indicate positive pressure in the enclosure. There are two connections on the I/O terminal blocks.

**Purge indicator and valve system**

The purge indicator installed on the Raman Rxn5 analyzer is of the Z-Purge variety from Purge Solutions, Inc. The indicator is certified for use in Division 2/Zone 2 hazardous areas. The Z-purge indicator has a **green** indicator light that indicates that the pressure inside the enclosure is above 5.1 mm (0.20 in) water column. The indicator provides a dry contact alarm relay for a remote alarm if needed; it is the installer's or customer's responsibility to interface to the alarm contacts.

The Z-Purge indicator is paired with a Purge Solutions manual leakage compensation valve. There are two modes of operation for the valve-dilution and leakage compensation. For a high flow dilution, the dial on the valve should be turned so the slot in the dial is horizontal and lined up with the "ON" position. Once the manual dilution has been performed for the specified time, the valve may be switched to the leakage compensation mode by turning the dial so the slot in the dial is vertical. Leakage compensation mode allows the enclosure to remain pressurized with a much smaller usage of purge air after the manual dilution has occurred.

Minimum purge time prior to power application is 9.5 minutes at 2.0 to 2.5 psi as indicated on the included pressure gauge.

**Thermal control**

Heat removal is a challenge in all devices that consume electrical power. The major power consuming and heat producing components in the Raman Rxn5 are conductively cooled through their heat sinks into plenums on either side of the analyzer into the external ambient environment. The external fan pulls air through each plenum and over all heat sinks. This design maximizes heat removal from the devices and minimizes reliance on active devices to remove heat from the enclosure.

Maintain at least 450 mm (18 in) below the analyzer to allow for proper airflow into the cooling plenums and for access to fiber-optic probe connections.

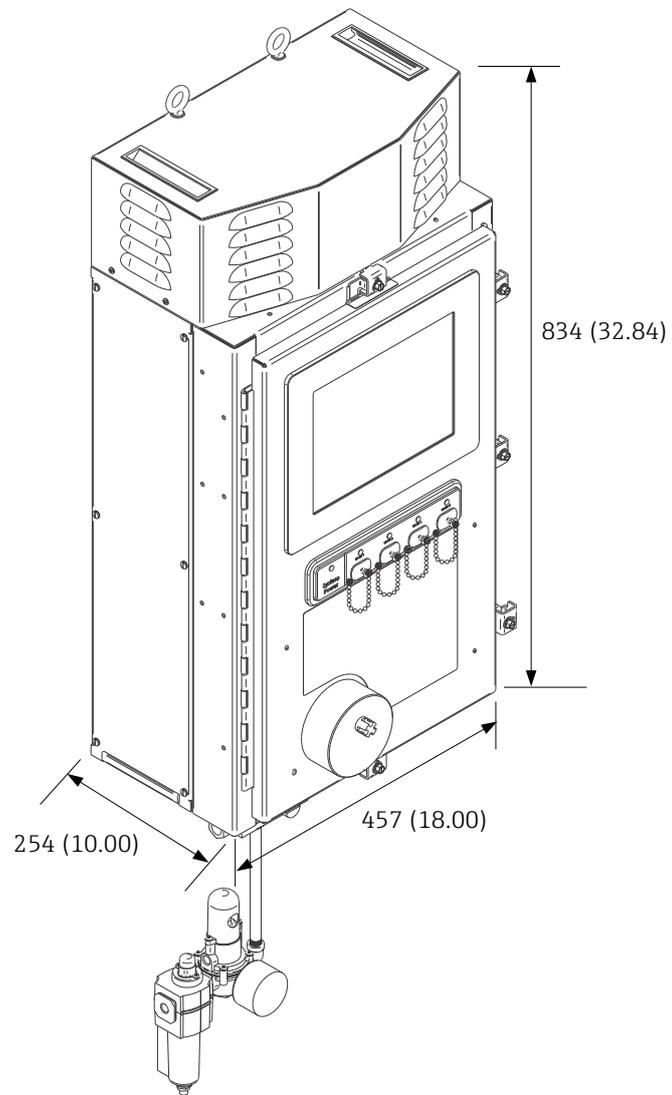
**Electrical power control**

The Raman Rxn5 thermal control system maintains power application to modules that may be temperature sensitive. The thermal control system has control over the electrical power of the following components: lasers, detection module, and touch screen monitor. The computer/hard drive, universal serial bus (USB) hub, purge indicator, calibration board, and all other miscellaneous electronic devices are always on if the systems is powered. The HVAC modules are controlled by the temperature control servo loop and can be turned on or off at any time by the control loop.

## Specifications

### Dimensions

The dimensions of the Raman Rxn5 are shown below.



A0054452

Figure 8. Raman Rxn5 analyzer. Dimensions: mm (in)

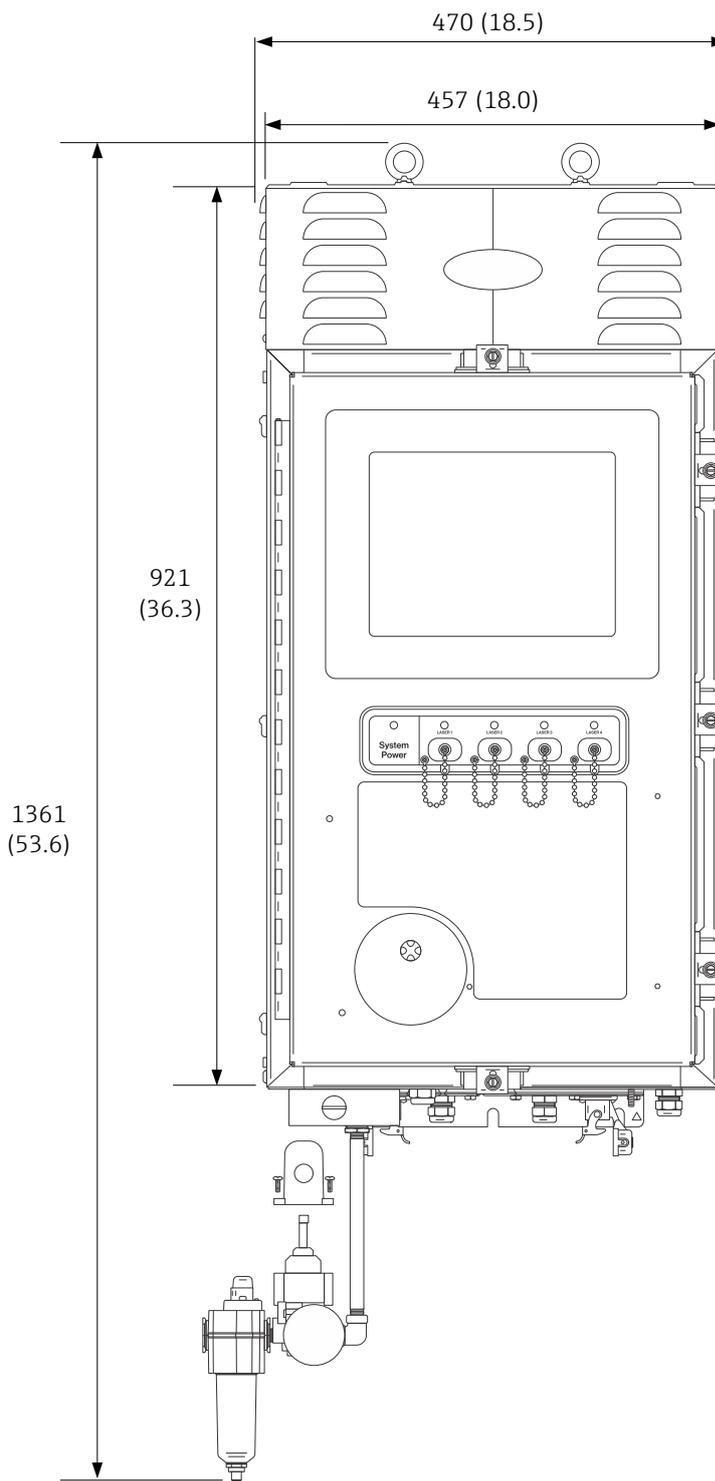
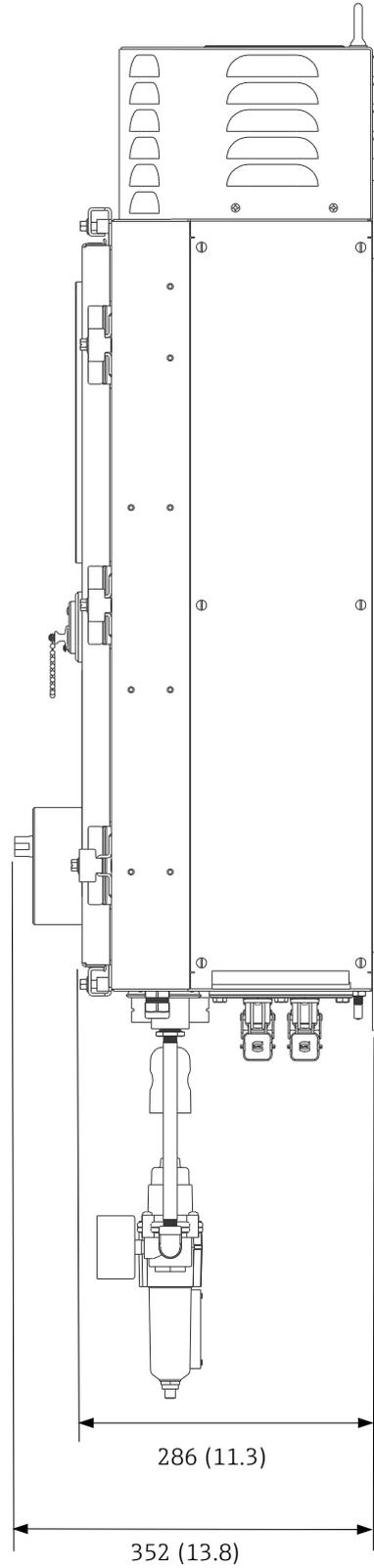
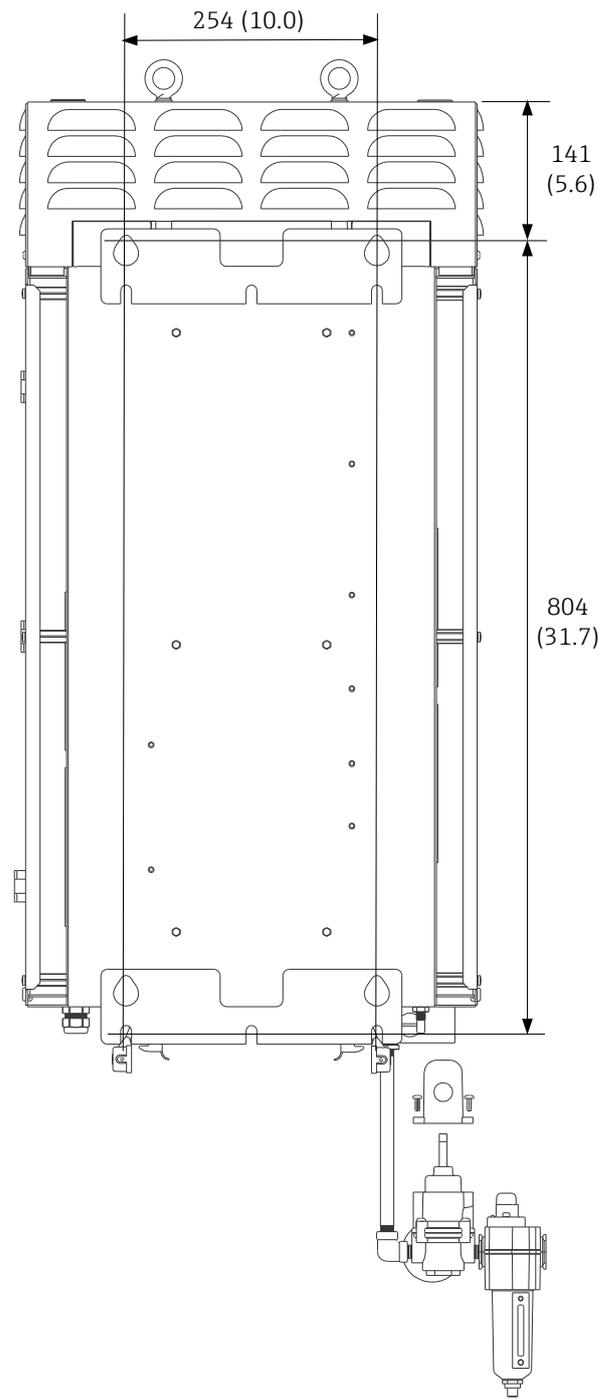


Figure 9. Raman Rxn5 front view. Dimensions: mm (in)



A0054454

Figure 10. Raman Rxn5 side view. Dimensions: mm (in)



A0054454

Figure 11. Raman Rxn5 rear view. Dimensions: mm (in)

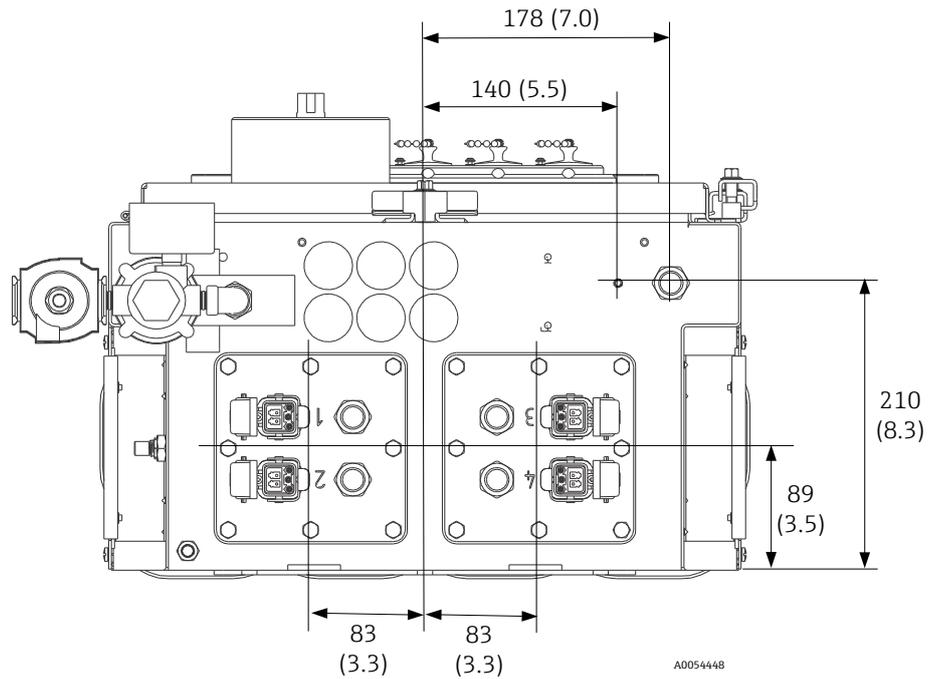


Figure 12. Raman Rxn5 bottom view. Dimensions: mm (in)

**Electrical and communications**

The specifications for electrical and communications are listed below.

| Item                                      | Description  |
|---|--|
| Input voltage                             | AC 90 to 264 V, 47 to 63 Hz standard   |
| Automation interface                      | Modbus (TCP/IP or RS485)   |
| User Interface                            | Touchscreen color LCD display  |
| Power consumption                         | < 300 W (maximum)<br>< 300 W (typical start-up)<br>< 200 W (typical running) |
| Sound level (from operator's perspective) | 60.1 dB maximum, A-weighted  |

**Physical**

The physical specifications are listed below.

| Item                                  | Description                                   |
|---------------------------------------|---|
| Enclosure type                        | Painted steel or optional 316 stainless steel |
| IEC 60529 rating (ingress protection) | IP56  |
| North American TYPE rating            | TYPE 13 <sup>1</sup>                          |
| Dimensions                            | 457 x 834 x 254 mm (18.00 x 32.84 x 10.00 in) |
| Weight                                | 61.2 kg (135 lbs)                             |
| Operating temperature (base unit)     | -20 to 50 °C (-4 to 122 °F)                   |
| Recommended storage temperature       | -30 to 60 °C (-22 to 140 °F)                  |
| Relative humidity                     | 0 to 90 %, non-condensing                     |
| Warm-up time                          | 120 minutes                                   |
| Sampling probe compatibility          | Raman Rxn-30                                  |
| Number of probes                      | Up to 4 (simultaneous operation)              |

<sup>1</sup> This is a self-declaration of conformance to UL 50E TYPE 13 requirements. It does not constitute UL certification or authorization to use the UL mark.

**Purge air supply**

The purge air supply specifications are listed below.

| Item   | Description     |
|--|-----------------|
| Purge air maximum temperature                | 40 °C (104 °F)  |
| Purge air dewpoint                           | -40 °C (-40 °F) |
| Purge air pressure range                     | 20 to 120 psi   |
| Inlet fitting                                | ¼-18 FNPT       |
| Maximum particle size                        | 5 microns       |
| Maximum flow rate during purge               | 2.0 SCFM        |
| Maximum flow rate for steady-state operation | 0.75 CFM        |

**Area classification and ratings**

The area classification and rating specifications are listed below.

| Item                            | Description                 |
|---------------------------------|-----------------------------|
| Environmental temperature range | -20 to 50 °C (-4 to 122 °F) |

**AC mains wiring**

The main power connection specifications are listed below.

| Item  | Description        |
|---|--------------------|
| Supply voltage range                                | AC 90 to 264 V     |
| Supply frequency range                              | 47 to 63 Hz        |
| Max inrush current                                  | 30 A               |
| Max steady-state current                            | 7.0 A              |
| Cable jacket diameter                               | 6 to 12 mm         |
| Conductor gauge range                               | 22 to 10 AWG       |
| Conductor stripping length                          | 9 mm (0.35 in)     |
| Maximum cable service loop (internal to Raman Rxn5) | 304.8 mm (12.0 in) |

**Low voltage I/O connections**

The available connections are listed below.

| Labels           | Description  | Signal Levels              |
|------------------|--|----------------------------|
| R3+, R3-, R3 GND | RS-485 communication to DCS                                | DC -7 to +12 V             |
| R4+, R4-, R4 GND | RS-485 communication to DCS                                | DC -7 to +12 V             |
| No labels        | (2) RJ45 optional TCP/IP to DCS or analyzer remote control | DC ±2.5 V per twisted pair |
| A+, A-           | Purge alarm  | DC 30 V, 150 mA maximum    |
| 1+, 1-           | Sampling output 1  | DC 24 V, 0.5 A maximum     |
| 2+, 2-           | Sampling output 2  | DC 24 V, 0.5 A maximum     |
| 3+, 3-           | Sampling output 3  | DC 24 V, 0.5 A maximum     |
| 4+, 4-           | Sampling output 4  | DC 24 V, 0.5 A maximum     |

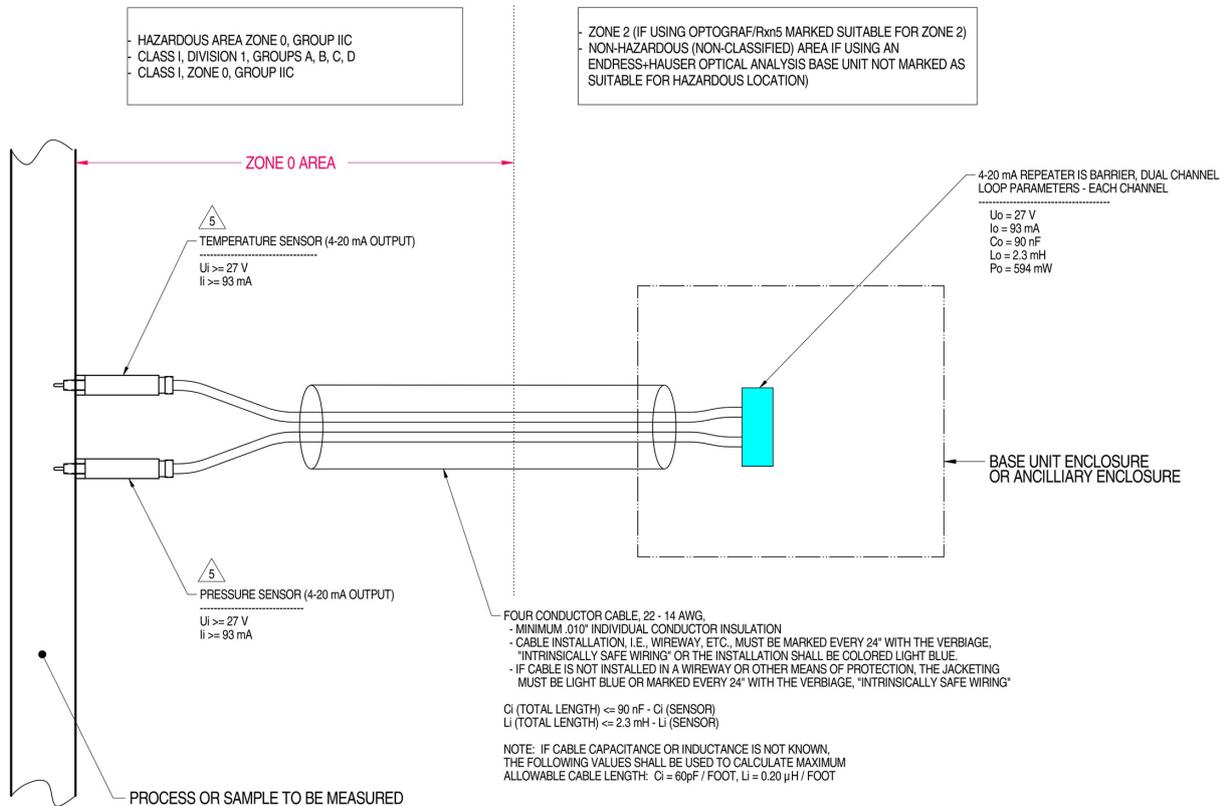
## Certificates and approvals

### Certifications

The Raman Rxn5 analyzer is certified for installation into hazardous areas. The certificate and approval information are listed below.

| Certification | Marking   | Temperature (ambient)       |
|---------------|---|-----------------------------|
| IECEX         | Ex ec ic [ia Ga] [op sh Gb] pzc IIC T4 Gc   | -20 to 50 °C (-4 to 122 °F) |
| ATEX          |  II 3(2)(1) G<br>Ex ec ic [ia Ga] [op sh Gb] pzc IIC T4 Gc | -20 to 50 °C (-4 to 122 °F) |
| North America | Raman Rxn5 analyzer Class I, Division 2, Groups B, C, or D, T4<br>Class I, Zone 2; IIB + H2, T4   | -20 to 50 °C (-4 to 122 °F) |
| UKCA          |  II 3(2)(1) G<br>Ex ec ic [ia Ga] [op sh Gb] pzc IIC T4 Gc | -20 to 50 °C (-4 to 122 °F) |
| JPEX          | Ex ec ic [ia Ga] [op sh Gb] pzc IIC T4 Gc   | -20 to 50 °C (-4 to 122 °F) |
| KTL           | Ex ec ic [ia Ga] [op sh Gb] pzc IIC T4 Gc   | -20 to 50 °C (-4 to 122 °F) |

**Control drawing for temperature and pressure IS circuit** Drawing 2012682 provides installation guidelines for IS temperature and pressure circuits and pressure IS circuit



MATERIAL: NA

FINISH: NA

NOTES: 1) CONTROL EQUIPMENT CONNECTED TO THE ASSOCIATED APPARATUS MUST NOT USE OR GENERATE MORE THAN 250 VRMS OR VDC.

2) INSTALLATION IN THE U.S. SHOULD BE IN ACCORDANCE WITH ANSI/ISA RP12.6 "INSTALLATION OF INTRINSICALLY SAFE SYSTEMS FOR HAZARDOUS (CLASSIFIED) LOCATIONS" AND THE NATIONAL ELECTRICAL CODE® (ANSI/NFPA 70) SECTIONS 504 AND 505.

3) INSTALLATION IN CANADA SHOULD BE IN ACCORDANCE WITH THE CANADIAN ELECTRICAL CODE, CSA C22.1, PART 1, APPENDIX F.

4) ASSOCIATED APPARATUS MANUFACTURER'S INSTALLATION DRAWING MUST BE FOLLOWED WHEN INSTALLING THIS EQUIPMENT

5) THE TEMPERATURE AND PRESSURE SENSORS MUST BE ENTITY APPROVED FOR CLASS I, ZONE 0, IIC OR CLASS I DIVISION 1, GROUPS A, B, C, D.

6) NO REVISION TO DRAWING WITHOUT PRIOR CSA-INTERNATIONAL APPROVAL.

7) WARNING: SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.

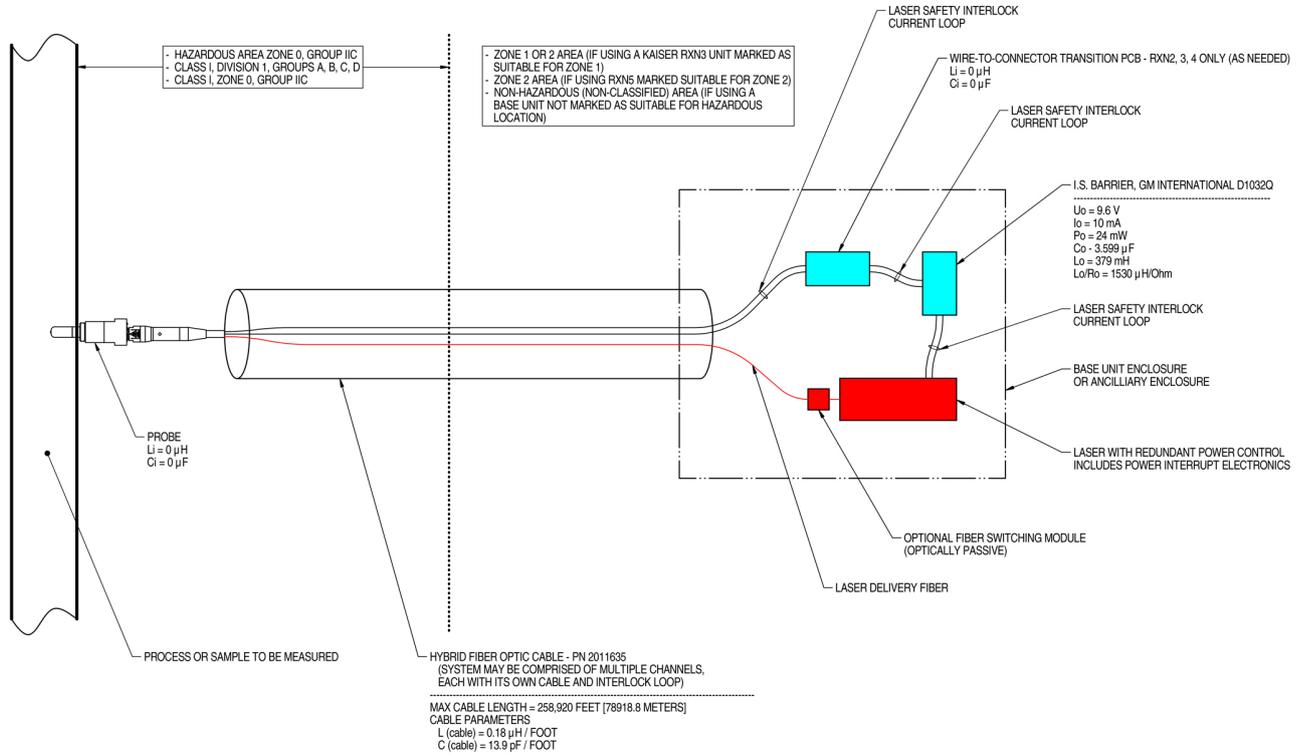
8) SYSTEM MAY BE COMPRISED OF MULTIPLE CHANNELS, EACH WITH ITS OWN CABLE, TEMPERATURE AND PRESSURE SENSOR AND ASSOCIATED 4-20 mA REPEATER IS BARRIER

A0050082

Figure 13. Control drawing for temperature and pressure IS circuit (2012682 X7)

**Control drawing for probe IS circuit**

Drawing 4002396 provides installation guidelines for the IS probe circuit. There are no end-user connections inside the Raman Rxn5 to be made for this circuit.



NOTES:

- CONTROL EQUIPMENT CONNECTED TO THE ASSOCIATED APPARATUS MUST NOT USE OR GENERATE MORE THAN 250 VRMS OR VDC.
- INSTALLATION IN THE U.S. SHOULD BE IN ACCORDANCE WITH ANSI/ISA RP12.6 "INSTALLATION OF INTRINSICALLY SAFE SYSTEMS FOR HAZARDOUS (CLASSIFIED) LOCATIONS" AND THE NATIONAL ELECTRICAL CODE® (ANSI/NFPA 70) SECTIONS 504 AND 505.
- INSTALLATION IN CANADA SHOULD BE IN ACCORDANCE WITH THE CANADIAN ELECTRICAL CODE, CSA C22.1, PART 18, APPENDIX J18.
- ASSOCIATED APPARATUS MANUFACTURER'S INSTALLATION DRAWING MUST BE FOLLOWED WHEN INSTALLING THIS EQUIPMENT.
- FOR U.S. INSTALLATIONS, THE PROBE MODELS RXN-30 (AIRHEAD), RXN-40 (WETHEAD) AND RXN-41 (PILOT) ARE APPROVED FOR CLASS I, ZONE 0 APPLICATIONS.
- NO REVISION TO DRAWING WITHOUT PRIOR CSA APPROVAL.
- WARNING: SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.

A0049010

Figure 14. Control drawing for probe IS circuit (4002396 X6)

## Specifications

### Gas certification

The table below describes the acceptable sample stream compositions for selected pre-defined prediction models. In any case the stream composition must be provided.

To qualify for one of the pre-defined prediction models the sample stream composition needs to lie within the range specified in the table by the minimum and maximum value for each gas. In addition, the sample pressure should be higher than 100 psia (7 BarA) and the sample stream should not include Hexane (C<sub>6</sub>H<sub>14</sub>).

| Feature 50                            |                                |                           |
|---------------------------------------|--------------------------------|---------------------------|
| Table 10 Natural Gas (+H2)            |                                |                           |
| Component Name                        | Chemical Symbol                | Allowable Component Range |
| Methane                               | CH <sub>4</sub>                | 70 to 99 %                |
| Ethane                                | C <sub>2</sub> H <sub>6</sub>  | 0 to 7 %                  |
| Propane                               | C <sub>3</sub> H <sub>8</sub>  | 0 to 2 %                  |
| Butane                                | C <sub>4</sub> H <sub>10</sub> | 0 to 1 %                  |
| Isobutane                             | C <sub>4</sub> H <sub>10</sub> | 0 to 1 %                  |
| Pentane                               | C <sub>5</sub> H <sub>12</sub> | 0 to 1 %                  |
| Isopentane                            | C <sub>5</sub> H <sub>12</sub> | 0 to 1 %                  |
| Neopentane                            | C <sub>5</sub> H <sub>12</sub> | 0 to 1 %                  |
| Nitrogen                              | N <sub>2</sub>                 | 0 to 2 %                  |
| Carbon dioxide                        | CO <sub>2</sub>                | 0 to 10 %                 |
| Hydrogen                              | H <sub>2</sub>                 | 0 to 22 %                 |
| Table 11 Natural Gas (+H2 + CO + NH3) |                                |                           |
| Component Name                        | Chemical Symbol                | Allowable Component Range |
| Methane                               | CH <sub>4</sub>                | 50 to 99 %                |
| Ethane                                | C <sub>2</sub> H <sub>6</sub>  | 0 to 7 %                  |
| Propane                               | C <sub>3</sub> H <sub>8</sub>  | 0 to 2 %                  |
| Butane                                | C <sub>4</sub> H <sub>10</sub> | 0 to 1 %                  |
| Isobutane                             | C <sub>4</sub> H <sub>10</sub> | 0 to 1 %                  |
| Pentane                               | C <sub>5</sub> H <sub>12</sub> | 0 to 1 %                  |
| Isopentane                            | C <sub>5</sub> H <sub>12</sub> | 0 to 1 %                  |
| Neopentane                            | C <sub>5</sub> H <sub>12</sub> | 0 to 1 %                  |
| Nitrogen                              | N <sub>2</sub>                 | 0 to 2 %                  |
| Carbon dioxide                        | CO <sub>2</sub>                | 0 to 10 %                 |
| Hydrogen                              | H <sub>2</sub>                 | 0 to 22 %                 |
| Carbon Monoxide                       | CO                             | 0 to 1 %                  |

|         |                 |           |
|---------|-----------------|-----------|
| Ammonia | NH <sub>3</sub> | 0 to 99 % |
|---------|-----------------|-----------|

**Table 20 Syngas**

| Component Name  | Chemical Symbol | Allowable Component Range |
|-----------------|-----------------|---------------------------|
| Methane         | CH <sub>4</sub> | 0 to 99 %                 |
| Carbon Monoxide | CO              | 0 to 99 %                 |
| Carbon dioxide  | CO <sub>2</sub> | 0 to 99 %                 |
| Hydrogen        | H <sub>2</sub>  | 0 to 99 %                 |
| Nitrogen        | N <sub>2</sub>  | 0 to 99 %                 |

**Table 30 Methane + non-CnHm**

| Component Name  | Chemical Symbol | Allowable Component Range |
|-----------------|-----------------|---------------------------|
| Methane         | CH <sub>4</sub> | 0 to 99 %                 |
| Nitrogen        | N <sub>2</sub>  | 0 to 99 %                 |
| Carbon dioxide  | CO <sub>2</sub> | 0 to 99 %                 |
| Carbon Monoxide | CO              | 0 to 99 %                 |
| Hydrogen        | H <sub>2</sub>  | 0 to 99 %                 |
| Oxygen          | O <sub>2</sub>  | 0 to 99 %                 |
| Ammonia         | NH <sub>3</sub> | 0 to 99 %                 |

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