Fiber Optic Cables for Raman Spectroscopy

Key Issues
- Remote analysis of process streams
- Indoor/outdoor use
- Integrated Safety interlock to prevent laser exposure

Introduction

Fiber optic technology revolutionized Raman spectroscopy by allowing Raman sampling probes to be located remote from a base unit. This enabled Raman spectra to be acquired from samples in hazardous environments that cannot be easily transported to a sampling chamber. Consequently, Raman entered several new arenas including the industrial process line, where the base unit is placed in a control room or other protected environment while the Raman probe is placed in the process line for real-time, *in situ* process monitoring and control.

In the majority of state-of-the-art remote dispersive Raman systems, the excitation radiation is delivered from the laser to the Raman probe through a single excitation fiber. The scattered radiation that is collected from the sample is delivered to the spectrograph through a single collection fiber.

Figure 1 shows a Kaiser Raman Rxn probehead with excitation and collection fibers. These optical fibers are constructed of a low-hydroxyl silica core surrounded by silica cladding. The outer packaging of the cable may vary depending on the application. Cables intended for industrial applications are often packaged with a robust polymer jacket and may be bundled with other optical fibers and a rigid strength member.

Laboratory Cables

In the laboratory, it is particularly critical to handle fiber optic cables properly to prevent damage. This is important from both a cost as well as a safety perspective. Damaged cables may disperse laser light into the laboratory environment, presenting an optical hazard to personnel in the area. Cables must be handled properly, inspected regularly, and replaced when damage is identified.

Figure 1. A Kaiser Raman Rxn probehead, equipped with a bIO-Optic probe, shows the electro-optic cable which integrates the optical fibers and laser interlock.

Process Cables

In the process environment, fiber optic cables are subjected to additional conditions that require consideration. The cable may need to be run through areas such as plenums, indoor ducts, conduits, or open cable trays, where temperatures along the length of the cable can range from as low as −40 °C to as high as 80 °C or greater. Outdoor cables may be exposed to harsh weather conditions, including rain, snow, and ice, as well as prolonged exposure to UV rays from the sun.

Fiber optic cables for the process environment come in three basic cable ratings: indoor, outdoor, and combined indoor/outdoor use. Indoor rated cables are flame resistant and are typically able to be installed in plenums and to be run through walls. Outdoor-rated cables are resistant to degradation by UV light and can survive in a broad temperature range. Indoor–outdoor rated cables combine the features of both indoor and outdoor cables.

Riser rated cables are popular options for cables used in the process environment. These cables are designed to be mounted in any orientation (including vertically) so that they can be run up a wall to reach overhead ductwork.

For installation in hazardous locations in Canada and the United States, Kaiser deploys a specialized hybrid cable

(containing both fiber-optic and electric members). This cable is marked as “Kaiser Optical Systems Inc. – Raman Fiber Cable Part#20111635 CSA-C/US FT-4 AWM Class I/II A/B 80C 30V” <|> <Date> Every 24 inches. This cable is called out as a component of the North American hazard area installation documentation and forms an intrinsic component of the probe assembly. The use of these cables is required for all North American hazardous locations installations when an installation is to meet North American certification.

Kaiser Raman Cables

General features and specifications for the Kaiser fiber optic cables are given in Table 1.

All Kaiser Raman probes use standard cables comprised of an integrated fiber cable assembly containing an excitation fiber and a collection fiber packaged in a robust PVC jacket to prevent breakage. Kaiser Raman fiber optic probes also have integrated the laser interlock into the probe termination for improved laser safety. The laser switches off within milliseconds, preventing laser light from being dispersed into the environment if the cable is severed.

Kaiser Raman’s standard fiber cables are indoor/outdoor, riser-rated fiber optic cables. These cables are also fully rated for flame/UV resistance and pull strength, maximizing their safety in the process environment. Kaiser Raman fiber cables are suitable for use in a variety of environments including direct burial, underground ducts, aerial installations, steam tunnels, building risers, cable trays, and harsh industrial settings.

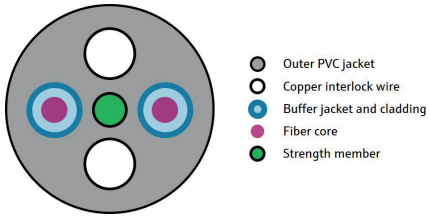

Figure 2. Cross section of a Kaiser Raman fiber optic cable.

A diagram of a Kaiser Raman fiber optic cable is found in Figure 2. The cable contains a rigid strength member, copper interlock wires (described above), and a protective outer PVC jacket.

Normally, the fiber cable is installed into cable trays. However, should individual site engineering specifications require it, the cable may be further protected by the use of conduits. Some customers run cables in positively purged conduits to minimize the chance of flammable gas egress in explosive environments.

For long fiber assemblies, removable pulling socks are available as an option to help with installation. These allow complete tested assemblies to be installed *in situ* without the need for onsite termination.

It is recommended that cables being run outdoors, overhead, or any place where the cable jacket may come contact with corrosive vapors are installed with an appropriately enclosed conduit. To install cables within a conduit, be sure to specify the cable with pulling eyes.

Table 1. Features and Specifications.

General Features:	Integrated copper conductor wire for interlock capability Kevlar® internal strength members Flame retardant Fungus resistant
Cable rating	Operating temperature: -40°C to +80°C Storage temperature: -55°C to +80°C Indoor/outdoor UV Riser-rated Cable tray–rated Certified: CSA-C/US AWM I/II, A/B, 80C, 30V, FTI, FT2, VW-1, FT4 Rated – AWM I/II A/B 80C 30V FT4
Bend radius	Installation: 6.3” (16.00 cm) Operation: 3.2” (8.13 cm)
Crush resistance	1700-2200 N/cm
Termination	Proprietary electro-optic

Why Kaiser Raman Does Not Use Stainless Steel Wrap

Spiral stainless steel wrap is often used as a strengthening agent in fiber optic cables in a variety of applications. However, stainless steel significantly increases the cable weight, making it very difficult to pull. This gives the cable less tensile strength relative to cables with an internal strength member. Stainless steel also reduces water resistance, increases the per-meter cost, and limits the ability to re-terminate damaged fibers in the field. Rigid polymer internal strength members, as used in Kaiser Raman fiber optic cables, avoid these disadvantages.

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