Application of Commercial Non-Dispersive Infrared Spectroscopy Sensors for Sub-ambient Carbon Dioxide Detection

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Monitoring carbon dioxide (CO_2) concentration within a spacecraft or spacesuit is critically important to ensuring the safety of the crew. Carbon dioxide uniquely absorbs light at wavelengths of 3.95 μm and 4.26 μm. As a result, non-dispersive infrared (NDIR) spectroscopy can be employed as a reliable and inexpensive method for the quantification of CO_2 within the atmosphere. A multitude of commercial off-the-shelf (COTS) NDIR sensors exist for CO_2 quantification. The COTS sensors provide reasonable accuracy so long as the measurements are attained under conditions close to the calibration conditions of the sensor (typically 21.1 °C and 1 atm). However, as pressure deviates from atmospheric to the pressures associated with a spacecraft (8.0–10.2 PSIA) or spacesuit (4.1–8.0 PSIA), the error in the measurement grows increasingly large. In addition to pressure and temperature dependencies, the infrared transmissivity through a volume of gas also depends on the composition of the gas. As the composition is not known *a priori*, accurate sub-ambient detection must rely on iterative sensor compensation techniques.

This manuscript describes the development of recursive compensation algorithms for sub-ambient detection of CO_2 with COTS NDIR sensors. In addition, the basis of the exponential loss in accuracy is developed theoretically considering thermal, Doppler, and Lorentz broadening effects which arise as a result of the temperature, pressure, and composition of the gas mixture under analysis. As a result, this manuscript provides an approach to employing COTS sensors at sub-ambient conditions and may also lend insight into designing future NDIR sensors for aerospace application.

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