# Technical Information
# **Rxn-41 Raman probe**

## System design and specifications

### Application

The Rxn-41 Raman probe is a rugged, process insertion probe with no sample handling system. Its single cable design streamlines installation, eliminates risk scenarios, and minimizes installation cost for long fiber runs in the process environment. The Rxn-41 probe is ideally suited for use in chemical plants and refineries to measure batch or continuous flow production. For direct measurements in cryogenic fluids, an optimized cryogenic version of the Rxn-41 Raman probe is available.

- **Chemical:** reaction monitoring, blending, feed and final product monitoring
- **Polymer:** polymerization reaction monitoring, polymer blending
- **Pharmaceutical:** active pharmaceutical ingredient (API) reaction monitoring, crystallization, polymorph, drug substance production unit operation
- **Oil and Gas:** any hydrocarbon analysis

### Device properties

- Electro-optical fiber connection
- High-purity sapphire window

### Benefits

- Constructed to individual site requirements
- Sealed probe design
- Integrated “laser on” indicator
- One in/one out fiber optics
- Direct insertion compatibility
- Complies with Pressure Equipment Directive (PED) Category 1 safety standards
- Rated to ASME B31.3
- Suitable for hazardous area/classified environments

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# Function and system design

## Application

The Rxn-41 Raman probe is intended for liquid immersion sample analysis in a process plant setting.

Recommended applications include:

- Chemical: reaction monitoring, blending, feed, and final product monitoring
- Polymer: polymerization reaction monitoring, polymer blending
- Pharmaceutical: active pharmaceutical ingredient (API) reaction monitoring, crystallization, polymorph, drug substance production unit operation
- Oil and gas: any hydrocarbon analysis

Using the device for any purpose other than that described may compromise personal safety or damage the measuring system. Improper use also invalidates any warranty.

## Rxn-41 probe

The parts of the Rxn-41 probe are shown below.

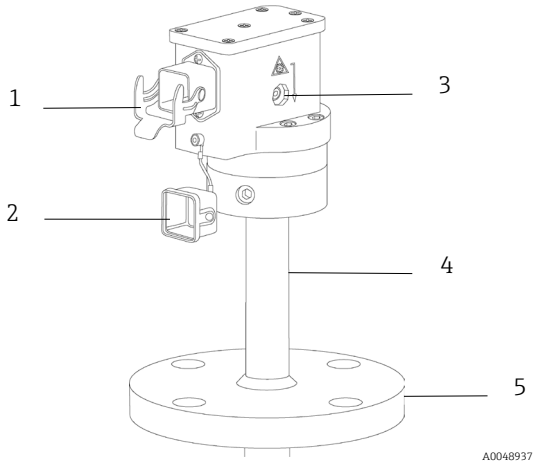



*Figure 1: Rxn-41 probe*

| # | Description |
|---|---|
| 1 | Electro-optical (EO) cable connector |
| 2 | EO connector dust cover |
| 3 | Laser emission indicator |
| 4 | Probe body |
| 5 | Flange (optional) |

### Laser safety indicator

The Rxn-41 probe forms part of the interlock circuit. If the fiber cable is severed, the laser will turn off within milliseconds of the breakage.

The interlock circuit is a low-current electrical loop. If the Rxn-41 probe is used in a hazardous classified area, the interlock circuit must pass through an intrinsically safe (IS) barrier.

## Process and probe compatibility

Before installation, verify that the probe's pressure and temperature ratings, as well as its materials, are compatible with the process conditions.

The probes should be installed using sealing techniques (e.g., flanges, compression fittings) appropriate and typical for the vessel or piping.

**⚠ WARNING**

**If the probe will be installed in a high temperature or pressure process, additional safety precautions must be taken to avoid equipment damage or safety hazards.**

- A blowout protection device is highly recommended in accordance with local safety standards.
- It is the responsibility of the user to determine if any blowout protection devices are required and ensure they are attached to the probes during installation.

**⚠ WARNING**

**If the probe being installed is constructed of titanium, the user should be aware that impacts or excessive process friction could cause a spark or otherwise cause ignition.**

- The user must ensure that precautions are taken when installing and using a titanium probe to avoid such an occurrence.

## Installation

Before installation in the process, verify that the amount of laser power out of each probe is no more than the amount specified in the Hazardous Area Equipment Assessment (4002266) or equivalent.

Standard eye and skin safety precautions for Class 3B laser products (as per EN 60825/IEC 60825 14) should be observed during installation as described below.

**⚠ WARNING**

**Probes are designed with specific sealing boundaries.**

The probe pressure specifications are only valid if sealing is accomplished on the intended sealing feature (shaft, flange, etc.).

- Service ratings may include limitations for fittings, flanges, bolts, and seals. The installer must understand these limitations and use appropriate hardware and assembly procedures for a pressure-tight and safe joint.

**⚠ WARNING**

**Standard precautions for laser products should be observed.**

- Probes should always be capped, pointed away from people, and pointed toward a diffuse target, if not installed in a sample chamber.

**⚠ CAUTION**

**If stray light enters an unused probe, it will interfere with data collected from the probe in use and may cause calibration failure or measurement errors.**

- Unused probes should ALWAYS be capped to prevent stray light from entering the probe.

**NOTICE**

**Install the probe so that it measures the flowing sample or sample region of interest.**

**NOTICE**

**Permanent damage may result if cables are not routed appropriately.**

- Handle probes and cables with care, ensuring they are not kinked.

Install fiber cables with a minimum bend radius according to the *Raman fiber-optic cables KFOC1 and KFOC1B Technical Information (TI01641C)*.

The Rxn-41 probe is designed for installation directly into process streams and reactor vessels according to the installation guidelines below:

- When installing a probe equipped with the non-removable, right-angle fiber connector assembly (EO style), it is recommended that the fiber cable assembly is disconnected from the probe during installation.
- Ensure that the laser interlock is connected to the safety indicator light and to any other safety systems, such as liquid level sensors or purges, appropriate to the installation.
- The Rxn-41 probes have no active electrical devices requiring earthing. The user should determine if the probe requires earthing for other reasons associated with its installation.
- When installing, follow good practices and select bolts and seals that are appropriate for the installation and service rating.

# Specifications

## Temperature and pressure

The temperature and pressure specifications for the Rxn-41 probe vary depending on the probe size and materials of construction. A cryogenic compatible version is available for the 1" or 2" Rxn-41 probe upon request.

Additional specifications include:

- Max pressure is calculated per ASME B31.3 2020 edition for material and probe geometry at temperatures not to exceed the maximum listed.
- Max service pressure ratings do not include the ratings of any fittings or flanges used to mount the probe into the process system. These items need to be independently evaluated and may lower the maximum service pressure of the probe.
- Minimum pressure rating: All probes have a minimum pressure rating of 0 Bara (full vacuum). However, unless specified they are not rated for low outgassing at high vacuum service.
- The probe withstands 0 to 100 °C (32 to 212 °F) water shock.
- The cryogenic probe withstands 30 to −196 °C (86 to −320.8 °F) liquid nitrogen shock.
- The temperature ramp is ≤ 30 °C/min (≤ 54 °F/min).

| Component | Materials of construction | Min temp | Max temp | Max service pressure |
|---|---|---|---|---|
| 1" Rxn-41 probe | 316L stainless steel | −30 °C (−22 °F) | 120 °C (248 °F) | 141.5 barg (2053 psig) |
| | C276 alloy | −30 °C (−22 °F) | 150 °C (302 °F) | 186.6 barg (2707 psig) |
| | Grade 2 titanium | −30 °C (−22 °F) | 150 °C (302 °F) | 144.1 barg (2090 psig) |
| 2" (nominal) Rxn-41 probe | 316L stainless steel | −30 °C (−22 °F) | 120 °C (248 °F) | 49.7 barg (721 psig) |
| | C276 alloy | −30 °C (−22 °F) | 150 °C (302 °F) | 68.8 barg (998 psig) |
| | Grade 2 titanium | −30 °C (−22 °F) | 150 °C (302 °F) | 51.5 barg (747 psig) |
| 1" cryogenic Rxn-41 probe | C276 alloy | −196 °C (−320.8 °F) | 70 °C (158 °F) | 213.7 barg (3100 psig) |
| | Hybrid metal combination (C276 tip/316L) | −196 °C (−320.8 °F) | 70 °C (158 °F) | 158.6 barg (2300 psig) |
| Cable and connector | Cable: PVC jacketed, proprietary construction<br>Connections: proprietary electro-optic | −40 °C (−40 °F) | 70 °C (158 °F) | not applicable |

## Flange temperature and pressure

The temperature specifications for probe flanges vary depending on the material of construction. The maximum pressure rating of a probe flange varies with the maximum rated temperature. Flanges with different materials of construction are covered under different standards. Flange ratings for 316L stainless steel and C276 are based on ASME B16.5. Flange ratings for Grade 2 Titanium are based on ASME BPVC VIII.1, Appendix 2. Flange ratings for DIN flanges are based on EN 1092-1.

Flange ratings may be different than the probe ratings. The rating for any probe with a flange shall be the lower of the rating for the probe and the flange. Any hydrostatic or other testing shall be performed at the pressure rating of the limiting component.

For cryogenic service, such as liquefied natural gas, the recommended probe is a 1", hybrid metal combination probe with a 316L stainless steel flange.

| Materials of construction | Min temp | Max temp | Class | Max service pressure |
|---|---|---|---|---|
| ASME B16.5-2018 flange ratings | | | | |
| 316L stainless steel (cryogenic) | −196 °C (−320 °F) | 70 °C (158 °F) | 150 | 14.5 barg (210 psig) |
| | | | 300 | 37.9 barg (549 psig) |
| | | | 600 | 75.8 barg (1099 psig) |
| 316L stainless steel | −30 °C (−22 °F) | 120 °C (250 °F) | 150 | 12.8 barg (185 psig) |
| | | | 300 | 33.4 barg (484 psig) |
| | | | 600 | 66.9 barg (970 psig) |
| C276 alloy (cryogenic) | −196 °C (−320 °F) | 70 °C (158 °F) | 150 | 18.8 barg (272 psig) |
| | | | 300 | 51.6 barg (748 psig) |
| | | | 600 | 103.2 barg (1496 psig) |
| C276 alloy | −30 °C (−22 °F) | 150 °C (300 °F) | 150 | 15.8 barg (229 psig) |
| | | | 300 | 50.3 barg (729 psig) |
| | | | 600 | 100.3 barg (1454 psig) |
| ASME BPVC VIII.1-2021, Appendix 2 flange ratings | | | | |
| Grade 2 titanium | −30 °C (−22 °F) | 150 °C (302 °F) | 150 | 10.2 barg (148 psig) |
| | | | 300 | 26.6 barg (387 psig) |
| | | | 600 | 53.2 barg (773 psig) |
| DIN EN 1092-1:2013-04 flange ratings | | | | |
| 316L stainless steel | −196 °C (−320 °F) | 70 °C (158 °F) | PN10 | 9.6 barg (139 psig) |
| | | | PN16 | 15.4 barg (223 psig) |
| | | | PN25 | 24.1 barg (349 psig) |
| | | | PN40 | 38.7 barg (561 psig) |
| 316L stainless steel | −30 °C (−22 °F) | 120 °C (250 °F) | PN10 | 9.0 barg (130 psig) |
| | | | PN16 | 14.5 barg (210 psig) |
| | | | PN25 | 22.7 barg (329 psig) |
| | | | PN40 | 36.4 barg (527 psig) |

**Liquefied natural gas (LNG) composition measurement**

The Rxn-41 probe is well-suited for use in global LNG markets. Coupled with an E+H Raman analyzer and LNG software method, this probe provides up to 10 times lower uncertainty than legacy GC vaporizer systems and a gross heating value (GHV) accuracy of ±3 Btu/scf. It does this in real time, by data collection in LNG through direct installation in process or transfer piping.

Standard configurations for LNG service have the following feature sets (custom probes are also available):

- Hybrid metal construction: stainless steel [UNS S31603] with an alloy C-276 [UNS N10276] tip
- Flange: ASME B16.5 2″ Class 150 raised face
- Lengths: three specific lengths to meet various piping sizes and flow rates
- Operating temperature: cryogenic operation from −180 °C (93 K) to −156 °C (117 K)
- Maximum insertion into flow: 76.2 mm (3.0 in)
- Maximum linear flow rate: varies with probe length

| Probe length (unsupported) | Maximum linear flow rate* |
|---|---|
| 140 mm (5.51 in) | 17 m/sec (55.7 ft/sec) |
| 220 mm (8.66 in) | 7 m/sec (22.9 ft/sec) |
| 240 mm (9.45 in) | 6 m/sec (19.6 ft/sec) |

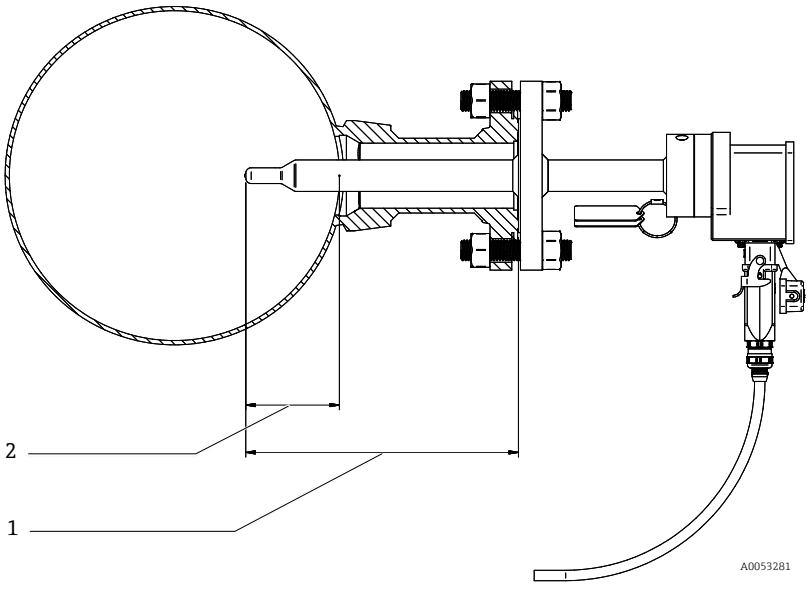



*Figure 2. Rxn-41 probe installation for LNG Service*

| # | Description |
|---|---|
| 1 | Probe length (unsupported) |
| 2 | Insertion into flow (exposed) |

* Flow rates are based on the calculation methodology defined in ASME PTC 19.3 TW-2016 and adapted for the Rxn-41 probe. These calculations assume the standard materials, geometry, and tolerances of the probe. They apply to LNG service within a temperature range of -180 to -156° C. LNG density ranges from 375 to 500 kg/m$^3$, and dynamic viscosity ranges from 0.292 to 0.073 cP. If installation details or LNG properties differ from these conditions, then contact the factory for application support.

## General specifications

General specifications for the Rxn-41 probe are listed below.

| Item | | Description |
|---|---|---|
| Laser wavelength | | 532 nm, 785 nm, or 993 nm |
| Spectral coverage | | Probe spectral coverage is limited by the coverage of the analyzer being used |
| Ambient temperature | | Nonexplosive environments:<br>−30 to 70 °C / −22 to 158 °F<br>Explosive environments:<br>T3/T4: −20 to 70 °C / −4 to 158 °F<br>T6: −20 to 65 °C / −4 to 149 °F<br>Limited to normal ambient temperature<br>IEC 60079-0 for Korea |
| Maximum laser power into probe | | < 499 mW |
| Working distance from probe exit | | short: 0 mm (0 in)<br>long: 3 mm (0.12 in) |
| IEC 60529 for (EO) right angle connector | | IP65 |
| IEC 60529 for (EO) straight stainless steel connector | | IP65 |
| North American TYPE rating for (EO) right angle connector | | TYPE 4X |
| Materials of construction:<br><br>Wetted materials | probe body | ▪ C276 alloy or 316L stainless steel<br>▪ Grade 2 titanium available upon request<br>▪ Hybrid metal combination (316L stainless steel, C276 alloy) available upon request |
| | window | high-purity sapphire |
| Probe immersible length | C276 alloy | ▪ 25.4 mm (1 in) Rxn-41: Up to 3040 mm (120 in)<br>▪ 60.3 mm (2 in) Rxn-41: Up to 4550 mm (179.1 in) |
| | 316L stainless steel | ▪ 25.4 mm (1 in) Rxn-41: Up to 3040 mm (120 in)<br>▪ 60.3 mm (2 in) Rxn-41: Up to 4550 mm (179.1 in) |
| | Grade 2 titanium | 25.4 mm (1 in) Rxn-41: Up to 350 mm (13.78 in) |
| Probe immersible diameter | C276 alloy | 25.4 mm (1 in)<br>60.3 mm (2-inch nominal; actual OD 2.38 in) |
| | 316L stainless steel | 25.4 mm (1 in)<br>60.3 mm (2-inch nominal; actual OD 2.38 in) |
| | Grade 2 titanium | 25.4 mm (1 in) |
| Chemical resistance | | Limited by materials of construction |
| Flanges | type | ▪ ASME B16.5<br>▪ EN 1092-1 Raised Face B1 flanges available upon request |
| | diameter | Standard diameters up to 3 NPS with custom sizes available. |

All fiber-optic cable specifications can be found in the *Raman fiber-optic cables KFOC1 and KFOC1B Technical Information (TI01641C)*.

**Dimensions: 1" probe**

The dimensions for the 1" diameter Rxn-41 probe and its tip are below.

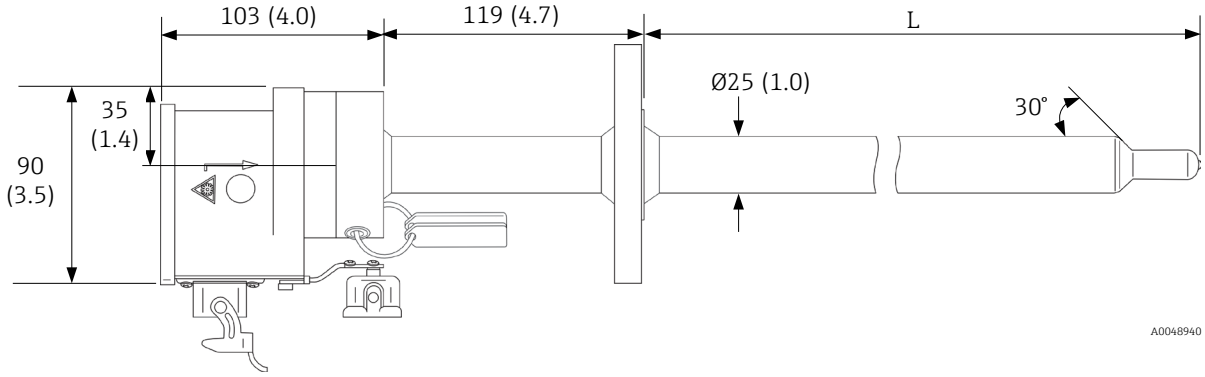



*Figure 3. Rxn-41 1" probe. Dimensions: mm (in)*
*L = immersible length per specifications*

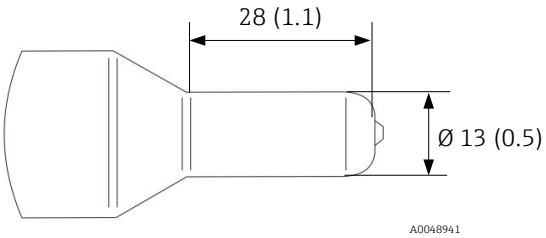



*Figure 4. Tip of 1" Rxn-41 probe. Dimensions: mm (in)*

**Dimensions: 2" probe**

The dimensions for the 2" (nominal) diameter Rxn-41 probe and its tip are below.

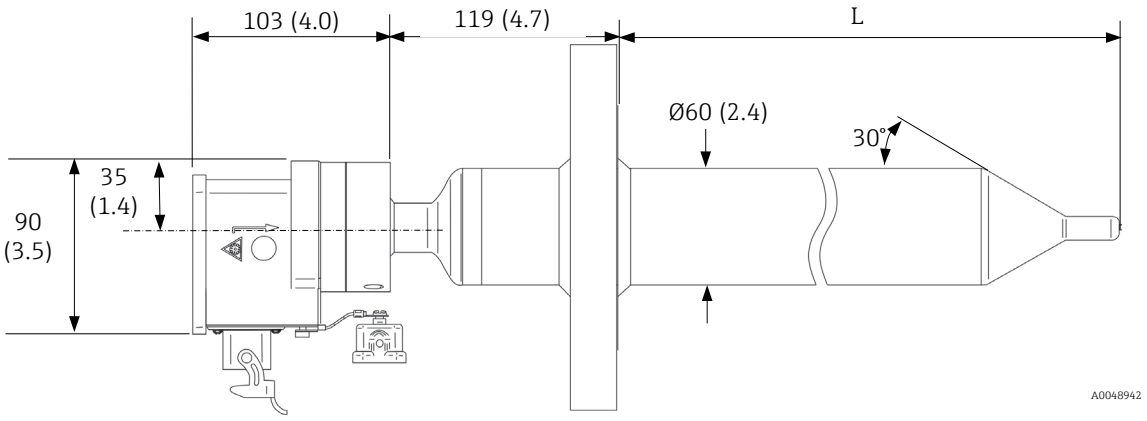



*Figure 5. Rxn-41 2" probe. Dimensions: mm (in)*
*L = Immersible length per specifications*

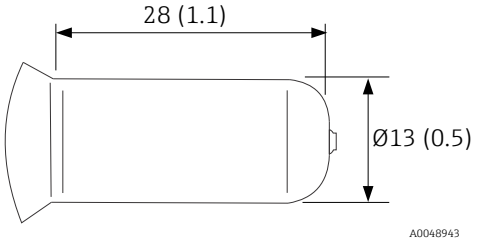



*Figure 3. Tip of 2" Rxn-41 probe. Dimensions: mm (in)*

**Maximum permitted exposure (MPE): ocular exposure**

For more assistance with taking appropriate precautions and setting the proper controls when dealing with lasers and their hazards, refer to the most current version of ANSI Z136.1 or IEC 60825-14. A correction factor (CA) may also be required and can be determined below.

| MPE for point source ocular exposure to a laser beam | | | |
|---|---|---|---|
| **Wavelength** ***λ (nm)*** | **Exposure Duration** ***t (s)*** | **MPE Calculation** | |
| | | ***(J·cm$^{-2}$)*** | ***(W·cm$^{-2}$)*** |
| 532 | $10^{-13}$ to $10^{-11}$ | $1.0 \times 10^{-7}$ | - |
| | $10^{-11}$ to $5 \times 10^{-6}$ | $2.0 \times 10^{-7}$ | - |
| | $5 \times 10^{-6}$ to 10 | $1.8\ t^{0.75} \times 10^{-3}$ | - |
| | 10 to 30,000 | - | $1 \times 10^{-3}$ |

| MPE for point source ocular exposure to a laser beam | | | | |
|---|---|---|---|---|
| **Wavelength** ***λ (nm)*** | **Exposure duration** ***t (s)*** | **MPE calculation** | | $C_A$ |
| | | ***(J·cm$^{-2}$)*** | ***(W·cm$^{-2}$)*** | |
| 785 and 993 | $10^{-13}$ to $10^{-11}$ | $1.5\ C_A \times 10^{-8}$ | - | 785: $C_A = 1.479$<br>993: $C_A = 3.855$ |
| | $10^{-11}$ to $10^{-9}$ | $2.7\ C_A\ t^{0.75}$ | - | |
| | $10^{-9}$ to $18 \times 10^{-6}$ | $5.0\ C_A \times 10^{-7}$ | - | |
| | $18 \times 10^{-6}$ to 10 | $1.8\ C_A\ t^{0.75} \times 10^{-3}$ | - | |
| | 10 to $3 \times 10^{4}$ | - | $C_A \times 10^{-3}$ | |

**MPE: skin exposure**

Refer to the table below from the ANSI Z136.1 standard to calculate the MPE for skin exposure to a laser beam.

| MPE for skin exposure to a laser beam | | | | |
|---|---|---|---|---|
| **Wavelength** ***λ (nm)*** | **Exposure Duration** ***t (s)*** | **MPE Calculation** | | $C_A$ |
| | | ***(J·cm$^{-2}$)*** | ***(W·cm$^{-2}$)*** | |
| 532, 785, and 993 | $10^{-9}$ to $10^{-7}$ | $2\ C_A \times 10^{-2}$ | - | 532: $C_A = 1.000$<br>785: $C_A = 1.479$<br>993: $C_A = 3.855$ |
| | $10^{-7}$ to 10 | $1.1\ C_A\ t^{0.25}$ | - | |
| | 10 to $3 \times 10^{4}$ | - | $0.2\ C_A$ | |

# Certificates and approvals

## Hazardous area approvals

The hazardous area approvals are listed below.

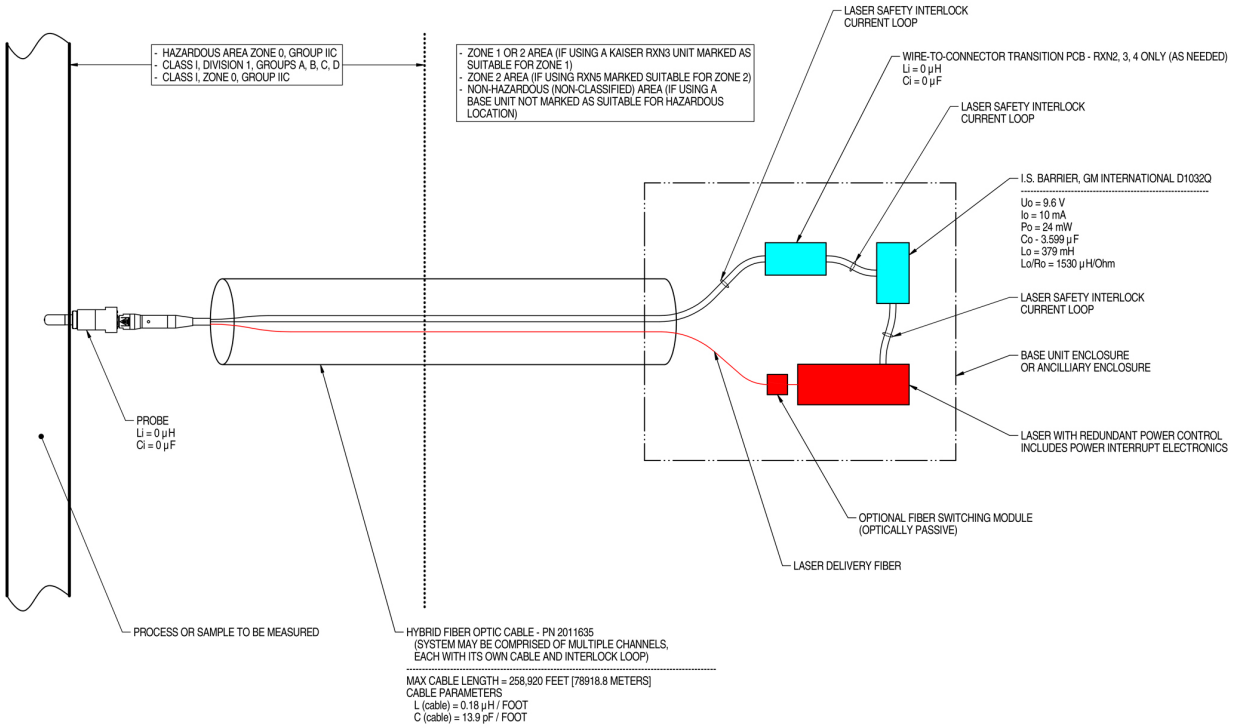
| Type | Description |
|---|---|
| Hazardous area approvals | **ATEX**<br>The Rxn-41 probe has been third-party approved for use in hazardous areas in accordance with Article 17 of Directive 2014/34/EU of the European Parliament and of the Council dated 26 February 2014. The Rxn-41 probe has been certified to the ATEX Directive for use in Europe, as well as in other countries accepting ATEX-certified equipment.<br><br>**IECEx**<br>The Rxn-41 probe can also be marked for International Electrotechnical Commission (IEC) Certification Systems for Explosive Atmospheres when installed in accordance with the Hazardous Area Installation Drawing.<br><br>**North American**<br>The Rxn-41 probe has also been approved for use in hazardous areas in the United States (US) and Canada by the Canadian Standards Association when installed in accordance with the Hazardous Area Installation Drawing.<br>The products are eligible to bear the CSA Mark with adjacent indicators 'C' and 'US' for Canada and US or with adjacent indicator 'US' for US only or without either indicator for Canada only. |

## Certifications and markings

Endress+Hauser offers certifications for the Rxn-41 probe. Upon purchase, ensure the desired certification(s) are selected to obtain appropriately marked probe tags. Select the desired certification(s) and the probe or probe tag will be marked accordingly. Refer to the *Rxn-41 Raman spectroscopic probe Safety Instructions (XA02784C)* for detailed certification and approval information.

## Hazardous area drawing

The Hazardous Area Installation Drawing is shown below.




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 18, APPENDIX J18.
4. ASSOCIATED APPARATUS MANUFACTURER'S INSTALLATION DRAWING MUST BE FOLLOWED WHEN INSTALLING THIS EQUIPMENT.
5. 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.
6. NO REVISION TO DRAWING WITHOUT PRIOR CSA APPROVAL.
7. WARNING: SUBSTITUTION OF COMPONENTS MAY IMPAIR INTRINSIC SAFETY.

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