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Abstract

The tests of gas detectors, mainly toxic gas detectors, are important when a company, whose develop this type of product, wants to insure the functionality and quality of their equipment. In this sense, it is fundamental to have a system capable of performing the test autonomously, ensuring the quality and repeatability of the results.

Depending on the type of gas and on the characteristics of gas detection, there are some solutions in the market but most of them are customized solutions that make the product development more expensive. The option of constructing a chamber for the testing of gas detectors is related with the fact that, on one hand test chambers with the necessary characteristics are not cost-effective and on other hand by lack of rigor and safety in the simplest chambers. So, it is intended to develop an automated standard solution that could be adapted for different type of gas detection, changing only the type of inputs – the sensors.

The objective of this work is to present the development of an airtight chamber capable of performing the necessary tests to attest the correct functioning of a gas detector used in Addressable Fire Detection Systems. The test chamber prototype will be described in terms of hardware and software, as well as the tests performed for two types of gas detection, Carbon Monoxide (CO) and Liquefied Petroleum Gas (LPG). The chamber is controlled by a computer through a graphical user interface generated by LABView Software. The experimental results show that this chamber is certainly an important equipment in the preparation of gas detectors for approval in an accredited laboratory.

Keywords: CGAS - PCB CGAS - CO transducer - LPG transducer - Firmware - LabVIEW - CGAS application

CGAS – Gas Test Chamber

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1 Introduction

The main objective of this work is to describe the development of an Automated Chamber for Testing Gas Detectors (CGAS) and present the experimental results to attest the correct functioning of a gas detector used in Addressable Fire Detection System. The CGAS consists of three parts, the processing unit (computer), the control unit and the test chamber. The chamber has several sensors and actuators, which will be monitored by the control unit equipped with a fire detection panel, where all the inputs are acquired, and the process control are realized. Finally, this control unit is controlled by the computer through a graphical user interface generated by LABView Software, where all the data (inputs and outputs) are monitored in a user-friendly environment Fig. 1. In the

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construction and development of this prototype, the description of the test chamber of Annex G of Standard EN 54–26 Fire detection and fire alarm systems - Part 26: Carbon monoxide detectors, was considered [1].

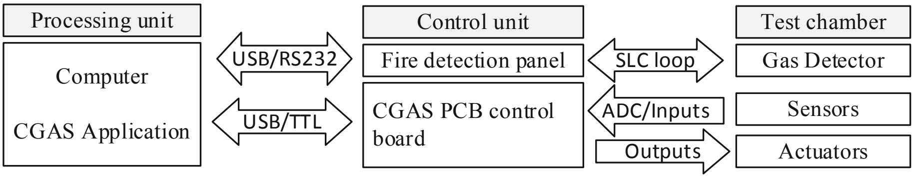


Fig. 1. Flow of data between the constituent parts of the CGAS

The chamber consists of an acrylic cube of about 0.05 m^3 with an access door to the inside, having detectors as inputs and the type of gas to be tested. The whole process is automated taking into account the following tasks:

– Door locking;
– Homogenization of the gas;
– Calculation of gas concentration in the chamber;
– No leakage;
– Data acquisition and registration;
– Exhaustion gas inside the chamber;
– Confirmation of the safe handling of the detectors under test.

To achieve these objectives, several types of sensors were used in parallel with the development of the electronics required for data collection and processing, recording and visualization in a graphical environment.

The CCGAS prototype will be described in terms of hardware and software, as well as the tests performed for two types of gas detection, Carbon Monoxide (CO) and Liquefied Petroleum Gas (LPG). The results show that this chamber is certainly an important equipment in the preparation of gas detectors for approval in an accredited laboratory.

Section 2 presents the State of Art in the area of Gas detection Chambers, Sect. 3 describes the design and development of all elements of the CCGAS, both hardware and software, and finally Sect. 4 draws some conclusions.

2 State of Art

Although the development of CGAS arose from the lack of a standard solution in the market, a research was done on solutions and technologies used in projects that approaches the CGAS solution, such as test chambers used or developed by laboratories and the instruments and transducers installed in such chambers. The analysis of the standard EN 54-26 was taken into account, where they are considered all the characteristics that the test chamber of carbon monoxide detectors used in fire detection systems should have [1].

The gas test chambers range from a simple acrylic box where the detectors are placed (being the gas concentration calculated by the ratio of the volume of air inside the box and the volume of gas injected manually through an inward syringe of the box), to automated chambers of thousands of euros, which behind the gas concentration control also checks other type of variables like temperature, humidity and pressure.

Automated gas test chambers are not a commercially available product, with the disadvantage of the existing ones are normally dedicated to a certain type of gas. Presently, gas test chambers must be customized at customer's request, which increase the costs of the Chamber project.

2.1 Analysis of Gas Test Chambers

In the research carried out on gas test chambers, a limited number of chambers has been identified. It was verified that they are projects carried out with their own objective and sometimes with the intervention of several entities. For example, the Gas Sensor Testing System of Kenosistec was developed with the partnership of ISTITUTO ITALIANO DEL MARCHIO DI QUALITÀ [2].

The chambers were developed with the purpose of testing/calibrating gas sensors, or detectors, and most of them are used for research or in certification of laboratories. The chambers analyzed were the following presented:

- "Full-Automatic GAS SENSOR EVALUATION EQUIPMENT" from Insistec, a company in the area of security and technology [3].
- "Gas Sensor Testing System" from Kenosistec, a manufacturer of fine film deposition equipment in nanotechnology, designed and developed with the help of IMQ ISTITUTO ITALIANO DEL MARCHIO DI QUALITÀ [2].
- GASI, a test gas mixing system and test chamber in the Federal Institute for Research and Materials Testing (BAM), Germany [4].

Insistec's "Full-Automatic GAS SENSOR EVALUATION EQUIPMENT":

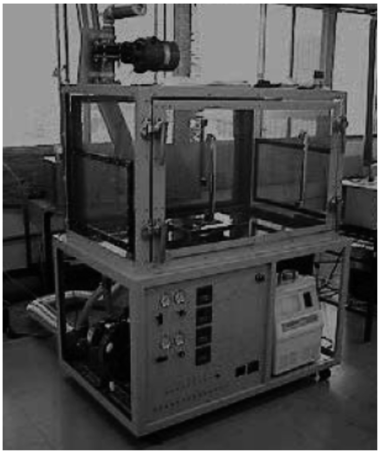


Fig. 2. Gas sensor evaluation equipment

This chamber was designed to test CO and CH4 gases and uses mass flow meters to inject exactly the amount of gas into the chamber, Fig. 2. It has two modes of operation, calibration and alarm [3]. In the calibration mode it uses two reference points: without presence of the gas and with high concentration. In the alarm mode it is tested the performance of the alarm activation of the sensors, in the presence of the gas above the operating concentration.

The system is controlled by software through a Peripheral Component Interconnect (PCI). The concentration of the gases is obtained by means of two analyzers, one of CO and another of CH4, with capacity of measuring 30–500 ppm and 1350–12250 ppm, respectively.

The density is controlled by gas purges until the analyzer measures the desired concentration and uses a fan for better gas distribution and homogenization. For the exhaustion of the gas inside the chamber two valves and two axial fans are used, one to extract and the other to inflate.

Kenosistec System for Gas Sensor Testing

The Kenosistec Chamber has the particularity of using three independent cells, each equipped with pressure, humidity, flow velocity and temperature sensors, Fig. 3. In this chamber the temperature besides being monitored is also controlled. The desired gas flow and concentration is calculated by a microprocessor which allows control of the dry and humid air flows, and the specific relative humidity is obtained. The gas concentration is calculated by means of spectrometers.

The cells are sealed and contain connections to feed the sensors and easily monitor the various signals by the control system. The system comes equipped with 3 thermal mass flow controllers for gases (two for air - dry and humid and one for gas) and also with a humidifier and a thermoregulated condenser.

The system allows automatic sequencing to be performed in accordance with the standards of the Italian Electrotechnical Committee (IEC). In addition to monitoring the process, the control software also records the data and reports.

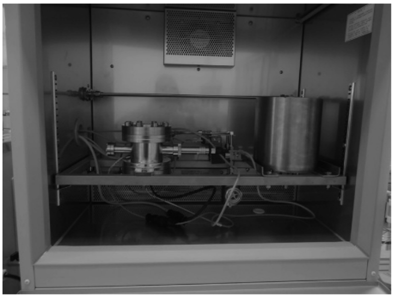


Fig. 3. Kenosistec system for gas sensor testing

BAM System for Testing and Calibrating Gas Sensors

The BAM system calibrates and tests gas sensors using a dynamic mixing system capable of generating different concentrations and blends up to three gases [4].

For this effect, thermal mass flow controllers are used for gases in the mixture and moisture is also controlled. The management of the test is performed by a computer that obtains the data through an IEEE-BUS network and is analyzed by the LabView and Excel software. In order to analyze more accurately the mixtures and concentrations of the gases this system has a hygrometer, a chromatograph and a spectrometer.

2.2 Justification for the Construction of the Gas Chamber

As previously noted, the existing gas test chambers do not provide a complete solution, either because of the lack of rigor and safety in the simplest chambers, or because of the high costs and waste of resources in custom chambers. For this reason and because of the interest of gas detector manufacturers in having test chambers that meet the requirements of the standards, it was decided to build a fully automatic test chamber capable of testing more than one type of gas.

Although the EN 54-26 standard is not publish yet, it will be a matter of time, and in this sense it is important that the CGAS is close to the one described in Annex G of EN 54-26 [1], so that the tests for development and design of the CO detector are as close as possible to the future tests to be carried out in accredited laboratories in the CE certification process. The examples described above do not meet the requirements of EN54-26, for example air velocity control in the vicinity of the detector.

2.3 EN54-26 Gas Test Chamber

The European Standard describes parameters and functionalities that carbon monoxide detectors used in fire safety and fire detection systems must comply with, as well as the tests to be performed to attest such functionalities.

Annex G of EN 54-26, [1], contains information on the construction of the gas test chamber to measure the value of the response to CO, Fig. 4.

According to the European Standard, the design and the characteristics of the gas test chamber must be taken into account to be considered a standard test. For this purpose, the following parameters must be considered:

- Chamber volume of 0.05 m^3 to 0.1 m^3, for better control and safety of people;
- The chamber must be sealed, so that there are no leaks or gas inlets, and the material used in the construction do not react with the gas;
- To improve the measurements of the gas concentration increase, the test must be done in a closed circuit;
- The air circulation around the detector must be as linear as possible and the circulation system must achieve a uniform distribution of gas temperature and concentration;
- The test chamber can be placed inside a climate chamber to allow heating and cooling during environmental conditioning;
- Particular attention should be taken to the arrangement of the elements within the chamber, in order to not disturb the test conditions.

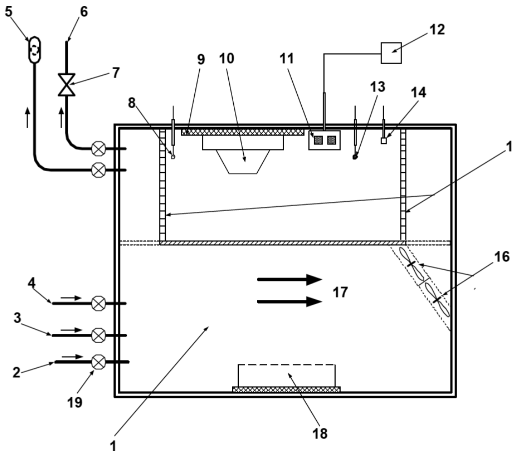


Fig. 4. The constituent elements of the chamber according to EN54-26: 1 Gas Test Chamber, 2 Clean air input, 3 Toxic gas input, 4 CO input, 5 Pressure Balancing Valve, 6 Exhaustion, 7 Vacuum pump, 8 Airflow probe, 9 Base for the detector, 10 Detector in test, 11 CO Sensor, 12 CO meter, 13 Temperature sensor, 14 Humidity, [1].

3 Construction and Assembly of CGAS

This section is dedicated to the description of the sensors and the transducers used in the CGAS, whether purchased or developed. Next, a brief description of the fire detection system installed in the CGAS and the actuators, followed by the development of the CGAS PCB hardware, the design and execution of its structure.

3.1 Automated Gas Detector Test Chamber Overview

The automated chamber design for gas detector testing can be divided into three parts: the processing unit, the control unit and the test chamber.

The processing unit is composed by a computer with a control program developed with the LabView software. This will manage the entire test by reading the data sent by the control unit, which allows the user to monitor the status of the test through the graphical environment.

The program will check the specified initial conditions of the chamber and then start the test flowchart.

Under the initial conditions, the program ensures that:

- The detector is present and it is correct;
- The door is closed;
- The temperature and the humidity are within the defined parameters;
- There is no gas present;
- Compressed air is available.

After confirmation of the initial conditions, the test is started with the following sequence:

– Close the exhaustion valve;
– Turn on yellow signaling;
– Open the gas for periods of time until the concentration reaches the maximum limit of the test or the detector activates the alarm;
– Record values read by sensor and detector;
– Analyze the data and classification of the detector (approved or rejected);
– Print a report;
– Open the exhaustion valve and inject compressed air to clean the chamber until the sensor no longer detects gas;
– Turn on the green flag and write the message "END OF TEST".

The control unit consists of two different systems, a fire detection center and a printed circuit board.

The fire detection unit is part of the actual simulation of the detector in its normal operation. The detector can be connected directly to the control panel terminal or through a module, if external power is required. The connection between the control unit and the detector, in addition to providing power for its operation, also uses an analog communication protocol where the detector is constantly interrogated by the control panel. It's in this device that, through RS232 serial communication, the processing system will find the response of the detector under test.

The control board is a board designed and dedicated to the project and consists of a microcontroller, digital and analog inputs and outputs and serial communication. The digital inputs are used to read the digital sensors, as well as the magnetic sensors dedicated to the positions of the door and valves; on the other hand, the digital outputs will operate the gas input and air circulation systems. The gas concentration is measured the transducers connected to the analog ports.

The pneumatic control of gas and compressed air admission system are also part of the control unit as well as the compressed air system through solenoid valves and a cylinder, whose main function is the opening and closing of the exhaustion valve and injection of clean air into the chamber.

The control of the gas input into the chamber is carried out by solenoid valves, where a pressure reducer and a flow rate are used, for greater precision of the gas input before the control by the solenoid valve. The gas is supplied to the system by small bottles used normally in detectors' tests.

The chamber is equipped with a luminous and audible signal and an emergency button that acts on the general power of the whole system.

The main purpose of the test unit is to contain and control the gas concentration. Its construction is in an acrylic sheet of cubic form and with a volume of 0.05 m^3 with an access door to the inside to proceed of the placement and the removal of detectors under test. The door is equipped with a lock and a hall effect sensor to determine its open or closed state. A gasket was also attached to the door to prevent possible gas leaks. For the exhaustion of the gases from its interior was constructed a valve, which opens and closes through the movement of a pneumatic cylinder. This cylinder has two magnetic sensors that determine the position of the valve, so it can transmit the information of its state.

The structure also contemplates a platform with a base for the detector, as well as two fans for better homogenization of the gas.

To monitor all the test, the camera is equipped with a humidity and temperature sensor, a LPG sensor and a CO sensor. For the detector, several connections were made available: the connection to the control unit, the 5 V and 24 V power supply and an analogue input.

3.2 Transducers and Actuators at CGAS

After researching the gas detector test chambers or similar equipment on the market, it is concluded that some of the instruments used are laboratory equipment with various functionalities and extremely costly for a single purpose. For this reason, some of the transducers chosen for this phase of the project have a main purpose of validating the concept, to comply with the EN54-26 standard and they will have to be calibrated by accredited laboratories.

The probe chosen to monitor the air velocity within the chamber and near the sensor was the E + E Elektonik® EE671-V2XCKD, Fig. 5. It is a probe used in heating, ventilation and air conditioning systems. The output of the probe is 0–5 V linear, which corresponds to a measurement range of 0–5 m/s with an accuracy of 3% between 0.5 and 5 m/s. It operates in a temperature range of −20° to 60 °C and a relative humidity of 5–95%, non-condensing.

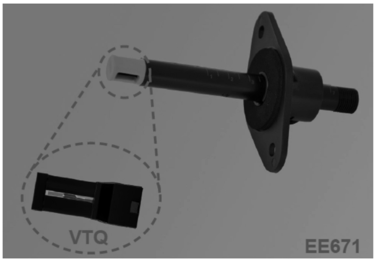


Fig. 5. Air velocity probe

Moreover, the temperature and humidity probe chosen for the project was E + E Elektonik®, with the designation of EE60, as shown in Fig. 6. It is a probe with an accurate measurement, protected from external influences and with good performance in corrosive and dirty environments, avoiding parasitic impedances on the sensor surface.

The humidity sensor is an HCT01-00D with a 0–100% measuring range and a corresponding analog output of 0–5 V, with a precision of 24% at a temperature of 20 °C of 2.5%. As far as temperature measurement is concerned, the probe is equipped with a Pt1000, with a measuring range of −40° to 60 °C and an analogue output of 0–5 V, the accuracy for a 24 V supply and a temperature of 20 °C of 0.3%.

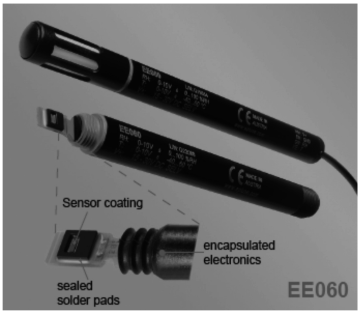


Fig. 6. Humidity and temperature probe

The gas sensors are influenced by the atmospheric pressure and for this reason it is necessary to monitor this pressure. The choice was the Kavlico brand P265-30A-4B sensor, based on ceramic capacitive technology, where it is a robust and a reliable transducer. Among its applications are industrial compressors and test equipment, with a range of 0–30 PSI and a total error of 2%, it has an analog output of 0.5–4.5 V and a power of 5 V.

The chosen CO sensor was ECO-Sure (2e). The main feature that led to this choice was the measurement range of 0 to 500 ppm.

To obtain an output signal capable of being processed by the CGAS PCB, a basic circuit was designed and constructed to convert the current output signal into voltage. This circuit uses an operational amplifier to convert the sensor output signal and a potentiometer to calibrate. The circuit, presented in Fig. 7, is powered by a 5 V. AQ2

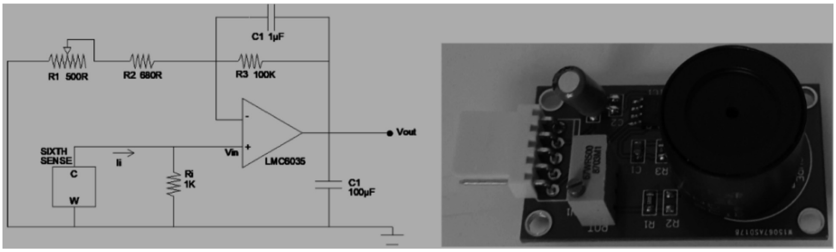


Fig. 7. ECO-Sure sensor (2e), schematic and PCB.

Given the importance of obtaining a reliable reading of CO, it was opted for the purchase of a precision CO bottle containing calibration gas of the GASIN brand with a concentration of 200 ppm.

For the LPG transducer, the same solution was applied as in the case of the CO transducer, which was its construction. The choice of the sensor fell on Figaro's TGS6810, a catalytic sensor with a fast and linear response in mV. This was the factor that weighed most in the choice, to obtain a linear response. The reading range of the sensor is between 0–100% LEL (lower explosive limit). The TGS6810 sensor was inserted into a circuit called the Wheatstone bridge, as recommended by the manufacturer in the datasheet. This transducer was designed only to validate the LPG test process and only one test was performed to verify the operation of the transducer at a constant concentration of 10000 ppm. The sensor was placed into an airtight container with a volume of 5000 ml, and 50 ml of the gas used in the CGAS was injected through a syringe, thereby obtaining a concentration of 10,000 ppm.

Gas detectors tested in the chamber will be used in fire detection systems, where the detector response is obtained through the Fire Detection Panel, so ensuring a real simulation of the response. The fire detection panel that equips the CGAS is a JUNIOR V4 of the manufacturer Global Fire Equipment [6].

The JUNIOR V4 control unit is powered by a 24 V power supply and the communication with the processing unit is done by RS232.

3.3 CGAS Pneumatic Installation

For the operation of the CGAS, it is essential to use compressed air, which has two functions: discard the atmosphere inside the chamber and move the exhaustion valve.

The inlet pressure of the compressed air should be between 2–7 bar and it shall be adjusted to a service pressure of 1.5 bar by the existing pressure regulator. This process is visually confirmed by the coupled pressure gauge. After the set pressure, the air passes through two filters, one for particles and one for water, Fig. 8. The pressure is controlled by a pressure sensor installed just after the filters. So, the electric circuit is constituted by two parts: one for the valve of the air inlet in the chamber and another for the valve that controls the movement of the exhaustion valve, as shown in Fig. 8.

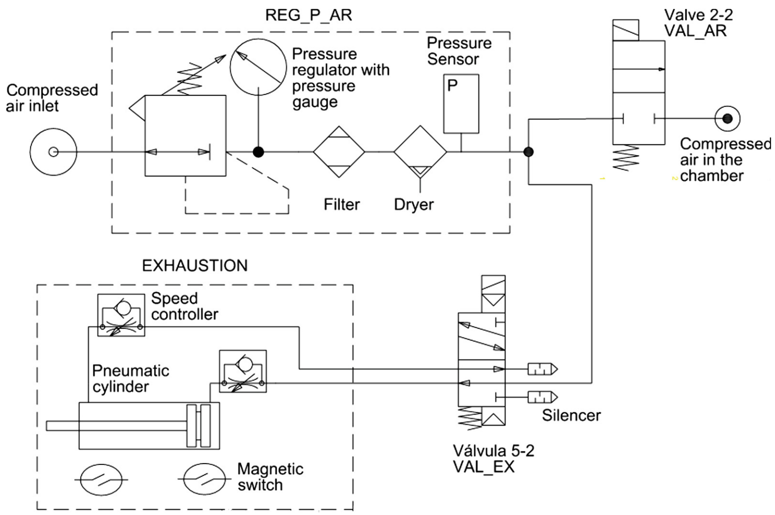


Fig. 8. CGAS pneumatic diagram

3.4 Gas Inlet System

The gas admission into the chamber is performed by a set of elements in order to allow greater control and repeatability of the tests. This system starts in gas storage in bottles, as shown in Fig. 9. As the available pressure varies with the amount of gas in the bottles and a constant pressure is important to achieve, a pressure regulator is used to have 1 bar of gas pressure. Before the gas is released into the chamber it passes through a flow regulator, allowing to adjust the gas release rate. Finally, a valve controls the gas that is introduced into the chamber, Fig. 9.

The LPG bottle used to make the test is a 100 ml bottle of ROTHENBERGER gas, which contains a mixture of Propane and Butane gas, liquefied petroleum gas composition [5]. The CO bottle is a disposable bottle of the brand GASIN with the reference 316785, with 110 L of gas and a concentration of CO of 5%.

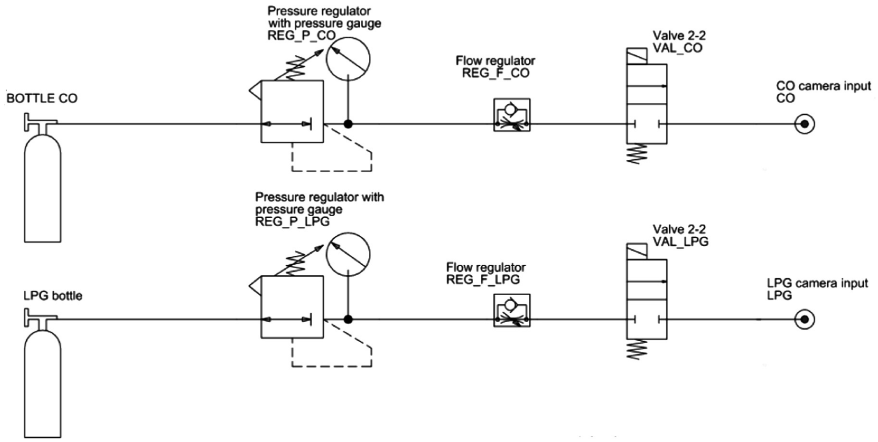


Fig. 9. Schematic of the gas inlet system

3.5 CGAS PCB Control Board

Figure 10 presents a photo of the PCB, which is divided in four parts: the power supply, the microcontroller, the inputs and the outputs. In what concerns the power supply, the PCB has an input for the 24 V (service voltage). Due to most of the transducers are powered by 5 V at considerable power consumption, two 5 V sources were designed, one for the microcontroller with an output current of up to 300 mA and another for transducers with a current output up to 3A. The microcontroller chosen was the PIC18F4550 from Microchip, the number of analog ports and the availability of UART ports for serial communication were preponderant.

The digital inputs are 24 V signals coming from the sensors, then these signals are isolated and converted to 5 V by optocouplers.

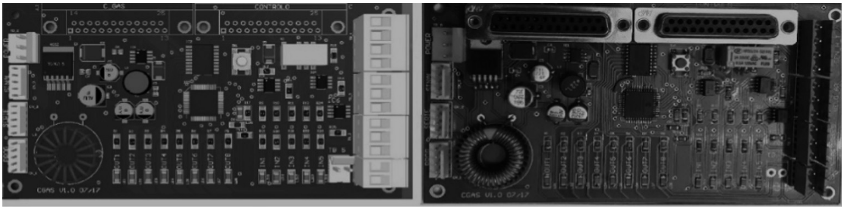


Fig. 10. Photography of the designed PCB_CGAS.

The outputs are converted from the 5 V supplied by the microcontroller to 24 V with output current up to 500 mA by the integrated circuit ULN2803. This integrated circuit consists of an array of Darlington transistors.

The ADC analog inputs, reading the sensors with analog outputs are connected directly to the microprocessor, as can be seen in Fig. 11.

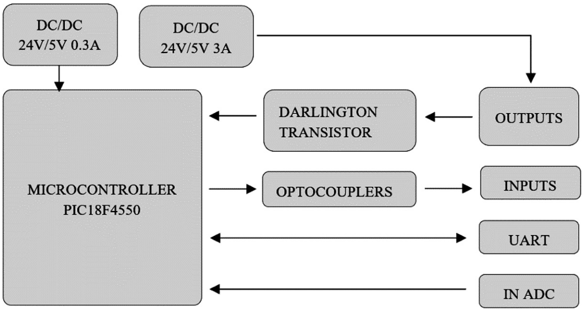


Fig. 11. Structure of PCB_CGAS

3.6 Design Automated Chamber for the Gas Detector Test

For a better execution and development of the project, it was done the 3D design of the structure that was necessary to build. Figure 12 presents the drawing of the chamber's structure, where at the top and left side of the chamber we find the two boxes that house the control units.

The boxes are made of 1.5 mm thick aluminum with 510 × 420 × 120 mm, the chassis were made of 3 mm thick aluminum to allow threaded bores for easier installation of the elements, the top box is fitted with the flags, Fig. 12. The chamber is a parallelepiped made in acrylic, with 10 mm of thickness and 550 × 410 × 418 mm of size, with four openings, including a door. The aluminum door allows an easy and frequent access to the inside of the camera. The top opening has been created for the purpose of being easily replaced in case it is necessary to change the drillings of the sensors that are installed in it. The same criterion applies to the left side opening, where the exhaustion valve and the gas and air intake holes are installed. Finally, the rear aperture serves to have full access to the chamber for the assembly of its interior. In all the openings a cavity was designed in the contour for the placement of an o-ring and thus guarantee the sealing.

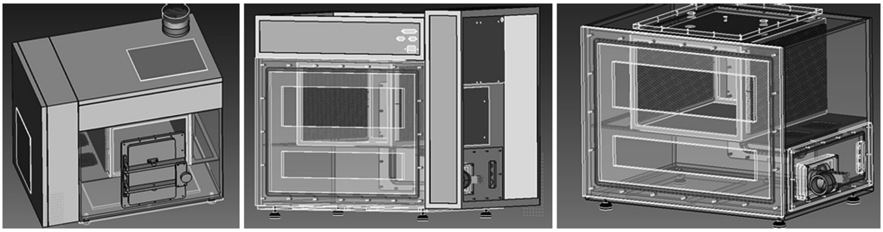


Fig. 12. Assembly of the structure

Figure 13 shows the exhaustion valve which has been designed to be moved by a pneumatic cylinder, wherein an acrylic piece with an O-ring is pressed by the pneumatic cylinder against a circular aperture, thereby closing the exhaustion port.

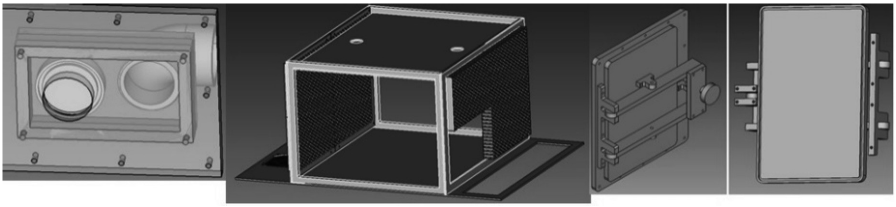
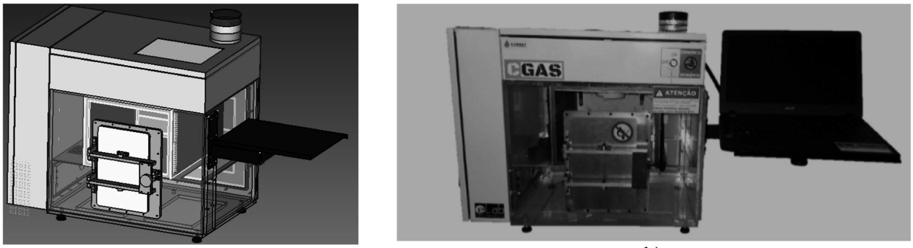


Fig. 13. Mounting of the exhaustion valve, interior of the chamber and door

The interior of the chamber is composed of several aluminum frames to form a closed circuit to the air, forced by two fans. The central horizontal plate supports the two circulation fans at one end and at the other end contains a groove for completing the closed loop for air circulation. This plate is supported by the two moldings, base and back with 10 mm of thickness. Between the two rims are two 3 mm thick frames that aggregate the 4 honeycomb filters in PLA Polymer, Fig. 12. It is in the top plate that the base is to be mounted for the detectors to be tested, where two holes were made which allow the sensors mounted on the top panel to access the interior of the chamber.

The door is an important element in the design because it is structural element that has more possibility to compromise the tests. The door allows easy access to the interior of the camera and at the same time ensures a good tightness. For this reason, it is constructed in aluminum of 10 mm of thickness, not to allow flexions when under the internal pressures. It has two rotation points, on the hinge and on the supports, which allow a perfect parallel with the ring in the lock, Fig. 12. The sealing is obtained by an O-ring installed in a cavity created in the periphery of the door and the closing force is exerted by the rotation of a handwheel, as it rotates on the screw that is attached to the ring.

The computer is another fundamental constituent element of the CGAS, since it controls all the process and defines the necessary connections. So, a support for a portable computer with two available heights was contemplated. Figure 14 shows the CCGAS final design and the prototype developed, (a) and (b) respectively, where the door and the PC support are present.

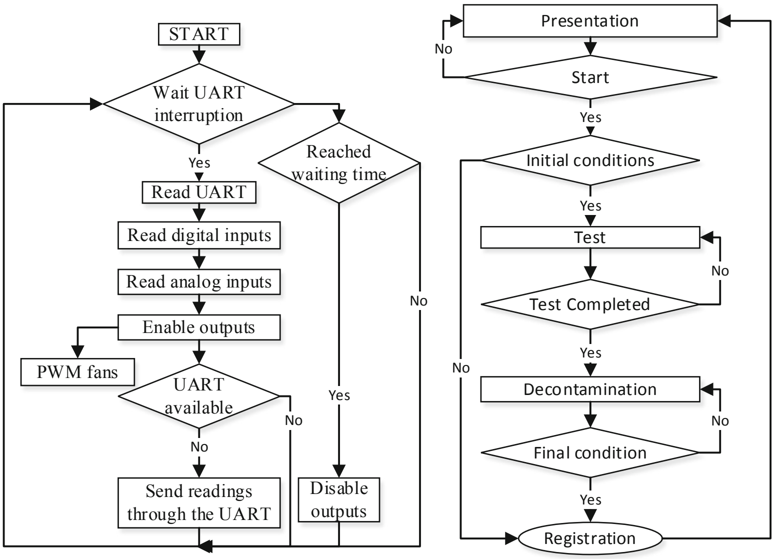


a) b)

Fig. 14. The CCGAS considering the final 3D drawing (a) and the developed prototype (b).

3.7 PCB CGAS Firmware

Figure 15(a) presents the flowchart of the Firmware. The firmware starts with the settings of the microcontroller registers, such as ports declaration and clock. After the settings, the firmware goes into a closed loop, waiting to receive information through the Universal Asynchronous Receiver/Transmitter (UART) serial communication port. After receiving the information and reading it, it will check the status of the digital and analog inputs, change the outputs according to the information received and finally send the information obtained at the inputs. If no information is received through the serial port during a certain time, the firmware disables all outputs for safety.



a) b)

Fig. 15. LabView, general flowchart of the CGAS application (a) and Firmware flowchart (b)

3.8 CGAS Application in LabVIEW

LabVIEW is a graphical programming software dedicated to creating and coding engineering systems. This software is a product of National Instruments™, but allows to operate with other development software or open source platforms [7].

The application is divided into three main blocks: presentation, test and decontamination, as shown in Fig. 15(b). The presentation represents the information of all the variables updated before the test (the initial conditions). It is this information that gives rise to the front panel - the interface for the user. The test, the most important block, is the phase in which the application changes and monitors the state of the actuators in the chamber, waiting for a certain result to complete the test. Once one of the expected results is reached, the final phase of chamber decontamination begins, changing the actuator states and monitoring until the final conditions are obtained, as shown in the Flowchart of Fig. 15(b). In the LabVIEW Block Diagram, the flowchart is applied using three types of structures: While Loop, Case Structure, and Flat Sequence Structure. The application starts within a While Loop for the presentation.

When the conditions necessary to start the test process are found, it enables the Case Structure and executes two sequences with a Case Structure and a While Loop, which are the test and the decontamination. In both cases, they expect certain conditions to be met before continuing to the next task.

The Block Diagram programming of Fig. 15(b) gives rise to the Front Panel of Fig. 16, that is accessible to the user.

- At the top, graphs of CO and GLP concentrations are plotted during the test.
- The camera's environmental information is in the left center.
- In the lower left corner are the printer settings and the offset windows of the gas sensors.
- In the center there are the requirements for the test, such as the maximum ppm of the gas and the maximum test time. Also, in the center within a square is the result of the test (approved or rejected) and the final values.
- At the bottom it is possible to see the test status information and error reporting.
- On the right are the buttons to choose the type of gas, the start button and the stop. Also, on the left are represented the states of the variables of input and output.

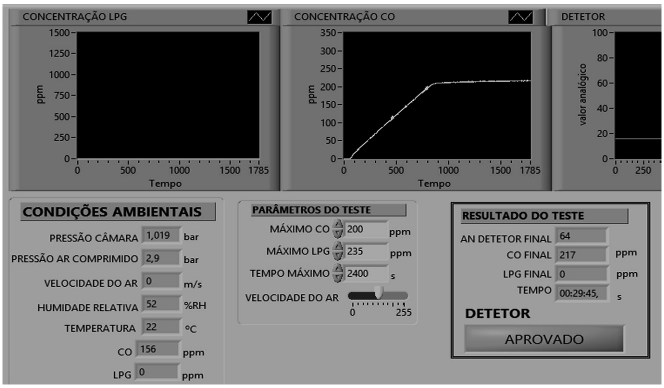


Fig. 16. LabVIEW - Front panel from a test realized during the CGAS development

4 Conclusion

The construction of the Automated Chamber for Testing of Gas Detectors, regarding the structure, had several planning and construction attempts. It began by planning its development in technical aluminum profile, easy to construct and design, but with serious problems in guaranteeing the sealing of the chamber.

The use of 3D printing proved to be an asset to the project, which made it possible to construct several pieces with some complexity without using expensive techniques. The transducers for the CO and LPG and also the hardware developed for the CGAS were also fundamental parts of the project. They were the ones that validated the main objective of the test - the measurement of the gas concentration. With these transducers it was possible to make the tests, however they must be periodically calibrated. Although some parts the CGAS does not comply with the tests of the EN54-26, it is easy to engage in its correction.

Several tests were carried out, including tests on commercially available CO and LGP detectors. These samples had positive results and were approved by the test in the CGAS.

From the tests realized with the two gas, CO and LPG, it can be concluded that the use of the CGAS allows a rigorous and safe test, which could be used for the entities who need to test gas detectors for development or certification.

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