

Technical Information

Rxn-40 Raman spectroscopic probe



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Function and system design

Fields of application

The Rxn-40 Raman spectroscopic probe is intended for liquid immersion sample analysis in a laboratory or process plant setting.

Recommended applications include:

- **Chemical:** Reaction monitoring, blending, catalyst monitoring, feed and final product monitoring
- **Polymer:** Polymerization reaction monitoring, extrusion monitoring, polymer blending
- **Pharmaceutical:** Active Pharmaceutical Ingredient (API) reaction monitoring, crystallization, polymorph, blending
- **Oil and Gas:** Any hydrocarbon analysis

Use of the device for any purpose other than that described, poses a threat to the safety of people and of the entire measuring system and is not permitted and invalidates any warranty.

Laser safety interlock

The Rxn-40 probe, as installed, forms part of the interlock circuit. If the fiber cable is severed, the laser will turn off within 20 milliseconds of the breakage.

NOTICE

Handle probes and cables with care.

Fiber cables should NOT be kinked and should be routed to maintain the minimum bend radius of 6 inches (152.4 mm).

- ▶ Permanent damage may result if cables are not routed appropriately.

The interlock circuit is a low-current electrical loop. If the Rxn-40 probe is used in a classified area, the interlock circuit must be run through an Intrinsically Safe (IS) barrier.

LED laser indicator

The location of the LED laser indicator depends on the assembly type.

- **Non-removable right-angle EO fiber connector (Figure 1):** The indicator is located on the assembly. When there is potential for the laser to be energized, the indicator light is illuminated.
- **Integrated stainless steel fiber connection shell option (Figures 2, 3 and 4 below):** The indicator is located on the fiber connection shell. When there is potential for the laser to be energized, the indicator light is illuminated.

LED laser
indicator

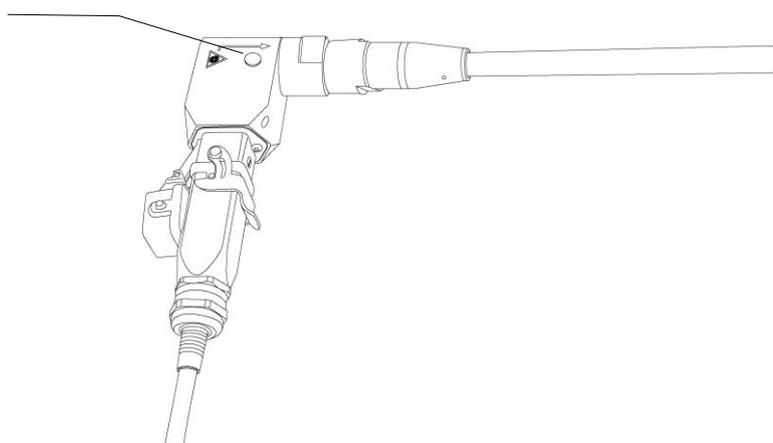


Figure 1: LED laser indicator on right-angle EO fiber connector

Rxn-40 probe, non-flanged configuration

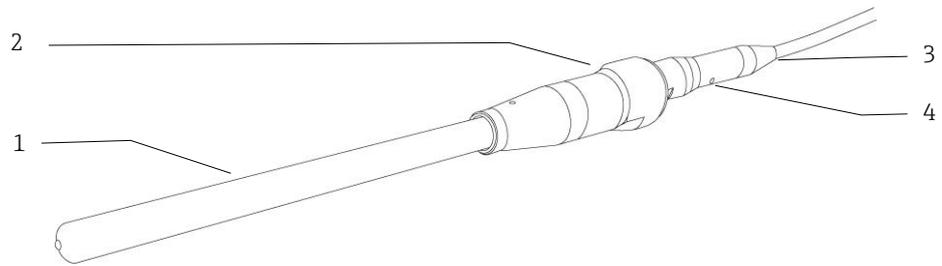


Figure 2: Non-flanged configuration of the Rxn-40 probe

#	Name	Description
1	Tip	316L Stainless steel, C276 Alloy or Grade 2 titanium Immersible length of 6, 12, and 18 or inches
2	Optic body	304 Stainless steel
3	Fiber cable	Cable: PVC jacketed, proprietary construction Connections: proprietary electro-optic
4	LED laser indicator	Illuminated when the laser is energized

Table 1. Rxn-40 probe parts, non-flanged configuration

Rxn-40 probe, flanged configuration

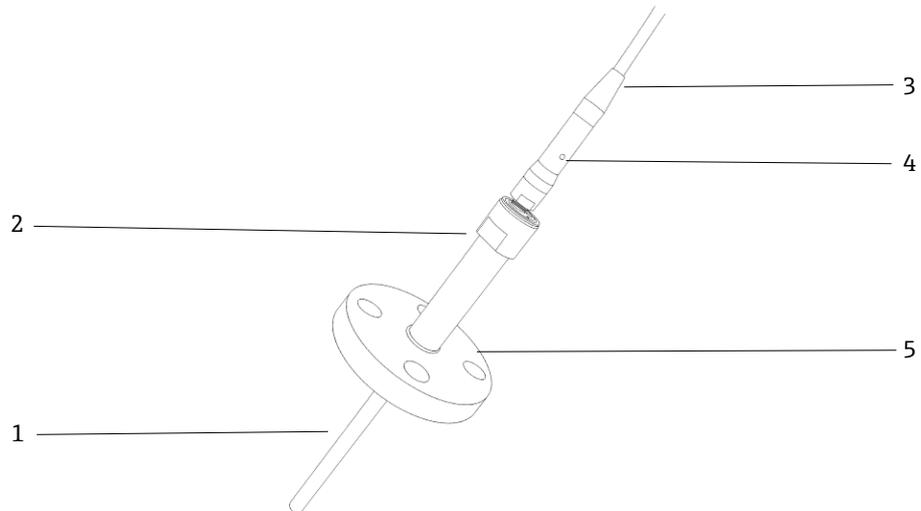


Figure 3: Flanged configuration of the Rxn-40 probe

#	Name	Description
1	Tip	316L Stainless steel, C276 Alloy or Grade 2 titanium
2	Optic body	304 Stainless steel
3	Fiber cable	Cable: PVC jacketed, proprietary construction Connections: proprietary electro-optic
4	LED laser indicator	Illuminated when the laser is energized
5	Flange	ANSI B16.5 and DIN EN1092 Type B flanges available

Table 2. Rxn-40 probe parts, flanged configuration

Rxn-40 probe, mini configuration

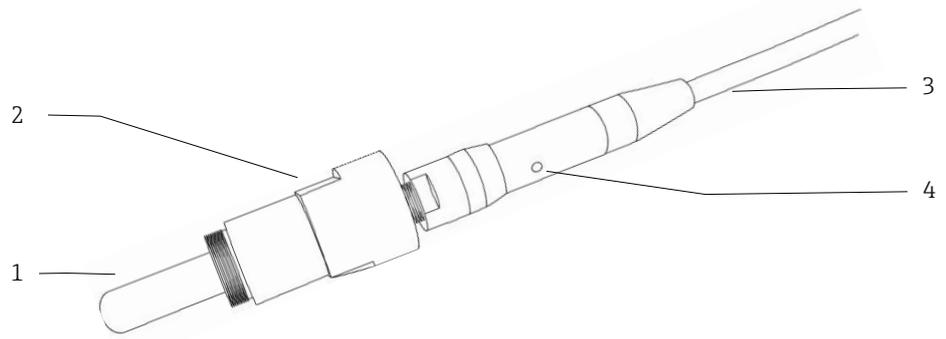


Figure 4: Mini configuration of the Rxn-40 probe

#	Name	Description
1	Tip	316L Stainless steel, C276 Alloy or Grade 2 titanium Immersible length of 1.4 inches
2	Optic body	304 Stainless steel
3	Fiber cable	Cable: PVC jacketed, proprietary construction Connections: proprietary electro-optic
4	LED laser indicator	Illuminated when the laser is energized

Table 3. Rxn-40 probe parts, mini configuration

Process and probe compatibility Prior to installation, the user must check that the probe pressure and temperature ratings, as well as the materials from which the probe is made, are compatible with the process into which it is being inserted.

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 blow-out protection device is highly recommended in accordance with local safety standards.

- ▶ It is the responsibility of the user to determine if any blow-out 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

Prior to 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	<p>Probes are designed with specific sealing boundaries.</p> <ul style="list-style-type: none"> ▶ The probe pressure specifications are only valid if sealing is accomplished on the intended sealing feature (shaft, flange, etc.). <p>Standard precautions for laser products should be observed.</p> <ul style="list-style-type: none"> ▶ Probes should always be capped and/or pointed away from people toward a diffuse target if not installed in a sample chamber.
⚠ CAUTION	<p>If stray light is allowed to enter an unused probe, it will interfere with data collected from a used probe and may cause calibration failure or measurement errors.</p> <ul style="list-style-type: none"> ▶ Unused probes should ALWAYS be capped to prevent stray light from entering the probe.
NOTICE	<p>Take care to install the probe such that it measures the flowing sample or sample region of interest.</p>

Data collection zone: Short vs. Long

The Rxn-40 probe comes with either a short (S) or a long (L) data collection zone depending on the version selected. A short data collection zone is generally used for opaque samples such as powders, gels, slurries, and paint. If an Rxn-40 probe with a long data collection zone were used to analyze these materials, most or all of the incident radiation would be lost to specular and diffuse reflection by material above the focal plane.

A long data collection zone is better for transparent samples, such as hydrocarbons and solvents, because it maximizes the signal intensity by using the entire effective focal cylinder.

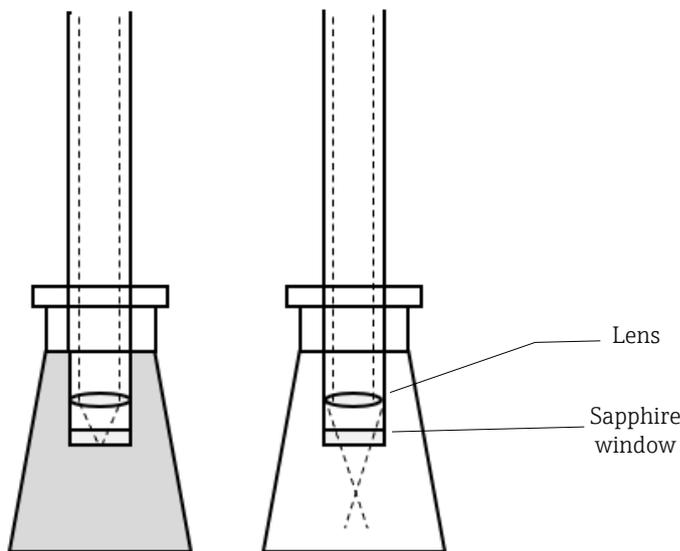


Figure 5. Use of Rxn-40 probe with short (left) vs. long (right) data collection zone

Focal plane

Spectral data is collected most efficiently at the focal plane.

NOTICE

The focus is set at the factory and cannot be adjusted by the user.

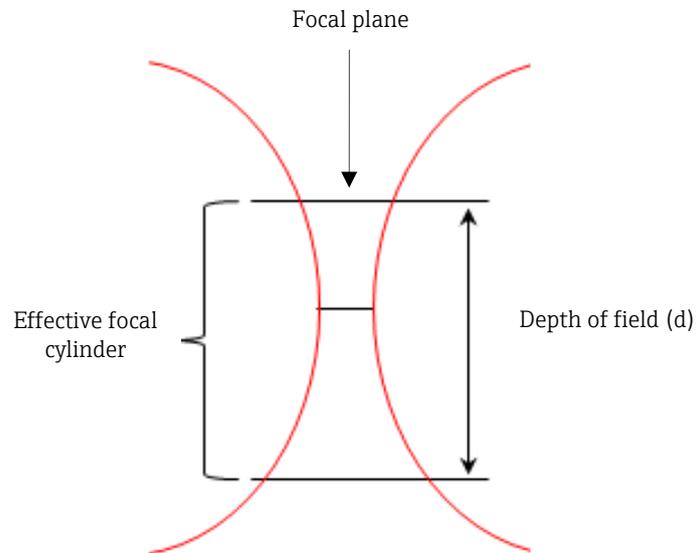


Figure 6. Effective focal cylinder

Specifications

Temperature and pressure

The temperature and pressure specifications for the Rxn-40 probe vary depending on the materials of construction. Additionally:

- Max Pressure is calculated per ASME BPVC VIII.1 UG-28(c) for material and probe geometry at the maximum rated temperature.
- 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 Bar (full vacuum). However, unless specified, they are not rated for low outgassing at high vacuum service.
- The temperature ramp is up to 30°C/min (86°F/min).

Component	Materials of Construction	Min Temp	Max Temp	Max Service Pressure Bar (psi)
Rxn-40 probe	Stainless Steel 316L	-30°C (-22°F)	120°C (248°F)	68.5 (990)
	Alloy C276	-30°C (-22°F)	280°C (536°F)	74.0 (1070)
	Titanium, Grade 2	-30°C (-22°F)	300°C (572°F)	29.0 (420)
Cable and connector	Cable: PVC jacketed, proprietary construction Connections: proprietary electro-optic	-40°C (-40°F)	70°C (158°F)	N/A

Table 4. Temperature and pressure specifications

General specifications

General specifications for the Rxn-40 probe are listed below.

Item		Description
Operating humidity		Up to 95% relative humidity; non-condensing
Probe body purge		Helium
Probe body hermeticity		Purge helium leak rate < 1×10^{-7} mbar·L/s
Chemical resistance		Limited by Materials of Construction
Raman excitation wavelength (λ)		532 nm or 785 nm or 993 nm
Window material		High-purity sapphire
Working distance from probe exit		Short: 0 mm Long: 3 mm
Focal length (f_o)		9 mm
Beam diameter (b_o)		5 mm
Probe immersible length	Rxn-40 non-flanged configuration	Up to 18 inches (457 mm) Grade 2 Titanium: Up to 350 mm Standard lengths are 6, 12, and 18 inches.
	Rxn-40 flanged configuration	Up to 15 inches (381 mm)
	Rxn-40 mini configuration	1.4 inches (36 mm)
Immersion shaft outer diameter	Rxn-40 non-flanged configuration	1/2 inch (12.7 mm) standard; custom diameters may be available. For example: 3/4 inch (19.05 mm) or 1 inch (25.4 mm) for Rxn-40, non-flanged or flanged configuration
	Rxn-40 flanged configuration	
	Rxn-40 mini configuration	1/2 inch (12.7 mm) standard; custom diameters may be available.
Probe, spectral coverage, 532 nm		175 to 4325 cm^{-1}
Probe, spectral coverage, 785 nm		150 to 3425 cm^{-1}
Probe, spectral coverage, 993 nm		200 to 2400 cm^{-1}
Fiber optic cable flame resistance		Certified: CSA-C/US AWM I/II, A/B, 80C, 30V, FT1, FT2, VW-1, FT4 Rated: AWM I/II A/B 80C 30V FT4

Table 5. General specifications

MPE: Ocular exposure

Refer to the tables below from the ANSI Z136.1 standard to calculate the Maximum Permissible Exposure (MPE) for point source ocular exposure to a laser beam.

A correction factor (C_A) may also be required and can be determined below.

Wavelength λ (nm)	Correction Factor C_A
400 to 700	1
700 to 1050	$10^{0.002(\lambda-700)}$
1050 to 1400	5

Table 6. Wavelength dependent correction factor C_A

Determining Maximum Permissible Exposure (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	$1.8 t^{0.75} \times 10^{-3}$	-
	10 to 30,000	-	1×10^{-3}

Table 7. MPE for ocular exposure with 532 nm laser emission

Determining Maximum Permissible Exposure (MPE) for Point Source Ocular Exposure to a Laser Beam				
Wavelength λ (nm)	Exposure Duration t (s)	MPE Calculation		MPE where $C_A = 1.4791$
		(J·cm ⁻²)	(W·cm ⁻²)	
785 and 993	10^{-13} to 10^{-11}	$1.5 C_A \times 10^{-8}$	-	2.2×10^{-8} (J·cm ⁻²)
	10^{-11} to 10^{-9}	$2.7 C_A t^{0.75}$	-	Insert time (t) and calculate
	10^{-9} to 18×10^{-6}	$5.0 C_A \times 10^{-7}$	-	7.40×10^{-7} (J·cm ⁻²)
	18×10^{-6} to 10	$1.8 C_A t^{0.75} \times 10^{-3}$	-	Insert time (t) and calculate
	10 to 3×10^4	-	$C_A \times 10^{-3}$	1.4971×10^{-3} (W·cm ⁻²)

Table 8. MPE for ocular exposure with 785 or 993 nm laser emission

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.

Maximum Permissible Exposure (MPE) for Skin Exposure to a Laser Beam				
Wavelength λ (nm)	Exposure Duration t (s)	MPE Calculation		MPE where $C_A = 1.4791$
		(J·cm ⁻²)	(W·cm ⁻²)	
532, 785 and 993	10^{-9} to 10^{-7}	$2 C_A \times 10^{-2}$	-	2.9582×10^{-2} (J·cm ⁻²)
	10^{-7} to 10	$1.1 C_A t^{0.25}$	-	Insert time (t) and calculate
	10 to 3×10^4	-	$0.2 C_A$	2.9582×10^{-1} (W·cm ⁻²)

Table 9. MPE for skin exposure with 532, 785 or 993 nm laser emission

Materials of construction

Materials of construction for the Rxn-40 probe are listed below.

Probe Type	Version		
	Alloy C276 [UNS N10276; Hastelloy C276]	316L [UNS S31603]	Titanium [UNS R50400]
Rxn-40 flanged or non-flanged, Non-Wetted	Alloy C276	Stainless steel (316L)	Titanium (grade 2)
	Stainless steel (303)	Stainless steel (303)	Stainless steel (303)
	Oxygen-free copper	Oxygen-free copper	Oxygen-free copper
	High temperature epoxy	High temperature epoxy	High temperature epoxy
Rxn-40 mini configuration, Non-Wetted	Stainless steel (303)	Stainless steel (303)	Stainless steel (303)
	Oxygen-free copper	Oxygen-free copper	Oxygen-free copper
Rxn-40 flanged or non-flanged, Wetted - in Contact with Sample	Alloy C276	Stainless steel (316L)	Titanium (grade 2)
	High-purity sapphire	High-purity sapphire	High-purity sapphire
Rxn-40 mini configuration, Wetted - in Contact with Sample	Alloy C276	Stainless steel (316L)	Titanium (grade 2)
	High-purity sapphire	High-purity sapphire	High-purity sapphire

Table 10. Materials of construction

Certificates and approvals

Hazardous area approvals

The hazardous area approvals are listed below.

Type	Description
Hazardous area approvals	<p>ATEX The Rxn-40 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-40 probe has been certified to the ATEX Directive for use in Europe, as well as in other countries accepting ATEX-certified equipment (Certificate # ITS10ATEX17085X).</p> <p>IECEX The Rxn-40 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. The IECEX Certificate of Conformity has Certificate # IECEX ITS 14.0015X.</p> <p>North American The Rxn-40 probe has also been approved for use in hazardous areas in the United States (US) and Canada by the Canadian Standards Association (Certificate # 2413954) 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.</p>

Table 11. Hazardous area approvals

Certifications and markings

Endress+Hauser offers certifications for the Rxn-40 probe to the standards below. Select the desired certification(s) and the probe or probe tag is marked accordingly.

Type	Description
ATEX marking and installations	<p>ATEX marking is available as an option at the time of purchase. Available markings: II 2/1 G Ex ia op is IIA or IIB or IIB+H2 or IIC T3 or T4 or T6 Ga</p> <p>Prior to the order, the marking for the particular probe/application must be determined. The customer must do one of the following:</p> <ul style="list-style-type: none"> Work with purchasing to identify the required marking OR Provide Endress+Hauser with a completed copy of the Hazardous Area Equipment Assessment (4002266). <p>Endress+Hauser will mark the Rxn-40 probes according to the customer's provided information. Endress+Hauser is not responsible for the customer's inaccuracies.</p> <p>⚠ WARNING In an ATEX-governed environment, only ATEX-marked probes may be used.</p>
North American hazardous area marking and installations	<p>CSA marking is available as an option at the time of purchase. Available markings: Ex ia op is IIA or IIB or IIB + H2 or IIC T3 or T4 or T6 Ga Class I, Zone 0 AEx ia op is IIA or IIB or IIB + H2 or IIC T3 or T4 or T6 Ga Class I, Division 1, Groups A, B, C, D T3/T4/T6</p> <p>Prior to the order, the marking for the particular probe/application must be determined. The customer must do one of the following:</p> <ul style="list-style-type: none"> Work with purchasing to identify the required marking OR Provide Endress+Hauser with a completed copy of the Hazardous Area Equipment Assessment (4002266). <p>Endress+Hauser will mark the Rxn-40 probes according to the customer's provided information. Endress+Hauser is not responsible for the customer's inaccuracies.</p> <p>For North American applications into classified environments, the probe set will have the CSA mark and can be considered intrinsically safe when installed according to the Hazardous Area Installation Drawing (4002396).</p> <p>⚠ WARNING In a CSA-governed environment, only CSA-marked probes may be used.</p>
IECEX hazardous area marking and installations	<p>IECEX marking is available as an option at the time of purchase. Available markings: Ex ia op is IIA or IIB or IIB + H2 or IIC T3 or T4 or T6 Ga IECEX ITS 14.0015X</p> <p>Prior to the order, the marking for the particular probe/application must be determined. The customer must do one of the following:</p> <ul style="list-style-type: none"> Work with purchasing to identify the required marking OR Provide Endress+Hauser with a completed copy of the Hazardous Area Equipment Assessment (4002266). <p>Endress+Hauser will mark the Rxn-40 probes according to the customer's provided information. Endress+Hauser is not responsible for the customer's inaccuracies.</p> <p>For IECEX applications into classified environments, the probe set will have the IECEX mark and can be considered intrinsically safe when installed according to the Hazardous Area Installation Drawing (4002396).</p> <p>⚠ WARNING In an IECEX-governed environment, only IECEX-marked probes may be used.</p>

Table 12. Certifications and markings

Hazardous area drawing

The hazardous area installation drawing is shown below:

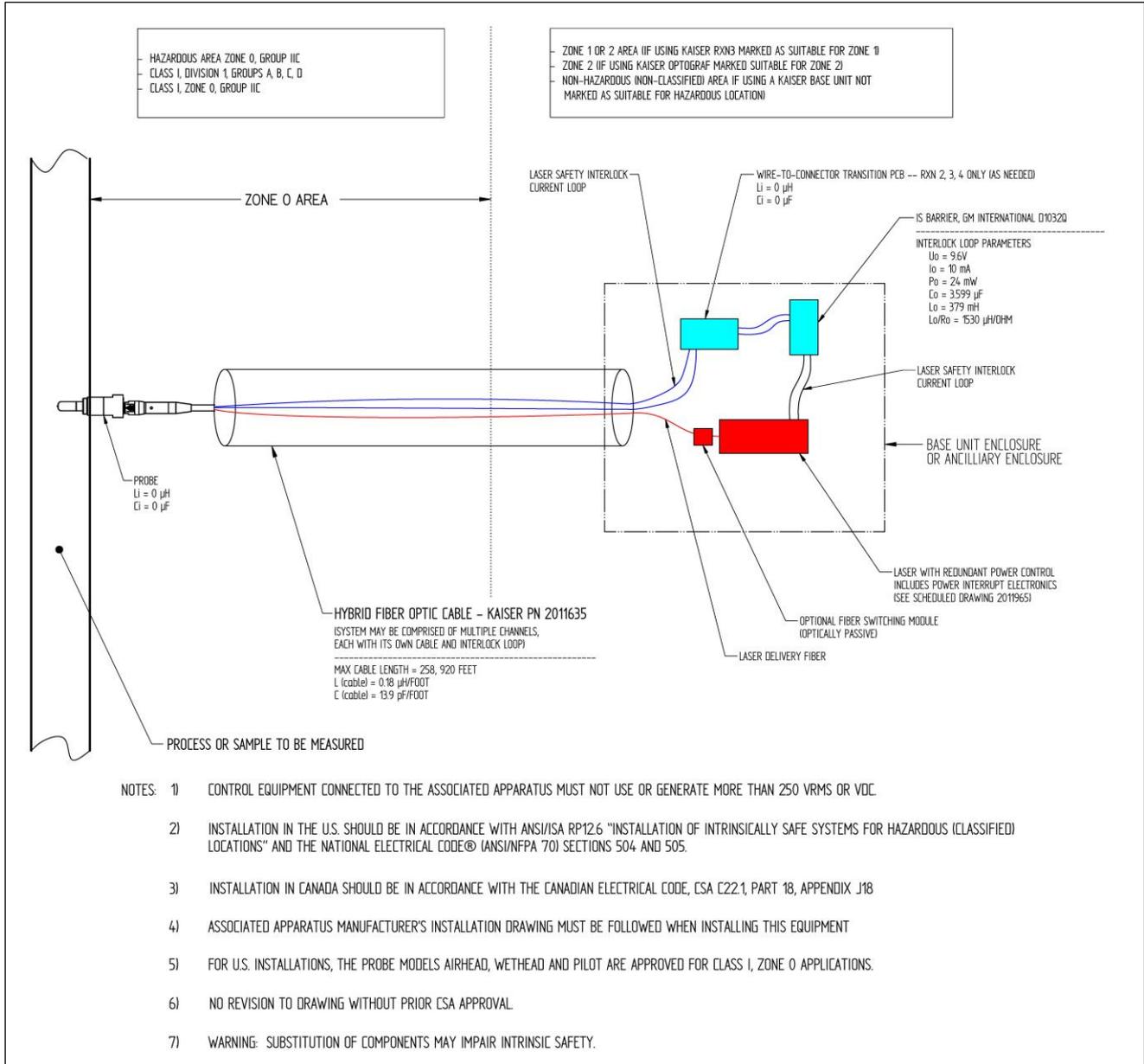


Figure 7. Hazardous Area Installation Drawing (4002396 version X4)

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