

Operating Instructions

Rxn-41 Raman spectroscopic probe



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1 General notes

1.1 Warnings

Structure of Information	Meaning
 WARNING Causes (/consequences) Consequences of noncompliance (if applicable) ▶ Corrective action	This symbol alerts you to a dangerous situation. Failure to avoid the dangerous situation can result in a fatal or serious injury.
 CAUTION Causes (/consequences) Consequences of noncompliance (if applicable) ▶ Corrective action	This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in minor or more serious injuries.
NOTICE Cause/situation Consequences of noncompliance (if applicable) ▶ Action/note	This symbol alerts you to situations which may result in damage to property.

1.2 Symbols on the device

Symbol	Description
	The Laser Radiation symbol is used to alert the user to the danger of exposure to hazardous visible laser radiation when using the Raman Rxn system.
	The High Voltage symbol that alerts people to the presence of electric potential large enough to cause injury or damage. In certain industries, high voltage refers to voltage above a certain threshold. Equipment and conductors that carry high voltage warrant special safety requirements and procedures.
	The CSA Certification Mark indicates that the product was tested against and met the applicable North American standards requirements.
	The WEEE symbol indicates that the product should not be discarded as unsorted waste but must be sent to separate collection facilities for recovery and recycling.
	The CE Marking indicates conformity with health, safety, and environmental protection standards for products sold within the European Economic Area (EEA).
	The ATEX Marking indicates the product has been certified to the ATEX directive for use in Europe, as well as in other countries, accepting ATEX-certified equipment.

1.3 U.S. export compliance

The policy of Endress+Hauser is in strict compliance with U.S. export control laws as detailed in the website of the [Bureau of Industry and Security](#) at the U.S. Department of Commerce. The Export Control Classification number for the Rxn-41 is EAR99.

1.4 Glossary

Term	Description
ANSI	American National Standards Institute
API	active pharmaceutical ingredient
ATEX	atmosphere explosible
BPVC	Boiler and Pressure Vessel Code
°C	Celsius
CDRH	Center for Devices and Radiological Health
CFR	Code of Federal Regulations
cm	centimeter
CSA	Canadian Standards Association
DIN	Deutsches Institut für Normung (German Institute for Standardization)
EO	electro-optical
EU	European Union
°F	Fahrenheit
ft	feet
IEC	International Electrotechnical Commission
in	inches
IPA	isopropyl alcohol
IS	intrinsically safe
kg	kilogram
lb	pounds
LED	light emitting diode
m	meter
mbar	millibar pressure unit
mm	millimeter
MPE	maximum permissible exposure
nm	nanometer
PAT	process analytical technology
psi	pounds per square inch
QbD	quality-by-design
RD	red
WEEE	Waste Electrical and Electronic Equipment
YE	yellow

2 Basic safety instructions

2.1 Requirements for personnel

- Installation, commissioning, operation, and maintenance of the measuring system may be carried out only by specially trained technical personnel.
- The technical personnel must be authorized by the plant operator to carry out the specified activities.
- The technical personnel must have read and understood these Operating Instructions and must follow the instructions contained herein.
- The facility must designate a laser safety officer who ensures staff are trained on all Class 3B laser operating and safety procedures.
- Faults at the measuring point may only be rectified by properly authorized and trained personnel. Repairs not described in this document must be carried out only directly at the manufacturer's site or by the service organization.

2.2 Designated use

The Rxn-41 Raman spectroscopic 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

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 invalidates any warranty.

2.3 Workplace safety

As the user, you are responsible for complying with the following safety conditions:

- Installation guidelines
- Local standards and regulations for electromagnetic compatibility

The product has been tested for electromagnetic compatibility in accordance with the applicable international standards for industrial applications. The electromagnetic compatibility indicated applies only to a product that has been properly connected to the analyzer.

2.4 Operational safety

Before commissioning the entire measuring point:

- Verify that all connections are correct.
- Ensure that electro-optical cables are undamaged.
- Ensure fluid level is sufficient for probe immersion (if applicable).
- Do not operate damaged products.
- Protect them against unintentional operation.
- Label damaged products as defective.

During operation:

- If faults cannot be rectified, products must be taken out of service and protected against unintentional operation.
- When working with laser devices, always follow all local laser safety protocols which may include the use of personal protective equipment and limiting device access to authorized users.

2.5 Pressure safety

Pressure ratings are based on the referenced standards for the probe. Fittings and flanges may or may not be included in the rating depending upon the probe configuration. Furthermore, product ratings may be affected by the bolting and sealing materials and procedures.

When planning for installation of an Endress+Hauser probe into the user's piping or sampling system, it is the user's responsibility to understand the limitations of the ratings and select appropriate fittings, bolts, seals, and procedures for alignment and assembly of sealed joints.

The user is solely responsible for any adverse outcomes resulting from the use of these ratings for sealed joints, failure to adhere to specified limitations, or disregard for accepted good practices in bolting and sealing.

2.6 Laser safety

Raman Rxn analyzers use Class 3B lasers as defined in the following:

- [American National Standards Institute](#) (ANSI) Z136.1, American National Standard for Safe Use of Lasers
- [International Electrotechnical Commission](#) (IEC) 60825-1, Safety of Laser Products – Part 1

⚠ WARNING

Laser radiation

- ▶ Avoid exposure to beam
- ▶ Class 3B laser product

⚠ CAUTION

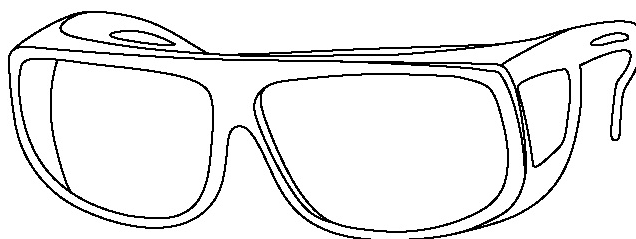
Laser beams can cause ignition of certain substances such as volatile organic compounds.

The two possible mechanisms for ignition are direct heating of the sample to a point causing ignition and the heating of a contaminant (such as dusts) to a critical point leading to ignition of the sample.

The laser configuration presents further safety concerns because the radiation is nearly invisible. Always be aware of the initial direction and possible scattering paths of the laser.

For 532 nm and 785 nm excitation wavelengths, use laser safety glasses with OD3 or greater.

For 993 nm excitation wavelength, use laser safety glasses with OD4 or greater.



A0048421

Figure 1. Laser safety glasses

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. See *Technical data* →  for relevant parameters to calculate maximum permissible exposure (MPE) and nominal ocular hazard distance (NOHD).

Refer to the *Rxn-41 Raman spectroscopic probe Safety Instructions (XA02784C)* for additional information on laser safety calculations.

2.7 Service safety

Follow your company's safety instructions when removing a process probe from the process interface for service. Always wear proper protective equipment when servicing the equipment.

2.8 Important safeguards

- Do not use the Rxn-41 probe for anything other than its intended use.
- Do not look directly into the laser beam.
- Do not point the laser at a mirrored or shiny surface, or a surface that may cause diffuse reflections. The reflected beam is as harmful as the direct beam.
- Do not leave attached and unused probes uncapped or unblocked.
- Always use a laser beam block to avoid inadvertent scatter of laser radiation.

2.9 Product safety

This product is designed to meet all current safety requirements and has been tested and shipped from the factory in a safe operating condition. The relevant regulations and international standards have been observed. Devices connected to an analyzer must also comply with the applicable analyzer safety standards.

Endress+Hauser Raman spectroscopy systems incorporate the following safety features to conform to the United States Government requirements found in Title 21 of the [Code of Federal Regulations](#) (21 CFR) Chapter 1, Subchapter J as administered by the [Center for Devices and Radiological Health](#) (CDRH) and IEC 60825-1 as administered by the [International Electrotechnical Commission](#).

2.9.1 CDRH and IEC compliance

Endress+Hauser Raman analyzers are certified by Endress+Hauser to meet CDRH and IEC 60825-1 design and manufacturing requirements.

Endress+Hauser Raman analyzers have been registered with the CDRH. Any unauthorized modifications to an existing Raman Rxn analyzer or accessory may result in hazardous radiation exposure. Such modifications may result in the system no longer conforming to federal requirements as certified by Endress+Hauser.

2.9.2 Laser emission indicator

The Rxn-41 probe, as installed, 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.

The laser emission indicator is located on the probe assembly. When there is potential for the laser to be energized, the indicator light is illuminated.

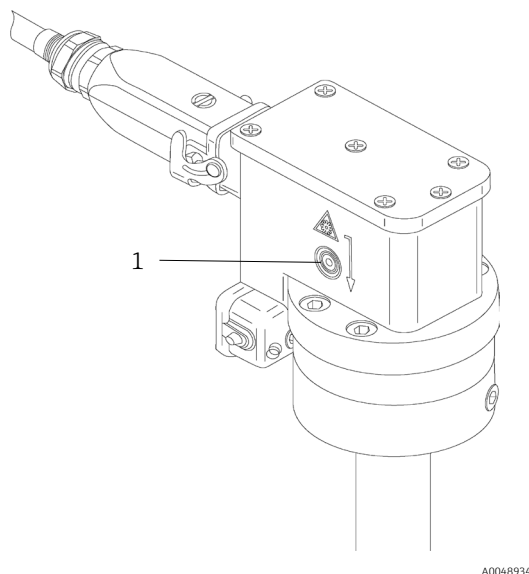


Figure 2. Location of laser emission indicator light (1)

2.9.3 Hazardous area approvals

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. Only the Rxn-41 probe with the ATEX badge has been certified to the ATEX Directive for use in Europe, as well as in other countries accepting ATEX-certified equipment.



Figure 3. ATEX label for use in hazardous areas

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 (4002396).

The products are eligible to bear the CSA Mark shown 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.



Figure 4. CSA label for use in hazardous areas in the US and Canada

The Rxn-41 probe can also be marked for [International Electrotechnical Commission](#) Certification Systems for Explosive Atmospheres (IECEx) when installed in accordance with the Hazardous Area Installation Drawing (4002396).

Only the Rxn-41 with the JPEx badge has been certified to meet Japan explosion proof requirements.



A0053030

Figure 5. JPEx product certification label

The Rxn-41 has been assessed against Regulation 42 of the Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016, UKSI 2016:1107 and been found to comply when installed in accordance with the Hazardous Area Installation Drawing (4002396).



A0045928

Figure 6. UK product certification label

Refer to the *Rxn-41 Raman spectroscopic probe Safety Instructions (XA02784C)* for more information on condition of use and appropriate markings required for your application.

3 Phase of product lifecycle

3.1 Documentation

All documentation is available:

- On the Endress+Hauser mobile app: www.endress.com/supporting-tools
- In the Downloads area of the Endress+Hauser website: www.endress.com/downloads

This document is an integral part of the document package, which includes:

Part number	Document type	Document title
KA01560C	Brief Operating Instructions	Rxn-41 Raman spectroscopic probe Brief Operating Instructions
XA02784C	Safety Instructions	Rxn-41 Raman spectroscopic probe Safety Instructions
TI01673C	Technical Information	Rxn-41 Raman spectroscopic probe Technical Information
BA02173C	Operating Instructions	Raman calibration Accessory Operating Instructions

3.2 Incoming acceptance

3.2.1 Notes on incoming acceptance

1. Verify that the packaging is undamaged. Notify the supplier of any damage to the packaging. Keep the damaged packaging until the issue has been resolved.
2. Verify that the contents are undamaged. Notify the supplier of any damage to the delivery contents. Keep the damaged goods until the issue has been resolved.
3. Check that the delivery is complete and nothing is missing. Compare the shipping documents with your order.
4. Pack the product for storage and transportation in such a way that it is protected against impact and moisture. The original packaging offers the best protection. Make sure to comply with the permitted ambient conditions. See the specifications listed in *Technical data* → .

If you have any questions, please contact your supplier or your local sales center.

NOTICE

Probe may be damaged during transport if packaged inadequately.

3.2.2 Product identification

3.2.2.1 Label

The probe is labeled with the following information:

- Endress+Hauser branding
- Product identification (e.g., Rxn-41)
- Serial number

Tags are permanently affixed and also include:

- Extended order code
- Manufacturer information
- Key functional aspects of the probe (e.g., material, wavelength, focal depth)
- Safety warnings and certification information, as applicable

Compare the information on the probe and tag with the order.

3.2.2.2 Manufacturer address

Endress+Hauser
371 Parkland Plaza
Ann Arbor, MI 48103 USA

3.2.3 Scope of delivery

The scope of delivery comprises:

- Rxn-41 probe in the configuration ordered
- *Rxn-41 Raman spectroscopic probe Operating Instructions*
- Rxn-41 probe Certificate of Product Performance
- Local declarations of conformity, if applicable
- Certificates for hazardous zone use, if applicable
- Material certificates, if applicable
- Rxn-41 probe optional accessories, if applicable

If you have any questions, please contact your supplier or local sales center.

3.2.4 Certificates and approvals

Refer to the *Rxn-41 Raman spectroscopic probe Safety Instructions (XA02784C)* for detailed certification and approval information.

3.3 Assembly

3.3.1 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. Please see the hazard area rating marked on each probe and the safety document for the probe type to confirm the maximum laser power allowed for the installation.

Standard eye and skin safety precautions for Class 3B laser products (as per EN-60825/IEC 60825-14) should be observed 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 a 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 such that it measures the flowing sample or sample region of interest.

3.3.1.1 Installation guidelines

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.

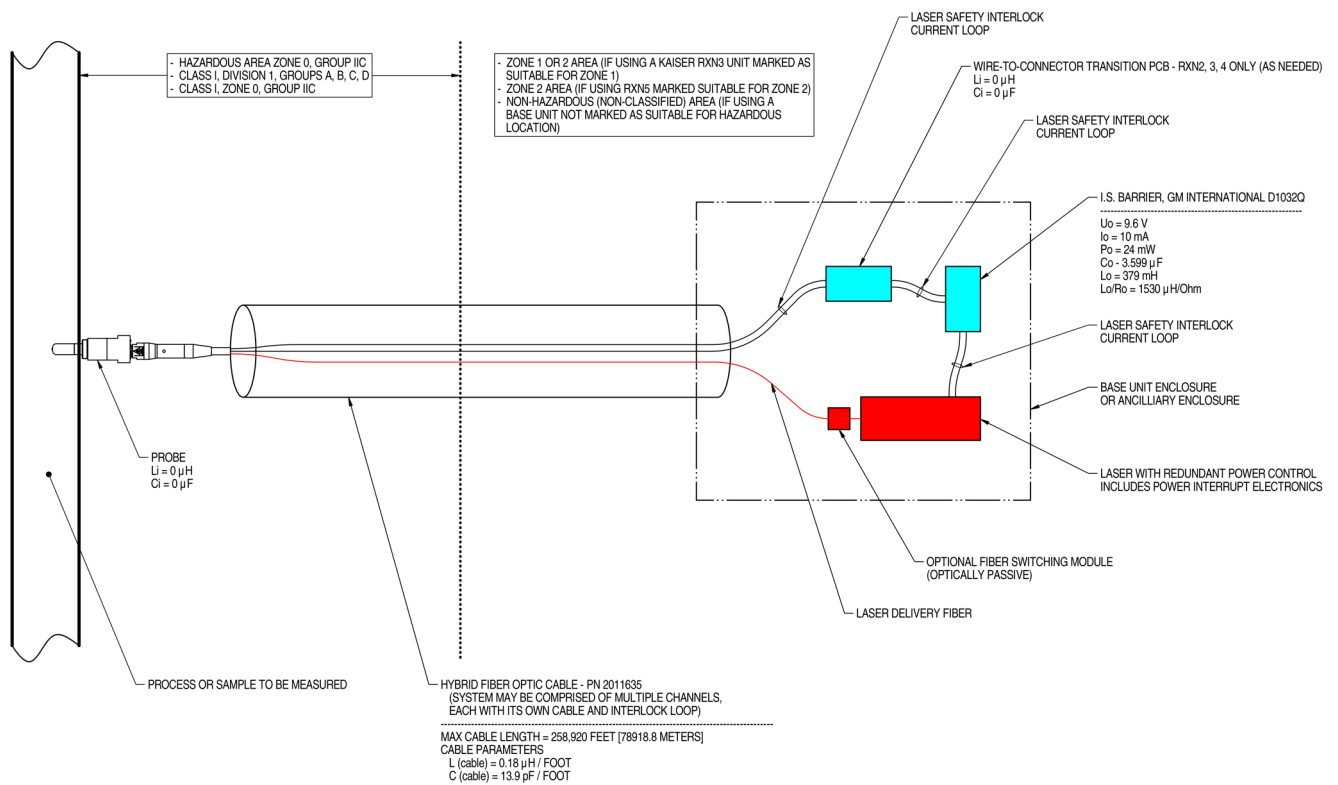
3.3.1.2 Hazardous area installation

For hazardous areas, the probe must be installed according to the Hazardous Area Installation Drawing (4002396).

Before installation, verify that the probe hazardous area markings are appropriate for the gas group, T-class, Zone, or Division it is being installed in. Please refer to IEC 60079-14 for more information on user responsibilities regarding use or installation of products in potentially explosive atmospheres.

NOTICE

When installing the probe head *in situ*, the user must ensure that there is strain relief at the installation location which complies with fiber bend radius specifications.



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)

3.3.1.3 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 and in accordance with any local construction codes.

⚠ 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.

3.4 Commissioning

The Rxn-41 probe is delivered ready to connect to a Raman Rxn analyzer. No additional alignment or adjustment to the probe itself is required. Follow the instructions below to commission the probe for use.

NOTICE

The probe installation and usage parameters may have specific requirements governed by the associated application.

- ▶ Refer to the appropriate certificate for ATEX, CSA, IECEx, JPEX, or UKCA for those specific requirements.

3.4.1 Receipt of probe

Perform the steps for incoming product acceptance described in *Incoming acceptance* → .

Additionally, upon receipt, remove the shipping container cover and inspect the sapphire window for any damage prior to installing into the process. If the window shows any visible cracks, please contact the supplier.

3.4.2 Probe calibration and verification

The probe and the analyzer must be calibrated before use. Refer to the applicable Raman Rxn2 or Raman Rxn4 analyzer Operating Instructions for further information on internal instrument calibration.

An intensity calibration must be performed before collecting measurements and after changing optics. Use the Raman calibration accessory (HCA) with an appropriate optic adapter to perform the probe calibration. All accessory information and calibration instructions can be found in the *Raman calibration accessory Operating Instructions (BA02173C)*.

The Raman RunTime software will not allow spectra to be collected without passing internal system calibrations.

After calibration, perform Raman RunTime channel verification using a Raman shift standard. Verification of the calibration results is recommended but not required. Instructions on verification with Raman shift standards can also be found in the calibration accessory Operating Instructions.

The recommended calibration and qualification sequence follows this order:

1. Internal analyzer calibration for spectrograph and laser wavelength
2. System intensity calibration using appropriate calibration accessories
3. System function verification using appropriate standard material

Contact your sales associate for specific questions related to your probe, optic, and sampling system.

3.5 Operation

The Endress+Hauser Raman Rxn-41 probe is a sealed immersion probe for *in situ* Raman spectroscopy of liquid-phase samples in a pilot or process plant setting. The Rxn-41 line of probes is designed to be compatible with Endress+Hauser Raman Rxn analyzers equipped with a laser operating at 532 nm, 785 nm, or 993 nm.

Refer to the applicable Raman Rxn analyzer Operating Instructions for additional instructions for use. Raman Rxn analyzer Operating Instructions are available by searching the Downloads area of the Endress+Hauser website: <https://endress.com/downloads>.

3.6 Diagnostics and troubleshooting

Refer to the table below when troubleshooting issues with the Rxn-41 probe. If the probe is damaged, isolate the probe from the process stream and turn off the laser prior to evaluation. Contact your service representative as needed for assistance.

Symptom		Possible cause	Action
1	Substantial reduction in signal or signal-to-noise ratio	Window fouling	1. Carefully remove probe from the process, decontaminate, and inspect optical window at tip of probe. 2. If necessary, clean the window before returning it to service. See <i>Probe inspection</i> →  .
		Cracked but intact fiber	Verify condition of fiber and contact your service representative for replacement.
2	Complete loss of signal while laser is powered and LED laser indicator is lit	Broken fiber without interlock wire breakage	Ensure all fiber connections are secure.
		Process material sticking on probe window	Remove the probe and clean the window
3	LED laser indicator on probe is not lit	Damaged fiber assembly or damaged Rxn-41 probe interlock	1. Look for signs of breakage in fiber. 2. Ensure probe is properly connected to the fiber. 3. Contact your service representative for replacement.
		Fiber cable EO connector not secured/latched	Ensure the EO connector is properly connected and latched at the probe (if applicable) and at the analyzer.
		Remote interlock connector disconnected	Ensure the twist-lock remote interlock connector at the rear of analyzer (next to fiber EO connector) is connected.
4	Unstable signal and contamination visible behind window	Window seal failure	1. Disconnect the probe and examine the area inside the window for moisture or condensation. 2. Examine the area inside the window for moisture or condensation. 3. Look for any sign of spectral deviation. 4. If any of the above are noted, contact your service representative to return the probe to the manufacturer.
5	Decreased laser power or collection efficiency	Contaminated fiber connection (dirt particles, dust particles, or otherwise) between analyzer and probe	Carefully clean the fiber ends at the probe. Refer to the applicable Raman Rxn analyzer and probe Operating Instructions for cleaning instructions and steps for starting up a new probe.
6	Laser interlock on analyzer causes laser to shut down	Laser interlock activated	Check for fiber breakage on all connected fiber-optic cable channels and ensure remote interlock connectors are in place on each channel.
7	Unrecognized bands or patterns in the spectra	Cracked but intact fiber	Verify possible causes and contact your service representative to return the damaged product.
		Contaminated probe tip	
		Contaminated internal optics of probe due to leakage	
8	Other unexplained negative performance of the probe	Physical damage to probe	Contact your service representative to return the damaged product.

3.7 Maintenance

3.7.1 Probe inspection

It is the customer's responsibility to determine the corrosion rate of any process probes and set appropriate inspection intervals to verify probe integrity.

NOTICE

Only 70 % IPA should be used for optical verification.

- ▶ Only 70 percent by volume (%v/v) will work. Endress+Hauser recommends using CiDehol 70 by Decon Laboratories.
- ▶ Use of any other liquid for verification will result in a failed verification and may result in damage to both the verification cell and the Raman probe.

3.7.2 Cleaning the probe window

If the Rxn-41 probe window has come in contact with a sample, dust or fingerprints, etc., it may need to be cleaned. Extra care must be taken to ensure that the window surface is not further contaminated during the cleaning process.

For all other maintenance, it is recommended that the Rxn-41 probe is serviced at the manufacturer's site.

To clean the Rxn-41 probe window:

1. Ensure that the laser is turned **OFF** or the probe is disconnected from the analyzer.
2. Blow off the surface with clean compressed air to remove any loose particles.
3. Wipe the surface using a swab **lightly** dampened with a solvent appropriate for the substance to be cleaned.

NOTICE

- ▶ Solvents may include reagent grade acetone, 100 % isopropyl alcohol (IPA) and deionized water. Please contact your service representative for other possible solvents.
 - ▶ Do not allow the solvent to drip behind the retaining components.
4. Wipe the surface dry with a new, clean swab.
 5. Repeat steps 3 and 4 with an additional solvent, if needed.
 6. Blow with clean, compressed air to remove any swab remnants.
 7. Inspect the surface to verify the effectiveness of the cleaning. Repeat the previous steps as necessary.

Verification with an inspection microscope in the cleaning process is highly recommended to look for smeared contaminants, swab remnants, etc., that may cause increased spectrum background.

3.7.3 Inspecting and cleaning the optical fibers

The optical fiber connectors must be clean and free of debris and oil to achieve optimal performance. If cleaning is required, refer to *Raman fiber-optic cables KFOC1 and KFOC1B Operating Instructions (BA02177C)*.

3.7.4 Purging and pressurizing interior volumes

Approximately every 5 years, any probes that have been located in hazardous areas should have their interior volumes re-purged and re-pressurized.

3.8 Repair

Repairs not described in this document must be carried out only directly at the manufacturer's site or by the service organization. For Technical Service, refer to our website (<https://endress.com/contact>) for the list of local sales channels.

If a product must be returned for repair or replacement, follow all decontamination procedures indicated by your service provider.

**WARNING**

Failure to properly decontaminate wetted parts before return can result in a fatal or serious injury.

To ensure swift, safe and professional product returns, please contact your service organization.

For additional product return information, refer to the following website and select the applicable market/region:

<https://www.endress.com/en/instrumentation-services/instrumentation-repair>.

4 Function and system design

4.1 Product description

4.1.1 The Rxn-41 probe

The Rxn-41 Raman spectroscopic probe, powered by Kaiser Raman technology, is intended for direct insertion in a pilot or process environment. The probe is compatible with Endress+Hauser Raman Rxn analyzers operating at 532 nm, 785 nm, or 993 nm and is certified for use in hazardous areas.

The Rxn-41 probe is ideally suited for use in chemical plants and refineries to measure batch or continuous flow production. It is also highly effective for use in pharmaceutical manufacturing facilities for glass lined reactors as part of a quality-by-design (QbD) solution using process analytical technology (PAT) analyzers.

For direct measurements in cryogenic fluids, an optimized cryogenic version of the Rxn-41 probe is available.

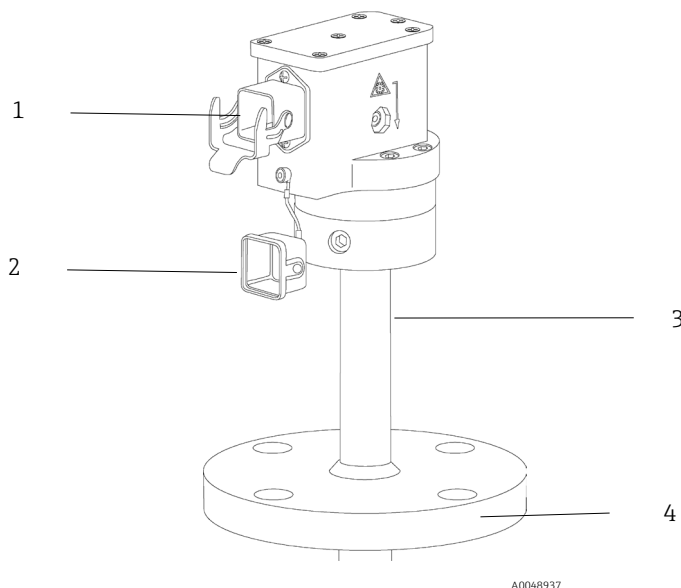


Figure 8. Rxn-41 probe

#	Description
1	Electro-optical cable connector
2	Electro-optical connector dust cover
3	Probe body
4	Flange (optional)

4.1.2 Benefits of the probe design

The Rxn-41 probe offers the following benefits compared to traditional probes:

- Sealed probe and optics design for compatibility with direct liquid insertion
- Fixed-optic design for long-term measurement stability and superior signal-to-background measurements
- Integrated “laser on” indicator
- Resistant to extreme chemical, temperature and pressure environments
- Designed and rated per ASME B31.3 Standard for Process Piping
- Many options available to meet individual site requirements
- Certified for use in hazardous areas
- Carries Canadian Registration Number (CRN) for installation in 13 provinces and territories.

4.2 Probe and fiber optic connection

The Rxn-41 probe connects to the Raman Rxn analyzer using a Raman fiber-optic cable. The EO fiber-optic cable has a single, robust connector that contains the excitation and collection fiber-optics as well as an electrical laser interlock. The fiber-optic cable is sold separately.

Fiber-optic cables are available in 5 m (16.4 ft) increments up to 200 m (656.2 ft) with the length limited by the application.

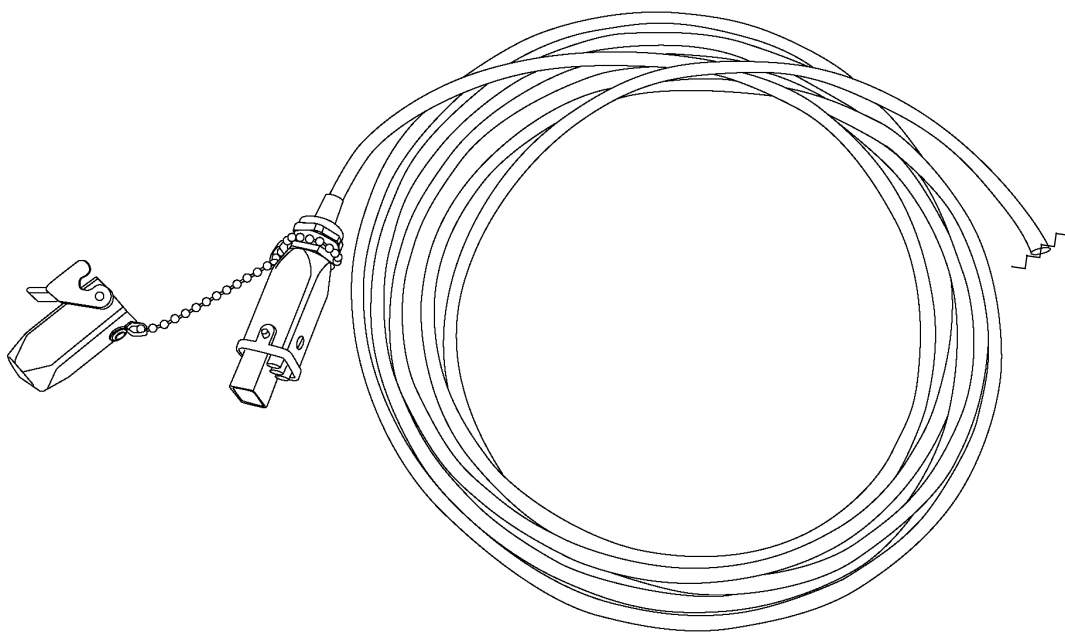
Endress + Hauser recommends using the KFOC1B Raman fiber-optic cable with the Raman Rxn analyzers and probes. Refer to the applicable Raman Rxn analyzer Operating Instructions for more information on analyzer connection.

NOTICE

Connection of the probe to the fiber-optic cable must be conducted by a qualified Endress+Hauser engineer or specially trained technical personnel.

- ▶ Unless trained by qualified personnel, customer attempts to connect the probe to the fiber-optic cable can result in damage and may void the warranty.
- ▶ Contact your local Endress+Hauser service representative for additional support regarding the probe and fiber cable connection.

The fiber connection for the Rxn-41 probe is a right-angle, direct fiber connection.



A0048938

Figure 9. EO fiber cable showing connector for analyzer

5 Technical data

5.1 Temperature and pressure specifications

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" Rxn-41 probe upon request. Additional specifications include:

- Max pressure is calculated as specified in ASME B31.3 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 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

5.2 Liquefied natural gas (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 $< 500 \text{ kg/m}^3$ (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)

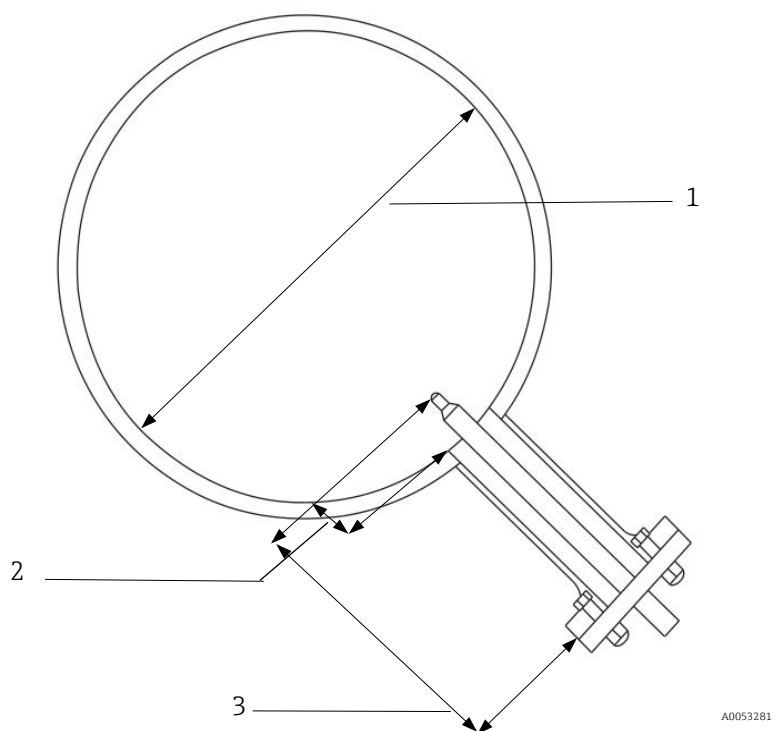


Figure 10. Rxn-41 probe installation parameters for LNG bunkering

#	Description
1	Pipe inner diameter
2	Exposed
3	Unsupported

5.3 General specifications

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:	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
Wetted materials	window	high-purity sapphire
Probe immersible length	C276 alloy	▪ 1" Rxn-41: Up to 3040 mm (120 in) ▪ 2" Rxn-41: Up to 4550 mm (179.1 in)
	316L stainless steel	▪ 1" Rxn-41: Up to 3040 mm (120 in) ▪ 2" Rxn-41: Up to 4550 mm (179.1 in)
	Grade 2 titanium	1" 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)*.

5.4 Maximum permissible exposure

The maximum permissible exposure (MPE) is the maximum level of laser radiation exposure that can occur before causing ocular or skin damage. The MPE is calculated using the laser wavelength (λ) in nanometers, the duration of the exposure in seconds (t), and the energy involved ($J \cdot cm^{-2}$ or $W \cdot cm^{-2}$).

5.4.1 MPE for ocular exposure

The ANSI Z136.1 standard provides means to perform MPE for ocular exposure. Please refer to the standard to calculate the relevant MPE levels for the case of laser exposure from the Rxn-41 probe and from the unlikely occurrence of laser exposure from a broken optical fiber.

MPE for point source ocular exposure to a laser beam			
Wavelength λ (nm)	Exposure duration t (s)	MPE calculation	
		($J \cdot cm^{-2}$)	($W \cdot cm^{-2}$)
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}

MPE for point source ocular exposure to a laser beam				
Wavelength λ (nm)	Exposure duration t (s)	MPE calculation		C_A
		($J \cdot cm^{-2}$)	($W \cdot cm^{-2}$)	
785 and 993	10^{-13} to 10^{-11}	$1.5 C_A \times 10^{-8}$	-	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}	$5.0 C_A \times 10^{-7}$	-	
	18×10^{-6} to 10	$1.8 C_A t^{0.75} \times 10^{-3}$	-	
	10 to 3×10^4	-	$C_A \times 10^{-3}$	

5.4.2 MPE for skin exposure

The ANSI Z136.1 standard provides means to perform MPE for skin exposure. Please refer to the standard to calculate the relevant MPE levels for the case of laser exposure from the Rxn-41 probe and from the unlikely occurrence of laser exposure from a broken optical fiber.

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: $C_A = 1.000$
	10 ⁻⁷ to 10	$1.1 C_A t^{0.25}$	-	785: $C_A = 1.479$
	10 to 3 x 10 ⁴	-	0.2 C_A	993: $C_A = 3.855$

5.5 Materials of construction

Material	Version			
	C276 alloy [UNS N10276; Hastelloy C276]	316L [UNS S31603]	Hybrid C276/316L	Titanium [UNS R50400]
Wetted	C276 alloy	316L stainless steel	C276 alloy/316L stainless steel	Grade 2 titanium
	high-purity sapphire	high-purity sapphire	high-purity sapphire	high-purity sapphire
Non-wetted	C276 alloy	316L stainless steel	316L stainless steel	Grade 2 titanium
	316/316L stainless steel	316/316L stainless steel	316/316L stainless steel	316/316L stainless steel
	303/304 stainless steel	303/304 stainless steel	303/304 stainless steel	303/304 stainless steel
	oxygen-free copper	oxygen-free copper	oxygen-free copper	oxygen-free copper
	high temperature epoxy	high temperature epoxy	high temperature epoxy	high temperature epoxy

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