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Contributors	LTU, DCI, CIRCE
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Abstract	In line with the overall scope of the project, this Deliverable is focused to the application of an innovative technology into a well-known production environment to enhance the process control and/or data reliability and availability. This document aims mainly to present the design of the Demonstrator that is going to be realised in order to test the effectiveness of the Fiber Optic temperature sensor into chemical plants. It will measure the temperature of the stream of the "LPG Header" toward the furnace. The implementation of the system is foreseen before the end of this year. The Demonstrator has been designed according to several requirement and on the base of specific needs rise up during the first phase of the project, as reported in deliverable D1.3.

Document History			
Ver.	**Date**	**Changes**	**Author**
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Content

List of Acronyms

ABBREV	Explanation
BC	Belt Conveyor
C2	Ethylene
C3	Propylene
CC4	C4 Crude Fraction – butane, butylene, butadiene, etc.
CCD	Charge-coupled device
CFD	Computational Fluid Dynamics
CSV	Comma Separated Values (file format)
DAU	Data Acquisition Unit
DB	Database
EOR	End of Run
FBG	Fiber Bragg Gratings
FOS	Fiber Optoc Sensor
GHG	Greenhouse Gases
HC	Hydro-carbons
HVC	High Value Chemicals
IP	Intellectual Property
IPC	Integrated Process Control
LPG	Liquefied petroleum gas
MOC	Management of Change
MOR	Mid of Run
MPC	Model Predictive Control
PAT	Process Analytical Technology
SOR	Start of Run
UV-VIS	Ultraviolet – Visible range

1 Introduction

Within DISIRE, the main objective is to reduce the operating costs and reduce the environmental footprint of the plant by optimizing the energy consumption.

In this sense the information provided by Fiber Optics temperature sensor can be useful to troubleshoot and solve problems related to insufficient heating capacity and insulation issues. These issues are faced whenever the fuel arrives to the furnace, dealing with the furnace control and thus the furnace' performance in terms of energy efficiency (i.e. LPG in liquid phase into the flow-meters coils).

The aim of this document is to indicate the demonstration platform targeted by the novel DISIRE technologies into a well known environment, namely: Fiber Optic temperature sensor and chemical furnace feeding system. Specifically, this deliverable provides details on the prototype specifications in terms of system characteristics, physical constraints, specific requirements such us power supply, security and access.

1.1. Methodology

The decision of the implementation of the demonstrator have been built up following a careful sharing of knowledge and opportunity among the involved partners: DCI, D'Appolonia and CIRCE (partially). A first survey took place in DCI premises in the first phase of the project, where the characteristics of fiber optics sensors and plant have been presented. In such occasion, and following evaluation activities, diverse interesting scenarios for technology testing have been identified (refer to Deliverable D3.1 and Paragraph 3).

The implementation of the demonstrator, that is a new high reliable technology applied to the cracking furnace headers, allows all the partners to test the effectiveness of the solution both in terms of performance and installation characteristics (refer to Paragraph **Error! Reference source not found.**). The implementation of the fiber optics in the plant is in fact a tricky issue to face during the installation activity.

The installation of the equipment is planned at the end of 2016, according to partners' availability: candidate month is October.

1.2. Partners involved

Partners and Contribution	
Short Name	**Contribution**
DAPP **DOW**	Directly involved in the whole demonstrator application as technology provider and end user.
CIRCE	Planning of the activity in relation to WP8

1.3. Applicative Environment and Scenario

The cracking furnace at DCI produces ethylene, propylene and CC4s (butane, butane, butylenes and butadiene).

See deliverable D1.2[1] for a detailed discussion of the process.

The foreseen enhancements to the monitored process and the expected impacts within DISIRE are linked to:

1. The research, development and field evaluation of a Fiber Optic Sensor (FOS) technology that can sense low and medium-high temperatures at the inlets (that is, the input products feeders);
2. The development and validation of improved CFD models of the combustion process aimed at generating information on the processes that is unavailable today and that will support future work on control optimization objectives.

The first point of the above list is the main subject of this deliverable. The above activities are linked to WP3 and WP8 activities in terms of sensor innovation and control process enhancement.

D'APPOLONIA, CIRCE and DCI identified during the first part of the project several feasible and interesting measurement scenarios to test the novel fiber optics measurement devices into the chemical plant:

- Temperature along the LPG header that feeds the cracking furnaces. This information is useful to troubleshoot and solve problems (insulation issues, insufficient heating capacity and others) that are faced whenever the LPG arrives to the flowmeters coils in the liquid phase leading to inaccurate readings that affect the furnace control and thus the furnace' performance in terms of energy efficiency;
- Temperature across the naphtha header to identify and prevent potential early vaporization phenomena that could affect cracking furnace performance;
- Temperature profile of primary fractionators in the distillation column (C-2001). Temperature range from 108°C to 200 ºC.

After a careful evaluation of specific advantages and drawbacks of the technology, the involved DISIRE partners selected distributed sensing based on Raman scattering (Paragraph 3.2) as the most suitable technology for the purpose of the industrial application of DISIRE project and to realise a demonstrator on the LPG header (first scenario of the above list).

1 Application scenarios and demonstration activities specifications, DISIRE deliverable, 2015.

2 Temperature Sensor – Fiber Optic Technology for Continuous Measurements

2.1. Details on Fiber Optic Based Temperature sensors

Within the DISIRE project, FOS were selected as the most promising type of sensors for the envisaged industrial application, due to their unique and peculiar combination of **features**, which can be schematized as follows:

- High sensitivity
- Inert and resistant to corrosion and chemicals
- Multiplexability (i.e. the chance to “read” more sensors at the same time)
- Insensitive to external perturbations (EM fields, MW radio-frequency & lightning strikes, humidity…)
- Resistance to high temperatures
- Long-distance remote monitoring
- Real-time monitoring
- Durability and high reliability in demanding environments (sensor design life of 30 years+)
- No need for electrical power
- No electronics or moving parts in monitoring zones
- Safe (operate around explosives and flammable materials)
- Extremely small for access into space restricted areas (ducts, oil wells, pipes)
- Measurable Parameters: Strain & Temperature (Directly) – Deformation, Pressure, Acceleration, Displacement, Humidity and Chemical Concentration (Indirectly).

In particular, two FOS technologies are investigated and evaluated as candidate for the specific project application, namely the Fiber Bragg Gratings (FBG) technology and the distributed sensing technology. Such technologies correspond to two completely different measuring approaches, in terms of spatial distribution of the measures.

Generally speaking, in fact, with reference to the **spatial distribution of measures**, sensors are classified as discrete (or “point”) sensors or as continuous (or “distributed”) sensors.

A point sensor measures a parameter related to a single specific position in the structure, whereas distributed sensor measures the parameter at several positions and can replace a chain of point sensors. Actually, a third strategy exists, namely the “quasi”-distributed sensing, that can be realized without or with integration. In the former case, discrete point sensing systems are simply realized with a high spatial density (huge number) of point sensors. In the latter case, the sensor performs intrinsically integrated measures (for example into large

Fabry-Perot cavities, >20 cm). The main advantage of integration is to avoid any blind zones (with no sensitivity), as shown in the following figure:

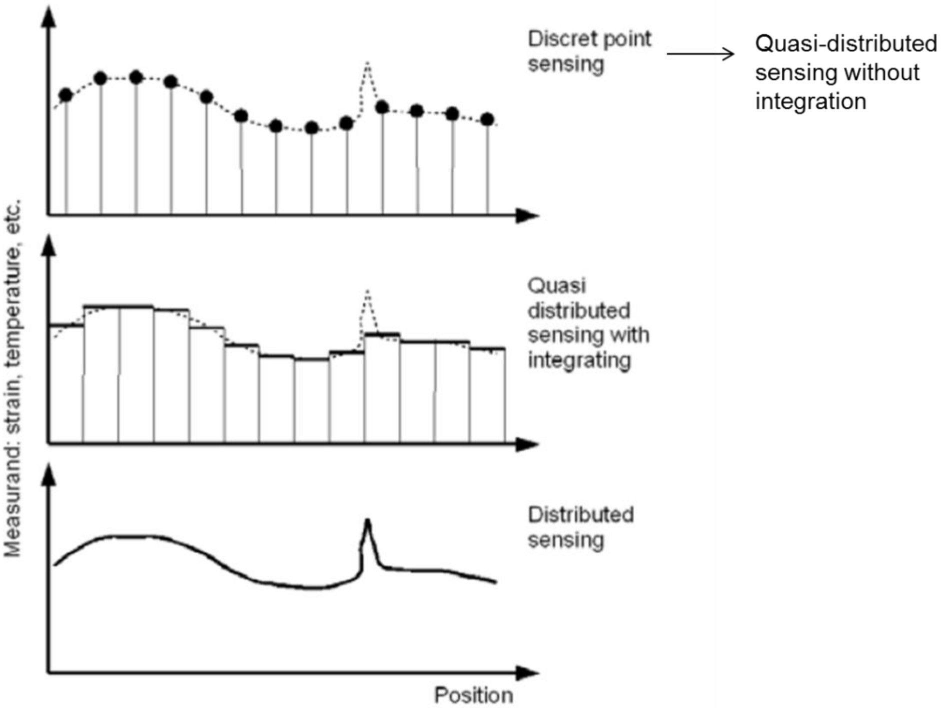


Figure 2.1:Concepts of point, quasi-distributed and distributed sensing [2].

[1]It is worth stressing that talking about gage length is not fully correct for distributed sensors, as it is a physical concept defined for discrete sensors, but it can help physically understanding the related phenomena if we think, in distributed sensing, to a moving and potentially variable gage length (while in point sensors it is fixed and constant). The more proper term for such concept, in distributed sensing, is "spatial resolution" (i.e. the length over which the average value is measured). Other basic parameter for distributed sensing is the "sampling interval", or "spatial accuracy" i.e. the smallest distance between two consecutive discrete points where the measure is taken.

Coming back to the DISIRE application, the first selected technology (FBG), is a point sensor, able to measure temperature only at specific hot points (which are placed along the fiber optics), with a spatial accuracy of about 0.5 cm; the latter selected technology (distributed sensing), as said, is able to provide the measurement in each point of the sensing cable, which, in turn, can be coincident with the optic fiber cable which transmits the signal.

Once defined the approach in terms of spatial distribution of measures, the **sensing technique** (i.e. the physical principle on which the measurement is based) must be selected, which in turn determines the necessary opto-electronic interrogation unit and the actual performances of measurement. In general, several sensing techniques are available in the field of FOS, namely the grating-based ones (FBG, LPG), Raman, Brillouin and Rayleigh scattering, interpherometry etc.

For the project purposes, the selected technique for point sensing is, as already specified, the FBG grating, while for distributed sensing the Rayleigh and the Raman scattering has been considered.

Physically speaking, the FBG sensor is an optical filter reflecting particular wavelengths while transmitting all others.

The wavelength reflected from Bragg grating depends on:

- Index of refraction of the core
- Periodicity of the grating

Both these parameters are affected by temperature, which can then be measured by the sensor.

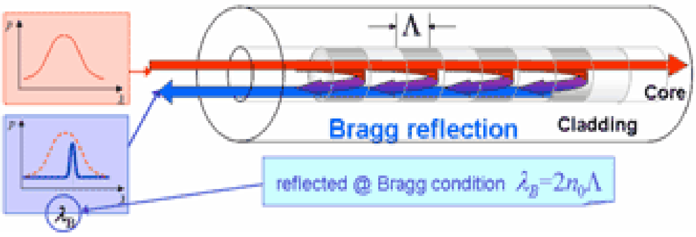


Figure 2.2: Working principle of FBG sensor.

In distributed sensing systems based on light scattering in standard optical fibre, measurement implies the analysis of back-scattered light emitted along the fiber when a laser pulse travels down the optical fiber. Backscattering is due to interaction of laser light with density fluctuations and molecular vibrations of the medium.

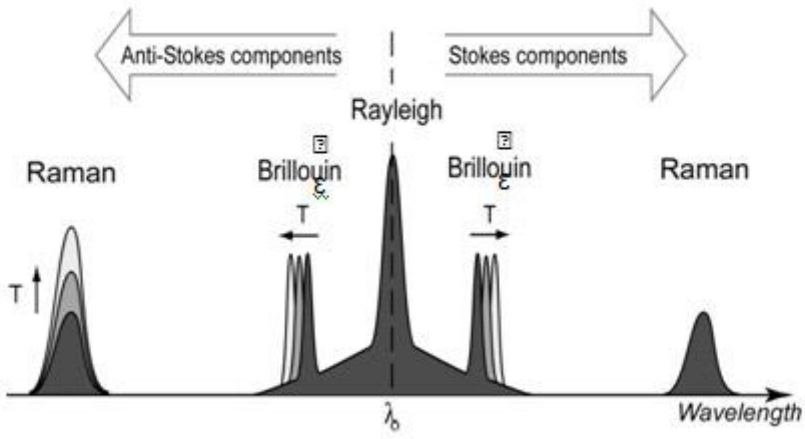


Figure 2.3: Typical spectrum of the backscattered light from a monochromatic laser source (single wavelength λo) propagating in an optical fiber [3]

Backscatter occurs at every point in optical fibers and comprises three significant forms relevant to distributed sensing (**Figure 2.3**):

- *Rayleigh scattering* – produces the largest magnitude of backscatter at the same frequency as the incident light; intensity variations in the backscattered signal at the same frequency are dependent on local temperature and strain. Another kind of measuring principle based on the analysis of Rayleigh scattered light relies on two OFDR measurements (the ongoing measurement and a reference state measurement), processed with an advanced correlation method that analyses the spectral lags of the Rayleigh backscattering peak: as detailed in [4], the frequency shift of the Rayleigh backscatter pattern is proportional to temperature or strain changes along the fiber axis[2];
- *Brillouin scattering* – produces backscatter of lower intensity than Rayleigh, due to an interaction between the propagating optical signal and thermally excited acoustic waves (acoustic phonons), and exhibits a frequency shift of around 10 GHz[3]. This frequency shift, the so-called Brillouin shift, is directly related to both local temperature and strain conditions of the fiber [5][5]; Brillouin scattering can be either spontaneous or stimulated[4]; the former is usually spatially resolved by means of OTDR localization technique, the latter, allowing more accurate measurement and more extended measuring length, is resolved by means of the OTDA localization technique [6][6];

[2] This method is used in the OBR reading unit of Luna Technologies

[3]0.1 nm at 1.5 micron wavelength

[4] Stimulated Brillouin Scattering (SBS)

- *Raman scattering* – produces backscatter of the lower intensity, due to thermally excited molecular vibrations (optical phonons), and exhibits a frequency shift of up to 13 THz[5]. The intensity of Raman scattered light is dependent only on the local temperature of the fiber (so it cannot be used for strain measurement) [5].

In each of the three cases, the spectrum of the backscattered light carries the information on temperature of the fiber. As the speed of light is known, it's possible determine the temperature profile scanning the entire length of the fiber (Figure 2.4).

For the purpose of the Project, both Rayleigh and Raman based techniques are considered suitable.

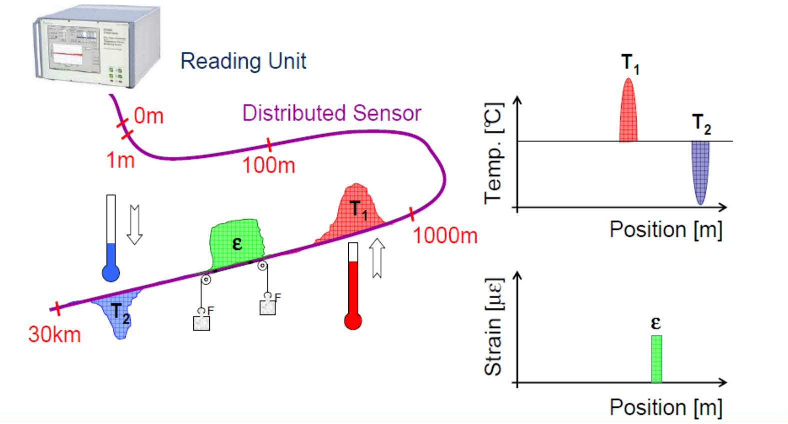


Figure 2.4: correlation between position and measures

The **performance specifications** of distributed monitoring system depend on several interrelated parameters (distance, spatial resolution, acquisition time, fiber attenuation…), as well as on the sensing technique. For example, measurement certainty depends on the configured spatial resolution, acquisition time, distance range and/or cumulative loss. The most appropriated performance description is a graphical presentation, specific for each sensing technique[6] (an example is reported in Figure 2.5:).

[5] 100 nm at 1.5 micron wavelength
[6] Or, more precisely, of the specific interrogator

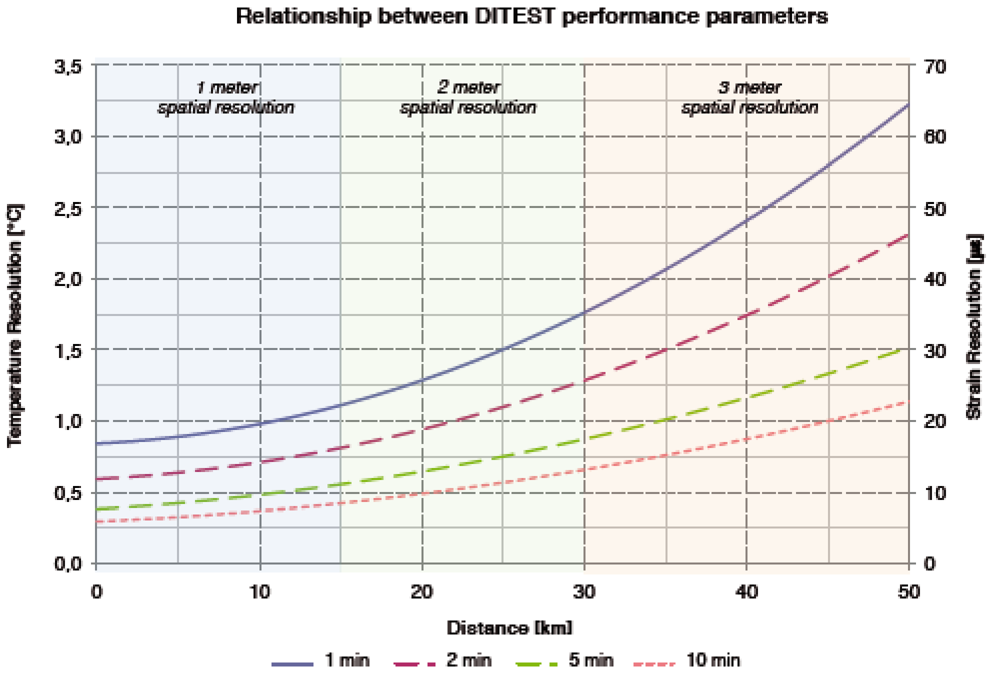


Figure 2.5:Measurement performances of the DiTest interrogator (Brillouin OTDR, produced by Omnisens); it shows typical achievable performances in terms of temperature and strain resolution obtained with the designated typical recommended spatial resolution from 1 m to 3 m depending on the distance range [7].

So, for example, in terms of spatial resolution, it is impossible to give an a-priori indication of the values achievable with distributed sensing in general, as it depends on the sensing technique and mainly on the measuring length (the shorter the length the better the resolution). In particular, with the Rayleigh technique based on OFDR localization technique[7], 1 cm spatial resolution can be achieved on a max measuring length of 70 m.

In principle, similar spatial resolution and measuring length can also be achieved, for example, by multiplexing 700 FBG sensors (1 every 1 cm for 70 m), so implementing the concept of “quasi-distributed sensing without integration”; nevertheless, this would imply, besides a complex data elaboration, an inconceivable sensor cost of about 700.000 € (compared to few tenth or hundreds of euros with distributed sensing). Similar costs considerations can be done for the further possible alternative choice, namely the implementation of the “quasi-distributed sensing with integration” concept by means, for example, of a sequence of 700 short-gage sensors (for example of Fabry-Perot type).

In other words, distributed sensing can replace complex integration of hundreds or thousands of sensors with one optical fiber system, providing a significant reduction in invest-

[7]implemented in the instrument called “Optical Backscatter Reflectometry” (OBR), commercialized by the American company Luna Technologies

ment, installation, calibration, and maintenance costs. Moreover, even not considering the cost and complexity issues related to hundreds of point-like sensors, the choice of their locations may be highly sensitive, and is an intensive research topic. In comparison, distributed sensing provides a more versatile and powerful monitoring tool as it requires much less a priori knowledge of the structure behaviour.

2.2. Specific issues related to DISIRE project

Both the investigated types of FOS are available in several commercial solutions able to measure high temperature values. Within DISIRE it has been found interesting the use of distributed sensing.

2.2.1. Fiber Optic Sensing Cable

Distributed sensing, in terms of sensors (or, more correctly, of sensing cables), commercial solutions suitable for the project are those produced by Smartec. A wide range of measurable temperature values is available from this producer:

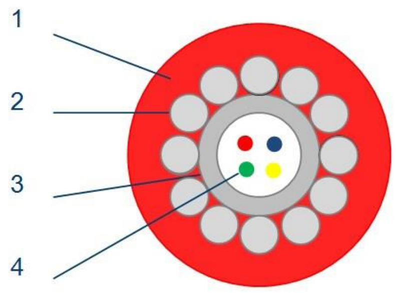
1) Ordinary temperature cable: -40 +85 °C;

2) Medium temperature cable: -40 +150°C;

3) High temperature versions: -65°C to 300°C (high cost and minimum length of 1 km).

Within the project, the ordinary solution is used: main features for the available products are described in the following.

- DiTemp® Ordinary Temperature Sensing Cable (Figure 2.6): it is a small fiber optic cable, armored with stainless steel loose tube gel filled, stainless steel strength members and PA outer sheath. The central loose tube is hermetically sealed and contains 4 fibers with a dual layer acrylate coating for in-creased micro bending performance. Tensile strength, crush resistance, lateral water tight-ness, chemical and abrasion resistance and rodent protection are very good, and the typical application is when small size and fast reaction to temperature changes are required in outdoors and harsh environment. The main specifications are reported in Figure 2.7



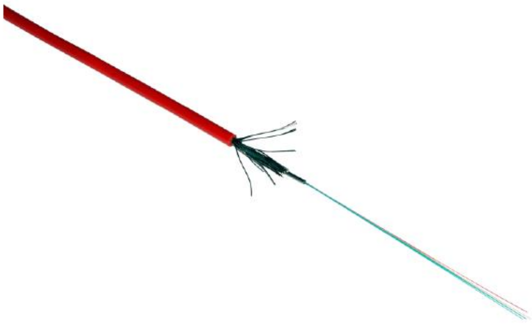


Figure 2.6: DiTemp® Ordinary Temperature Sensing Cable; 1: PA outer sheath; 2: Stainless steel wires, 316L; 3: Stainless steel loose tube, 316L; 4: Bend insensitive multi-mode optical fibers

Temperature range	
Operating temperature:	-40 °C to +85 °C
Storage temperature:	-40 °C to +85 °C
Installation temperature:	-10 °C to +50 °C
Short-term temperature (max 1 h):	-50°C to +150°C

Technical Data	
Outer diameter:	3.8 mm
Weight:	26 kg/km
Max crush resistance:	800 N/cm
Max tensile strength:	1300 N (installation)
Max tensile strength:	900 N (operation)
Min bending radius:	80 mm (with tensile)
Min bending radius:	60 mm (without tensile)
Hydrostatic pressure:	300 kPa (bar)

Figure 2.7: main technical specification of the DiTemp® Ordinary Temperature Sensing Cable

- DiTemp® Ordinary Temperature Sensing Cable HDPE (Figure 2.8): it is a quite small fiber optic cable, armored with stainless steel loose tube gel filled, stainless steel strength members and HDPE outer sheath. The central loose tube is hermetically sealed and contains 4 bend insensitive fibers with a dual layer acrylate coating for increased micro bending performance. With respect to the previous cable type the mechanical properties are similar, while it guarantees an extra protection for harsh environments, being the outer sheet made of HDPE.

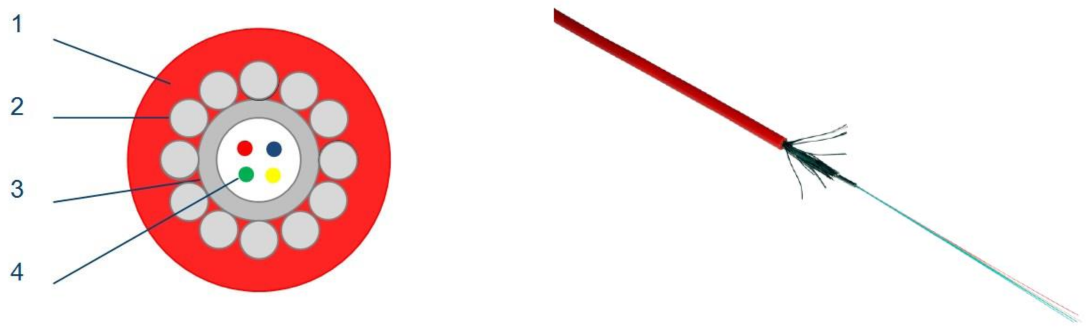


Figure 2.8: DiTemp® Ordinary Temperature Sensing Cable HDPE; 1: HDPE outer sheath; 2: Stainless steel wires, 316L; 3: Stainless steel loose tube, 316L; 4: Bend insensitive multi-mode optical fibers.

- DiTemp® budget Temperature Sensing cable (Figure 2.9): it is a quite small fiber optic cable, armoured with different protective layers that includes a 2.2 mm Stainless Steel loose tube, a Kevlar reinforcing sheath, a Stainless Steel braiding sheath and an outer PE jacket. The central loose tube contains up to 4 fibers with acrylate coating. Thanks to its package design, the typical application is for outdoors and harsh environment when high tensile strength, crush resistance, chemical and abrasion resistance and good rodent protection are required. The main specifications are reported in Figure 2.10.

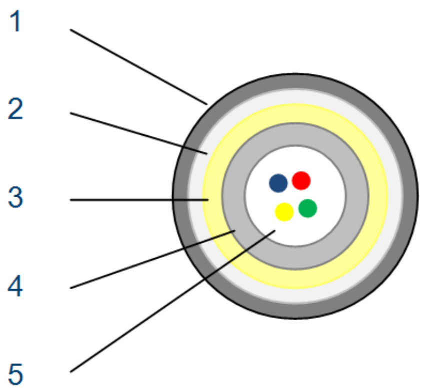


Figure 2.9: DiTemp® budget Temperature Sensing cable; 1: PE outer jacket; 2: stainless steel braiding sheath; 3: kevlar sheath; 4: stainless steel loose tube; 5: temperature multi-mode optical fibers.

TEMPERATURE RANGE

- Operating temperature -55 °C to +85 °C
- Storage temperature -55 °C to +85 °C
- Installation temperature -10 °C to +50 °C

TECHNICAL DATA

- Outer diameter 5.0 mm
- Weight 38 kg/km
- Max crush resistance 3300 N/cm
- Max tensile strength 2000 N (installation)
- Max tensile strength 1100 N (operation)
- Min bending radius 100 mm (with tensile)
- Min bending radius 75 mm (without tensile)

Figure 2.10: main technical specification of the DiTemp® budget Temperature Sensing Cable

2.2.2. Data Acquisition Unit

The sensing cable is connected to the Data Acquisition Unit (DAU), either directly or through a portion of standard (i.e. not specific for high temperature) fiber optic cable.

As mentioned before, both Raman and Rayleigh based techniques, corresponding to two different types of DAU, are considered suitable for the purposes of the Project.

For the *Rayleigh technique*, the OBR4600, produced by Luna Technologies (Figure 2.11), is considered, characterized by the following specifications:

- Optical Backscatter reflectometer for distributed temperature and strain profiles monitoring based on Rayleigh scattering;
- Fiber typology: graded index fiber;
- Maximum device length in standard mode: 70 m (2 km in extended range mode);
- Minimum spatial resolution: 1 cm;
- Temperature resolution: ± 0.1 °C
- Operating Temperature (depending on cable): up to 170 °C

For the *Raman technique*, the DiTemp, produced by Smartec (Figure 2.11), is considered, characterized by the following specifications:

- Raman OTDR interrogator for distributed temperature profiles monitoring
- Fiber Typology: standard Single Mode Fiber (SMF) or Multi Mode Fiber (MMF)
- Maximum device length: 12 km
- Minimum spatial resolution: 1 m;
- Minimum spatial accuracy: 0.5 m;
- Temperature resolution: ± 0.1 °C
- Operating Temperature: -5°C to 40 °C

Figure 2.11: DAUs for distributed sensing: OBR4600, produced by Luna Technologies (left); DiTemp, produced by Smartec (right).

3 Industrial Demonstrator

3.1. Advantages and Potentials of the implemented solution

The application of distributed FOS technology for temperature monitoring in the DOW plant will lead to the advantages already described in section **Error! Reference source not found.**, with particular emphasis on insensitivity to external perturbations (EM fields, MW radio-frequency & lightning strikes, humidity…), resistance to high temperatures and harsh environments, low invasivity, safety (in operating around explosives and flammable materials) and distributed sensing.

3.2. Architecture and specifications

On the basis of a survey carried out the 11th of July 2016 on the DOW plant in Tarragona, it has been finalized the design of the pilot monitoring system for the temperature along the LPG header that feeds the cracking furnaces (see § 1.1).

The main objective of the system is the monitoring of temperature along the pipeline (expected at the furnace end) and identification of the temperature profile in order to optimize pre-heating and point out possible segments with anomalous temperature drop.

Taking into account the available framework (§ 1.3), after a careful evaluation of specific advantages and drawbacks of both FBG and distributed sensing (§ 2), the involved DISIRE partners selected the distributed sensing based on Raman scattering as the most suitable technology for the purpose of the industrial application of DISIRE project.

The scheme of the system is reported in Figure 3.1.

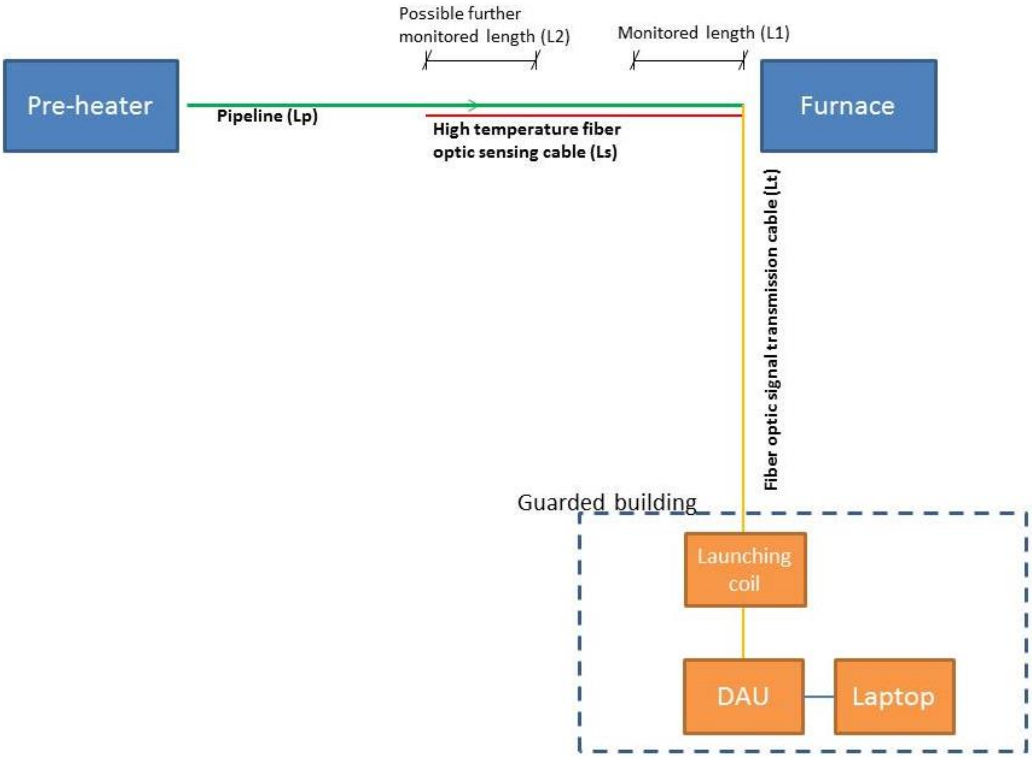


Figure 3.1: Block Scheme of the Temperature Monitoring System

In the scheme, the length of each pipe or cable segment is indicated in parenthesis. The configuration foresees:

- DAU: DiTemp, produced by Smartec, based on Raman scattering effect will be used; it will be connected to a PC for data archiving, and it will be placed in a guarded building, provided with 220 Vac electric power.
- Sensing cable: it will be the DiTemp® Ordinary Temperature Sensing Cable. This choice takes into account that the maximum involved temperature is below 50 °C, and that high cable flexibility (main feature of this system) is an added value during the installation around the complex shape of the pipeline.

The use of the DiTemp® Ordinary Temperature Sensing Cable will be limited to the pipeline, while the signal will be transmitted to the DAU by means of a fiber optic connection cable with enough thermal resistance to withstand the temperatures and tensile forces during cable positioning.

3.3. Installation Management and Data Interpretation

The sensing cable will be installed in such a way to be in contact with the pipeline, in order to measure its external temperature. A representative example of installation is shown in Figure 3.2. Plastic clamps will be used at this aim, gluing with epoxy resin will also be considered as an option, in case specific issues should arise during the application.

Figure 3.2: Example of fiber optics installation on pipe

The temperature of the internal side of the pipeline, in direct contact with the carried fluid, will then be obtained by data post-processing, on the basis of the knowledge of the pipeline structure (and hence thermal conductivity).

Data acquisition will be carried out continuously (without operator supervision) for the minimum significant observation time, between 2 and 5 days, to be agreed with DOW and strictly dependent on the available plant configuration (§ 3.4).

The main characteristics of temperature sampling are:

- The spatial resolution of the measures will be of 1 m, with a sampling resolution of 0.5 m;
- The temperature resolution will be 0.1 °C;
- The sampling frequency will be agreed with DOW (up to a maximum of 0.1 Hz).

The raw data will be in .txt format, organized in two corresponding series, one for temperature and one for the abscissa value (along the fiber) where data is measured.

It’s worth evidencing that, as the final data of interest is related to the inside of the pipe, in principle the measured temperature could be biased (with respect to the value that it would have on the external side of the pipe in the ideal steading state conditions) by external environmental effects, like sunlight, wind, etc.. Such risk is minimized by the presence of the insulating coating.

Actually, preliminarily to the sensing cable installation, the insulating coating of the pipeline will be removed in order to apply the sensor in direct contact with the pipeline. After cable installation, re-application of the coating is then highly advisable, in order to minimize possible biasing due to environmental effects (sunlight, wind, etc.). In the case coating re-application is not possible due to any operational constraint, possible back-up solutions to minimize environmental data biasing (and/or to estimate it) are the following:

- Application of the sensing cable in a position, relative to the pipe, able to minimize sunlight exposition (for example, on the bottom of the pipe);
- Installation of the sensing cable placing a short length not in contact with the pipe to be able to locally measure the ambient temperature and allowing, in post-processing stage, an estimation of the biasing effect.

Taking into account possible obstruction constraints, due to the high complexity of the plant, only limited portions (of lengths L1, L2 … Ln, not necessarily adjoining) of the pipeline will be sensorized, starting from the furnace to the pre-heater.

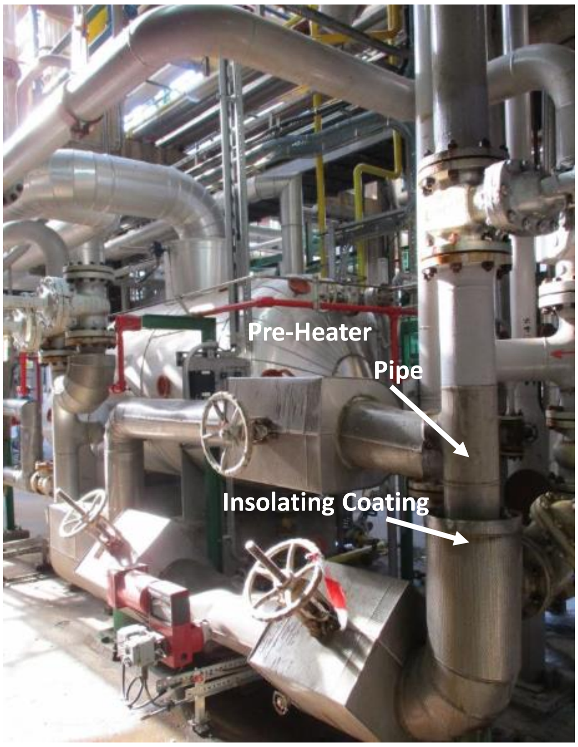


Figure 3.3: Pre-Heater surrounded by pipes with insulating coating

The sensing cable will be laid for the maximum possible length (Ls), compatibly with possible obstructions due to the plant complexity, preventing reasonably comfortable working conditions for insulating coating removing and re-application and for sensing cable application.
For what concerns the actual length (Lt) of the signal transmission cable (connecting the last measuring point to the DAU), it has to be considered that a launching reel of about 1 km will be available. The excess length of fiber optics will be placed in the same building where the DAU and the laptop will be stored as shown in Figure 3.4.

Figure 3.4: Closest Building to the Controlled Pipeline where Measurement Items can be Installed

3.4. Plant Configuration during the Testing Section

To test the effectiveness of the temperature acquisition system, the LPG Header should be used in all applicable configurations.
In particular, the pre-heater should be operated to have a fuel temperature variation allowing the characterisation of thermal function transfer of the pipeline and system testing. The system stimulation will be done through the pre-heating set point variation.

4 Conclusions

The performance and robustness of the Fiber Optics temperature sensor is assessed in tailored small-scale demonstrator in the DOW's premises.

This document presents the specifications of fiber optics testing demonstration that is useful the understand the real effectiveness of the application of such technology in the chemical industry. Although the system is implemented in only one scenario, the results can be extended to other DOW premises and other industrial sectors.

Within the project, some other opportunities have been individuated and are to be investigated in the future according to the experience of the demonstrator. The demonstrator will allow understanding the possibility of system implementation in an already existing industrial plant:

- **monitoring of possible anomalous temperature in big power line bundles**, provided the installation of the FOS is forecasted already in the design stage;
- **detecting possible leakages in the same pipelines** where the fiber are used for temperature monitoring.

5 References

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