The Development of a CO Detector:
Working toward the Zero Occurrence of CO Poisoning

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1. General Description

Although there is an urgent need for a detector capable of measuring high concentrations of CO (carbon monoxide) gas on site, following recent CO poisoning accidents caused by incomplete combustion of CO, no such detector has been available. We therefore developed a small CO detector capable of measuring CO concentration over a wide range, from low to high, using a sensor with an entirely new design. (We received the Combustion Society of Japan's technology award for fiscal 2005 for this technology.*) This paper reports on this development project.

* Combustion Society of Japan's technology award for fiscal 2005:
The Combustion Society of Japan's technology award is granted to individuals and groups that made a significant contribution to the research and development of applied combustion technologies. The award in fiscal 2005 mentioned here was in appreciation of the "gas selectivity" technology (selective sensing of CO only) of the sensor jointly developed by Sakaguchi Giken Co., Ltd. and Tokyo Gas Co., Ltd.

2. Background and Objective

The inhalation of CO gas, even of low concentration (several hundred ppm), may result in severe after-effects and even the loss of life if the person inhaled the gas for a long time. Three years ago, at a Chinese noodle shop in Takadanobaba, the use of a noodle cooker without running a ventilation fan killed two persons by CO poisoning. This accident was widely reported by the media.

To eliminate CO poisoning accidents like this, we should be able to monitor the amount of CO gas produced by gas appliances. However, existing models of CO detectors have the following handicaps:

- the measurement is inaccurate with a concentration of 2000ppm and higher; and

- the detector is easily affected by H_2 and other gases produced while combustion is incomplete.

With this in mind, we developed a CO detector free of these handicaps. In this paper, we first clarify the significance of being able to measure highly-concentrated CO gas by describing the characteristics of CO poisoning, and then describe the advantages of the CO detector we developed.

3. What is CO Poisoning?

At room temperature, CO exists as a gas with no taste, smell or pungency; therefore, we cannot be aware of its presence in the surrounding atmosphere. Since it has a molecular weight almost equal to that of air, it floats in the air (without being concentrated near the ceiling or near/under the floor). Since CO is 250 times more fusible with hemoglobin (Hb) in the blood than O_2, it easily enters the body even when its concentration is low and quickly produces a state of hypoxia. Table 1 shows the relationship between the level of CO-Hb concentration in blood and physical symptoms.

With a gas appliance that consumes a large amount of gas, such as the cooking burners for commercial use, incomplete combustion due to a problem with intake or exhaust or due to improper maintenance of the appliance, may result in a high CO concentration (from several thousand ppm to several percent). In that case, the inhalation of the contaminated air, even for a short duration, may result in death.

Table 1 Relationship between the CO-Hb concentration and the states/symptoms

CO-Hb	State	Symptom
60-100%	Death	90% and above: instant death 80%: speedy death 60%: coma or the loss of consciousness; a slow process to death
40-60%	Severe	50% and above: coma or fainting 40%: sharp headache and nausea
25-40%	Mrild	Headache, nausea and difficulty in walking

4. Advantages of the Newly Developed Sensor

The detector we developed has a catalytic combustion type sensor. (See Figure 1 for its construction.) The advantages of the new sensor in comparison with the conventional sensor are described below. (See Table 2 for the comparison between the new and conventional sensors in terms of construction.)

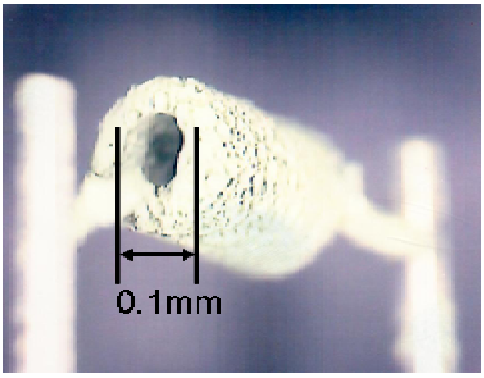

Figure 1 Enlarged view of the new sensor

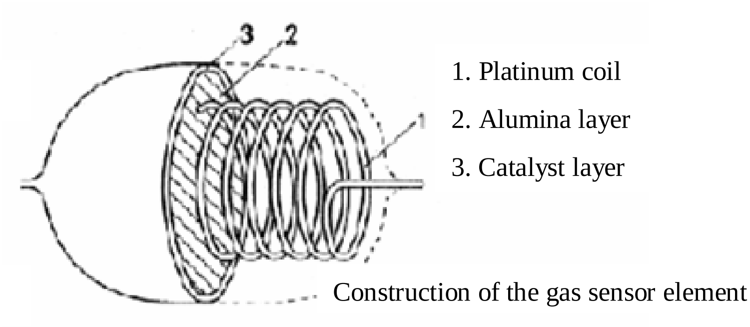

Figure 2 Enlarged view of the conventional catalytic combustion type sensor

(1) Large surface, cylindrical shape and porous design of the sensor

The sensor is designed to easily permit the flow of gas. Since the exhaust is removed quickly after combustion in the sensor, a sufficient flow of oxygen improves the efficiency of transforming CO into CO_2. This enables a large amount of CO (highly-concentrated CO) to be measured.

(2) Lightness of the sensor and a large temperature resistance coefficient value of the wiring material

Since the heat capacity of the carrier is small, and the temperature resistance coefficient value of the nickel wire used in the new sensor is better than that of the platinum wire used in the conventional sensor, substantial changes in temperature and resistance are obtained even at a low input level. With this ability to capture a small change in temperature, the new sensor is capable of measuring a very small amount of CO (low concentration CO).

Table 2 Comparison of construction between new and conventional sensors

	New catalytic combustion type sensor	Conventional catalytic combustion type sensor
Constitution	Nickel wire + catalyst	Platinum wire + catalyst
Construction	The catalyst is bake-formed to have a cylindrical shape. The porous design enlarges the surface area for reactions.	Adopts a spherical design. The catalyst paste is spread over the entire coil surface by means of surface tension.

Thus, the CO sensor we developed has the following epoch-making advantages that were unachievable in the past:

a. The new sensor is capable of measuring in the concentration range between 0.01% and 5%. (Conventionally, the measurement range was between 0.03% and 0.2%.)

b. The new sensor maintains linearity up to a high density (of 50,000ppm or higher).

c. The new sensor achieves selective sensing of CO unaffected by the presence of methane, ethane, propane, CO_2, and most remarkably, of hydrogen.

(See Figure 3 for items b. and c.)

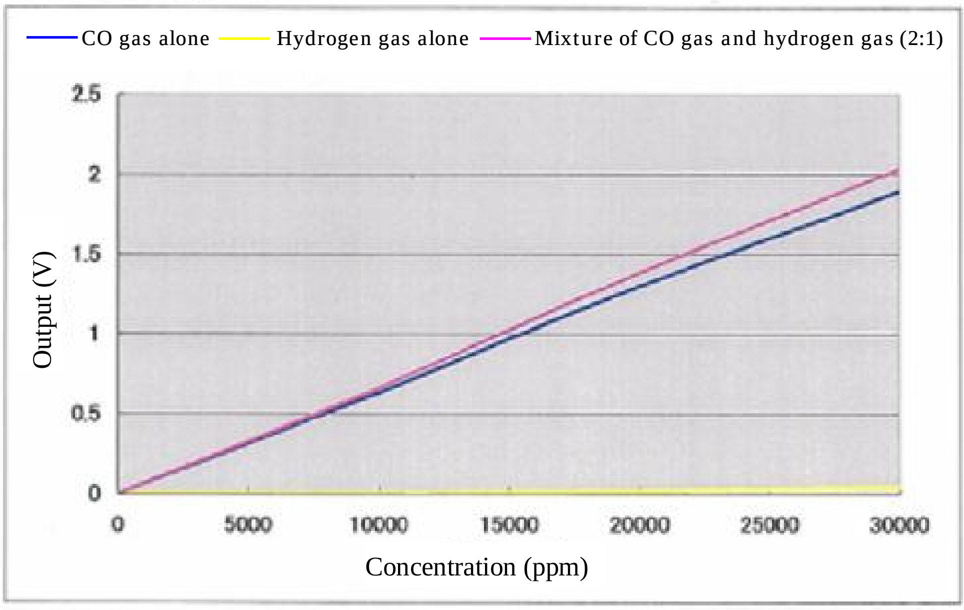

Figure 3 CO detection sensitivity characteristic

5. CO Detector

Figure 4 shows two CO detectors equipped with the new sensor we developed. Our first model is shown on the left. Even though a trial use of the first model at Tokyo Gas revealed no problem involving performance, it still had some problems for wider application, that is, problems associated with portability and ability to read the sensor outdoors. We downsized and improved the unit by fundamentally redesigning the drive circuit board, dimensions, and other specifications, which resulted in the current model shown on the right. Table 3 lists the specifications of the downsized detector. In terms of the measurement range, size, and battery life, the detector has achieved a level of performance that allows practical use. Even though the detector is usually powered by lithium batteries, it can be powered by manganese batteries in case the lithium batteries have failed during field use.

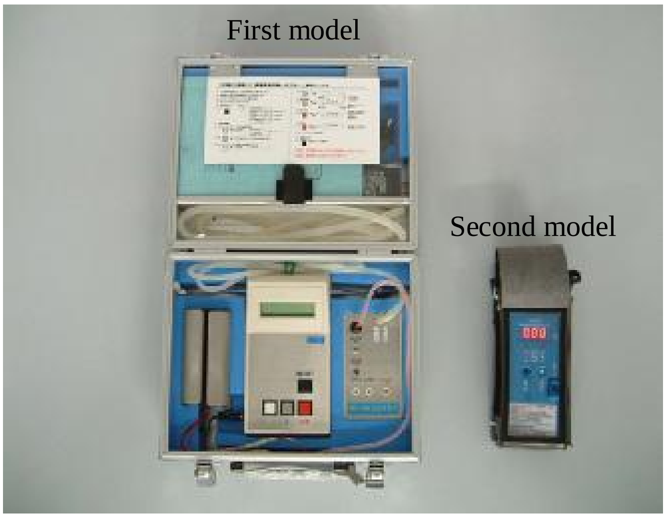

Figure 4 Newly-developed detectors

Table 3 Detector specifications

Measuring target	CO
Sensor	Catalytic contact type
Range	0.00 to 5.00%
Concentration display mode	Peak holding
Accuracy	±10%RD
Power	9VDC (six AA batteries)
Power consumption	0.55mA (average)
Battery life	3 hours with alkaline batteries
External dimensions	W75 x H177 x D47
Weight	Approx. 0.9kg

6. Conclusion

Tokyo Gas has put 60 prototype units of the downsized detector to trial use for about a year. These have been well received in the field because measurements can be taken over a wide concentration range, from low to high, using this small detector alone.

In the future, we plan to address the following tasks in order to make the detector easier to use:

- improvement of the detector based on feedback from the field test (ease of use, etc.); and
- evaluation of the long-term stability (determination of the maintenance interval).

Additionally, in view of the fact that CO poisoning is taking the lives of about 4,000 persons per year in fire hazards and other circumstances (including suicide), we are considering the possibility of using the new CO detector for wider purposes.

Source: “City Gas Symposium” handouts