INTEGRATED SENSOR HANDLED BY ROBOT FOR DOSE RATE MEASUREMENT

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Abstract - New Nuclear and Radiological threats and growing industrial risks have increased the advantages of robotic systems for inspection or intervention, particularly in harsh environments. In this context, a specific radiometer has been developed and integrated on a land robotic system The main goal of our new dosimeter is to achieve a highly reliable dose measurement even in drastic environment conditions (vibration for instance). Thus, new algorithms have been investigated and implemented to make false alarm rate insignificant. This paper presents some experimental results for this radiometer and its robot integration in the frame of SRIP (Systèmes Robotisés d'Intervention pour sapeurs Pompiers) research project. This device will soon be marketed by the French company SDS

1. Introduction

New Nuclear and Radiological threats and growing industrial risks have induced new needs as the use of robotic systems. The SRIP research project (Systèmes Robotisés d'Intervention pour sapeurs Pompiers), in the frame of the French ANR program agency, aims to develop a land robotic system with increased detection capabilities adapted to the needs of rescue teams. This development was run by a consortium of complementary partners: ECA Company for robotic, CEA and INERIS bringing their knowledge in detection technologies and ENSOSP and SDIS 13 providing their intervention and rescue skills. The system includes a modular robot base integrating a large choice of sensors (chemical, radioactive…) and more particularly a new radiometer achieving a highly reliable dose measurement even in drastic environment conditions (vibration for instance). In this paper, dosimeter developments and experimental results are presented in section 2. The SRIP robot using our new radiometer is described in section 3.

2. Warning dosimeter

Main characteristics

Among all the sensors integrated in the system, the need analysis has shown the great interest of a radiation dosimeter providing a warning signal to intervention staff. This sensor must be miniature, robust to manage harsh environments and its cost should be as low as possible. This specific radiation meter has been developed by the CEA LIST. This detector is 8.5 cm long with a 3.6 cm diameter and consists in an ambient dose compensated Geiger Müller tube (ZP1202 from Centronic firm) with a specific electronic. This detector measures the ambient gamma dose rate and provides a warning signal above a chosen dose rate level. The dosimeter response has been tested at CEA LNE Laboratoire National Henri Becquerel with ^{137}Cs and ^{60}Co calibrated irradiators for dose rates ranging from about 4 µSv/h to 5 mSv/h. The power characteristics of this sensor are a USB, 4V – 12V or 15V power supply or an automatic battery recharge (option), up to 10 hours of battery autonomy. It weights 88 g and dimension is 90 mm x 32 mm. The sensor can communicate through USB, RS232, ZigBee and open drain (open collector) for alarm information.

a) Linearity

The linearity measurements allowed evaluating the relative sensitivity of the detector with regard to incident radiation energy. A 35 % difference was observed between the ^{137}Cs and ^{60}Co irradiation which is consistent with the manufacturer given energy response of compensated Geiger Müller tubes (about 20 % between ^{137}Cs response and ^{60}Co response [1]). Figure 1 shows the good linear response of the detector according to the dose rate for ^{137}Cs and ^{60}Co sources.

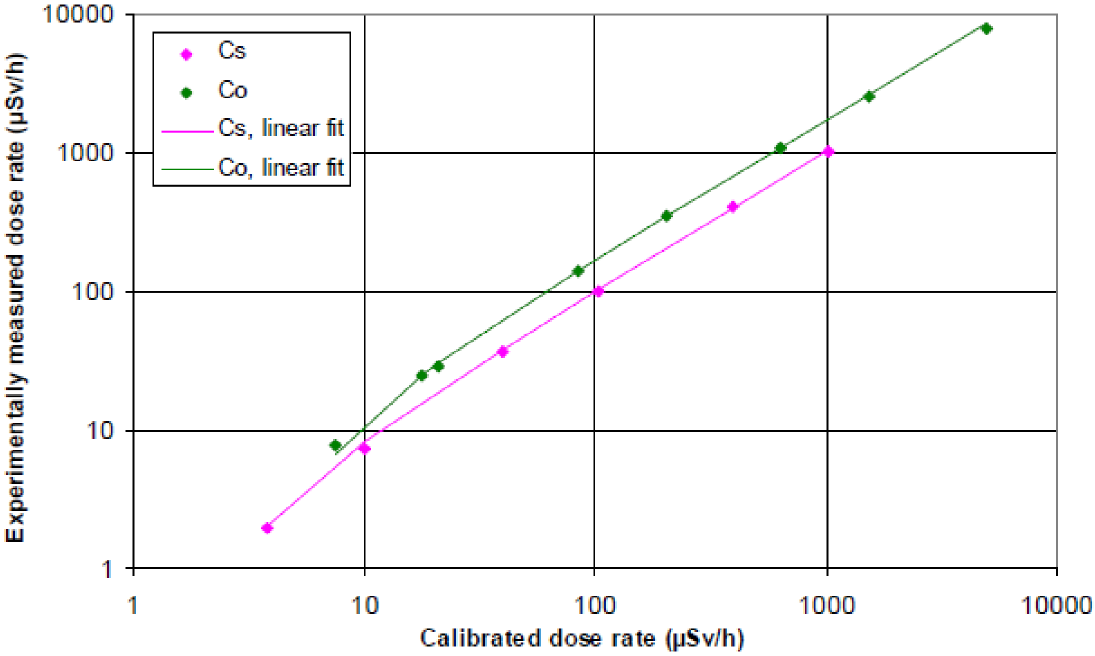

Figure 1 : Linearity of the dosimeter response with calibrated dose rate

The relative discrepancies between experimental dose rate measurements and linear adjustment are given in Table 1. It can be noticed that these discrepancies are most often below 10 %.

Table 1 : Relative discrepancies between experimental measurements and linearity

^{60}Co		^{137}Cs	
dose rate (µSv/h)	**relative discrepancy**	**dose rate (µSv/h)**	**relative discrepancy**
7.52	7.99%	3.84	-0.09%
17.90	0.52%	10.01	-9.71%
21.05	-2.97%	39.96	-3.86%
85.50	-1.59%	104.00	-1.20%
203.00	0.79%	395.60	1.49%
636.00	-0.06%	1030.40	-0.20%
1530.00	-4.21%		
4990.00	-10.45%		

b) Angular response

The angular response of a detector is very important to get an idea of the relevance of measurements with respect of the position of the detector. Angular response measurements were performed with a ^{137}Cs source (see Figure2). As shown in Table 2 and Figure 3, the angular response is very uniform with a standard deviation of about 5 %.

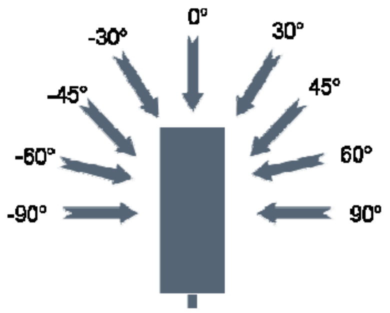

Figure 2 : Angular measurements of dosimeter response

Table 2 : Normalized counting rates with regard to the orientation

Angle (°)	Normalized counting rate (%)
-90	103.37
-60	101.20
-45	103.37
-30	103.37
0	93.58
0	91.40
30	95.21
45	99.02
60	104.46
90	105.01

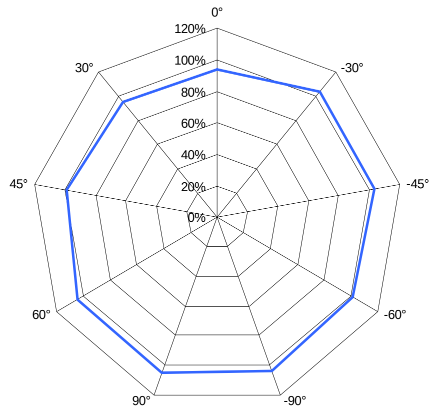

Figure 3 : Normalized counting rate with regard to the orientation

c) Real time response

The detector time response was studied through real time measurements. The counting rate was measured every 250 ms. Typical dose rates measured at 3.8 µSv/h and 18 µSv/h are illustrated in Figures 4 and 5. It clearly appears that the filtering is more efficient for higher dose rates (above 15 µSv/h) where the number of pulses per 250 ms is more significant. Nevertheless, the achieved dose rate precision of measurements is enough to be compared to a warning level.

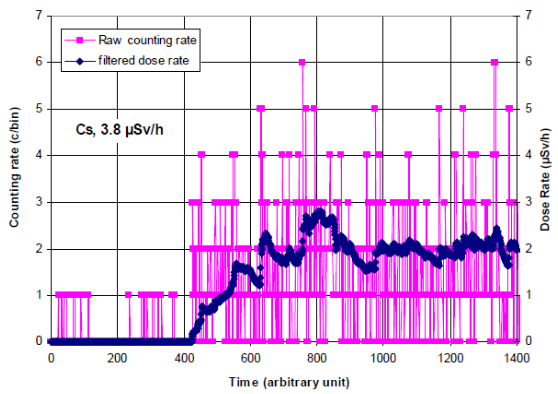

Fig. 4. Real time counting rate and filtered dose rate measured with a ^{137}Cs irradiator at 3.8 µSv/h.

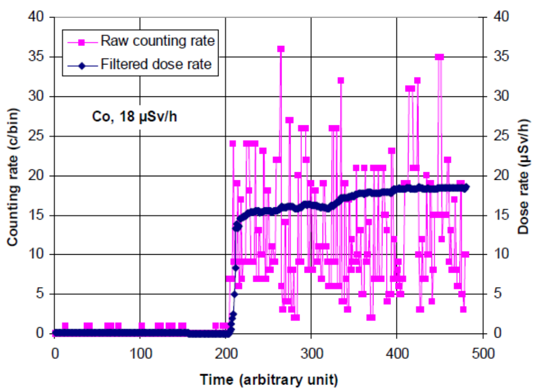

Fig. 5. Real time counting rate and filtered dose rate measured with a ^{60}Co irradiator at 18 µSv/h.

The response time of the radiometer is less than 10 s for the dose rate below 100 µSv/h and less than 2 s for the other dose rate.

3. SRIP robot description

After the need analysis of the envisaged scenarios, the SRIP robot has been developed with specific technical characteristics. The robot is remotely controlled by cable or radio, depending of the incident configuration. A 20 kg payload capability allows to load multiple sensors (camera equipment, microphone, loudspeaker, warning dosimeter represented in Figure [6], explosive safety module...).
The temperature use ranges from -15°C to +55°C. The robot also resists to various chemicals such as acids, bases, ammoniac, chlorine and varios harsh environments as shown in Figure [7]. The robot evaluates the different risks before any human intervention. In situation it adapts to any type of ground : fields, subways, 30 cm obstacle clearance, slopes and stairs up to 45°.

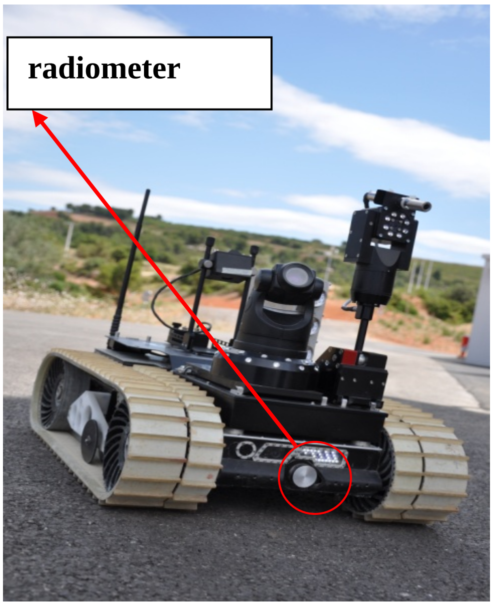

Figure 6 : SRIP Robot (courtesy of ECA)

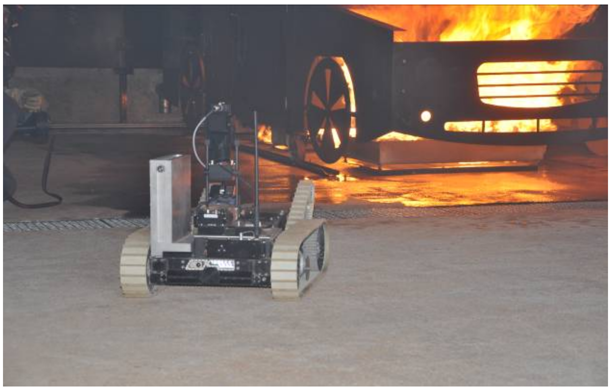
Figure 7 SRIP robot in situation

The command and control unit is light and easy to use and the setup time is fast (<2 min). The figure [8] shows a situation without any alarm (the dose rate is below the alarm setting), and the figure [9] a situation with an alarm (the dose rate is up to the alarm setting).

Figure 8: No radiological warning situation

Figure 9 : radiological warning situation

4. Discussion and conclusion

This new warning radiometer has shown good results during the different tests: a good linearity (discrepancies bellows 10 % for dose rate measurements), angular response about 5% and good real-time performances. With its compact and robust metal case it represents a good tool to be embedded inside drones (aerial or terrestrial).
This new warning radiometer will soon be marketed by the French company SDS

5. References

[1] http://www.centronic.co.uk/downloads/Geiger_Tube_theory.pdf