Application note

Analysis of aviators' breathing oxygen by integrated FTIR spectroscopy

Introduction

Military aircraft use compressed oxygen cylinders to provide breathing air to pilots and crew, ensuring environmental control under any flight conditions. Each cylinder of aviators' breathing oxygen (ABO) must be validated before takeoff to ensure safety. Validation involves analyzing both oxygen and contaminant concentrations, and an incorrect assessment of either can unnecessarily ground flights. The oxygen production and distribution process must be carefully controlled to maintain high-purity O_2, free from contaminants like methane (CH_4) or acetylene (C_2H_2), which pose combustion or explosion risks. Other common contaminants include chlorofluorocarbons and hydrochlorofluorocarbons (CFC/HCFC, also known as Freons) used as solvents or refrigerants.

Fourier transform infrared (FTIR) spectroscopy is a powerful technique for analyzing gas sample purity in industrial or environmental applications. Many gases have unique infrared signatures, allowing FTIR spectroscopy to analyze multiple compounds in a single analysis. FTIR analysis is fast, precise, and requires minimal sample handling, making it a preferred solution over other analytical techniques. Thermo Fisher Scientific's FTIR capabilities make it an excellent choice for analyzing ABO for contaminants.

Figure 1. ABO gas analyzer.

Deployment

The Thermo Scientific™ Antaris™ FTIR Gas Conditioning and Analysis System is designed for immediate deployment. It ships in a custom-designed ruggedized case with racks for the FTIR gas analyzer and an optional O_2 analyzer. All necessary sample handling regulators, manifolds, and gauges are integrated into the unit. Startup requires only removing the case panels and attaching purge lines. This integrated design simplifies shipment and deployment, enabling rapid and reliable measurements.

Measurement

Each Antaris gas analysis system is calibrated in house using various concentrations of 23 of the most common contaminants typically found in ABO. Each species is measured at various concentrations and ranges. The high spectral resolution and broad bandwidth of the Antaris system allow it to analyze and deconvolute multiple gases in one spectrum. Calibration models are built using selective regions of the IR spectrum for each of the species. Models are produced using a CLS algorithm within TQ Analyst.

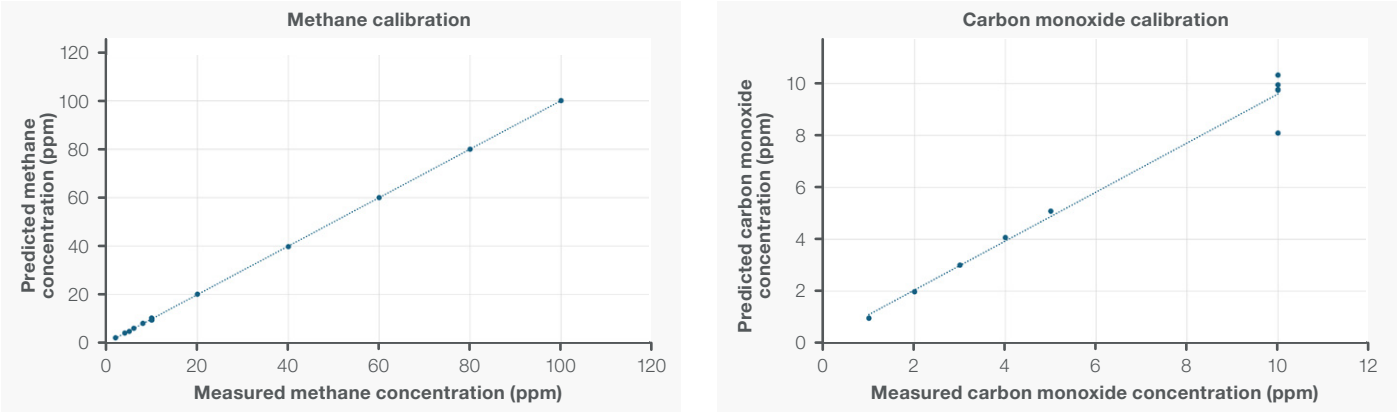

Figure 2. Figures of merit for the tested contaminants. All species demonstrate excellent linearity and sensitivity.

Species	Calibration range (ppm)	R^2	Calibration error (ppm)	Limit of detection (ppm)
Methane	2.0–100.0	1.0000	0.1617	0.15
Ethane	2.0–10.0	0.9999	0.0257	0.11
Ethylene	1.0–10.0	0.9999	0.0276	0.12
Acetylene	2.0–10.0	0.9999	0.0232	0.09
Propane	2.0–10.0	0.9996	0.0547	0.13
Propene	2.0–10.0	0.9996	0.0546	0.12
Freon-11	2.0–10.0	0.9982	0.1195	0.11
Freon-12	2.0–10.0	0.9997	0.0515	0.12
Freon-13	1.0–10.0	1.0000	0.0139	0.16
Freon-22	1.0–10.0	0.9983	0.1135	0.14
Freon-113	1.0–10.0	0.9999	0.0215	0.13
1_1_1-Trichloroethane	2.0–10.0	0.9988	0.1019	0.35
Trichloroethylene	3.0–10.0	1.0000	0.0079	0.19
Nitrous oxide	1.0–10.0	0.9999	0.0319	0.10
Carbon monoxide	1.0–10.0	0.9997	0.0514	0.14
Carbon dioxide	4.0–10.0	0.9958	0.1505	0.60
Freon-141b	1.0–10.0	0.9999	0.0219	0.15
Sulfur hexafluoride	1.0–10.0	1.0000	0.0081	0.15
Freon-225	2.0–10.1	0.9925	0.3118	0.16
PFBI	0.75–2.99	0.9999	0.0108	0.09
Freon-134A	5.0–10.0	1.0000	0	0.17
Freon-125	2.0–4.0	0.9999	0.0094	0.04

Table 1. Figures of merit for Antaris gas analysis system calibration.

The calibrations come integrated into Thermo Scientific™ RESULT™ Software that helps a user navigate through the stages of sample collection and data analysis. Also included in RESULT software are workflows that perform instrument suitability testing to ensure that the Antaris system is performing within specifications and that any subsequent measurement made can be trusted. The RESULT workflows generate signed reports showing the status of the instrument and the pass/fail status of the contaminant analyses.

Thermo Fisher Scientific provides Antaris FTIR gas conditioning and analysis systems to meet the highest military standards for US and NATO forces. Beyond military aerospace, FTIR spectroscopy may be used to certify oxygen or breathing air cylinders used by fire fighters or scuba divers, or to evaluate environmental samples.

Learn more at **thermofisher.com/antarisigs**