RESOURCE ARTICLE

Operating experience review of an INL gas monitoring system

This article describes the operations of several types of gas monitors in use at the Idaho National Laboratory (INL) High Temperature Electrolysis (HTE) laboratory. The gases monitored in the lab room are hydrogen, carbon monoxide, carbon dioxide, and oxygen. The operating time, calibration, and both actual and unwanted alarms are described. The calibration session time durations are described. Some simple calculations are given to estimate the reliability of these monitors and the results are compared to operating experiences of other types of monitors.

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INTRODUCTION

This article describes the operations of the hazardous gas monitoring systems in use in Idaho National Laboratory's High Temperature Electrolysis (HTE) laboratory. The monitors read carbon monoxide, carbon dioxide, hydrogen, and oxygen levels in the room. There are two gas monitor units per gas species, and they have been operating since their initial calibration in early December 2006. The HTE laboratory is described in 1,2. The lab room is 21.5 m in length, 9.2 m wide, and 6.4 m high. One end of the room was used for a set of small furnaces to test 'button' electrolysis cells (see Figure 1) and the other end of the room was used for the large electrolysis experiment (see Figure 2). The large experiment has created between 0.1 and 0.2 kg-hydrogen per hour by steam electrolysis with electrolytic cell stacks, and has operated for up to 2,500 hours in a campaign.[1,2] All four monitored gases can be effluents from the electrolysis tests, with hydrogen and oxygen being the largest mass flow rates. While hydrogen production per hour was low, the long duration tests created enough hydrogen that potential leakage to the room would pose a hazard.

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SYSTEM DESCRIPTION

The monitors have been described in previous papers,[3,4] so this description will be brief. Commercially available gas monitors were chosen for each type of gas to be sensed. The carbon dioxide monitor uses an infrared sensor element. The hydrogen monitor uses a 'catalytic converter' ceramic bead sensor. The oxygen and carbon monoxide monitors use electrochemical sensor heads. Gas monitors can be placed in either 'spot' or 'area grid' configurations. Literature guidance on floor area coverage per monitor was between 37 and 93 m^2. In this case, area coverage of 97 m^2 in the rectangular room also served to place gas monitors near the experiment areas. The monitors all report to central panels, each control panel is located near one of the two personnel door exits from the laboratory. The oxygen, carbon monoxide and carbon dioxide monitors are all located on a wall roughly 3 feet from the floor, as shown in Figure 3. The hydrogen monitors are located on the ceiling, away from ventilation system ducts, as shown in Figure 4. The monitors are operated year round, except for special circumstances when experiment operations are completely shut down or there is a shutdown with maintenance work that includes the use of chemicals that have been found to give false positive alarms from the gas monitoring system. For that reason, a good estimate of operating time per calendar year is 8,590 hours (a year minus one week). The monitoring systems were commissioned, calibrated and began operation in December 2006; they have been in operation for eight years. Typical monitor readouts are given in Table 1. The warning and evacuation alarm setpoints of the monitors are given in Table 2.[3] For best accuracy, the CO_2 monitors were tuned to their warning and evacuation set point ppm values using nitrogen gas rather than using the variable, ambient CO_2 concentration in air as a zero point.

MONITOR OPERATING EXPERIENCES

To discuss the operating experiences of these gas monitors, a few definitions are needed. These definitions are to clarify the terms actual alarm, unwanted alarm, and spurious alarm. An actual alarm is defined as a condition of the gas sensor reading the gas it was designed to detect and which has leaked or issued from the experiment apparatus. Therefore, an actual alarm is a gas monitoring system alarm annunciation caused by the in-room release of one of the process gases used

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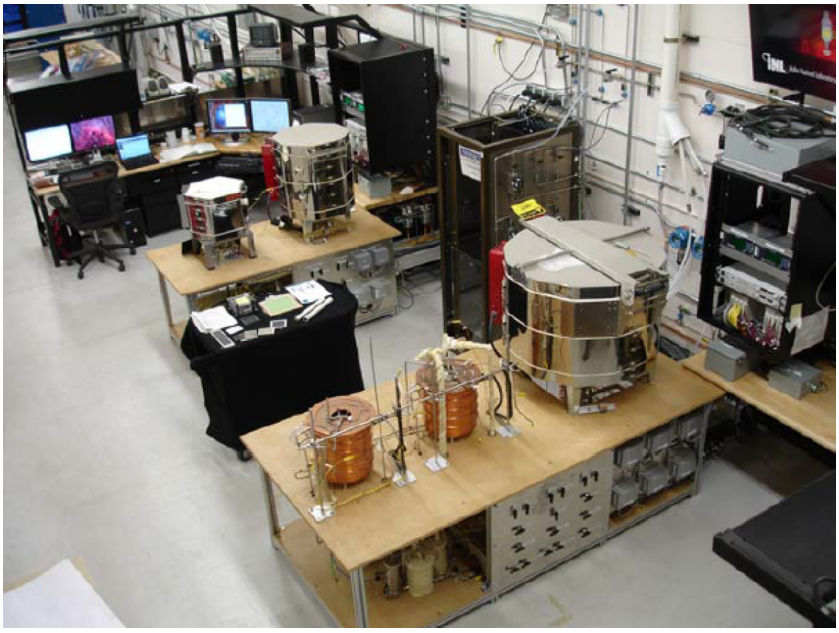

Figure 1. The high temperature solid oxide electrolysis 'button cell' bench scale experiments. The gas monitors on the wall are noted by their blue casings.

Figure 2. The large furnace with one electrolysis stack in place.

in, or produced by, the electrolysis or other experiments housed in the lab room. In the eight years of experiment operations discussed here (2007–2014), there have been two actual alarms from the set of monitors.

Unwanted alarms are defined as gas monitor alarms caused by similar gases (sometimes referred to as cross-sensitive gases) or from the 'principal' gas the sensor is designed to detect, but the similar or principal gas did not originate from the electrolysis experiment or any of its support apparatus. That is, principal gases or similar vapors have entered the laboratory room and caused an alarm condition. There have been several events of this type; the actual and unwanted alarm events are discussed below.

Spurious alarms are defined as false alarms; that is, alarms that sound despite no change in the usual gas concentration in the room air. Spurious alarms could be generated from power fluctuations, electronic noise spikes, electromagnetic energy from nearby equipment, etc. There have been no spurious alarms with these gas monitors since their first actuation in December 2006; the monitors have only alarmed when some type of intrusion gas has caused an alarm.

CO Infiltration Events

The unwanted alarms in the HTE laboratory have all occurred with the CO monitors. From examination of Table 2, it is obvious that these monitors are the most likely to actuate since they are set to low concentration values, 13 and 25 ppm, while the monitors for other gases are set to values in the thousands of ppm. The unwanted alarms have been traced to two types of events. The first type of unwanted alarm event is CO gas from outside the building infiltrating into the laboratory. The main experiment occupies a lab room called Bay 9, but there are other experiments in operation in the other eight bay rooms of the building. Adjacent rooms have had equipment placed, and sometimes road trucks deliver equipment and forklifts move the equipment from trucks into these adjacent rooms. On two occasions (see Table 3) where such vehicles were operating, the CO monitor farthest from the roll-up door to the exterior of the building reached its low level alarm point of 13 ppm. The staff believed that the vehicle exhaust gas was leaking through wall penetrations of the common wall between the two bays as well as through the Bay 9 exterior roll-up door, which is not a tightly sealed door. The staff believed air currents carried the CO infiltration gas to the farther monitor location. The staff noted the characteristic smell of exhaust from internal combustion engines; the forklift was a large, rough terrain model. In another event in 2007, a

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