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PROJECT FINAL REPORT

Grant Agreement no: 613795
Project acronym: SAFETYPACK
Project title: Innovative non-intrusive laser gas sensors on food production for real time quality/safety in line control of food packaging and bottling systems
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Date of latest version of Annex I against which the assessment will be made:
Periodic report: 1st □ 2nd X
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1 Executive summary

SAFETYPACK aims to realize new contactless non-intrusive laser-based gas sensors that will provide the food manufacturing industry with a real time in line control technology that can perform quality and safety control of a wide range of sealed food in modified atmosphere packaging (MAP).
In food packaging industry the use of gases other than air in the process of manufacturing and sealing of food items for distribution to the consumer chain (supermarkets, retail points,etc) has progressively grown. It follows that the precise measurement and control of the inside atmosphere represent a requirement in the food and packaging industries. Ideally, the control should be made in-line after closure to monitor the integrity of the seal and its evolution in time.
In-line non-intrusive contactless gas sensors, based on laser spectroscopy, have been developed and validated in the project timeframe. The sensors can operate both on (partially) transparent (food trays and bags, bottles) as well in almost non-transparent containers. What is new in SAFETYPACK technology is the possibility to measure the gas content using laser spectroscopy within diffusive materials (such as paper, plastic and food itself) with a new method of inspection and its adaptation to measure closed containers of different shape, colors and transparency, such as food trays, bags, milk containers and bottles.
The equipment has been demonstrated and validated with two in-line pilot installations regarding tortilla bread and cheese production, being able to inspect 100% of the production.
SAFETYPACK has provided:
• Non-intrusive real-time in-line food packaging inspection
• Fast & high precision and accuracy gas sensors
• Inspection unit available for exploitation in food industry
SAFETYPACK fully responds to the topic regarding in-line safety and quality control on food processing and supporting the overall objective to secure quality, safety and shelf life for European food products.

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2 Project context and main objectives

The SAFETYPACK project Consortium developed a new technology to improve quality and safety of food products. This technology is based on laser gas sensing and with this project we want to move relatively quickly through the TRL process to be deployed into the commercial marketplace starting from dairy industry. Food safety/quality and reduction of wasted products are among the most pressing emerging challenges for companies in the food supply chain. Global population is expected to grow to 9 billion and demand for food by 77% by 2050. The efficiency of the food supply chain shall be increased, and waste shall be reduced, to satisfy consumer demand for food, by increasing food safety/quality. One of the most important reasons for analysing foods from both the consumers and the manufacturers standpoint is to ensure that they are safe. It would be economically disastrous, as well as unpleasant to consumers, if a food manufacturer sells a harmful product.
SAFETYPACK project focuses on packaging opportunities that will reduce food waste. We have been focused on one of the main aspects related to food packaging: internal gas monitoring. In the food packaging industry, employing gases other than air (Modified Atmosphere Packaging, MAP) within the packages of food items to be distributed to the retail sector (i.e., supermarkets, convenience stores) has increased to protect fresh and processed foods at every stage of the supply chain, and to extend product shelf life. Indeed, controlling the gas composition inside the packages is a quality check of the packaging process itself and a way to assess food quality and safety. In order to maintain the quality and extend the shelf-life of food products, the consistency of the products has to be checked after that they have been packed on the production lines, and the importance of this monitoring action has been recognized by food producers, but has not been implemented yet.

The SAFETYPACK technique is able to check the internal gas composition in food packages in a contactless non-invasive way and in real-time in-line operation, by using laser spectroscopy. The SAFETYPACK inspection machine allows to guarantee the fulfilment of the safety control on the full production. In the following lists we report the safety items that will be provided:

- Measure of gas content inside food packages (O_2 and/or CO_2 concentration)
- 100% of inline production inspected
- Assess of the product shelf life
- reduction of customer complaints

The introduction of the SAFETYPACK inspection machine in the production line will improves product quality and will help the food industry to reach the target of total product quality.
In the following list we briefly report the project objectives expected and the related fulfillment that have been obtained by the consortium during the project timeframe.

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1) **The first Project Objective is related to achieve the following characteristics**:
- Non-intrusive real-time in-line food packaging inspection
- Fast & highly accurate gas sensor
- Sensor available for exploitation in food industry.
- Supporting the overall objective to secure quality, safety and shelf life for European food products

SAFETYPACK inspection system integrates two sensors able to perform precise measurement and control of the inside atmosphere in food trays. The control is been done in-line immediately after closure or later to monitor the integrity of the seal and its evolution in time of 100% of the production. The SAFETYPACK inspection system can perform quality and safety control on a wide range of sealed food. In the following figure we show the two versions of the SAFETYPACK equipment that have been realized during the project timeframe for the automatic inline inspection on mozzarella cheese bags (left) and tortillas bread packages (right).

2) The second Project Objective is related to a Tool Predicting the Features.
The SAFETYPACK inspection system is able to perform the analysis composition of the sealed tray giving the possibility to determine the future quality of the final product. The integrated machine software provides a full control of the processing parameters and helps operators and production managers to check and control the full production. In the following figure we report the machine main operator interface with the available inspection data that are acquired for each food tray.

<table>
<tr>
<td>
</td>
<td>Available data:
- **Production line speed**
- **Total products**
- **Total accepted product**
- **% Total accepted product**
- **Total rejected product**
- **% Total rejected product**
- **Code and name of production line**
- **Code of size in production.**
- **Date/time of production start**
- **Last reject: Indicates cause of rejection of last product**
- **Control Devices Condition: Indicates status of ejector**</td>
</tr>
</table>

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	- **Active alarms**

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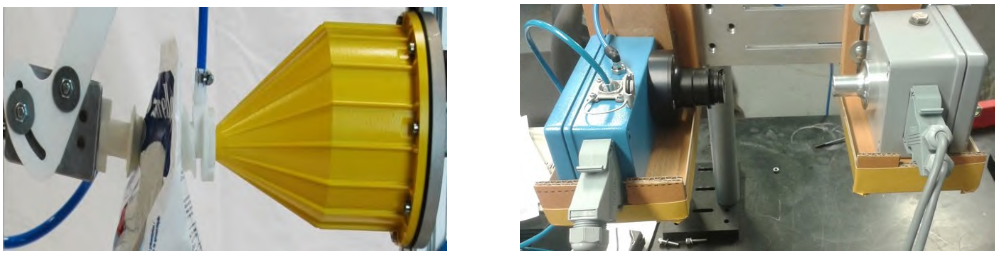
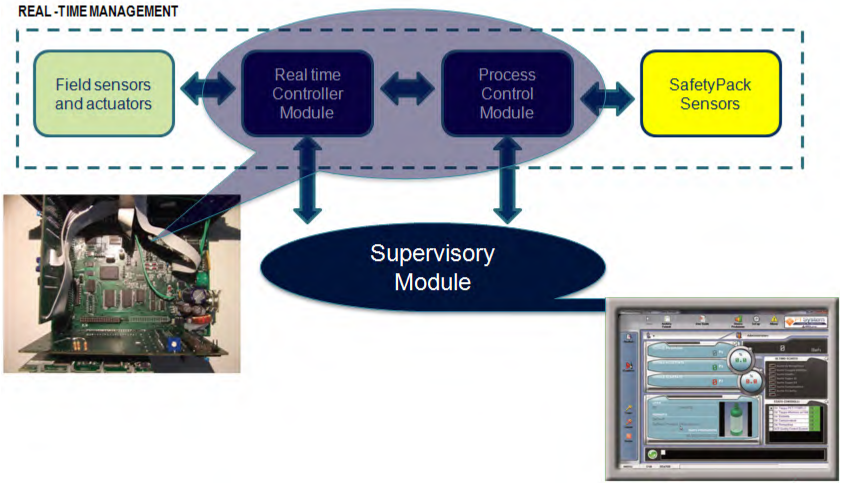
3) The third Project Objective is related to implement Fast Reaction Time.
The laser sensors that can be installed in the SAFETYPACK machine can reach very fast reaction time giving the possibility to implement packaging atmosphere analysis in less than 0,2 seconds.



The two laser sensors for mozzarella cheese (left) and tortilla bread (right)

SAFETYPACK equipment can reach a fast reaction time target thanks to the above developed sensors technology and to the real time management control system that has been implemented.



4) The fourth Project Objective is related to the Reduction of non-conforming products.
The SAFETYPACK inspection system, giving real-time measurements, gives the possibility to the industrial process control system to immediately react to production problems influencing the internal gas composition and to decrease the non-conforming % of the products. The inline machine has an automatic reject mechanism that is able to remove from the production line the not compliant products, and to advise the operator about the not conformity reason. In the following figure we report the SAFETYPACK reject device during its functioning.

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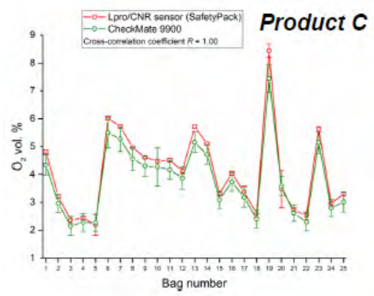
The probability of "false alarm" for in-line sensor application is around 0.2%. The SAFETYPACK automatic inspection enables very reliable and reproducible check of food production.





5) **The fifth Project Objective is related to implement an auto-adaptive inspection equipment.**
The SAFETYPACK inspection system is able to inspect a wide range of food tray from transparent to semi-transparent, to coloured ones. In the following figure we show the two types of food packages that have been used to perform inline production verification and that have been completely and successfully industrially validated during the project timeframe

Mozzarella cheese bag and tortilla bread package

6) **The sixth Project Objective is related to the implementation of an in-line contactless real-time inspection equipment.**
The SAFETYPACK system is installed inline to perform 100% of the industrial production of a wide variety of food processes, covering at the same time also a wide range of existing MAP methods. The system has been installed and fully validated at the two end-users factories, Santa Maria (Sweden) and Latteria Soligo (Italy), to implement the new production process in the two selected products reported above and to present officially the technology to the market.

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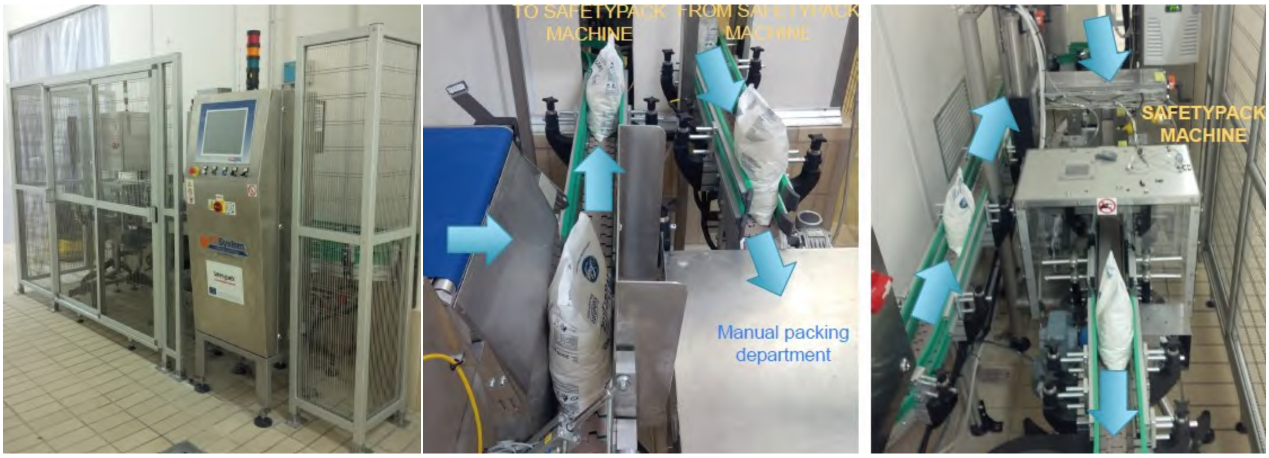
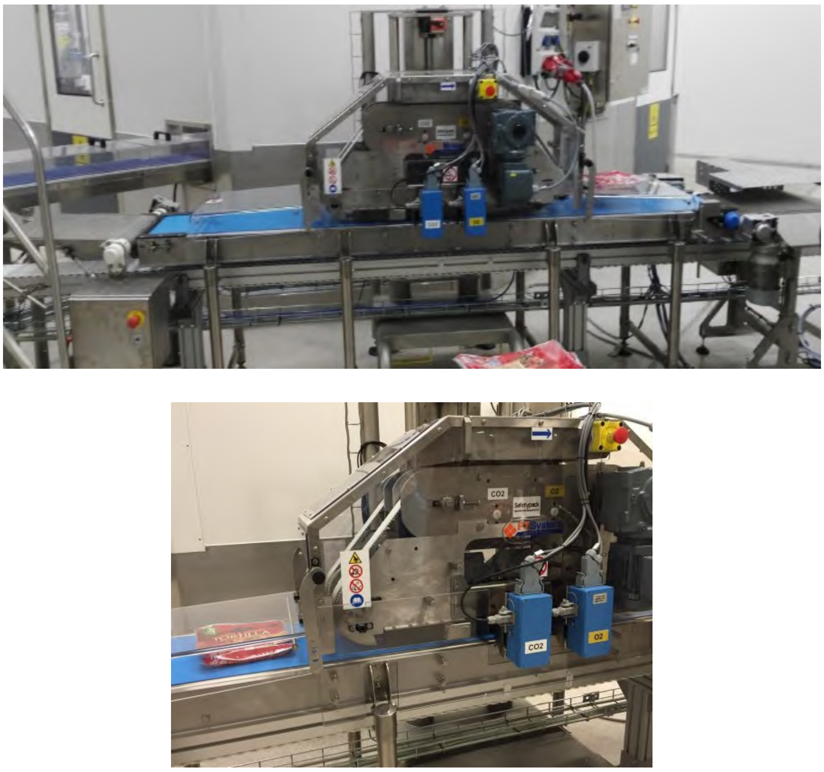


SAFETYPACK installation at Latteria di Soligo mozzarella production line (Italy)



SAFETYPACK installation at Santa Maria tortilla bread production line (Sweden)

SAFETYPACK has demonstrated the viability of the new safety and quality inspection system in in-line control of food packaging directly integrated in industrial plant. MThe SAFETYPACK system is ready for **exploitation in the worldwide Food Industry and primarily in the EU market.**

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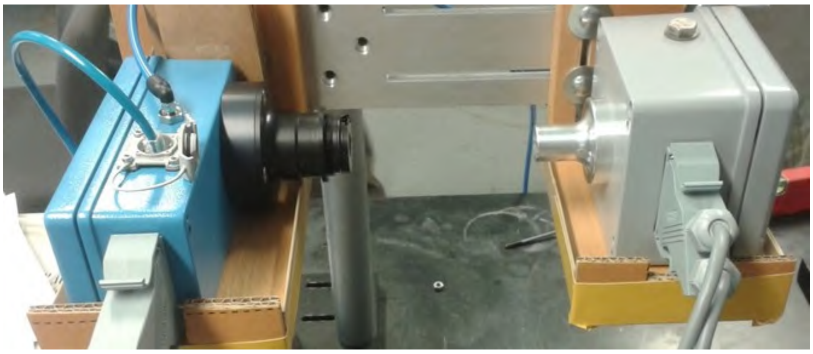
3 Main S & T results/foregrounds

The main S&T results are represented by the two developed sensors based on laser absorption spectroscopy developed for the two end-users, by a demonstration unit that is mainly used for exploitation purposes and by the two SAFETYPACK machines for inline control installed at the end-users' production plants. On this section we report a detailed description of the above results,

Sensor developed by Neo (Norway) and Gasporox (Sweden)

The sensor has been developed for the application, demonstration and validation on the production line of tortilla bread at Santa Maria (Sweden).

It should be possible to adapt the sensor for both collimated light measurements or headspace GASMAS measurements, since it is not possible to predict in advance which case will be the most favourable. The proposed concept allows this adaptation by removing collimating optics at the detector side and introducing a scattering film at the boundary of the sample. Headspace GASMAS has the potential advantages of increasing the total measured light transmission and increasing the effective optical path length. It may also under some circumstances make the measurement more robust to variations between samples. The sensor is shown in the figure below.



The system is based on the LaserGas III platform, a modular technology platform for industrial tunable diode laser spectroscopy. A modular approach to the sensor is ensured by separating the application-specific components to smaller units that may be tailored according to the gas to be measured and the specific geometry of the product to be inspected. The laser and detector heads contain the laser and photodiode required for measurement of the selected gas at an appropriate wavelength. The opto-mechanical interface of the laser/detector heads can be adapted to the product by suitable variations of the front-end design.

LaserGas III uses a direct absorption scheme whereby the transmitter unit laser driver periodically drives a linear ramp current through the laser diode. The current ramp creates a linear wavelength scan in the emitted laser light. The laser diode is temperature stabilized to ensure correct emission wavelength. The laser light passes through the gas volume of interest before it reaches the photodiode in the receiver unit. A transimpedance amplifier with automatic gain control converts the resulting photodiode current to a voltage that is sampled in by a high-speed A/D-converter. The automatic gain control facilitates operation in highly fluctuating transmission conditions over a large dynamic range.

Pre-processing of the sampled data is performed by the CPU in the receiver unit for data reduction before transmission over the RS-485 link to the transmitter unit which contains the main CPU. Essentially the pre-processing involves averaging of the sampled ramps as a noise reduction measure. The averaging time is configurable from 1 ms up to several minutes depending on the application. The averaging can be controlled with an external synchronization source so as to ensure that measurements are performed only when a

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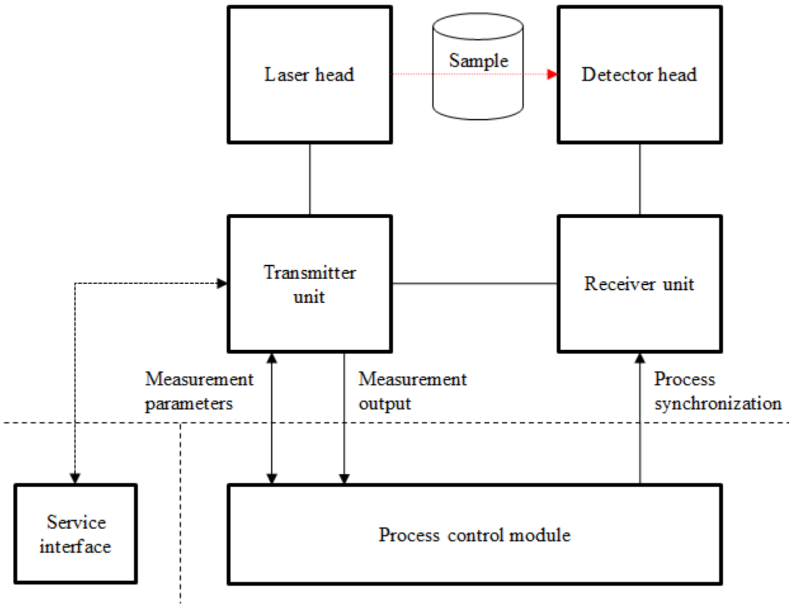
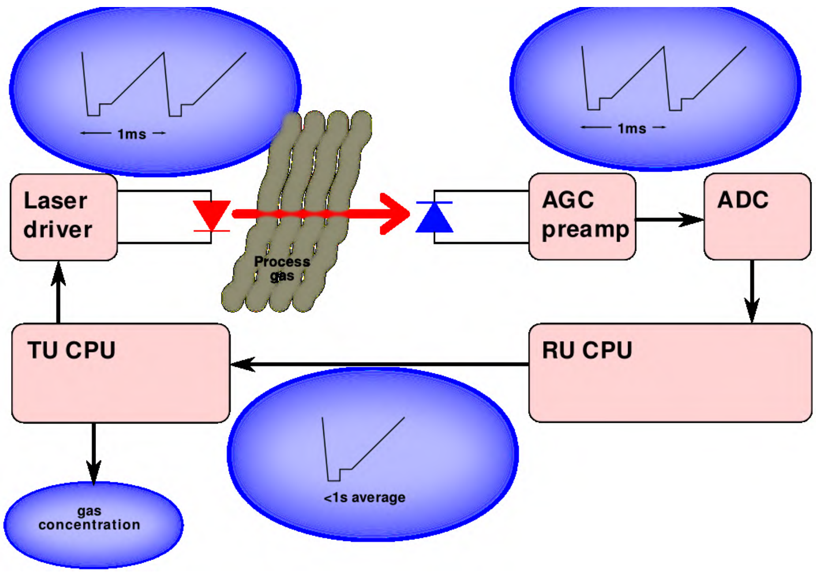
sample of interest is present in the laser beam path. This function is an essential part of the interface to the process control module in the final system.
On the transmitter unit incoming averaged ramps from the receiver unit are processed on the main CPU and the gas concentration is calculated, using calibration parameters stored on-board. The gas concentration, instrument status and ancillary measured parameters such as the transmission are then presented on the outputs.
The system architecture and the schematic of LaserGas III signal path are shown in the following figures.





The mechanical assembly is realized to create an headspace between laser and detector where the measurements can be perfomed, the so-called "tunnel geometry". The laser and the detector are configured in an opposing one-pass configuration.

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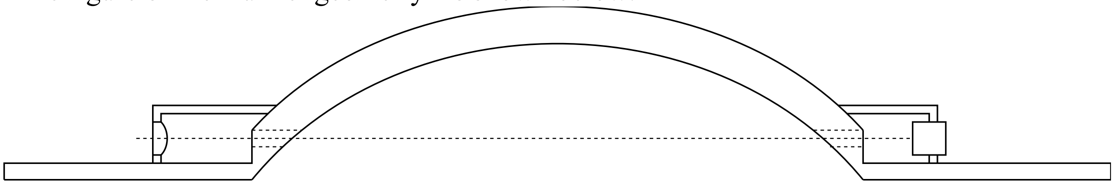
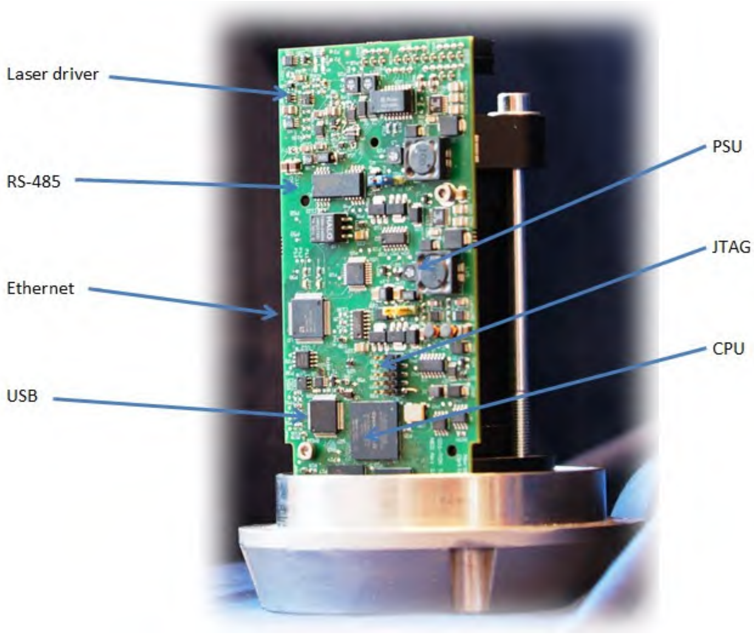
A schematic figure of the "tunnel geometry" is shown below.



Atmospheric O_2 in the spaces between the collimating lens and the sample, and between the sample and the detector, respectively, needs to be removed since it is much higher than the concentration to be measured inside the sample. This is realized by flowing nitrogen in these cavities and letting the gas bleed out through the openings toward the sample.

The sensor is based on transmitter and receiver units. The transmitter unit contains the laser driver with temperature regulator, the main CPU system, and the primary digital and analog I/O interfaces. The laser driver is capable of driving both VCSEL and DFB lasers, configurable by component values in the laser driver circuitry. The main CPU is an Altera Nios II 32-bit soft-core processor implemented in FPGA. It runs an embedded Linux operating system hosting the main system application as well the embedded web server for system configuration, a MODBUS TCP server and other system services.

The transmitter unit electronic is shown in the figure below.



The laser head consists of the laser diode and the laser optics. The laser diode is selected depending on the gas to be measured. In a direct line-of-sight application with a mostly transparent sample the optics would be a collimating lens. A window may be placed in the front of the laser head to protect the lens and also provide a flat surface that can be placed in direct contact with the sample with only a minimal air gap in between.

The receiver unit contains the photodiode preamplifier and the high-speed A/D-converter sampling system. The preamplifier contains an automatic gain control unit that permits using the same amplifier configuration for wide ranges of optical power levels and transmission through the sample.

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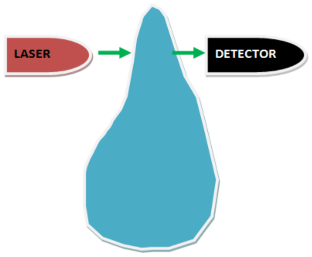
The receiver unit also contains the 4-20 mA current loop inputs for temperature and pressure. Temperature and pressure can alternatively be input via the MODBUS TCP interface or possibly the process control module interface.

Sensor developed by CNR (Italy) and LPRO (Italy)

The sensor has been developed for the application, demonstration and validation on the production line of mozzarella bags at Latteria di Soligo (Italy).

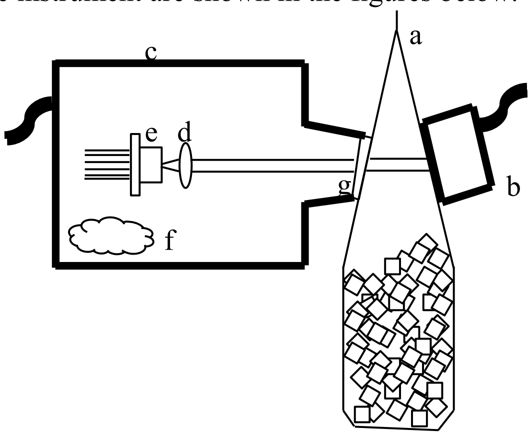
The sensor works in transmission, i.e. the laser and the sensor are placed one in front of the other on the two sides of the bag to be inspected. The instrument works measuring the absorption in the 760 nm band of O_2. The laser is a DFB used with WMS (Wavelength Modulation Spectroscopy) technique. scheme. WMS is more accurate than direct absorption spectroscopy and gives higher immunity from interference signals, therefore allowing the detection of very weak absorption signals. The digital synchronous implementation of modulation/demodulation of the optical signal has been preferred for robustness in an industrial environment.

A schematic of the measurement geometry is shown in the following figure.



An important constraint when measuring oxygen is having the least possible optical path in the atmosphere to avoid the addition of a large background absorption, therefore the laser and the detector has to be kept in proximity with the packaging, to reduce the external cavities where atmospheric oxygen can be trapped.

A schematic and a picture of the instrument are shown in the figures below.



Legenda: a) sample under test; b) photodiode; c) oxygen-free container; d) collimation lens; e) laser diode; f) oxygen scavenger; g) laser assembly output window

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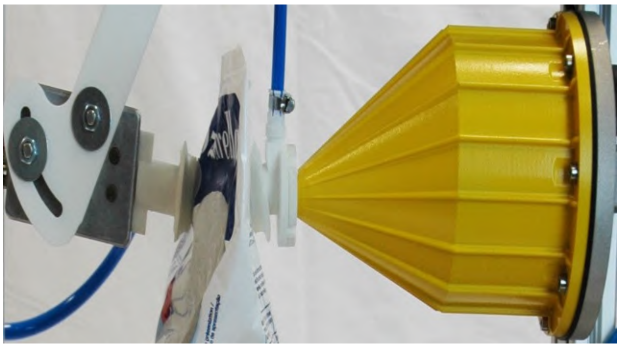
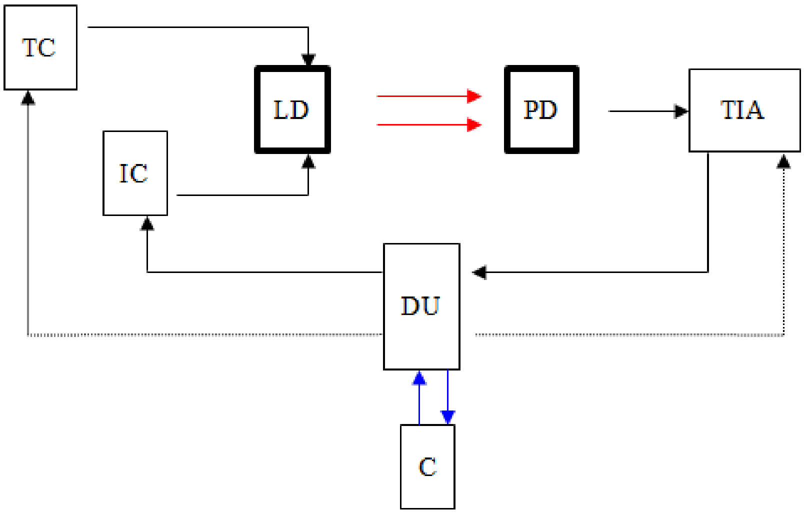
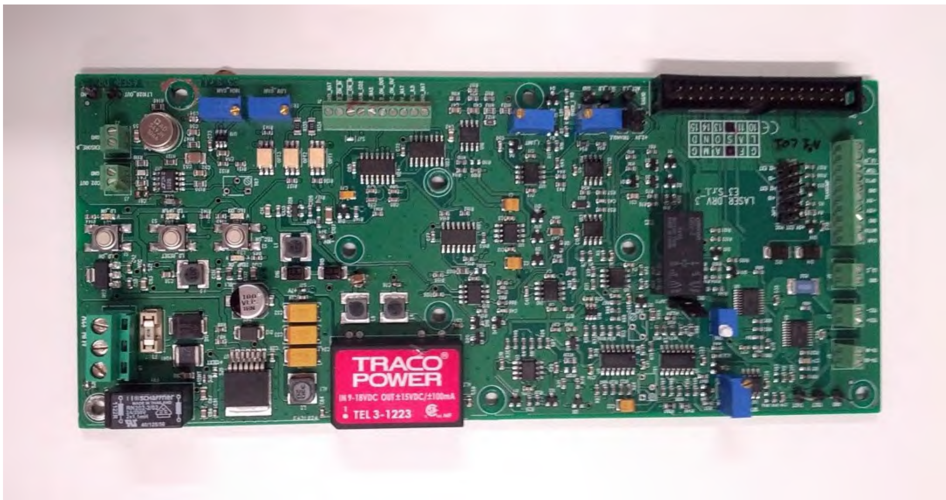


The detection head is based on different electronic modules. The laser current and temperature are driven by two modules: the current module and the temperature control and stabilization module. A digital unit provides the modulating signal to the current module in order to give the proper variation to the current and then to power and frequency of the laser. As the sensor is working in WMS mode in addition to the triangular scanning waveform there is also a sinusoidal modulation. The laser detector is followed by a transimpedance amplifier. The output amplified signal goes to the A/D sampling that is synchronous with the generating D/A clock. Finally, a computer module performs the data analysis.
A schematic of the components of the detection head is shown in the next figure.



The laser control modules have been developed in a single custom-made board as shown in the figure below. Particular care was devoted to the performance regarding stability and reproducibility of the signals.



For DU a commercial board by National Instrument has been used. Typical values used for triangular frequency is 20 to 2000 Hz, 20 to 100 kHz for sinusoidal modulation.
One of the main issues with WMS technique applied to Tunable Diode Laser Absorption Spectroscopy (TDLAS) for gas sensing comes from the relationship between absorption features and the demodulated signals. In such instruments, the actual absorption signal is masked by the modulation process and thus sensitive to its parameters and to the physical behaviour of the components involved in the setup. Moreover, absorption parameters such as line width and shape become just artefacts at the end of the modulation-demodulation chain and are not easily detectable. The detection of those parameters is possible through a fitting technique which is aware of the modulation scheme. The key of this method stands in the source emission and modulation being modelled in both power and wavelength; this model is then fed to an absorption simulation to achieve a synthesized WMS signal. By optimizing the parameters in the absorption simulation through a least-square fitting routine, the experimental signal is fitted against the synthesized signal, giving the desired absorption parameters as an output.

Demonstration unit developed by CNR and LPRO (Italy)
In order to properly test the sensor for demo and exploitation purposes, the head and the detector jointly developed by CNR and LPRO have been assembled in a demonstration unit. It is a fully autonomous device that allows operation at the side of the line as well as in the laboratory. In this way, the performance of the instrument can be assessed and the operator can get a feeling on how in-line operations will work. This is very important for exploitation purposes.
The complete measuring system is shown in the following figure.

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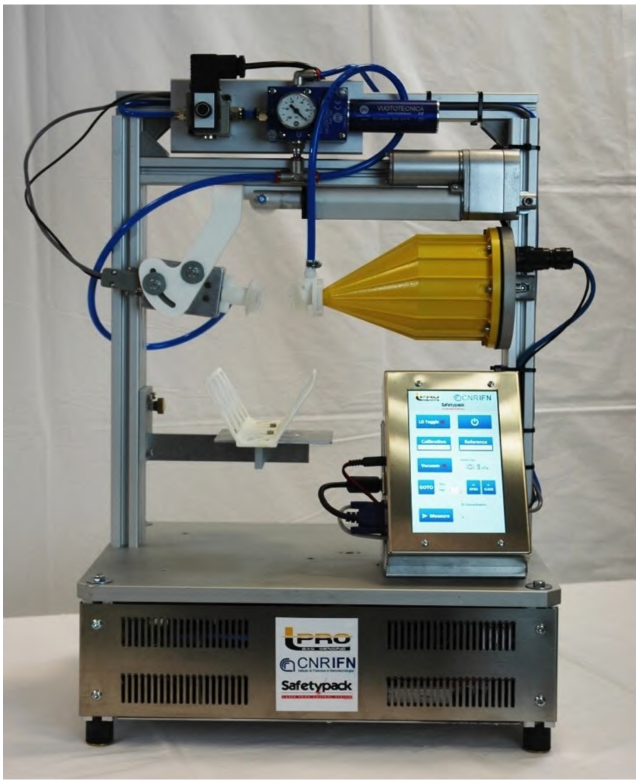

The demonstration unit can be operated quite easily.
The output and input windows of the laser source and the detector have vacuum suction cups attached. The suction cups are required to maintain the container (that may be partially rigid as a cup or totally elastic as a bag) rigidly connected to the instrument and to eliminate the external oxygen that, being at a concentration definitely higher than inside the sample, may disturb the measurement. Moreover, a special net basket supporting tested packages is provided. Either trays, bags or cups can be tested, giving high flexibility to the demonstration unit. Once the sample to be measured is placed in the basket between the source and the detector windows, the two suction cups are operated to assure an almost perfect contact respectively between the laser head and the sample and between the sample and the detector. The influence of external air, which is present in the optical pathway, is reduced to an almost negligible level.
The sensor is controlled through a built-in tablet PC. The measurement process is activated by pushing a dedicated button displayed on the touch screen of the PC. One measurement at a time can be performed. The O_2 concentration can be read from the touch screen with the precision of two decimals. For off-line operations the instrument works with a 4s integration time.
The demo unit has a built-in touch screen that is the operator interface; but there is also the possibility to connect a PC as well as connection to the net for monitoring the operation and/or changing parameters.

SAFETYPACK Inline Inspection Equipment
The SAFETYPACK inline inspection machine is based on the above sensors and integrated in an automatic testing machine with the following characteristics:

- Products come from the production line in serial mode (parallel analysis of products is not managed at present)

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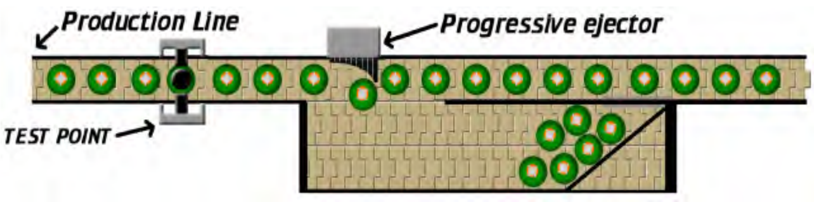
- They are pre-ordered, i.e., they are entering into the measurement system presented to the measure a minimum and proper spacing between adjacent products is created
- A proper geometry for the measurement is guaranteed by the mechanical realization of the system, e.g., bags to be measured are placed in the vertical position or a proper headspace is created on horizontal trays
- The packages are analyzed, giving two possible results: good/reject
- ”Good” packages are passed to the following part of the production line
- ”Bad” packages are ejected out from the production line

A schematic of the inspection machine is shown in the following figure.



The in-line installation has been done using the configuration shown in the next figure. It consists of a multi-threading system that simultaneously controls the measuring head: laser module and photodiode module, both synchronized with the products in-line as well the result of the analysis: good/reject, handling of anomalies in the measuring process, and control of the measuring parameters. The main CORE software communicates with a dedicated thread with GUI (Graphical User Interface) that allows to set up the parameters, as product type and threshold values, to provide possible errors signals and corresponding alarms. The communication is done with TCP/IP protocols. Another dedicated thread is devoted to the control of the productive process, e.g. presence of the product, speed of the line, …. Furthermore, it communicates the result of the measurement, in term of good/reject. The communication is done in real time with digital signals.

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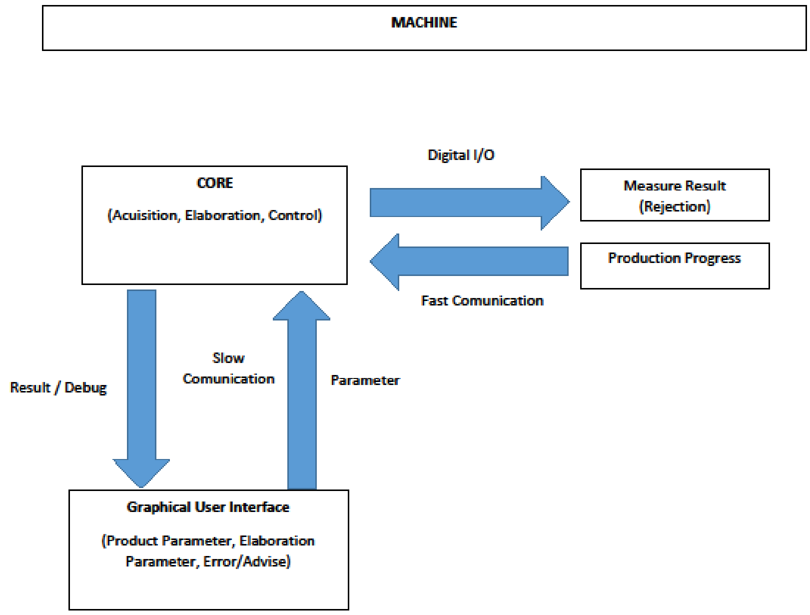
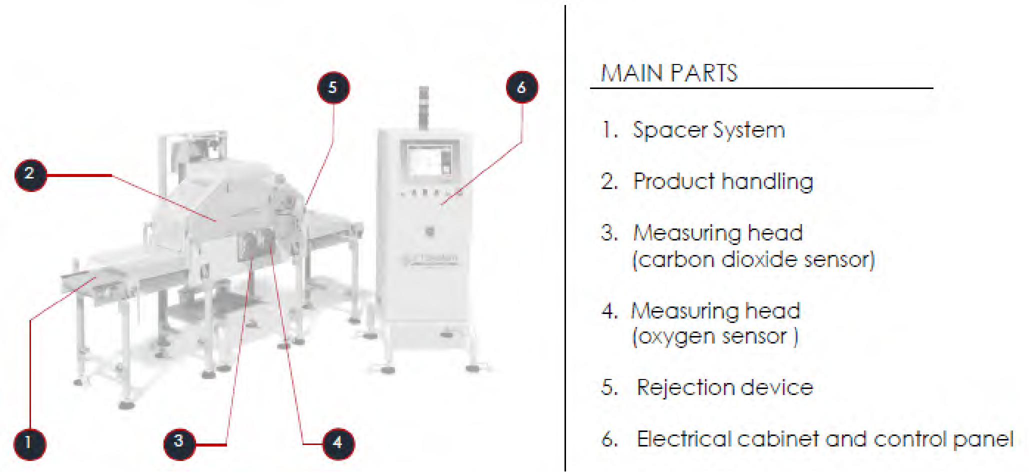


According to the architecture discussed above, the main parts of the machine are the following, as also shown in the following figure:

- Spacer system
- Product handling
- Measuring head
- Rejection device
- Electrical cabinet and control cabinet



In the following figures we report the two inline machines developed and industrially validated during the project timeframe:

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1. one has been installed in Latteria di Soligo, Italy, and it is used to inspect the oxygen content inside mozzarella bags in one of the end-user's production lines
2. one has been installed in Santa Maria, Sweden, and it is used to inspect oxygen and carbon dioxide content inside tortilla bread packages in one of the end-user's production lines


Inline SAFETYPACK Equipment for Tortilla Bread Products Inspection


Inline SAFETYPACK Equipment for Mozzarella Products Inspection

Inline Equipment for inspection of mozzarella cheese bags
The following pictures present the in-line machine and the mechanical customization for the implementation of the O_2 measurement on the inline production of mozzarella cheese bags.

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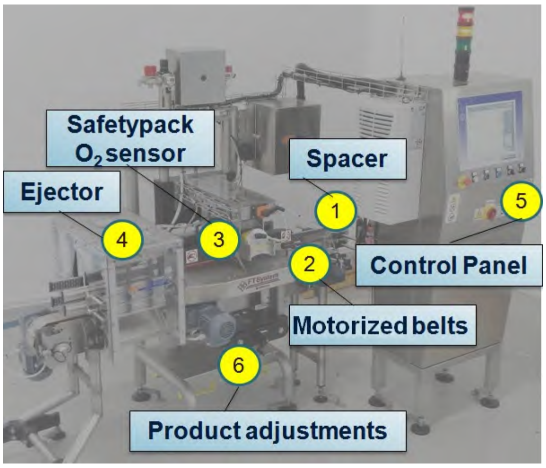
SAFETYPACK machine: In-line version installed at Latteria di Soligo plant



In-line SAFETYPACK system architecture:

1 = Spacer: it introduces programmable gap between products
2 = Motorized belts: they perform product compression to create the head space for the measurement
3 = SAFETYPACK O_2 sensor, SAFETYPACK measurement head
4 = Ejector: it takes out from the line the non-compliant products
5 = Control Panel: it includes the electrical components and the control of the whole system
6 = Product adjustments: they make the manual mechanical adjustments in order to adapt the machine to the different product sizes in production

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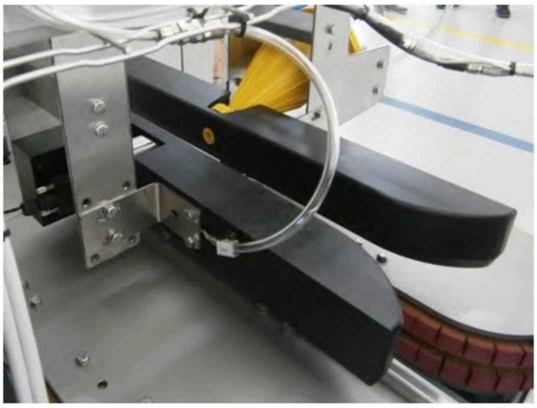
Spacer system. It is expected that the products before the spacer system arrive in accumulation. The task of this pneumatic device is to create a space between packages to enable their inspection and proper rejection in the case of non-compliance.

Motorized belts and head space creation. The motorized belts transport the product at the point of inspection and apply a slight compression on the bottom of the bags. The upper part of the package inflates inside special sliding guides which contain the expansion, thus creating a head space whose dimensions are known and suitable for the measurement with laser spectroscopy.



O_2 measuring head: the measuring head integrates the SAFETYPACK sensor.

Control Panel: electrical cabinet and industrial PC.

Inline equipment for inspection of tortilla bread packages

The following pictures present the in-line machine and the mechanical customization for the implementation of the O_2 and CO_2 measurement on the inline production of tortilla breads packages.

SAFETYPACK machine: In-line version installed at Santa Maria plant.

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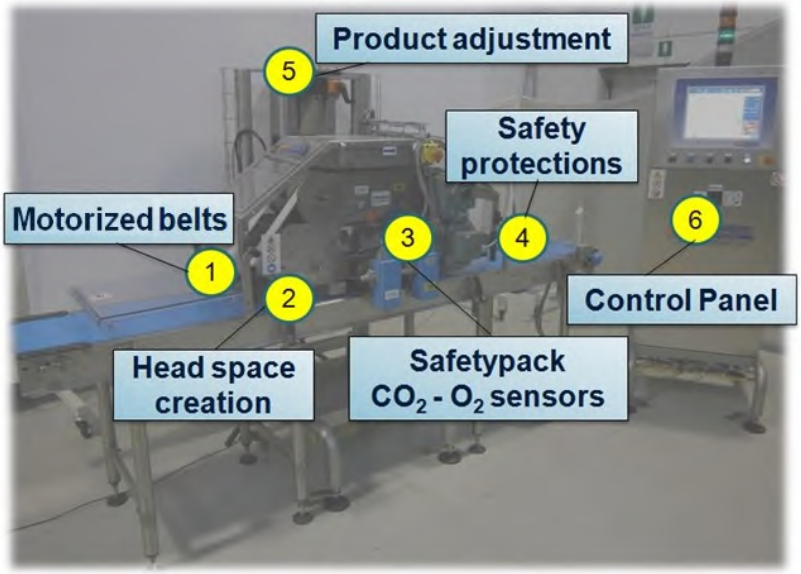

In-line SAFETYPACK system architecture:

1 = Motorized belts. They manage product handling

2 = Head space creation. By means of the motorized-belts group the product is compressed sideways in order to create the head space for the CO_2 and O_2 measurements.

3 = SAFETYPACK CO_2 and O_2 sensors, measurement heads.

4 = Safety Protections. The couple of openable protections (infeed-outfeed) ensure the complete safety of the operator during the operating cycle of the machine and during maintenance and cleaning operations.

5 = Product adjustment. It makes the manual mechanical adjustment in order to adapt the machine to different product sizes in production.

6 = Control Panel. It includes the electrical components and the control of the whole system.

Motorized Belts: The product handling is used to create the headspace, required to perform the measures of O_2 and CO_2 by the sensor. To implement the measurement concept, the mechanical system includes the use of three

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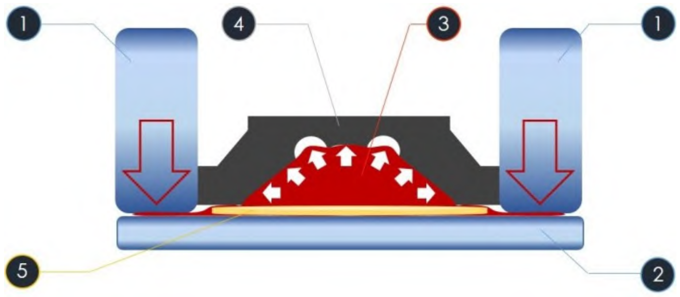
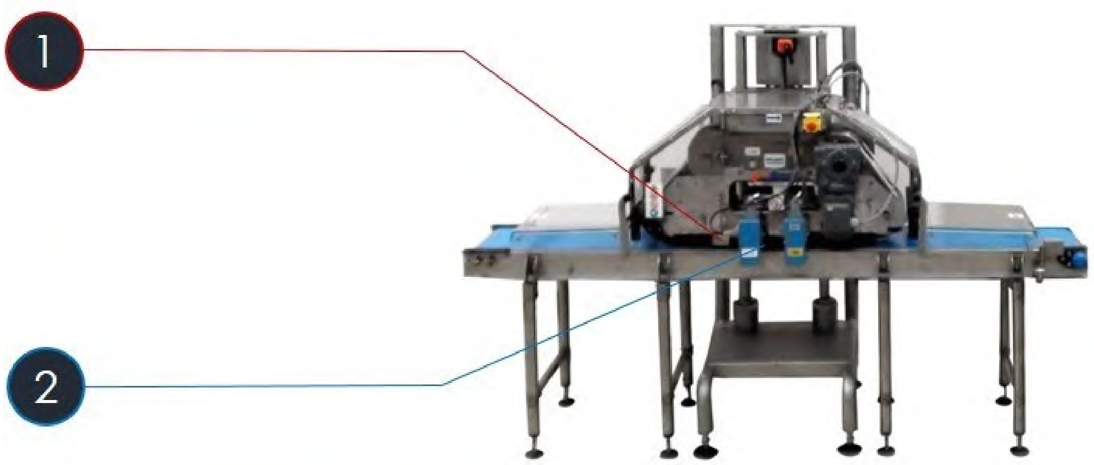
belts, one on the bottom that will hold and move the pack, and other two on the top of the pack in order to laterally compress the pack of tortillas to create the head space



Head space creations: The concept of long tunnel has been designed, by creating a proper headspace in order to ensure uniformity in applying the product compression force and reliability in creating the headspace.



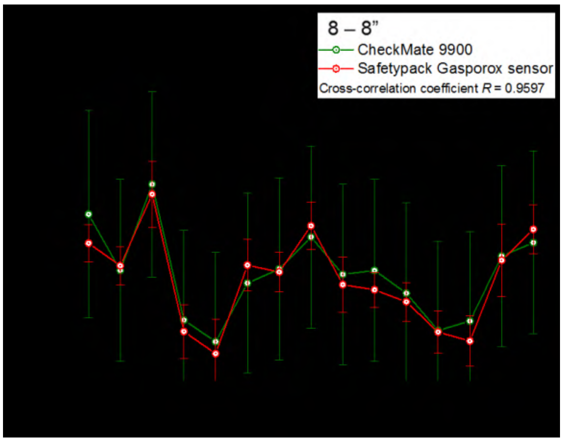
SAFETYPACK CO_2 and O_2 sensors.

Control Panel: Electrical cabinet and industrial PC

Validation measurements

Both the SAFETYPACK systems have been fully validated for inline operation by the Consortium team. The system performance have been evaluated and validated vs. an invasive and calibrated method that is used to measure the gas concentration inside closed containers and is normally taken as a standard, the Dansensor Checkmate 9900.

Regarding validation measurements of the Gasporox/NEO optical sensor deployed at the premises of Santa Maria, the precision of the non-intrusive measurements and cross-correlation with intrusive measurement data is the same for both oxygen and CO_2 measurement channels. Repeatability of non-intrusive measurements of CO_2 is however, approximately 10 times better than that of oxygen concentration measurements due to higher measured concentration of CO_2. Despite a low correlation coefficient value for oxygen, the results confirm practical usability of the non-intrusive instrument as well as the high precision of the measurements of a few %. SAFETYPACK sensor measures the same oxygen concentrations as CheckMate 9900 intrusive sensor within the error bars, i.e. within the confidence interval of one standard deviation. A number of failure situations regarding packaging units condition and placing on conveyor were observed. They have implications on the measurement but can be acted on by identified solutions. The result from one of the calibration runs is shown in the following figure. It shows high precision and almost perfect correlation between intrusive and non-intrusive measurements.



Regarding validation measurements of the CNR/LPRO optical sensor deployed at the premises of Latteria di Soligo, three validation experiments with mozzarella cheese bags have been performed measuring (i) 13 samples over 10 passes, (ii) the same product 20 times, (iii) packages directly from the production line. The results of measurements and data analysis confirmed that the precision and repeatability of inline non-intrusive measurements are very satisfactory. The measured oxygen concentration is falling during the initial few measurements. After a few minutes the non-intrusively measured concentration reaches a stationary value. This is also observed slightly in the measurements from the first experiment. This does not influence the readiness of the sensor equipment for inline implementation. A typical result from one of the calibration runs is shown in the following figure. It is plotted the averaged results of oxygen concentration measurements in 13 bag samples, conducted over 10 passes. It shows high precision and perfect correlation between intrusive and non-intrusive measurements.

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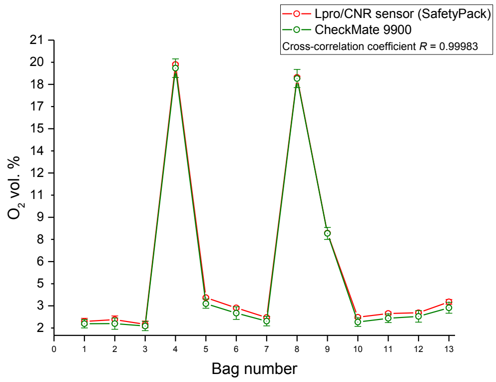

Foregrounds

SAFETYPACK has demonstrated the feasibility and viability of the new safety and quality inspection system for real-time in-line control of food packaging with two fully validated installations. The system is ready for **exploitation in the food industry.**

The use of the SAFETYPACK technology will help food producer to obtain the HACCP certification system in case of MAP usage and it gives the company the ability to:

- Communicate confidence to consumers, showing that food is produced through safe processes
- Demonstrate that they have taken all reasonable precautions to ensure the safety of food
- Reduce the number of checks carried out by customers, therefore save costs and management time
- Reduce waste and the product recalls
- Improve relations with the authorities responsible for food safety
- Increase the efficiency of processes.

The added values that will be obtained by the SAFETYPACK project are reported in the following list.

A) **Food Safety:** it will be possible to monitor the 100% of the production obtaining an higher quality product, with increment product life and greater safety for the consumer.

B) **Reduction of non-conforming products:** The SAFETYPACK inspection system it is able to guarantee the decrement of the non-conforming % of the products, due to the possibility to measure the gas composition in real time.

C) **Socio-Economic benefits**: the use of SAFETYPACK inspection will be used to
   - Increase the workers security as it allows a better control of the CO_2 loss in the packaging department and its consequences for health
   - Reduce wasted food and the non conformity products avoiding the delivery to the final customers and the related complaints
   - In terms of performance, SAFETYPACK platform guarantees better productivity as production problem can be solved faster and statistical manual check will be eliminated
   - The SAFETYPACK inline inspection system will be able to determine the future quality of the final product.
   - The integrated machine software will provide a full control of the processing parameters

D) **Inline contactless real time inspection equipment**: the SAFETYPACK inspection system is a very innovative methodologies as it implements contactless non- intrusive laser gas sensors that can perform quality and safety control on a wide range of sealed food.

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Exploitable foregrounds

The exploitable foregrounds are here listed, as also reported in the Participant Portal.

1. **General advancement of knowledge**

   Extension of the research activities from the food sector also to other fields where the analysis of gas content in close containers is required.

   Exploitable products: Application of laser spectroscopy on control of industrial process, pollution monitoring, quality certification of sealing processes

2. **Commercial exploitation of R&D results**

   Extension of the SAFETYPACK approach and methodology to a broad range of food applications

   Exploitable products: Realization of machines based on the SAFETYPACK approach for different food and beverage sectors. The SAFETYPACK approach and methodology can be extended to a broad range of food applications: 1) Soft drinks (tea, energy drinks and carbonated soft drinks etc.) bottled in PET bottles. 2) Fruit juice (hot filling, not MAP, but with vacuum inside) bottled in HDPE bottles?- Fish (tuna, salmon, shrimp etc.) packed in trays with film. 3) Bakery (e.g. flatbread) packed vertically in bags. 4) Semi-preserved products (e.g. fish or vegetables) packed in trays with film. 5) Meals (e.g. pre-cooked pasta with a section for sauce) packed in trays with film. 6) Salads (different shapes and cuts of salad) packed in bags. 7) Meat and meat products (poultry, pork and beef) packed in thermos-formed trays with film. For most of these foods, present quality control includes methods that are off-line and destructive for the package and the food products.

3. **Commercial exploitation of R&D results**

   Exploitable output at two levels: SAFETYPACK system, the inline quality control system for packed products; SAFETYPACK module, the off-line stand-alone quality control instrument for laboratory use.

   Exploitable products: the exploitable output of the SAFETYPACK project results can be considered at two different levels: 1) SAFETYPACK system, the inline quality control system of all or selected packed products. 2) SAFETYPACK module, the off-line stand-alone quality control instrument for laboratory use. The main product resulting from the project is a non-intrusive laser sensor system or module/instrument for food packaging applications. The laser sensor system has been validated and demonstrated in two in-line pilot installations, a production site for soft tortilla bread and one for mozzarella cheese. Goals of the dissemination of the SAFETYPACK exploitation plan are the following: 1) To increase awareness of the SAFETYPACK system and modules on selected markets. This is done by communication via press releases and articles in relevant technical media; participations in conferences and fairs. 2) To identify criteria for buyer intention. This is done by: interviews with potential customers on the selected markets; preliminary sales meetings with potential customers.

4. **Commercial exploitation of R&D results**

   If the control of the internal atmosphere will be required as a standard quality check on 100% production, the SAFETYPACK approach is the only one capable to fulfil the requirements.

   Exploitable products: The SAFETYPACK system is able to measure in real time and inline operation 100% of the MAP production in a broad range of packages. At present, these types of measurements are done offline on a statistical basis, since few samples are tested on a random choice with destructive techniques. If the control of the internal atmosphere will be required as a standard quality check on 100% production, the SAFETYPACK approach is the only one capable to fulfil the requirements.

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4 Potential impact and main dissemination activities

The potential impact of the SAFETYPACK inspection unit implemented to control the atmosphere integrity inside the packaging is strictly related to the expectations of consumers. The requests for continuous increase in quality and extension of the product lifespan is pushing the industry to increase quality control in the production process. Therefore, companies are more and more requested to communicate complete information about the quality of the food product. Consumers are normally careful in looking at the information contained in the product label about each relevant attributes, including those related to the production system. The SAFETYPACK quality inspection system helps in increasing the quality assessment regarding working conditions, environmental standards, food safety and quality.
SAFETYPACK inspects all packages and reject all non-conforming ones therefore that human error is removed from the process. The total production quality is assured by the full in-line control that guarantees that every package leaving the factory has been inspected and fulfil the standard requirements when it come out at the end of the production line. This information could be extremely valuable when dealing with customer complaints.
The SAFETYPACK machine is cost-effective, automated and with high-quality standards, using completely innovative principles as totally non-invasive inspection, real-time parallel processing, applicability to a wide range of containers, reliability by process control. The inline inspection system provides a significant advantage over conventional approaches that are based on manual laboratory tests done on a limited number of samples. Indeed, it provides a much more flexible platform for in-line inspection allowing industry users to gain a greater value from the capital investments done in inline inspection equipment.
The final results of SAFETYPACK can be summarized as following:
1 - Inspection system able to perform precise measurement and control of the inside atmosphere in food tray used by food and packaging industries.
2 - Innovative methodology, as it implements contactless non- intrusive laser gas sensors that provides the food manufacturing industry with a real-time in-line control of the total production.
3 - Tool Predicting the Features, since it is able to perform the analysis composition of the sealed tray giving the possibility to determine the future quality of the final product.
4- Full quality inspection, since the inline SAFETYPACK system is able to inspect 100% of the production. The system allows to reach the quality control on the full production in real-time.
5 - Fast Reaction Time, since the implemented sensing technologies has a very fast inspection time as short as fractions of a second.
6 - Reduction of non-conforming products since the atmosphere composition inside the food tray and the tray sealed property are verified in real time. Using the SAFETYPACK inline inspection system, the quality department has the possibility to react in real time to any production problem related to the packaging line, either solving it immediately or stopping the production until the problem has been solved. In any case, the nonconforming percentage of the products is decreased and consequently the production of waste is reduced, with both ecologic and economic advantages.
7 - Auto-adaptive inspection equipment, since it can be applied to the inspection on a wide range of food trays from transparent to semitransparent, to colored ones.
8 – End-users applications: SAFETYPACK has been demonstrated for in in-line control of food packaging directly integrated in mozzarella cheese and tortilla bread industrial plants.

The definition of factors influencing the acceptability, implementation, societal risks and impacts of the SAFETYPACK inspection unit to be implemented in the control of the atmosphere integrity inside the packaging system is strictly related to the expectation of the consumer nowadays. Consumer drives for more quality, together with the conventional conviction that product lifespan is shortening, have pushed marketing researchers to look for new tools to implement quality control processes. It is possible to define a market-

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based innovation as a product that results from combining skills and resources in such a way that buyers perceive an improvement in the relationship between price and value, relative to competing products. SAFETYPACK acts in improving the food quality and safety and these aspects are directly connected to the main expectations from the consumers. SAFETYPACK is the result of three distinct behavioural components: customer orientation, competitor orientation, and inter-functional coordination. The project results are expected to provide outcomes of major relevance for developing countries, where food quality standards are typically poor.

In the following we report a detailed SWOT-analysis.

Strengths:

- There is a definite need for a high speed device in the food industry market place
- It utilises non-intrusive technology
- It is implementable on existing packaging line
- It is safe in use
- It senses the gas levels and check the integrity of the seal
- Increased food safety and reduced food waste
- Enhance the prestige of the brand

Weaknesses:

- Possible use of more than one check points of gas level for the same packaging and dual sensors or reciprocating sensors
- All types of metalised packaging: SAFETYPACK sensors cannot work with aluminium trays or metalised films

Opportunities:

- SAFETYPACK could be used as a tool to extend shelf life of gassed products, where the shelf life is based on actual gas composition
- Target markets in Germany and the UK as the willingness of adopting new technologies is high and these two being the fifth and sixth largest markets worldwide.
- Target market: The meat industry as the turnover accounts for 54 % of the EU food and drink market.

Threats:

- Packaging systems not suitable for the SAFETYPACK: Skin packs and all types of vacuum packs, as there is no headspace
- All types of fresh unwrapped produce, especially in third world emerging markets
- Non-acceptance of the technology by major supermarkets. In the UK, the major supermarkets are the driving force for packaging, labelling and quality inspection systems. Current trends in the UK are moving in the direction of skin packs.

The introduction on the market of SAFETYPACK product to the food industry is influenced by various parameters, including those mentioned in the following

- Purchase price
- Switching costs, cost for switching to alternative technology
- Investment size
- Repayment period
- Return on investment, different economic models

The economic barriers of SAFETYPACK is highly specific for individual companies. For example when considering repayment period, some companies stick to a repayment period of five years and others a period of less than a year. No companies are comparable as their actual situations are varying regarding among other things the aspects listed:

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- Economic stability
- Profit
- Ownership
- Supply chain
- Sensitivity and stability of delivery, sales and suppliers
- Product portfolio
- Production rate

The financial feasibility of the proposed activities is the outcome of a realistic and reasonable budget, taking into account the appropriateness of the requested amount in relation to the scale and type of the activities, to the expected results and to the size of the partnership.

The following table reports how SAFETYPACK project results will contribute to the expected impacts set out in the work programme.

Expected Impacts	**SAFETYPACK Contribution**
Fast development, commercial take-up and/or wide deployment of sustainable innovative solutions in enabling and industrial technologies and/or for tackling societal challenges	The SAFETYPACK equipment combines mature laser spectroscopy sensor integrated in an automatic inline inspection machine to obtain consistent increment of quality, security and safety. As a consequence, a higher level of food safety and shelf life extension is reached that is a great added value for the health of the consumers.
Improved shelf life due to the use of SAFETYPACK equipment	Increment of calendar time for the expired data and the warranty of the food safety/integrity/quality for the full shelf life, food producers will be able to increase their sales.
New approaches and methods for MAP packaging sector	Through the demonstrators built by the use-cases, measureable objectives are assessed and managed. Reduction of wasted food, increase of cost saving
Improved sustainability across the entire product and production life-cycles	SAFETYPACK capabilities enhance the reliability and performances of present food products
Increased support for open best-practice HACCP standards	Open up for production best-practice reference models and knowledge architectures and standardized methods

In the following table we report the expected impacts on the most important sectors.

Expected Impact on EU food sector	**Contribution of SAFETYPACK**
Enhanced capability for reaction to market and efficiency demands. **Reduced time-to market**	Delivery of SAFETYPACK Platform based on laser Spetroscopy contactless sensor and inline real time control
Reduce complexity of logistic procedures. Increase of productivity. Reduce waste.	Development of novel methods for inline inspection to enhance production quality and safety. New concept of quality management
Productivity and quality increase through the use of the new available equipment.	Supporting manufacturers, suppliers and providers in Production organization and control and in automatic

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Increased performance/productivity **Increment of shelf life**	procedures
Reinforced capacity to manufacture high-quality food product	Managing & manufacturing for reducing time, resources, costs and waste

The supply of incorrectly gassed products are immense in the food production sector, and the associated costs make a system such as SAFETYPACK a viable proposition. SAFETYPACK effectively becomes an insurance policy to cope with the unknown: breakdowns happen when least expected and rework becomes very expensive. The supermarket fines can ultimately lead to cancelled contracts, without take care about brand reputation on the market that can create very dangerous economic problems.

Simplified and Short Business Plan
The dissemination strategies are externally oriented and focused on promotion. The exploitation interest of SAFETYPACK partners is focused on the in-line inspection system and gas sensors, in order to generate new customers and commercial collaborations in their current area of operation. It also includes to rise the quality and safety profile for the food manufacturers. The definition of the market and the specific customer needs and products provide the background knowledge for constructing an effective dissemination strategy with the main goal to create awareness and pave the way for future sale of the systems and modules (exploitation results). The market and customer knowledge is primarily collected from earlier customers and areas of interest of the team.

Food market analysis
The food industry is highly competitive and manufacturers are continually trying to increase their market share and profits. To do this they must ensure that their products are of higher quality, less expensive, and more desirable than those of their competitors, whilst ensuring that they are safe. Packing foods in a modified atmosphere can have significant effects on many of these extrinsic factors, and many developments in packaging materials have been driven by the need to reduce the impact of these environmental factors, extend shelf life, reduce waste. With increased expectations for food products of high quality and safety standards, the need for accurate, fast and objective quality determination of these characteristics in products continues to grow. For the producers, today's quality control includes methods that are off-line and destructive for the package and the food product. Therefore, the product will either go to waste or be returned to the production line for repackaging. Typically, the problems causing rejections, in view of the quality requirements are:
(1) wrong concentration of gas
(2) insufficient sealing and therefore lack of tightness of the package
(3) holes in the package and therefore leak from the package.
When companies are considering a possible investment in a SAFETYPACK system for in-line measurements or stand-alone testing, as a quality control instrument, the aspects presented below are essential in assessing if SAFETYPACK is the right technology for the company and if the investment in a SAFETYPACK system or module has a reasonable payback period.

Value adding of inspection
Often value adding only relates to product attributes, while quality control is considered as unavoidable, which does not contribute to the value. Below is listed some arguments that can put companies' mind-set to **the test:**

- If a company doesn't perform inspection during the production, some products may be shipped with defects.

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- Quality inspections are a source of data and manufacturing intelligence on how the production processes are performing; they provide insights into how a better product design might lead to higher quality and less waste.
- Quality inspections can help to **reduce future costs,** including rejected or returned products.

Economic Viability/competitors

The economic viability model of SAFETYPACK can be used to demonstrate the characteristics of potential customers. The inspection system has to assure effective benefit and do not interfere with production efficiency. Any significant shift in the cost of energy could have an impact on operating costs. The cost of the SAFETYPACK system is estimated to €70,000. SAFETYPACK inline equipment is very competitive with current used providers of gas measurement solutions and leak detection reported on the following table

Manual inspection equipment in use nowadays			
Technology	Needle extraction	Fluorescing patches	Traditional laser method
Price (approx.)	2-12 kEUR	5-15 kEUR	7-60 kEUR
Packaging types	Most packages Not glass containers	Transparent packaging	Transparent Well-defines geometry
Providers	Mocon, Dansensor, WITT, CO2 Meter	Mocon, PreSens, Ocean Optics, OxySense	Wilco, Lighthouse
Leak inline inspection equipment in use nowadays			
Technology	Co2 sniff	Pressure decay chamber	Fluorescing patches
Price (approx.)	70 kEUR	90-200 kEUR	90 kEUR
Packaging types	Tray	all	Tray
Providers, companies	Ishida	Dansensor, WITT	Gea

Sales

Packaging is critically important for food, given that an estimated 50% of all purchasing decisions are made at the point of sale. The differentiating effect created by packaging can be significant not only for communicating brand information to the shopper, but also for driving in-store sales. In addition to its traditional role, packaging can offer retailers value-added functionality, such as active packaging and smart tagging. Retailers will increasingly try to capitalize on these initiatives to generate significant cost savings and differentiate themselves from competitors. Food security, food prices, and food safety summarize the multitude of concerns consumers have about food.

Market Analysis

The available market is very large as no one of the worldwide. Producers have the need for such kind of inspection system and quality level both in EU, North America and rest of the world.

Target Market

The target market are all the food producers using MAP.

Advances in food processing and food packaging play a primary role in the increment of the food safety. Simply stated, packaging maintains the benefits of food processing after the process is complete, enabling foods to travel safely for long distances from their point of origin and still be wholesome at the time of consumption.

Food packaging can retard product deterioration, retain the beneficial effects of processing, extend shelf life, and maintain or increase the quality and safety of food. This is the reason why MAP has increased during the last years. MAP is the practice of modifying the composition of the internal atmosphere of a package

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(commonly food packages, drugs, etc.) in order to improve the shelf life. In this preservation technique, the air surrounding the food in the package is changed to another composition. This way the initial fresh state of the product may be prolonged. MAP is applied to various types of products. The mixture of gases in the package depends on the type of product, packaging materials and storage temperature.
Even if MAP presents many advantages, there are some risk factors to consider, such as:
1) Unhealthy food and already contaminated.
2) Food not subject to thermal stabilization.
3) Interruption or incorrect management of the refrigeration chain.
4) Losses due to packaging defects.
5) Impurity gases.
6) Improper mixing of gases

The improper mixing of gases can represent a serious risk factor; therefore, the continuous monitoring of the gas concentration is essential to keep the entire process under control. In the market evaluation, the project Consortium analyzed these five main sectors with particular attention on the European market. The Consortium analyzed the trend of the market and the real needs within each sector considering the kind of product, the kind of packaging, the type of gas concentration and line production speed.

In the following figure we report the analysis of the EU Food market

Dairy Sector

KIND OF PRODUCT	Cheese (Mozzarella cheese, Ricotta cheese…)
KIND OF PACKAGING	Plastic bag - Trays with film
TYPE OF GAS CONCENTRATION	O2 and/or CO2
SPEED OF THE LINE	Min. 10 pieces/minute - Max. 80 pcs/min
CUSTOMER'S NEEDS	Measurement of gas concentration to preserve the product shelf-life, leak detection
MEASUREMENT RANGES REQUIRED	Low O2 (< 5%); High CO2 (>20%).
ADVANTAGES	Fully automatic in line inspection; Real time production line control; 100% of the production inspected
TARGET PRICE	To be defined in function of the application. In general, with 1 sensor around 60K -70K Euro; with 2 sensors around 90K-110K Euro.

Beverage Secor

KIND OF PRODUCT	Beverage (wine, fruit juices…)
KIND OF PACKAGING	PET – HDPE-GLASS bottles
TYPE OF GAS CONCENTRATION	O2 and/or CO2
SPEED OF THE LINE	Min. 200 pieces/minute - Max. 1000 pieces/minute
CUSTOMER'S NEEDS	Measurement of gas concentration to preserve the product shelf-life Pressure detection
MEASUREMENT RANGES REQUIRED	Low O2 (< 5%) ; High CO2 (>50%) or Low CO2 (<1%)
ADVANTAGES	Fully automatic in line inspection; Real time production line control; 100% of the production inspected
TARGET PRICE	To be defined in function of the application. In general, with 1 sensor around 30K -40K Euro (Pressure detection); with 1 sensor around 40K - 50K Euro (Gas concentration); with 2 sensors around 60K -70K Euro (Pressure detection); with 2 sensors around 70K -80K Euro (Gas concentration);

Meat Sector

Bakery Sector

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KIND OF PRODUCT	Bakery (e.g. flatbread, Tortillas, Piadina)
KIND OF PACKAGING	Packed vertically in bags
TYPE OF GAS CONCENTRATION	O2 and/or CO2
SPEED OF THE LINE	Min. 10 pieces/minute - Max. 120 pieces/minute
CUSTOMER'S NEEDS	Measurement of gas concentration to preserve the product shelf-life
MEASUREMENT RANGES REQUIRED	Low O2 (< 5%) ; High CO2 (>30%), >50%)
ADVANTAGES	Fully automatic in line inspection; Real time production line control; 100% of the production inspected
TARGET PRICE	To be defined in function of the application. In general, with 1 sensor around 60K-70K Euro; with 2 sensors around 90K-100K Euro.

KIND OF PRODUCT	Fresh and cured meat – Poultry - Fish
KIND OF PACKAGING	trays with film
TYPE OF GAS CONCENTRATION	O2 and/or CO2
SPEED OF THE LINE	Min. 10 pieces/minute - Max. 200 pieces/minute
CUSTOMER'S NEEDS	Measurement of gas concentration to preserve the product shelf-life
MEASUREMENT RANGES REQUIRED	Low O2 (> 50%) and High CO2 (>50%) or High O2 (> 50%) and High CO2 (>20%).
ADVANTAGES	Fully automatic in line inspection; Real time production line control; 100% of the production inspected
TARGET PRICE	To be defined in function of the application. In general, with 1 sensor around 50K-60K Euro; with 2 sensors around 80K-100K Euro; ..

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Sales Forecast

SECTOR	2017		2018		2019		2020		2021	
	Average Price 80K		Average Price 65K		Average Price 65K		Average Price 65K		Average Price 65K	
	n°	TOT	n°	TOT	n°	TOT	n°	TOT	n°	TOT
FRESH PASTA - READY TO EAT FOOD	1	80 K	3	195 K	10	650 K	20	1.3M	40	2.6 M
DAIRY - CHEESE	2	160 K	5	325 K	10	650 K	15	975 K	30	1.95 M
BAKERY	2	160 K	5	325 K	10	650 K	15	975 K	30	1.95 M
BEVERAGE	1	80 K	3	195 K	5	325 K	10	650 K	20	1.3 M
FRESH AND CURED MEAT - POULTRY- FISH	1	80 K	3	195 K	10	650 K	20	1.3 M	40	2.6 M

Sales Strategies
SAFETYPACK technology will be offered in the market with a reference price that it's higher respect to the traditional statistical equipment used nowadays as the user Return Of Investment can be very high directly in the first years of usage.

Societal impact
SAFETYPACK gas sensor is a great advancement in food packaging industry. Technological advancement is changing societal risk constellations. In many cases the results are significantly improved, such as, in the case of SAFETYPACK, longer shelf life of products and waste reduction. However, the novelty of technological innovations also frequently comes with it unintended and unforeseen consequences, including new risk types.
In many respects, inline food monitoring represents an attractive innovation for the future. Greater safety and convenience, spare of time otherwise required for laboratory analysis of packaging, and improvement of the product safety level are a few of the most commonly expected advantages. At the same time, the gas sensors and laser technologies—like any other technology—are susceptible of errors.
Economic risks—for food packaging industry—must also be considered, as well as social risks, such as food safety concerns. Analysis and evaluation of the possible risks of damaged packages are an essential part of a responsible research and innovation process and thus equally important preconditions for acceptance both on the individual and societal levels.
This chapter provides answers to the following questions as they apply specifically to technology assessment: What specific societal risk are posed by food gases, and sensors to monitor packaging? Are there raising awareness on the usage of MAP technology?
The food gases used in MAP technology are identified as food additives. Food additives must be approved by EU legislation: *Criteria of the gas purity*, Regulation CE 1333/2008 and Regulation 231/2012; *The traceability and re-traceability of the food products along the food chain*, Regulation UE 178/2002.
The focus of the evaluation for societal impact of sensor-based control systems in food packaging sector is on the safety risks resulting from exposure through accidental contact with laser light by the operator. Indeed, the risk assessment for operators has to take into account (laser class risks and safety requirements), as already done during the SAFETYPACK project.
Communication to the customers is also very important. Open communication and clear expectations can spell the difference between public awareness about food safety and the real help of these new technologies.

The research leading to these results has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement n° 613795

The use of MAP technology represents a very interesting opportunity for the preservation of many fresh foods, there are some application aspects of this technology which need to be considered very carefully in order to make this technology more efficient, and other aspects which need to be studied in more depth. It has been shown that the efficiency of MAP technology depends on the content of the gases applied to the packaging. The SAFETYPACK sensors have a unique role in monitoring this in order to guaranty MAP technology to preserve the food product efficiently for the entire pre-established preservation period. With the introduction of the SAFETYPACK sensors, we expect the improvement of related research on the levels of accuracy in the composition of the mix of gases on the shelf life of the product. Furthermore, we await food waste reduction due to better control systems**.**

Dissemination and Exploitation of Results

Partners spread SAFETYPACK activities during worldwide exhibitions, such as:

- PACK EXPO International
- AIPIA World Congress
- Emballage
- Food Processing & Packaging Exposyum
- FoodPex
- International PackTech

Here is an example of participations during 2016

Partners market strategy to create awareness of SAFETYPACK projects in all UE countries have been based on publishing articles and promotion material on specific food sector media:

- Tecnalimentaria - www.tecnalimentaria.it
- Packaging Observer COM.PACK - www.packagingobserver.com
- Tecniche nuove (Il latte) - www.lattenews.it
- Italia Imballaggio - http://dativoweb.net/it/italiaimballaggio-magazine
- Italian Dairy world - www.lattenews.it
- Il Mondo del Latte - www.assolatte.it
- Packaging News - www.packagingnews.co.uk
- Processing & Packaging Machinery Association - www.ppma.co.uk
- The Trade Association For The British Dairy Industry (Dairy UK) - www.dairyuk.org
- Pack Report - www.packreport.de
- Creativver Packen - www.creativverpacken.de
- Food supply - www.food-supply.dk
- Packmarked - www.packm.dk
- InPak, Plus process, food magazine, Plast Panorama, Pack + Plast, Scandinavian food and drink - www.techmedia.dk/

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Partners acted also in having direct contact and interviews with essential gatekeepers in selected food companies, for example:

- Italy: Trevisanalat, Brazzale, Caglificio Clerici Spa, SterilGarda, Granarolo
- UK: Dairycrest
- Sweden : TetraPak, Arla Foods, Skånemejeriet, Norrmejerier
- Denmark: Arla Foods, Thise Mejeri, Cremo Ingredients, Dupont Nutrition

No	Exploitable result	Type	Owner	Business Prospects	Beneficiary
1	Use-case demonstrators and internal SAFETYPACK capability demonstrators	Use-case specific	All partners	Excellent opportunity	All partners
2	SAFETYPACK demonstrators where sensitive data are removed	External networks	All partners	Excellent opportunity	Commercial networks
3	SAFETYPACK machine	Models and components	FT, MA	Excellent opportunity	FT, MA
4	Categories of knowledge models, methods and workspace knowledge	Knowledge models	Use-case partners	Excellent opportunity	Commercial networks
5	SAFETYPACK platform capabilities and services	Services, tools, models	FT, MA	Very good	All partners
6	Business model for Dairy sector	Models	Open to all	Very good	All partners involved

Many external activities have been done to present the technology and the project outcomes to the public. Here we briefly mention the **dissemination events organized by EC**.

1. SAFETYPACK on Euronews, October 2015

Euronews is a multilingual news television channel, headquartered in Lyon, France. Created in 1993, it aims to cover world news from a pan-European perspective. The SAFETYPACK project has been presented on the Futuris broadcast by Denis Loctier, Euronews science producer, working in cooperation with the European Commission DG Research and DG Connect. The broadcast was filmed in Latteria Soligo, Italy on 16 October 2015. The interview was broadcasted on Euronews, Futuris, "A brighter future ? EU researchers harness the power of light", 26 October 2015 in 13 languages. The full interview is available on http://www.euronews.com/2015/10/26/a-brighter-future-eu-researchers-harness-the-power-of-light/

2. SAFETYPACK at EXPO Milan, October 2015

The SAFETYPACK Coordinator was invited to present the project results at the workshop on "Innovative and Sustainable Food Packaging Technologies" - Funded by the EU FP7 Framework, 06 October 2015, EU Pavillion, EXPO Milan 2015. The workshop has been organized by DG Research and Innovation, Directorate F – Bioeconomy, Unit F.3 – Agri-Food Chain. Title of the presentation was "SAFETYPACK, a new technology for in-line real-time monitoring of gas content in packaging". 12 EC projects were presented at the workshop.

3. SAFETYPACK at Horizon 2020 Societal Challenge 2 Info Week, Bruxelles, June 2016

The SAFETYPACK project has been presented at the Societal Challenge 2 Dissemination Event, jointly organised in Brussels by DG AGRI, DG RTD and the Research Executive Agency on 27 June 2016. The conference was one of the events organised in the frame of the SC2 Info Week information event. The project presentation was structured in four parts: 1) introduction to the problem addressed by the project; 2) project presentation; 3) role of each partner; 4) project results; 5) dissemination activities; 6) lesson learnt.

4. SAFETYPACK on CORDIS

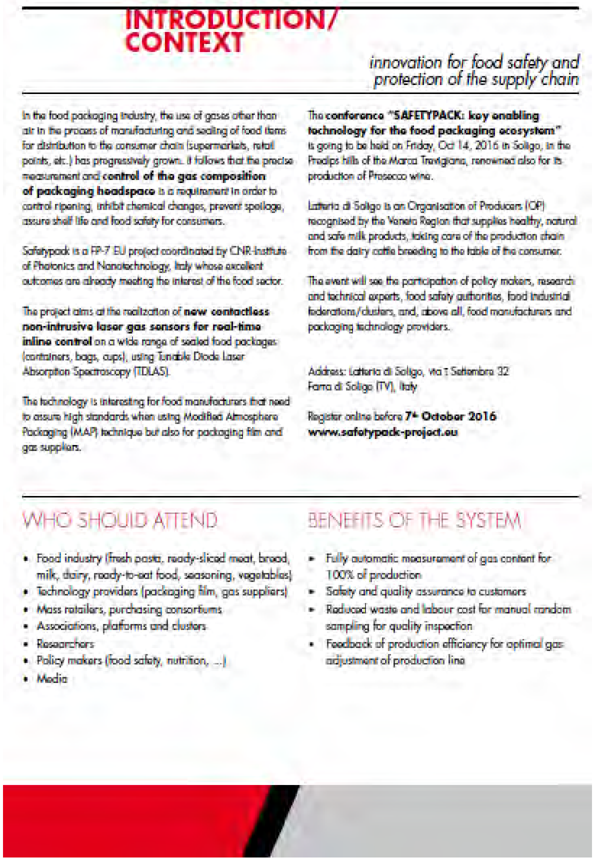
CORDIS (the European Commission's primary service for EU-funded research results) will publish an article about the results of the SAFETYPACK project, as communicated to the coordinator on 2 November 2016. The project was highlighted by the EC's Project Officer and selected by the CORDIS Editorial Team to be written about in a "Results in Brief" article. Results in Brief will be included in the printed monthly *research*eu results magazine*, also available as e-books and PDF at: http://cordis.europa.eu/research-eu. The services is provided by the European Commission, as part of its strategy on the effective dissemination and exploitation of research results.

Workshops have been organized to present the new available technology to the industrial sector.

In-field demonstration sessions have been done at both the two end-users, Santa Maria, a Swedish bakery facility, and Latteria di Soligo, a dairy producer in Italy, where two SAFETYPACK systems have been installed and are fully operative for inline operation.

The SAFETYPACK **final conference "SAFETYPACK: innovative application on laser monitoring of food package internal gas composition"** has been organized on Friday, Oct 14, 2016 in Pieve di Soligo (TV), Italy.

The research leading to these results has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement n° 613795



INTRODUCTION/ CONTEXT

innovation for food safety and protection of the supply chain

In the food packaging industry, the use of gases other than air in the process of manufacturing and sealing of food items for distribution to the consumer chain (supermarkets, retail points, etc.) has progressively grown. It follows that the precise measurement and **control of the gas composition of packaging headspace** is a requirement in order to control ripening, inhibit chemical changes, prevent spoilage, assure shelf life and food safety for consumers.

Safetypack is a FP-7 EU project coordinated by CNR-Institute of Photonics and Nanotechnology, Italy whose excellent outcomes are already meeting the interest of the food sector.

The project aims at the realization of **new contactless non-intrusive laser gas sensors for real-time inline control** on a wide range of sealed food packages (containers, bags, cups), using Tunable Diode Laser Absorption Spectroscopy (TDLAS).

The technology is interesting for food manufacturers that need to assure high standards when using Modified Atmosphere Packaging (MAP) technique but also for packaging film and gas suppliers.

The **conference "SAFETYPACK: key enabling technology for the food packaging ecosystem"** is going to be held on Friday, Oct 14, 2016 in Soligo, in the Prealps hills of the Marca Trevigiana, renowned also for its production of Prosecco wine.

Latteria di Soligo is an Organisation of Producers (OP) recognised by the Veneto Region that supplies healthy, natural and safe milk products, taking care of the production chain from the dairy cattle breeding to the table of the consumer.

The event will see the participation of policy makers, research and technical experts, food safety authorities, food industrial federations/clusters, and, above all, food manufacturers and packaging technology providers.

Address: Latteria di Soligo, via I Settembre 32
Farra di Soligo (TV), Italy

Register online before **7th October 2016**
www.safetypack-project.eu

WHO SHOULD ATTEND

- Food industry (fresh pasta, ready-sliced meat, bread, milk, dairy, ready-to-eat food, seasoning, vegetables)
- Technology providers (packaging film, gas suppliers)
- Mass retailers, purchasing consortiums
- Associations, platforms and clusters
- Researchers
- Policy makers (food safety, nutrition, ...)
- Media

BENEFITS OF THE SYSTEM

- Fully automatic measurement of gas content for 100% of production
- Safety and quality assurance to customers
- Reduced waste and labour cost for manual random sampling for quality inspection
- Feedback of production efficiency for optimal gas adjustment of production line