THE FIFTH TRIENNIAL
INTERNATIONAL AIRCRAFT FIRE AND CABIN SAFETY RESEARCH CONFERENCE

Atlantic City, New Jersey, USA
October 29th -November 1st, 2007

FUEL TANKS EXPLOSION PROTECTION SYSTEM FLIGHT TEST AND NEW FRONTIERS

D. Cannoletta[1], G. Iazzetta[1], K. Susko[2], M. Shahriari, M. Lagarese[1], A. Della Rocca[1], D. Scalvini[3]
[1] *Technical Direction - Airframe Systems, Alenia Aeronautica S.p.A., Pomigliano D'Arco*
[2] *President - Aviation Safety Facilitators Corporation, Elmont, New York*
[3] *Technical Direction - Flight Test, Alenia Aeronautica S.p.A., Pomigliano D'Arco*

Nowadays all the military and civil authorities are promoting the fuel tanks protection for safety and security issues. For instance, the TWA 800 accident occurred on Boeing 747 flying over New Your on July 17th 1996 and the loss of RAF C-130K Hercules in Iraq during January 2005 military operations highlighted this improvement as urgent and mandatory. Much research has been performed in order to demonstrate that fuel tank inerting is an effective protection against the known ignition sources coming from thermal effects, electrical sparks and small caliber bullets. The latter risk has gathered high resonance on the aviation stakeholders, both in civil and military field, due to the recent unfortunate terrorist events.

Alenia Aeronautica has gained a proven experience through first turboprop application on G222-AAA aircraft, toward the innovative evolution on C-27J programme.

Figure 1: C-27J Aircraft

The aircraft is equipped with an inerting system that is integrated with the onboard platform to generate nitrogen enriched air delivered to the fuel tanks. The operation is ensured by On Board Inert Gas Generating System (OBIGGS) that relies on air separation membranes to treat the air supply, filtering the nitrogen and venting the oxygen outboard.

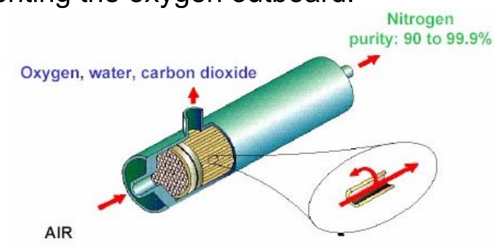

Figure 2: Air Separation Membrane

The next frontier of the technology is related to the monitoring feature checking the system effectiveness and allowing the crew action. The capability is strongly required by the civil authorities to meet the certification standards and by the military forces to enable critical missions. In fact, the improvement allows the flight crew to be promptly informed about any malfunction. In this case, the maintenance can be invoked or the flight profile can be changed, as required. For instance, a military intervention can be safely aborted leaving low altitude operations close to hostile regions and preventing any attack from the ground. The procedure compensates the aircraft vulnerability following system failure. The enabling technology is focused on the oxygen probes reading the oxygen concentration in the fuel tanks to confirm that the value is below the safety level. Unfortunately, even if the oxygen sensors are widely diffused, no application is already available for fuel tanks installation due to the equipment contamination by the fuel vapors.

For the first time on C-27J aircraft, a monitoring system has been developed

exploiting oxygen probes that process optical signal and are compliant with fuel environment.
The operational principle is based on the encapsulation of luminescence complexes in fuel resistance glass/ceramic coating to measure the oxygen partial pressure. By the way, oxygen as a triplet molecule is able to quench efficiently of the luminescence of certain luminophores. This effect is called "dynamic fluorescence quenching." Collision of an oxygen molecule with a fluorophore in its excited state leads to a non-radiative transfer of energy.
The degree of fluorescence quenching relates to the frequency of collisions, and therefore to the concentration, pressure and temperature of the oxygen-containing media.
The flight test instrumentation for C-27J aircraft military certification integrated a monitoring system to record the oxygen concentration in the main and auxiliary tanks on the right wing for the inerting system performance verification.
The measurement system architecture was composed of the following equipment:

- 3 electronic boxes
- 3 computer boxes
- 10 oxygen probes
- 1 keyboard
- the thermocouple wires and an the optical fibers routing

In fact, a thermocouple has been embedded in each oxygen probe for the relevant effect compensation. However, the acquisition system was completed by two separate sensors measuring the absolute pressure in each fuel tank. The correlation was performed in a deferred calculation for the final measurement of the oxygen concentration.

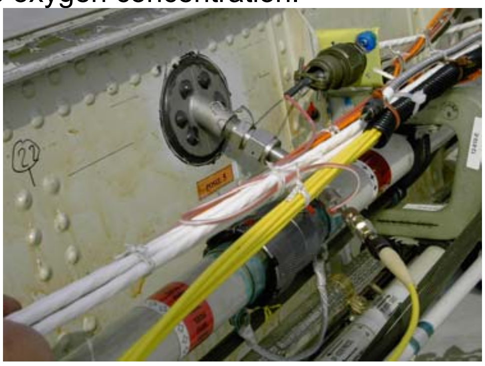

Figure 3: Oxygen Probe Installation

For certification purpose, the probes must be installed in the most critical areas with the maximum oxygen concentration, ensuring that everywhere the value is below the safety level.
This issue opens the view on another strategic capability about the prediction of oxygen concentration distribution in the fuel tanks. For this purpose, the probes installation on C-27J was driven by the fuel tank models reproducing the inert gas distribution in the internal structure.

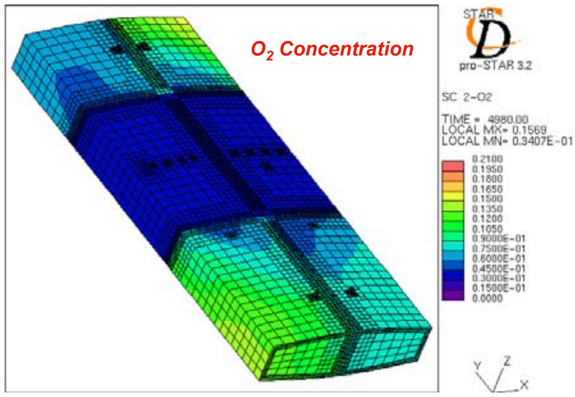

Figure 4: Oxygen Concentration Simulation

The successful test campaign, resulted in C-27J certification (July 2006), demonstrated the maturity of this technology. Further developments are in progress on the oxygen probes improvements (such as adding pressure and temperature sensor embedding optical fiber) and on the avionic integration.

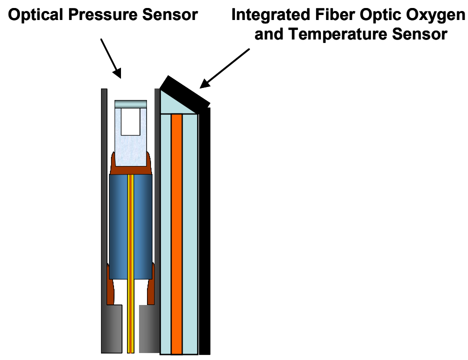

Figure 5: Real Time Oxygen Probe Concept

The upgrading steps are aimed at the real time measurement availability at point of sample, to the flight crew for the transmission to the advisory caution alert warning system. The achievement allows the integration of the fuel tanks protection system with the relevant monitoring system as industrial application.