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Comparison of four low-level carbon monoxide alarms suitable for home use or when traveling

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ABSTRACT

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Introduction/Background: Interest in carbon monoxide (CO) alarms that are more sensitive than is required for standard residential CO alarms is growing, as reflected by increased marketing of "low-level" alarms capable of measuring CO levels as low as 10 PPM. At the same time, publicity surrounding CO poisoning events among travelers in lodging facilities has stimulated interest in travel CO alarms. We sought to evaluate four low-level alarms that could be used in the home and especially when traveling.

Materials/Methods: Two each of four brands of low-level alarms (CO Experts, Forensics, Kidde, and Sensorcon) were acquired by retail purchase and tested. The eight alarms were simultaneously exposed in an environment with a slowly increasing level of CO from indoor burning of charcoal briquets. CO levels displayed on the alarms were recorded once per minute. Activation of preset alerts on the alarms were noted. Finally, alarms were compared for ease of use and features available.

Results: All brands of alarms measured CO similarly over the range from 10-120 PPM. All alarms performed as claimed by their manufacturers, both regarding range of CO reported and preset alert activation. Each alerted at CO levels below that required by the Underwriters Laboratories 2034 Standard.

Summary/Conclusions: Since all low-level CO alarms tested measured CO similarly, consumers seeking a low-level CO alarm for use while traveling should base their decision on features desired and price. There are definite differences between the alarms tested, in terms of features, expected durability, ease of operation and price. ∎

KEYWORDS: alarm; carbon monoxide; toxicity; travel

INTRODUCTION

In response to reports of hotel and motel carbon monoxide (CO) poisoning published in the medical literature and publicized by the lay media [1-4], interest has grown in travel CO alarms. As a result, some portable CO detectors are being marketed specifically for the traveling public to carry and use for protection while staying in lodging facilities. Other CO alarms are being marketed as more sensitive than is required by the current Underwriter's Laboratories standard for residential CO alarms [5]. The logic for such a "low level" alarm is that an individual should presumably want to be alerted to an impending significant CO exposure as early as possible, or that CO exposure at low level on a chronic basis may be hazardous to health.

Some devices are appropriate both for travel (portable size, battery operation) and low-level CO detection. Presuming that the traveler seeking a CO alarm would want to be alerted to low levels of CO, we compared four of several commercially available CO alarms marketed as low-level

Table 1. Photographs, physical characteristics, and cost of the four CO alarms tested

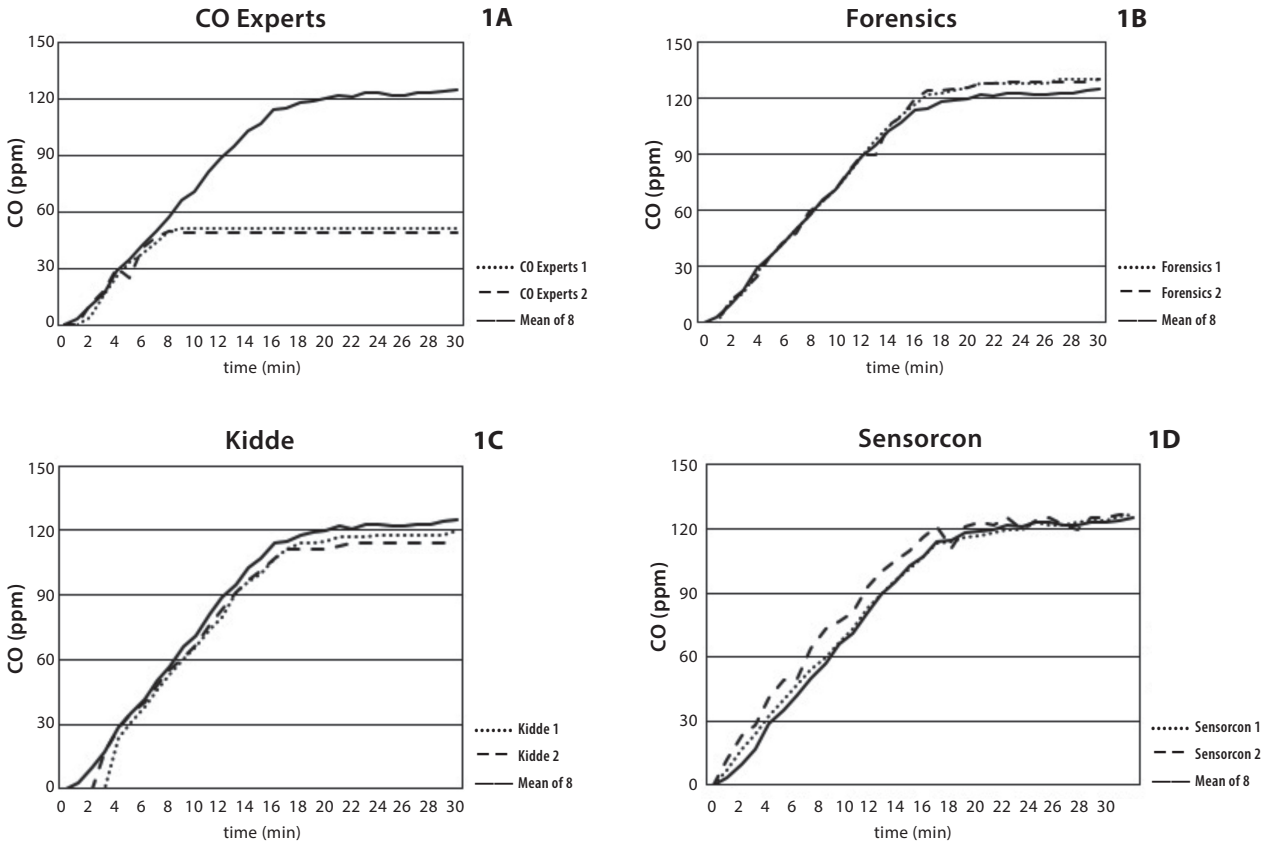
	Manufacturer	Model	Power	Size	Retail Cost *
	**CO EXPERTS**	"Ultra" Low Level Carbon Monoxide Health Monitor	2 AAA batteries	2.0 x 1.5 x 3.0" 4 ounces	$209
	**FORENSICS**	Travel & Personal CO Detector Model TRAVEL001	2 CR2 batteries	2.5 x 1.75 x 0.65" 2 ounces	$100
	**KIDDE**	KN-COU-B Ultrasensitive Carbon Monoxide Monitor	3 AA batteries	4.5 x 1.5 x2.8" 5.3 ounces	$63
	**SENSORCON**	The Inspector Industrial Pro	1 CR123A battery	3.2 x 2.2 x 0.9" 4 ounces	$159

* Amazon.com 09/2020

with the goal of determining whether there are characteristics that would make one be selected over another as a travel alarm. The study was not intended to be an exhaustive review of all devices on the market, but rather to contrast features of four in the hope that they would guide the reader when selecting one for personal use.

METHODS

A pair of each of four commercially available CO alarms was acquired through online retail purchase (Amazon.com) (Table 1). No devices, funding or input of any type were provided by the manufacturers. Those selected are small enough for travel, use batteries for power, have a reasonable price point, have digital displays of ambient CO



Figures 1A-D
Ambient CO levels measured by each pair the four brands of low-level alarm tested, compared to the mean level measured simultaneously by all eight alarms.

and are claimed to report CO levels at least as low as 10 parts per million (ppm).

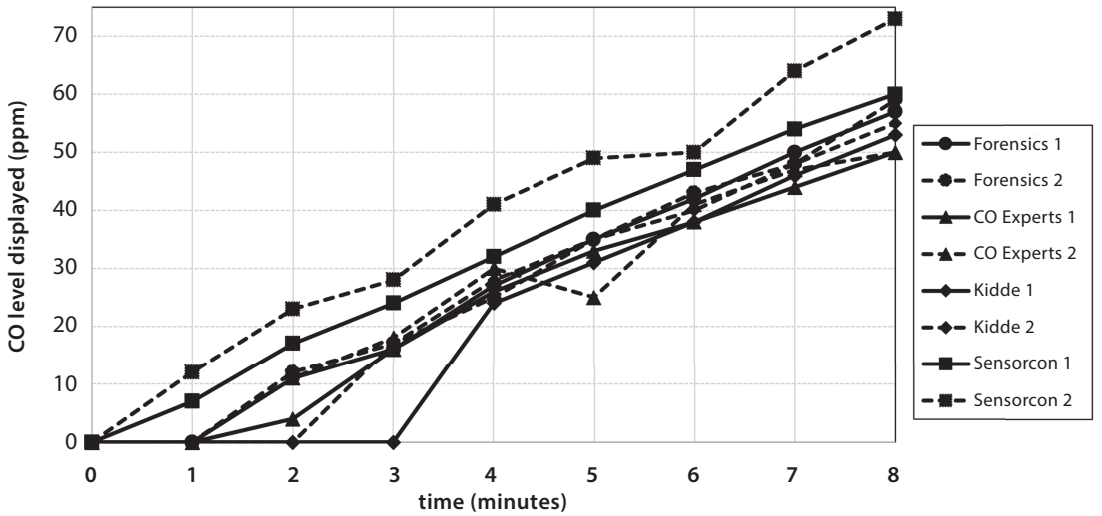
The devices were operated per their accompanying instructions. CO testing was performed in a one-car detached garage as previously described [6]. The devices were placed on a shelf in the garage at a height halfway from the floor to the ceiling. Digital readouts, auditory and visual alerts were easily assessed through a glass window. Measurements of CO concentration as displayed on each device were recorded once per minute for 30 minutes while burning 2.3 pounds of charcoal in the garage as a CO source. The ignited charcoal was not placed in the garage until the surfaces of briquettes were ash gray in color, with little visible smoke production, indicating a smoldering burn. It was our goal to achieve an exposure that was below that which would trigger an alert from a residential CO alarm manufactured to the UL 2034 standard.

RESULTS

Figures 1A-D display the CO levels measured by the devices and recorded from their digital readouts. Each graph shows the results from two alarms of the same brand and compares them with the mean from all eight devices tested. As would be expected from a source producing a relatively constant amount of CO, the level in the garage rose in a linear fashion until reaching equilibrium with leaks in the building construction and diffusion through walls.

Figure 2

CO levels (ppm) displayed on each of the eight alarms tested over the range from 0 to approximately 50 ppm.



From a practical and clinical standpoint, all devices measured CO similarly over the range tested. The detectors manufactured by CO Experts displayed peak CO concentration of 50 pp, (Figure 1A), consistent with their claim of displaying that as a maximum level. Figure 2 displays the individual CO measurements of the eight alarms over the range of 0 to approximately 50 ppm. Alerts (visual, auditory and vibratory) occurred as claimed by their manufacturers within the CO range tested (Table 2).

DISCUSSION

Home residential CO alarm performance is regulated by UL 2034 [5]. This standard was designed to prevent acute CO exposures that would result in a carboxyhemoglobin level greater than 10%. Residential alarms must alert if CO is present at a level of 70 ± 5 ppm for 60 to 240 minutes, 150 ± 5 ppm for 10 to 50 minutes, or 400 ± 10 ppm for four to15 minutes. All four of the devices tested alert at CO levels far below this standard.

As can be seen in Table 2, levels triggering alerts on these devices are variously 5, 9, 25, 35, 50 and 200 ppm CO. Many of these levels appear to have been adapted from standards of various U.S. federal agencies or organizations. The Environmental Protection Agency (EPA) has established the U.S. National Ambient Air Quality Standard for CO at 9 ppm for eight hours and 35 ppm for one hour [7]. They have not established a CO standard for indoor air [7].

The National Institute for Occupational Safety and Health (NIOSH) [8] has established a recommended workplace exposure limit for CO of 35 ppm as an eight-hour time weighted average and 200 ppm as a ceiling [8]. The NIOSH limit is based on the risk for cardiovascular effects. The current Occupational Safety and Health Administration (OSHA) permissible exposure limit in the workplace is 50 ppm as an eight-hour time-weighted average [9].

The literature and manuals accompanying the devices frequently explain the levels chosen for their devices. Literature accompanying the device manufactured by CO Experts notes that the device does not replace a UL 2034 device if one is required in the residence, but instead it is intended to be a "CO Health Monitor," designed to "provide the vital protection you and your entire family needs from

Table 2. Threshold CO levels and alerts issued by each of the four alarms.

Manufacturer	CO Range Display	Threshold (ppm CO)	Alert
CO Experts	>4 – 50 ppm	5-24 ppm x 24 h	Red LED flashes 1/m plus one set of 4 beeps/m
		25-34 ppm x 8 h	Red LED flashes 1/m plus one set of 4 beeps/m
		35-50 ppm x 1 h	Red LED flashes 2/m plus one set of 4 beeps 2 times/m
		>50 ppm x 4 m	Red LED flashes 3/m plus one set of 4 beeps 3 times/m
Forensics	9 - 999 ppm	9 ppm	Red LED flashes
		25 ppm X 1 m	Red LED flashes plus buzzer
		50 ppm immediate	Red LED flashes plus buzzer
Kidde	10 - 999 ppm	"Low" level	Green LED flashes 4 times, then off x 10 s
		"Mid" level	Green LED flashes 4 times, red LED flashes 2 times, chirps 2 times/10 s
		"CO Alarm" level	Red LED flashes 4 times, chirps 4 times/5 s
Sensorcon	0 - 1,999 ppm	35 ppm (default, adjustable 5-100 PPM)	4 red LEDs flash every 3 s, audible alarm, vibration
		200 ppm (default, adjustable)	4 red LEDs flash every 2 s, audible alarm, vibration

Chronic Low Level CO Poisoning." It is marketed not as an alarm for prevention of acute, severe CO poisoning, but instead as a "health monitor" which is said to be appropriate for "pregnant women, infants, young children, the elderly and people with chronic medical illness." Its lowest alert occurs when 5 ppm CO is detected for 24 hours. This is a level that would probably be exceeded in many homes from time to time. According to the EPA, average levels in homes without gas stoves vary from 0.5 to 5 ppm [7]. Levels near properly adjusted gas stoves are often 5 to 15 ppm; those near poorly adjusted stoves may be 30 ppm or higher [7].

The device manufactured by Forensics is marketed as a "Travel and Personal CO Detector." It has progressive alerts at 9, 25, and 50 ppm CO. It should be noted that the 9 ppm alert is visual only and an audible alert does not occur until 25 ppm. Instructions instruct the user to ''ensure the detector in line of sight for visual alarm in case buzzer alarm cannot be heard."

The Kidde monitor has three alert levels, designated as "Low," "Mid," and "CO Alarm" alerts. The accompanying literature contains a table that subdivides each of these into numerous time (minutes) x concentration (CO ppm) products at which various alerts occur (Figure 3). As can be seen in Figure 3, the device has no alert at CO concentrations lower than 20 ppm. After 20 to 115 minutes at 20 ppm, the device issues the "Low" level alert, which is visual only. When 20 ppm has been present for longer than 115 minutes, the device emits a "Mid" alert, which adds an auditory cue. The lowest level of CO that causes a "CO Alarm" alert is 40 ppm, when present for more than 475 minutes. It is unlikely even a sophisticated consumer has the knowledge necessary to navigate these time-concentration products to discern the relative risks associated with each. The three alert levels are represented by various combinations of red and green LED flashes and chirps (Table 2). As the signaling system is complex, a reference card explaining the various combinations of signals is provided by the manufacturer for mounting on the wall adjacent to the device.

Sensorcon's Inspector Industrial Pro is actually marketed as a personal CO monitor for use in the industrial workplace. However, its size, battery operation and CO sensing range make it appropriate for use as a travel alarm, as well. It has

Figure 3. Approximate low-level, mid-level or alarm times

ppm of CO concentration	display	times in minutes		
		low-level	mid-level	CO alarm
<10	display '0'	no alert	n/a	n/a
10		no alert	n/a	n/a
20		20-115	>115	n/a
30		0-55	>55	n/a
40		0-40	40-475	>475
50	display CO concentration in parts per million (ppm)	0-30	30-175	>135
60		0-25	25-115	>100
70		0-20	20-60	60-240
80		0-15	16-65	>65
90		0-12	12-45	>45
100		0-10	10-30	>26
150		0-7.5	7.5-21	10-50
250		0-5	5-12	>8
400		0-4	3-8	4-15

default alarms set at 35 and 200 ppm, probably because of its intended workplace application and NIOSH regulations described above. The low-level alarm can, however, be adjusted anywhere from 5 to 100 ppm CO and the high-level alarm from 5 ppm higher than the low setting to 200 ppm. It displays CO concentrations from 0 tp 1,999 ppm alerts with a combination of visual, auditory and vibratory stimuli. It is easy to use and understand.

CONCLUSIONS

So, is one of the devices tested best for use as a low-level CO alarm and for travel? The answer is dependent upon the consumer's desire. All four of them worked exactly as claimed. In our opinion the device manufactured by CO Experts is limited by its range of CO display (maximum 50 ppm) and potential for frequent alarms, especially in a natural gas-heated environment. The device made by Forensics does not issue an audible alert until the CO concentration is 25 ppm, and some may desire a lower threshold. We found the Kidde alarm to be overly complex with regard to interpretation of the threshold levels programmed and alert signaling system. We had no criticisms of the Sensorcon alarm. The ability for the consumer to adjust the alarms to the level desired seems to be an advantageous feature, the device displays CO concentrations from 0 to 1,999 ppm, and its industrial construction suggests that it will hold up under travel conditions. Its system of auditory, visual, and vibratory alerts was excellent. While this device was designed for industrial use it would be an ideal low-level travel CO alarm.

It must be recognized that this study was limited by the fact that the marketplace for low level CO alarms is a large and fluid one. Other low-level alarms are undoubtedly available which might be suitable for travel use that were not examined. Some may be different models manufactured by the same companies. This study was not meant to be exhaustive, testing every alarm available for sale. Hopefully this discussion of features and operating characteristics will provide guidance in evaluation of those available for purchase.

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