Midstream GAUTENG
john@networksense.tech
+27 (0) 83 376 8427
www.networksense.tech

Cable Installation Considerations for Fire Detection

Introduction

Distributed fiber optic sensing, particularly Distributed Temperature Sensing (DTS), is a highly effective technology for monitoring large or linear assets. Its ability to provide continuous temperature readings over long distances makes it an ideal solution for fire detection in tunnels, industrial sites, large buildings, and complex infrastructure. Unlike traditional Linear Heat Detection (LHD) systems that rely on electrical sensing, Fiber-Optic Linear Heat Detection (FO-LHD) systems use fiber optic cables, offering significant advantages in safety, durability, and efficiency.

Introduction Where is FO-LHD Used?

FO-LHD systems are widely used in environments where fire detection must cover large areas or challenging conditions. Common applications include:

- **Tunnels** (road and rail)
- **Railway and metro stations**
- **Cable trays, ducts, and shafts**
- **Parking structures**
- **Industrial sites** (refineries, steel plants, factories)
- **Hazardous environments**
- **Storage tanks with floating roofs**
- **Mining operations**
- **Conveyor belt systems**
- **Nuclear power plants** (requiring specialized fiber)

Why Use Fiber Optic Fire Detection?

One of the key benefits of fiber optic fire detection is its ability to monitor large areas from a single central location. The fiber-optic cable itself is lightweight, easy to install, and resistant to environmental factors like electromagnetic interference, moisture, and dust.

FO-LHD systems continuously analyse temperature changes over time and location, triggering alarms based on maximum temperature thresholds, rate-of-rise detection, and ambient temperature differences. These advanced detection methods increase sensitivity while reducing false alarms. Alarm parameters can also be customized for different zones, making the system highly adaptable to various environments.

Fire Detection in Explosive Environments

In hazardous areas, FO-LHD systems provide a significant safety advantage because they do not require electrical power at the sensing points, reducing explosion risks. However, safety evaluations must also consider potential optical energy release in case of a cable break, fire spread risks, electrostatic discharge, or lightning transmission through the cable. Before deploying the system in explosive environments, it is essential to verify that the FO-LHD solution meets ATEX / IECEX safety standards for the specific application.

Optimizing System Performance

To achieve maximum reliability and accuracy, the performance of a fiber optic fire detection system depends on several factors:

- **System configuration** – ensuring compatibility between the fiber-optic cable and the interrogator unit (DTS device)
- **Cable type and installation method** – selecting the right cable for the environment and asset being monitored
- **Cable positioning** – optimizing placement to enhance detection sensitivity and response time
- **Environmental conditions** – considering temperature fluctuations, radiation exposure, humidity levels, and chemical resistance

This guide provides best practices for selecting and installing fiber optic cables to maximize the performance of DTS-based fire detection systems.

Choosing the Right Cable for Fiber Optic Fire Detection

The fiber-optic cable is a critical component of an FO-LHD system and must be certified alongside the DTS interrogator unit according to national safety standards. Typically, FO-LHD system suppliers provide pre-certified cables, which are tested for compatibility and performance. Selecting the right cable requires considering both the operational needs of the monitored asset and the compliance requirements of the DTS interrogator unit. Deviations from certified cable designs may affect detection accuracy and system reliability.

Fiber Type and Configuration

Most FO-LHD cables use multi-mode fibers, allowing redundancy and dual-end/loop measurements (Class A setup). In cases where certification is not required, or when specialized cables are needed, fiber selection should be based on the interrogator's specifications and the environmental conditions (temperature extremes, radiation exposure, humidity, and chemical resistance).

For specialized applications like nuclear power plants or high-temperature zones, fibers with pure-core silica or phosphorous-free coatings can be used to increase durability. To ensure long-distance performance and high accuracy, fibers should have low attenuation and sufficient bandwidth, with compliance to telecom standards like ITU-T G651 being a reliable indicator of quality.

Cable Design and Protection

Fiber optic cables are typically designed using either loose tube or tight-buffered configurations, which help maintain low attenuation and protect the fibers after installation.

- Loose tube cables allow for slight movement of the fiber within the tube, reducing strain during temperature fluctuations or mechanical tension.
- **Armoured cables** (Fiber in Metal Tube - FIMT) provide additional protection in environments with high mechanical stress (e.g., risk of impact, rodent damage, or chemical exposure).
- **Flame-retardant** (FRNC) or **low-smoke zero-halogen** (LSZH) jackets help prevent fire spread and reduce toxic emissions in case of a fire.
- **Dielectric cables** (non-metallic) are a lightweight and cost-effective option for environments with minimal mechanical risks.

Cable Impact of Cable Design on Fire Detection Response Time

The diameter of the fiber-optic cable significantly affects thermal response time. A larger cable takes longer to detect temperature changes, so selecting the right size is crucial. Cables ranging between 2 mm and 5 mm in diameter generally provide fast and reliable detection, meeting the response time requirements of fire safety standards.

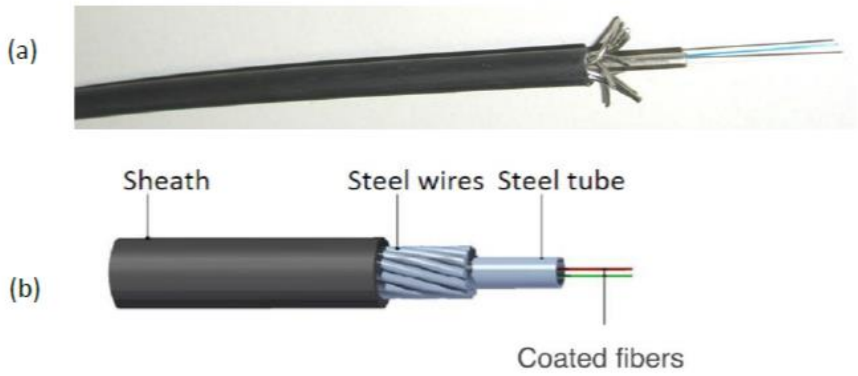

Figure 1: Example of fiber-optic cable - FIMT with stranded wires and plastics sheath (a) picture of real cable and (b) cable schematic

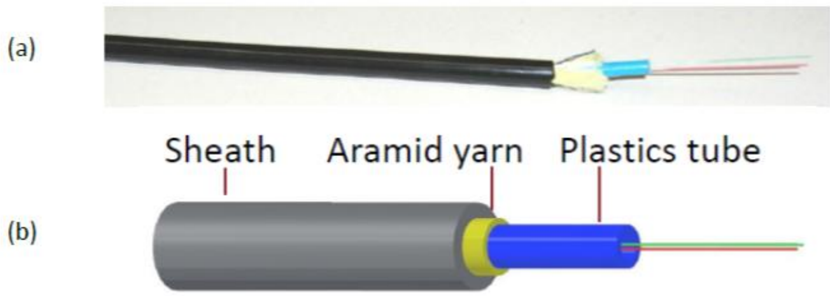

Figure 2: Example of fiber-optic cable – loose tube plastic cable (a) picture of real cable and (b) cable schematic

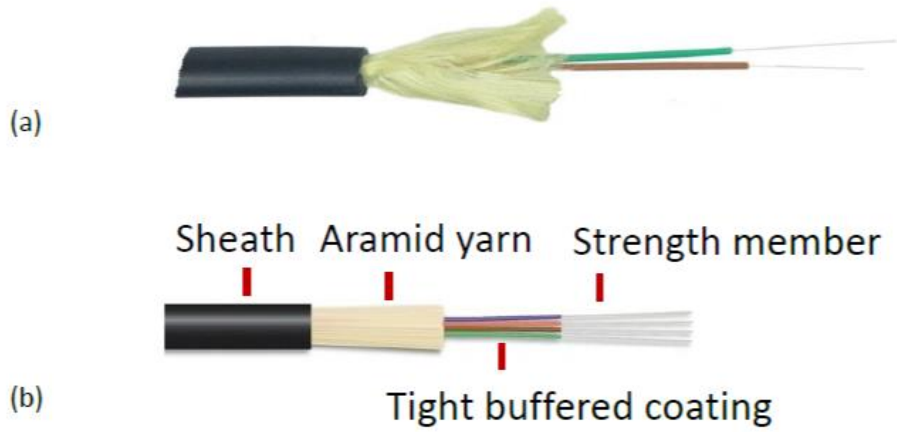

Figure 3: Example of fiber-optic cable – tight buffered plastic cable (a) picture of real cable and (b) cable schematic

Bare loose tubes are prone to kinking and mechanical stress, which can impact performance. To prevent this, fiber-optic cables are reinforced with protective layers such as:

- Secondary tubing for extra durability
- Stainless steel wires or aramid fibers for strain relief
- Plastic sheaths for improved handling and protection against mechanical or chemical damage

Cable Marking

Proper cable marking is essential for accurate alarm zone configuration. Meter markings along the cable help define precise alarm boundaries during installation, ensuring an effective zone plan. Additionally, regulatory approvals often require specific markings, so only cables that meet these standards should be used in approved applications.

Cable Installation

Installation methods should comply with local regulations and environmental conditions while protecting the cable from:

- Weather exposure
- Accidental or intentional damage
- Performance disruptions due to improper placement

Cable Mounting for Fire Detection

Fiber-optic fire detection cables respond to heat from convection and radiation. To ensure fast and accurate detection:

- Allow for free airflow around the cable
- Avoid direct contact with large heat-absorbing surfaces (such as walls)
- Maintain a small distance from the ceiling—typically between 5 and 50 cm (2 to 20 inches)

The cable should be securely mounted but not over-tightened to prevent strain. To avoid sagging, support the cable every 1 to 1.5 meters (3 to 5 feet) using appropriate mounting clips.

Cable Choosing the Right Mounting Materials

The choice of mounting materials should align with project requirements. For example:

- High-grade stainless steel is recommended in corrosive or salt-heavy environments
- Non-metallic clamps may be preferred for lighter or non-conductive installations

By following these guidelines, fiber-optic cables can be properly installed, ensuring long-term reliability and optimal fire detection performance.

Figure 4: Different cable clips for mounting fiber-optic cable at a distance to a ceiling or wall

To ensure optimal responsiveness to heat, the fiber-optic cable should be free from any barriers or obstacles between it and potential heat sources. A dark-coloured cable can also enhance sensitivity to heat radiation. These considerations ensure the cable detects heat more effectively, especially from convection and radiated heat sources.

Creating a Zone Plan

A zone plan should be used to document the layout of the fiber-optic cable, including meter markings for key points such as the start of the asset, splicing locations, and zone boundaries. This helps in configuring precise alarm zones during installation. If needed, test zones can be included for regular system checks without interfering with the ongoing operations, like closing a tunnel for maintenance. Heating the cable helps refine zone boundaries, as the actual length of the fiber may vary slightly from the marked measurements.

Cable Handling and Storage

When handling fiber-optic cables, always ensure that they are stored upright on their drum to prevent damage. During installation, avoid exceeding the maximum pull force or the minimum bending radius to ensure the cable's integrity.

Cable Positioning for Optimal Fire Detection

Effective fire detection depends on understanding the nature of heat development and distribution in the area. The cable should be placed close to the expected heat source to provide reliable detection. For instance, on a coal conveyor, the highest risk is smouldering coal, so positioning the cable near the conveyor's lower frame is optimal.

In other environments, such as tunnels or large rooms, the cable should be positioned to minimize the distance between the ceiling and the cable. A general rule is to keep the maximum distance between the cable and any ceiling point under 3.5 meters (11.5 feet). This usually results in 7 meters (23 feet) of cable spacing. For tunnels, if the ceiling is flat, the cable should be installed no more than 5 meters (16.5 feet) apart, while a curved ceiling allows for up to 6 meters (20 feet) of spacing, as long as the cable is placed at the centre of the ceiling.

Avoiding False Alarms

When positioning the cable, ensure its placed away from heat sources such as lights and areas with sudden temperature fluctuations. Where possible, use less sensitive settings in these areas to avoid false alarms.

Cable routing and extra lengths

To ensure smooth installation:

- Leave an extra 3 to 5 meters (10 to 16 feet) of cable at the start of the installation to allow for proper splicing.
- At the end of the installation, leave at least 20 meters (66 feet) of unused cable behind the last fire compartment to prevent issues with fiber-end reflection.
- If clear mapping between fire compartments is necessary, ensure an additional 20 meters (66 feet) of cable at the crossing of compartments.

Redundancy

Redundancy is critical for meeting fire detection standards. The most straightforward way to achieve full redundancy is to use two fibers from the same cable, measuring from opposite ends with two separate interrogators. This ensures the system can handle a single failure. A partial redundancy, known as a "Class A" configuration, can be achieved by measuring two fibers from opposite ends using a single two-channel interrogator.

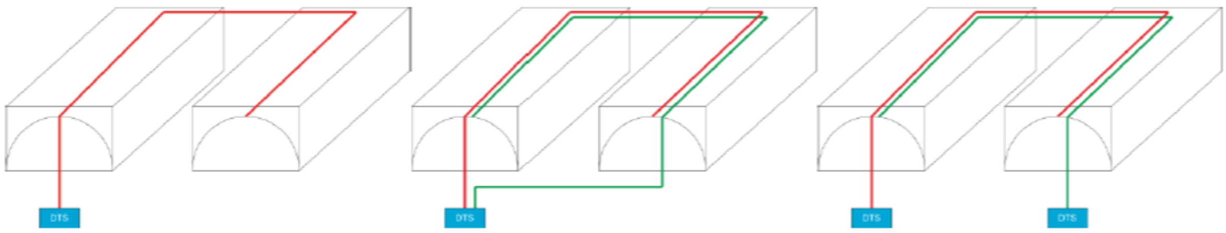

Figure 5: Non-redundant (left), cable-redundant or "Class A" (middle) and fully redundant (right) FO-LHD configurations using the example of a two-tube tunnel

International Fire Protection Standards

Fire protection systems are subject to strict regulations, making it crucial for all stakeholders—designers, planners, manufacturers, and users—to follow national and international standards. These standards govern the planning, installation, service, and use of fire detection equipment. It's important to note that fire detection approvals may apply to specific system configurations, such as measurement ranges, alarm parameters, and the number of channels. Therefore, it's essential to review the entire approval documentation to ensure the fiber-optic linear heat detection (FO-LHD) system meets the specific project requirements.

Guidelines in Europe

In Europe, FO-LHD systems must comply with the EN 54-22 standard. Additionally, the planning, design, installation, commissioning, and maintenance processes are covered by EN54-14 and VdS 2095, or other guidelines specific to national regulations, such as the German DIN VDE 0833-2.

Guidelines in the United States

In the U.S., FO-LHD systems must adhere to UL 521 and/or FM3210/FM3010 standards. Fiber-optic cables used for fire detection should be installed according to the following codes:

- NFPA No. 70 (National Electric Code)
- NFPA No. 72 (National Fire Alarm and Signaling Code)

Guidelines in Canada

In Canada, FO-LHD systems must meet the ULC-S530 standard. Installation of fiber-optic cables for fire detection must follow the following regulations:

- ULC-S524 (Standard for the Installation of Fire Alarm Systems)
- CSA 22.2
- The National Building Code of Canada
- The Canadian Electrical Code, Part 1
- The National Fire Code of Canada

By understanding and adhering to these standards, you can ensure your FO-LHD system is compliant, reliable, and optimized for fire detection in various environments.