# Determination of Carbon Monoxide Detector Location in General Aviation Aircraft to Improve Safety

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**Abstract.** There are many sources of carbon monoxide (CO) leakage into the cabin of General Aviation (GA) aircraft. Exposure to CO, which is part of the engine exhaust in GA aircraft, can impede the pilot's ability to direct the airplane which may lead to accidents. In order to prevent accidents, an electrochemical CO detector can be used to alert the pilot to the presence of CO. The objective of this study was to determine the best location for CO detector placement in GA aircraft. Early CO detection as well as visibility and accessibility of the detector were some of the parameters involved in determining the optimum CO detector location. Considering these issues, five detector placement locations were considered: visor, instrument panel, leg area of front seats (left and right sides), and rear seat. Field tests to monitor CO levels during GA flights were conducted at Kansas State University at Salina using data logging CO detectors. The results from these measurements have been categorized according to several different variables and then analyzed statistically. Measurements taken so far during the summer and early fall indicate that the majority of CO exposure events occurred on the ground before take-off. During such ground-based CO exposure events, the timing was consistent with open windows allowing exhaust fumes to enter the cockpit area. This paper will also discuss the results of additional measurements taken during the winter months when other modes of CO exposure may be involved.

## 1. Introduction

Carbon monoxide is an odorless, colorless, and toxic gas. Many sources could leak this poisonous gas into the cabin of general aviation aircraft. All these sources are related to exhaust system. According to one study 70% of exhaust system failures result in a carbon monoxide exposure in the cockpit [1]. Exposure to CO can result in pilot becoming confused or incapacitated so the end result most likely could be an accident. Sixty seven of the 68,640 cases between 1962 and 2005 in the National Transportation Safety Board (NTSB) accident/incident database happened were directly related to CO-exposure [1]. The consequences of these incidents were 99 fatalities. In order to prevent such accidents, an electrochemical CO detector can be used to alert the pilot to the presence of CO. The objective of this study was to determine the best location for CO detector placement in GA aircraft.

## 2. Experimental Method and Results

To determine the best location, some parameters are involved. Three parameters that affect the CO detector placement are early CO detection which involves closeness to the heating system duct and ventilation system, visibility, and accessibility for pilot. With respect to these parameters five locations are selected to mount CO detectors: visor, instrument panel, leg area of front seats (left and right sides), and rear seat. Figure 1 shows the location of instrument panel CO detector.

Advantages and limitations of different sensor technology types were reviewed with a consideration to applicability and suitability for use in a general aviation environment. Due to considerations of detector accuracy, quick response time, low false alarms, and low power consumption requirements, electrochemical sensor-based carbon monoxide detectors appear to be the most suitable technology for use in a general aviation environment. Field tests to monitor CO levels during GA flights were conducted at Kansas State University at Salina using data logging electrochemical CO detectors, along with GPS to record the altitude. The CO exposure data in cabin were gathered weekly from June 2007 to February 2008. Sample collected data are shown in figure 2. In this figure vertical lines show the take off and landing times and each curve shows the amount and duration of CO exposure in the cabin. To analyze the data, CO exposure was summarized based on frequency and magnitude of exposure events. An exposure event is defined as a non-zero CO level measured by a detector. Variables of interest included maximum level of CO detected by each detector in an event, status (open/closed) of fresh air vents and windows, and whether the event happened on the ground or in the air.

Table 1 depicts number of events above specific CO amount along with the status of window and whether the event happened on the ground or in the air. Until Feb 2008, 120 flights were monitored with 8 of these flights having events of 50 parts per million (ppm) CO exposure or more. However, in seven of those flights with 50 ppm or more, the CO exposure occurred on the ground. Moreover, during such ground-based CO exposure events, the timing was consistent with open windows allowing exhaust fumes to enter the cockpit area.

Further studies also clarified that detector near the opened window (closest to the tailpipe) more consistently detected CO in the cabin (on the ground). To determine the best location for CO detector placement in GA aircraft, it was decided to determine the sensitivity. Sensitivity is defined as probability that the alarm will go off at the given threshold given that the CO level is above 50 ppm somewhere in the cabin. As figure 3 shows if the alarm levels are set to different levels, each CO detector will present different sensitivity. For alarm level up to 30 ppm, instrument panel will show the greatest sensitivity (100%). So according to data that have been gathered so far, and based on sensitivity measure, instrument panel location shows the best performance compared with other CO detectors.

Fig.1. The location of instrument panel CO detector in GA cabin

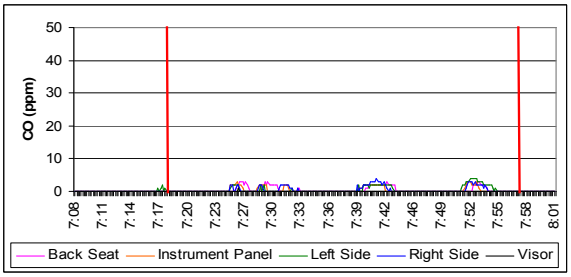


Fig. 2. Corresponding graph for sample collected data

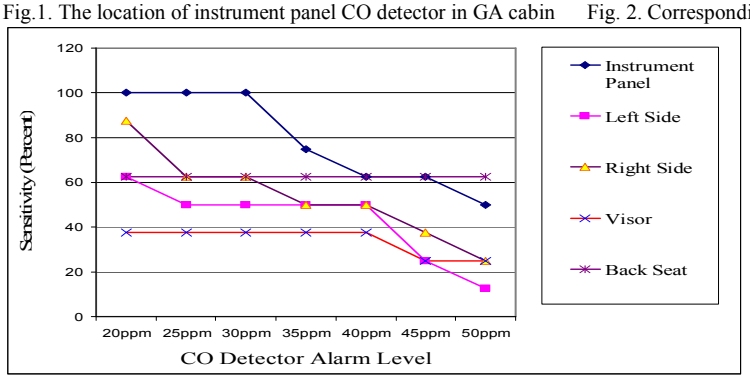


Fig.3. CO detectors sensitivity: ≥50 ppm

Table 1: Number of events above specific CO amount

| CO level | >0 ppm | >10 ppm | >20 ppm | >30 ppm | >40 ppm | >50 ppm |
|---|---|---|---|---|---|---|
| Aircraft location (ground) | 174 | 66 | 39 | 22 | 11 | 7 |
| Window open in ground | 73% | 70% | 62% | 73% | 82% | 86% |
| Aircraft location (air) | 162 | 24 | 10 | 5 | 1 | 1 |

## 3. Conclusions

GA aircraft accidents caused by CO exposure motivated conducting this research. The objective of this research was to determine the best location for CO detector placement in GA aircraft so that this detector can be used to alert the pilot to the presence of CO. A data driven approach was used through field tests monitoring CO levels during GA flights which were conducted at Kansas State University at Salina using data logging CO detectors. The result showed that according to data that have been gathered so far, and based on sensitivity measure, instrument panel location shows the best performance.

## 4. Acknowledgements

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References

[1] M. Assadi, A. Ahmady, S. Muthuswamy, Analysis of the Effect of CO Exposure on Accidents/Incidents in GA aircraft, WSU GRASP,2008.