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Some images courtesy of BAE and Divex
INTRODUCTION

Analox Military Systems (AMS) is part of the Analox Group, a specialist producer of gas detection solutions for hostile environments. AMS was created in 2011 specifically to meet the requirements of the military market. Its continuing success is the result of innovations such as miniaturised infra-red gas sensors that work at hyperbaric pressures. Analox gas detectors are now widely installed in submarine rescue vessels and the company supplies its products to more than 20 countries.

AMS monitoring equipment is used in the life support systems of our clients to both protect and sustain lives. Our manufacturing and service centre is fully compliant with all UK export licensing requirements and International Traffic in Arms Regulations (ITAR). AMS is wholly committed to pushing the boundaries of what can be achieved in hostile, safety critical environments. Not only do we develop standard, cutting-edge gas monitoring equipment, we can also provide you with bespoke solutions to meet specific needs.
EXPERTISE

As an active participant in the submarine escape and rescue community since 1997, Analox has extensive experience in designing and manufacturing submarine atmosphere monitoring systems. These adaptable technologies find applications not only in escape and rescue but also in systems which are used for special operations, diver deployment and routine gas analysis. We are committed to using our expertise to become the first choice for atmosphere monitoring for the world’s submarine nations.

As a supplier of bespoke solutions for submarine atmosphere monitoring we understand the complexities of the environment in terms of pressure, temperature and humidity variations. Requirements vary between types of submarine and different solutions can be tailored to suit the needs of diesel electric, air-independent propulsion (AIP) and nuclear boats. Monitoring systems typically incorporate one or more of the following technologies:

- centralised atmosphere analyser
- distributed sensor network using gas specific sensors
- carbon monoxide detectors
- CO, O2, CO2, and refrigerant gas detectors
- portable backup and emergency analysers
CENTRALISED ATMOSPHERE ANALYSER

Analox’s Centralised Atmosphere Analyser (AA) can monitor up to 30 different gases from various locations around the boat. This is ideal for nuclear boats which need to sample a large number of gases at low concentrations. The AA is typically installed in a central location and supplied with sample lines from a number of locations around the boat. Multiple analysers can be connected together to provide system redundancy.

The AA provides real-time continuous monitoring of life support gases such as oxygen, carbon dioxide, carbon monoxide, hydrogen and refrigerants. Non-standard gases are also continually monitored, but generally only displayed on request. These include methanol, hydrogen cyanide, hydrogen chloride, oxides of nitrogen, sulphur dioxide and specific hydrocarbons.

The gases are detected by using a combination of sensor technologies; a mass spectrometer and FTIR (Fourier Transform Infra Red) analyser, which offer the following benefits:

• ideal for monitoring low (ppm) concentrations of trace gases
• can be programmed to look at new gas species as they become of interest through the boat’s operational life
• has potential to identify unknown pollutants in the atmosphere by doing a mass scan

The Atmosphere Analyser has a datalog capability, which allows data to be downloaded to both a USB storage device and hard drive. A digital output to the submarine’s platform management system via RS485 can also be provided.
DISTRIBUTED SENSOR NETWORK

Analox’s distributed sensor network comprises a centrally located PLC user interface linked to discrete gas sensors or sensor modules located around the boat. Typical gases monitored include oxygen, carbon dioxide, carbon monoxide, hydrogen, in addition to refrigerant gases, submarine pressure and humidity. This system is ideal for diesel boats which need to monitor life-support gases and contaminants to MPC60 minute and MPC24 hour limits but may have limited space.

A distributed sensor network offers:
• flexible system architecture
• any number of sensors, or integrated sensor blocks can be connected to the central display
• sensors can be tailored to suit the requirements of the Navy, updated throughout the boat’s life as requirements or technology advances
• HMI repeater displays could be located in different locations on the boat
• optional UPS for emergency use
• sensors located in the area where the gas poses a direct risk
• central display of information from all remote sensors
• password protected ‘Admin’ mode data logging and retrieval via USB port
• data output to central submarine platform management system
CARBON MONOXIDE MONITORING

CO monitoring in the submarine environment requires a different technology than that used in off-the-shelf carbon monoxide detectors. Standard electrochemical sensors are extremely cross-sensitive to hydrogen, making them unsuitable for use in the submarine environment. AMS’s solution for routine CO monitoring of the submarine atmosphere is the COSAMS unit (Carbon Monoxide Submarine Atmosphere Monitoring System) which uses an infra-red measuring technique, which ensures it is not cross sensitive to hydrogen. A multi-gas version of the system is also available (COSAMS+). These are both described below.

COSAMS

COSAMS offers continuous, real-time monitoring of CO in the living accommodation and machinery spaces. The maximum permissible concentrations (MPCs) of CO allowed on submarines vary from nation to nation and with the type of boat, diesel electric, AIP, nuclear, owing to their different submergence times. A typical continuous exposure level would be between 15 to 25ppm, with higher limits (up to 175ppm) in emergency situations e.g. 60 minute and 24 hour limits, and it’s these limits which define the measuring range for the COSAMS unit.

CO is measured with an infra-red (IR) sensor using a gas filter correlation technique, this sensor is ideal for use where accurate low level measurements are required or where background gases have the potential to interfere with the measurement. CO absorbs infra-red light at 4.66μm of the electromagnetic spectrum. A narrow band-pass optical filter is fitted between the IR source and detector to only allow light at 4.66μm to reach the detector.

The more gas present the more light is absorbed and the lower the signal reaching the detector. Water vapour also absorbs IR light at 4.66μm so this effect must be eliminated.

The gas filter wheel contains a reference filter and a measuring filter, by looking at the relative IR absorption of the system when the reference filter is present in the optical path versus when the measuring filter is present, it is possible to reject IR absorption from sources other than CO. This technique allows the sensor to effectively ignore the presence of water and make accurate CO measurements in high humidity environments, such as those found on a submarine.

Analox then apply our unique pressure and temperature correction technology to the IR sensor to ensure the COSAMS unit will provide an accurate reading of CO in the submarine environment, particularly during submarine snorkelling.
The COSAMS+ provides CO, O₂, and CO₂ monitoring in one fixed unit, making it ideally suited to the living and machinery spaces. It offers:

- a local display of information and local alarms
- local monitoring of gas hazards in the areas where they present the greatest risk
- modular design allowing additional sensors to be added during the boat’s life
- combined sensor block which enables fast and easy calibration, minimising maintenance tasks for the crew

An internal sample pump is used to draw a sample of submarine air over the sensors inside the unit, which is displayed on the unit, and could be sent via Ethernet back to a central PLC or the submarine platform management system. COSAMS+ incorporates our unique pressure and temperature correction technology to ensure the sensors will provide accurate readings of gases in the submarine environment, particularly during submarine snorkelling.

The specifications are:

- power supply: 115/230VAC or 24VDC
- size: 479(h) x 280(w) x 175(d) mm
- weight: <18kg
Accurate monitoring of the submarine atmosphere is crucial in selecting the appropriate course of action. In any DISSUB situation the senior survivor has to decide whether to continue waiting for rescue or to initiate an emergency escape. This decision must be informed by accurate, up-to-date information on the submarine’s atmosphere. Analox’s portable analyser the Sub MkIIP is specifically developed in response to this requirement, and offers an effective alternative to the traditional solution which involves pressure correcting colorimetric tubes.

**SUB MkIIP PORTABLE ANALYSER**

Analox’s market-leading portable analyser for operation in a DISSUB situation, the Sub MkIIP, is designed specifically for submarine escape situations. The Sub MkIIP is currently the only portable, continuous analyser of its type capable of meeting NATO STANAG 1320 Ed 4 ‘Minimum requirements for atmospheric monitoring equipment located in submarines with escape capability’. During its development phase the Sub MkIIP was subjected to extensive testing, including DISSUB and Survivex exercises. It is validated to be operational over a 0.8 to 10BarA pressure range, from 0°C to 40°C, in up to 100% relative humidity.

The Sub MkIIP’s internal batteries provide sufficient power for more than seven days of continuous real-time measurements of partial pressure oxygen, partial pressure carbon dioxide, depth and temperature. This feature provides reassurance to survivors in a DISSUB who face a stressful and difficult situation. As atmospheric conditions deteriorate the elevated concentrations of carbon dioxide pose a hazard to health, and the decreasing oxygen levels affect decision-making. The Sub MkIIP is designed to be quick and easy to use, whilst ensuring accuracy and reliability are never compromised.
SUB MkIIIF FIXED ANALYSER

The Sub MkIIP shares its technological heritage with a fixed analyser unit, the Analox Sub MkIIIF, which is used to monitor the atmosphere in submarine rescue vehicles and surface decompression chambers. The Sub MkIIIF measures not only the levels of partial pressure oxygen and partial pressure carbon dioxide but also the pressure, temperature and relative humidity of the environment. The Sub MkIIIF control panel is mounted at atmospheric pressure in the pilot compartment or the chamber and it may be connected to up to three remote sensor modules installed inside the hyperbaric/pressurised compartment. These two units share many features and are intended to complement each other in a single-source monitoring solution for escape and rescue.

CASE STUDIES

In recognition of these capabilities Analox was commissioned in 2003 to provide atmosphere monitoring instruments for the NATO Submarine Rescue System (NSRS). These were installed in the submarine rescue vehicle, the transfer-under-pressure system and the mother ship decompression chamber. In a similar project in 2004 Analox provided atmosphere monitoring equipment for the US Navy submarine rescue vehicle (SRDRS PRM), including main and backup systems for both the pilot and rescue compartments. Additional commissions included the design, manufacture and supply of submarine gas monitoring systems to the Japanese Navy. These were installed on the rescue vessels Chihaya and Chiyoda and the research submarine Shinkai 6500. More recently Analox has supplied hyperbaric monitoring systems to James Fisher Defence for use on both the Singapore SRV DSAR-6 and the Swedish Navy SRV URF. These systems employ Analox’s latest intelligent sensors and modular construction techniques to allow the equipment to be maintained and supported by the customer.
PORTABLE GAS MONITORS

Portable monitors may be used as an emergency backup to a main atmosphere monitoring system or for specific uses such as confined space entry.

The Sub Aspida is a dual O2/CO2 portable monitor for routine monitoring of the submarine atmosphere. This offers partial pressure O2 and CO2 monitoring over the submarine operating pressure range without giving false alarms. The Sub Aspida has both audio-visual and vibration alarms and is designed to be maintained by the customer.

Operating ranges are:
- O2 range: 0 to 1200mBar ppO2 (or 0 to 100%)
- CO2 range: 0 to 5%

Analox also offer the 100HYP, a compact partial pressure oxygen analyser which is a great value alternative to colorimetric tubes.
SPECIAL FORCES DEPLOYMENT

Submarines are increasingly used for the insertion of Special Forces for covert missions. This brings military diving into the submarine environment – with a need to monitor the partial pressure of gases within the hyperbaric compartments on the boat to ensure divers are compressed and decompressed safely.

This brings an interesting set of challenges, not only in the design of the gas monitoring system but also in the selection of materials suitable for a hyperbaric (enriched oxygen) atmosphere. Another challenge is to provide breathable air for the divers – either when they are in the diving chambers or breathing from dive cylinders. The concentration of contaminants allowed in diving grade air are significantly lower than those allowed in submarine air so if the submarine air is being used to fill dive cylinders this can be problematic, this is where AMS can help, contact us to discuss your specific requirements.
AMS DESIGN CAPABILITIES

AMS has extensive experience in designing and manufacturing both commercial off-the-shelf (COTS) and bespoke atmosphere monitoring systems. We understand the issues faced on a submarine for example the specific requirements for shock, vibration, noise, material selection and the dynamic changes in temperature and pressure on board. Interference from other gas species can also make it problematic to use standard industrial sensors or readily available commercial off-the-shelf sensors.

EQUIPMENT THROUGH-LIFE SUPPORT

AMS is proud of the high level of support offered to customers. Support commences with presales advice and ongoing support through the purchasing process – then continues with aftersales care. AMS products’ in-service life and design life means a piece of equipment may need to be supported for 15 to 30 years.
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