Wireless sensor networks for early fire detection

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Wireless Sensor Networks for early Fire Detection

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Introduction

In 23rd November 2009, the detection sensor for carbon monoxide (afterwards named CO), was tested in a room used as the lighting of controlled fires c/o the Fire Brigades Provincial Command of Turin, Susa Detachment, thanks to the supervision and organization of Ing Vincenzo Bennardo.
In this context 3 tests were carried out to validate the effectiveness and reliability of the sensor in object.

The regulations analysis turned out necessary to determine the tests to perform for the characterization of the sensor designed for the smouldering fires detection.
Because there isn't a specific rule about the carbon monoxide detection it was taken into account the rule UNI EN 54:2007, *"Fire systems of detection and signalling"* as a guide line. Although the carbon monoxide detection sensor isn't mentioned in the rule UNI EN 54:2007, the same rule indicates that can be used as an instrument of reference and guide line for any kind of sensor.
The fire sensitivity tests have to be leaded in a rectangular room with a flat and horizontal ceiling with the following dimensions:

- length: 9 – 11 m;
- width: 6 – 8 m
- height: 3,8 – 4,2 m

Fires can be classified according to 2 evaluation parameters:

- on the strength of the involved fuel (fires of solid material, liquid, gases, metals and electrical material);
- on the strength of the flame that develops (smouldering and opened fires)

Technical Synthesis

The test carried out had as an aims:

- to show the sensor sensitivity to the carbon monoxide emissions;
- test the correct functioning of the sensor;
- test the answer times of the whole system

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Before any fire the room test has to be ventilated with clean air until the elimination of carbon monoxide and the excess smoke, to obtain the following conditions:

Air Temperature: (23 ± 5) °C
Carbon Monoxide Concentration: 0 ppm

Test 1

The first test saw the realization of the *smouldering fire by the decomposition of the organic substances caused by heat - PIROLISI-*
To carry out this test it was necessary to realize an heating plate with technical characteristics that allow the increase of temperature of the contact surface between the plate and the wood of 600°C in a useful range of 11 minutes as described by the rule UNI EN 54-7.
To attend the test were used 10 beech wood dry slumps (humidity content of about 5%), each having dimensions 75 mm x 25 mm x 20 mm.

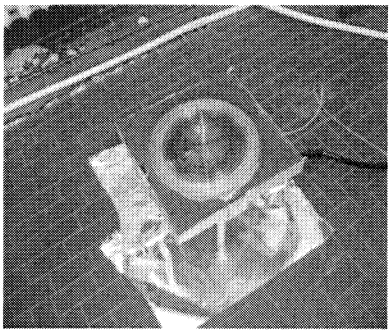

Figure 1 - Heating plate

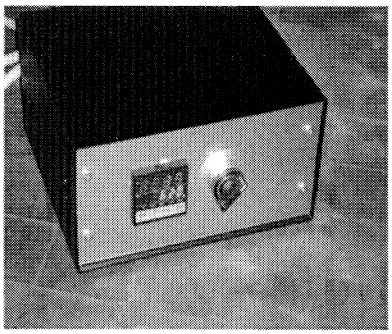

Figure 2 - Regulation and alimentation

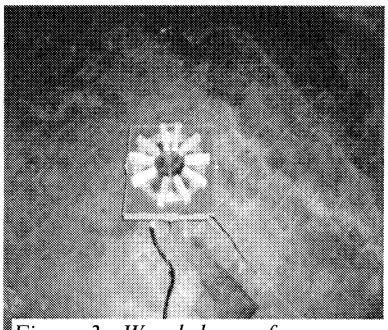

Figure 3 - Wood slumps fpr smouldering fire test

After having placed the heating plate (Picture 1) it was set a temperature of 620°C (as we can see in Picture 2). Going on the slumps (Picture 3) got this temperature and produced Carbon Monoxide.

The results coming from the test outlined a rapid answer of the Minteos sensor. The instrument detected the same percentage in ppm (5ppm correspond to the pre-alert) measured by the reference instrument of the Fire Brigades in Susa.

Test 2

In the second test was produced a ***smouldering fire with embers***
The material used was composed by about 90 twisted cotton wicks, of the length of about 80cm and the weight of about 3kg.

Figure 4 - Wicks lighting

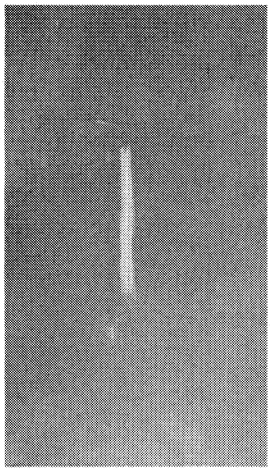

Figure 5- Smoke production inside the room

Figure 6 - Burned wicks after the test

We proceeded with the lighting of the bottom extremities of each wick to let each wick to go on burning with embers. The flames were extinguished immediately at their appearance

The test highlighted the instants in which the prototype sensor emits the pre-alert signal, at the achievement of a threshold value established at 5ppm and an alert one, at the achievement of a value established at 15ppm.TEST 3

The third test saw the realization of an ***open fire with plastic material***
The test was realized placing the fuel, foam of soft polyurethane, without additive that retard the flame and with a density of about 20kg/m^3 on three carpet.

The plastic panel was lighted starting from a corner of the lower carpet and to facilitate the lighting it was used a little quantity of clean fuel material (5 cm^3 of methylated spirits).
The test ended at the exhaustion of the combustion of the inflamed material.

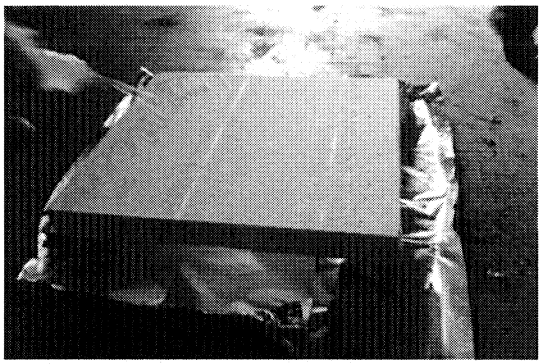

Figure 7 - Methylated spirits pored on the polyurethane foam

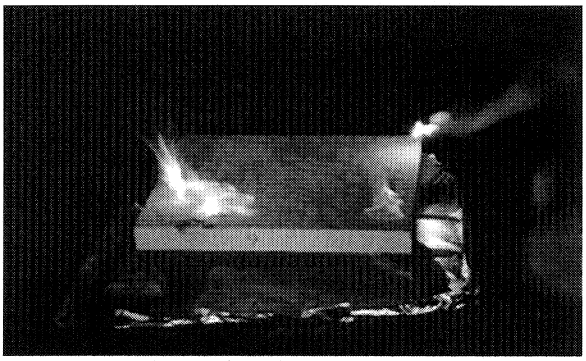

Figure 8 - Lighting of the foam

The test highlights the instants in which the sensor prototype emits the pre-alert signal (5ppm) and the alert (15ppm). In this test we notice a little delay in the receipt of the signals substantially due to the rapid development of Carbon Monoxide.

Although this the times are compatible for a ready intervention by the predisposed authorities because we just talk about a delay of few seconds or a very lower time than the action times of a human being.

Conclusions

All the tests highlighted the correct functioning of the Carbon Monoxide detector designed by Minteos: the pre-alert was transmitted to the Minteos Operative Center in correspondence of a concentration of Carbon Monoxide in the environment equal to 5ppm as detected from the Fire Brigades sensor, while the alert was forwarded in correspondence of a Carbon Monoxide Concentration of 15ppm as detected by the Fire Brigades sensor.

References

Regulations UNI EN 54:2007, *"Fire systems of detection and signaling*