

Technical Information

Rxn-41 Raman spectroscopic probe

System design and specifications

Application

The Raman Rxn-41 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 Raman Rxn-41 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

Your benefits

- Constructed to individual site requirements
- Sealed probe design
- Integrated "laser on" indicator
- One in/one out fiber optics
- Direct insertion compatibility
- Meets Category 1 pressure equipment safety standards
- Suitable for hazardous area/classified environments



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Function and system design

Application

Using the device for any purpose other than that described may compromise personal safety, damage the measuring system, and invalidates any warranty.

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.

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 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.

Rxn-41 probe

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

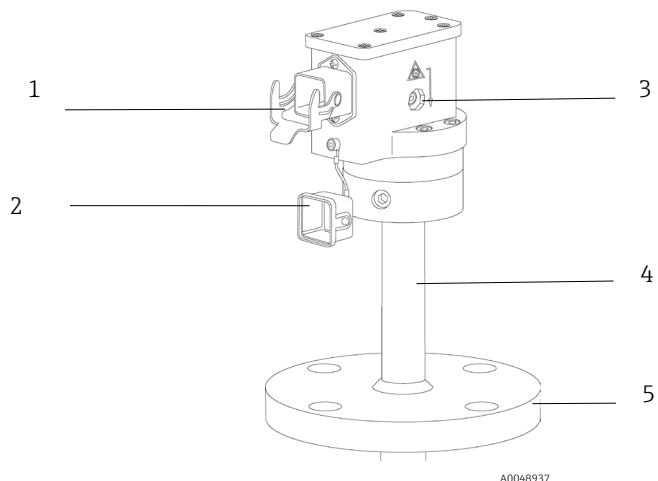


Figure 1. Rxn-41 probe

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

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. 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	Take care to install the probe so that it measures the flowing sample or sample region of interest.

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.

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 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 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 alloy are based on ASME B16.5-2018. Flange ratings for Grade 2 Titanium are based on ASME BPVC VIII.1-2021, Appendix 2. Flange ratings for DIN flanges are based on EN 1092-1:2013-04.

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)	10	9.6 barg (139 psig)
			16	15.4 barg (223 psig)
			25	24.1 barg (349 psig)
			40	38.7 barg (561 psig)
316L stainless steel	−30 °C (−22 °F)	120 °C (250 °F)	10	9.0 barg (130 psig)
			16	14.5 barg (210 psig)
			25	22.7 barg (329 psig)
			40	36.4 barg (527 psig)

LNG process composition and temperature specifications

An optimal configuration of the Rxn-41 probe has been identified for the optimal for the measurement and custody transfer of liquefied natural gas (LNG) on LNG bunkering ships:

- Hybrid metal combination (C276 tip/316L body)
- ASME B16.5 2", Class 150 raised face flange
- 220 mm (8.67 in) unsupported length for pipe inner diameters less than or equal to 254.0 mm (10.0 in)
- 240 mm (9.45 in) unsupported length for pipe inner diameter greater than or equal 254.0 mm (10.0 in)
- Cryogenic operation from -180 °C (93 K) to -156 °C (117 K)
- 25.4 mm (1.0 in) recommended exposed length for pipe inner diameter less than 152.4 mm (6.0 in)
- 76.2 mm (3.0 in) recommended exposed length for pipe inner diameter greater than 152.4 mm (6.0 in)

With this probe configuration, wake frequency stress calculations indicate that for turbulent flow conditions, the 220 mm (8.67 in) unsupported length probe satisfies the strength and serviceability requirements of ASME PTC 19.3 TW 2016. This applies to typical LNG stream with a density < 500 kg/m³ (31.21 lb/ft³) for flow rates up to the levels specified below.

The table provides maximum flow rates for the 220 mm (8.67 in) probe for pipe inner diameters from 50.88 to 250.0 mm (2 to 10 in), and for the 240 mm (9.45 in) probe for pipe inner diameters of 304.8 to 355.6 mm (12 to 14 in).

Pipe inner diameter	Recommended probe insertion length	Maximum linear flow rate	Maximum volumetric flow rate
220 mm (8.67 in) unsupported length			
50.8 mm (2.0 in)	25.4 mm (1.0 in)	14 m/sec (46 ft/sec)	100 m ³ /hr (26,430 gal/hr)
101.6 mm (4.0 in)	25.4 mm (1.0 in)	14 m/sec (46 ft/sec)	400 m ³ /hr (105,600 gal/hr)
152.4 mm (6.0 in)	76.2 mm (3.0 in)	14 m/sec (46 ft/sec)	900 m ³ /hr (237,750 gal/hr)
203.2 mm (8.0 in)	76.2 mm (3.0 in)	14 m/sec (46 ft/sec)	1600 m ³ /hr (422,670 gal/hr)
254.0 mm (10.0 in)	76.2 mm (3.0 in)	14 m/sec (46 ft/sec)	2500 m ³ /hr (660,420 gal/hr)
240 mm (9.45 in) unsupported length			
304.8 mm (12.0)	76.2 mm (3.0 in)	12.5 m/sec (40.8 ft/sec)	3293.3 m ³ /hr (870,000 gal/hr)
355.6mm (14.0 in)	76.2 mm (3.0 in)	12.5 m/sec (40.8 ft/sec)	4474.4 m ³ /hr (1,182,000 gal/hr)

Rxn-41 probe installation
parameters for LNG bunkering

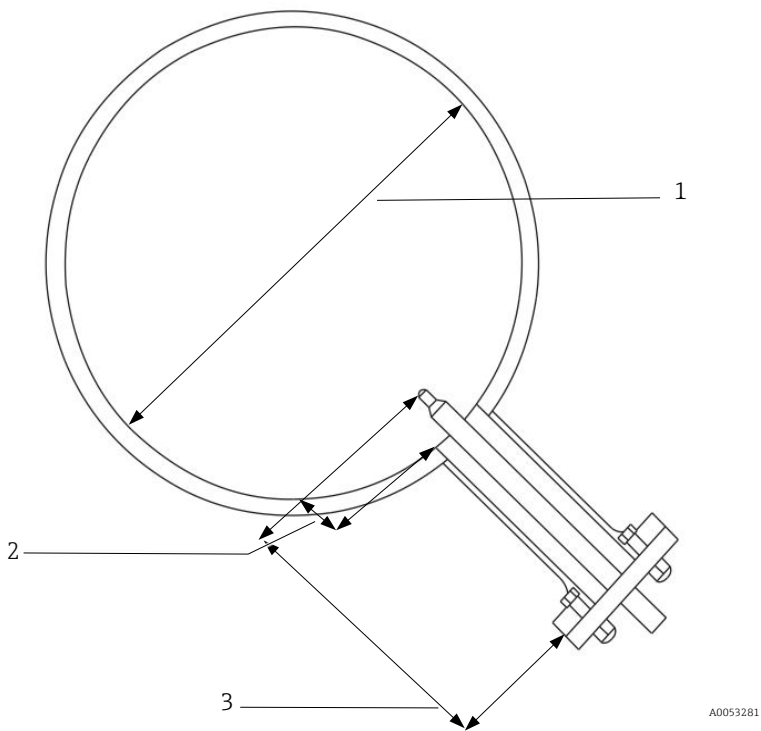


Figure 2: Rxn-41 probe installation parameters for LNG bunkering

#	Description
1	Pipe inner diameter
2	Exposed
3	Unsupported

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: -30 to 150 °C / -22 to 302 °F Explosive environments: T4: -20 to 70 °C / -4 to 158 °F T6: -20 to 65 °C / -4 to 149 °F Limited to normal ambient temperature IEC 60079-0 for Korea
Maximum laser power into probe		< 499 mW
Working distance from probe exit		short: 0 mm (0 in) 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 13 ¹
Materials of construction: Wetted materials	probe body	■ C276 alloy or 316L stainless steel ■ Grade 2 titanium available upon request ■ 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) ■ 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) ■ 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) 60.3 mm (2-inch nominal; actual OD 2.38 in)
	316L stainless steel	25.4 mm (1 in) 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 ■ DIN EN1092 Type B flanges available upon request
	diameter	38.1 mm (1.5 in) minimum to 305 mm (12 in) maximum

¹ 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.

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.

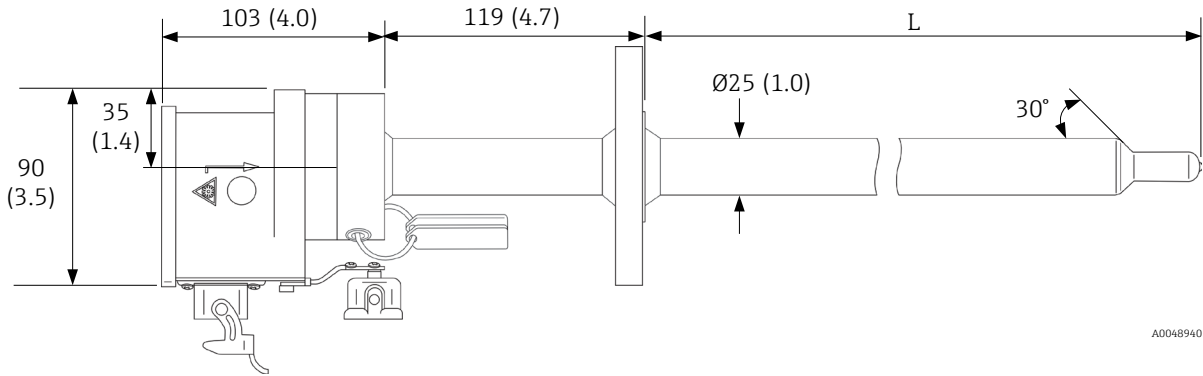


Figure 3. Rxn-41 1" probe. Dimensions: mm (in)
L = immersible length per specifications

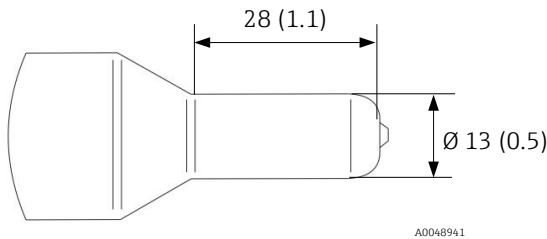


Figure 4. Tip of 1" Rxn-41 probe. Dimensions: mm (in)

Dimensions: 2" probe

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

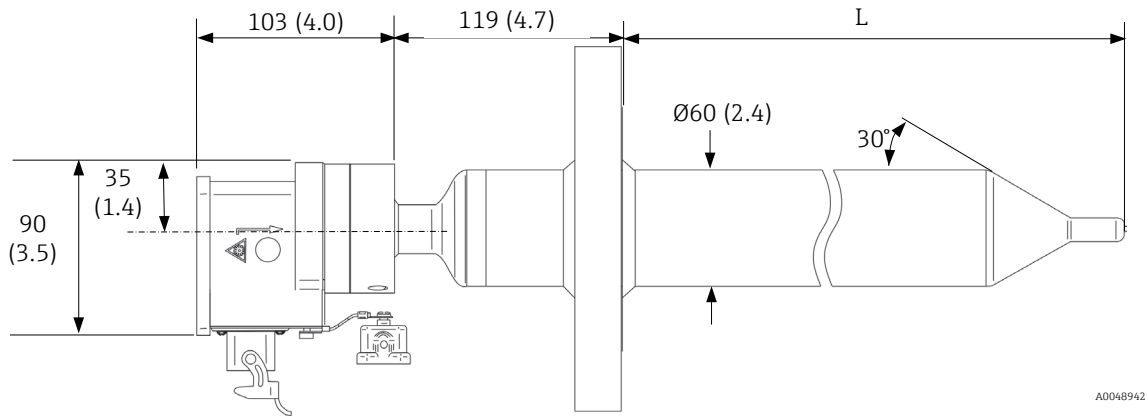


Figure 5. Rxn-41 2" probe. Dimensions: mm (in)
L = Immersible length per specifications

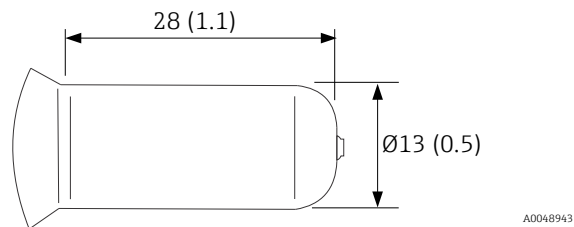


Figure 6. Tip of 2" Rxn-41 probe. Dimensions: mm (in)

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 (C_A) 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 × 10 ⁻⁷	-
	10 ⁻¹¹ to 5 × 10 ⁻⁶	2.0 × 10 ⁻⁷	-
	5 × 10 ⁻⁶ to 10	1.8 t ^{0.75} × 10 ⁻³	-
	10 to 30,000	-	1 × 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 × 10 ⁻⁸	-	785: C_A = 1.479 993: C_A = 3.855
	10 ⁻¹¹ to 10 ⁻⁹	2.7 C_A t ^{0.75}	-	
	10 ⁻⁹ to 18 × 10 ⁻⁶	5.0 C_A × 10 ⁻⁷	-	
	18 × 10 ⁻⁶ to 10	1.8 C_A t ^{0.75} × 10 ⁻³	-	
	10 to 3 × 10 ⁴	-	C_A × 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 × 10 ⁻²	-	532: C_A = 1.000
	10 ⁻⁷ to 10	1.1 C_A t ^{0.25}	-	785: C_A = 1.479
	10 to 3 × 10 ⁴	-	0.2 C_A	993: C_A = 3.855

Certificates and approvals

Hazardous area approvals

The hazardous area approvals are listed below.

Type	Description
Hazardous area approvals	ATEX 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. IECEX 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. North American 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. 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.

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.

A0049010

Figure 7. Hazardous Area Installation Drawing (4002396 version X6)

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