OBIGGS / OBOGS STUDY (WITH SPECIAL EMPHASIS ON OXYGEN ASPECTS)

AIR LIQUIDE TECHNIQUES AVANCEES

FRAME OF THE STUDY

- Study ordered by the DGAC (Direction Générale de l 'Aviation Civile) to Air Liquide and Airbus France

- The purpose of the study is to combine the skills of an on board gas generating systems supplier and an aircraft manufacturer to investigate the main issues related to the future installation of OBOGS (On Board Oxygen Generating System) and OBIGGS (On Board Inert Gas Generating System) in commercial aircraft

⇒ The study will hence rely on « real systems in real aircraft »

PARTICIPANTS

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\+ Several experts in the field of OBIGGS/OBOGS systems, system certifications specialists, physiologists, airline maintenance people

AIR LIQUIDE
TECHNIQUES AVANCEES

TARGET OF THE STUDY

The following systems are considered for the three safety requirements :

- **Fuel Tank Explosion Protection System**
  - OBIGGS for fuel tank inerting (refer to K. Beers presentation)
- **Cargo Compartment Fire Protection System**
  - Combination of water mist system for fire knockdown and OBIGGS for cargo compartment inerting (refer to K. Kallergis presentation)
- **Emergency Oxygen System for cabin decompression**
  - OBOGS for on line oxygen supply to the passengers for protetion against hypoxia

SPECIAL EMPHASIS ON OBOGS

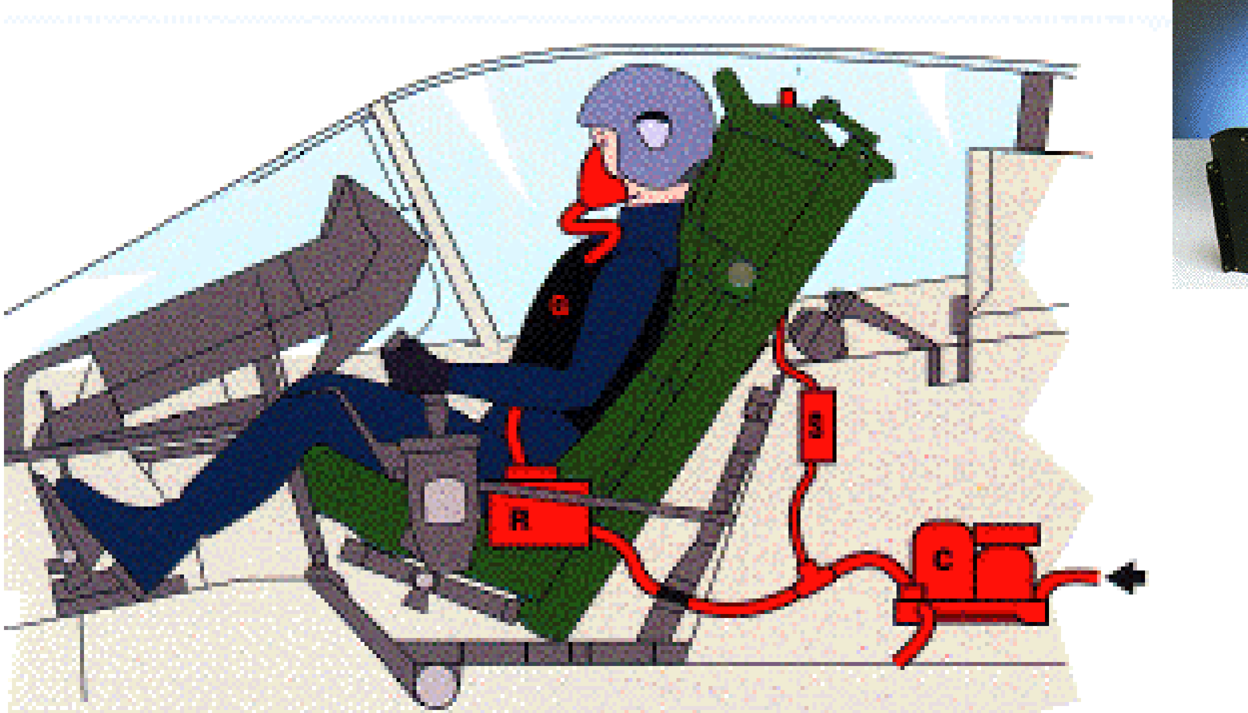
- **In the frame of long range operations, the on site generation of oxygen would reduce the hazard related to stored oxygen in HP cylinders as well as increase the flexibility of the aircraft**

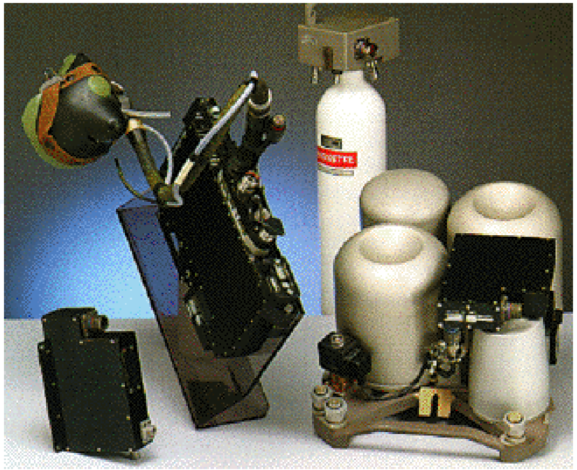
- **OBIGG systems for fuel tank inerting and cargo compartment fire protection have been intensively addressed in other working groups :**
  - **Fuel Tank Harmonization Working Group**
  - **FIREDETEX Consortium**

- **Interest of aircraft manufacturers have been raised to install OBOG systems, justifying the focus made on OBOGS**

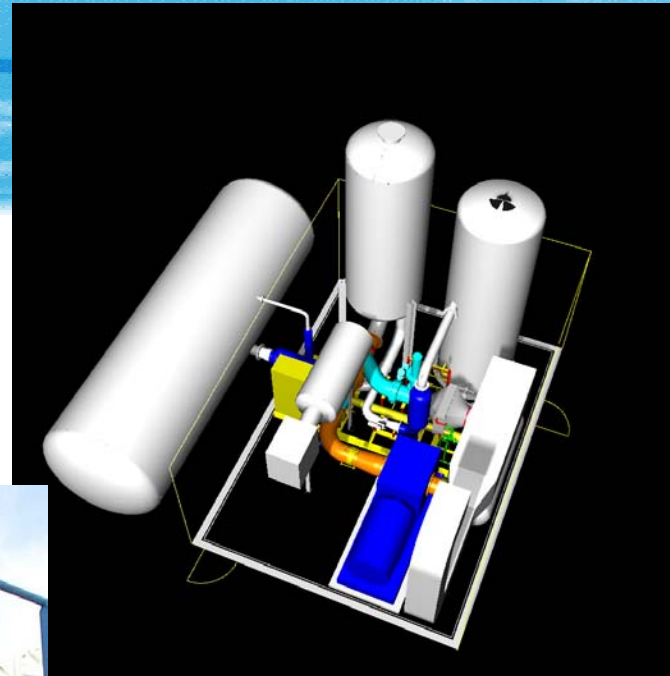
OBOGS EQUIPMENT FOR MILITARY AIRCRAFT

Unlimited on board oxygen supply





INDUSTRIAL APPLICATIONS



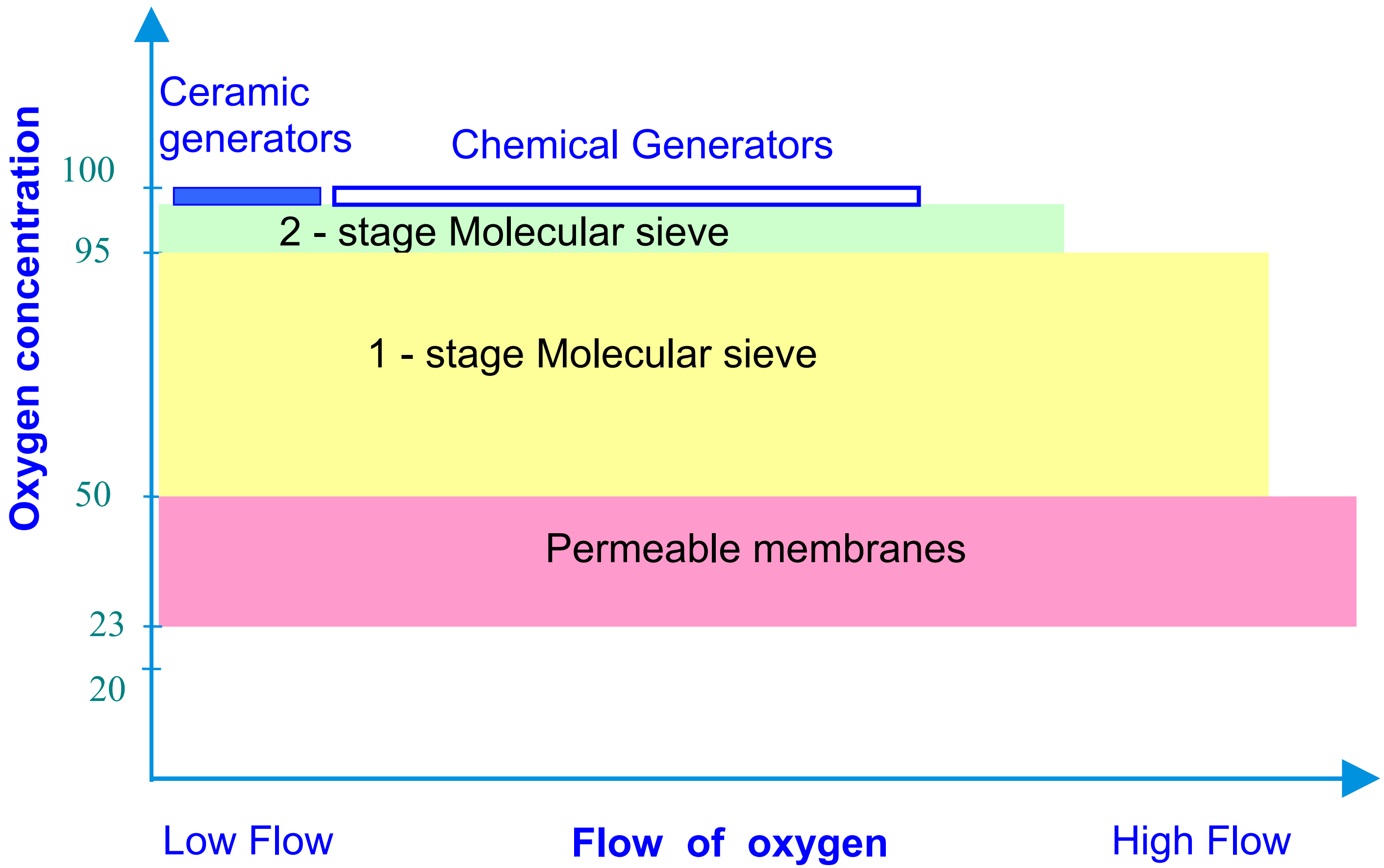
From 8 to 130 t/d

STUDY ORGANIZATION

- **Progress report n°1 - OBIGGS/OBOGS** - *Completed*
  - Analysis of the oxygen and nitrogen needs aboard commercial aircraft
  - State of the art of suitable air separation technologies
- **Progress report n°2 - OBIGGS/OBOGS** - *Completed*
  - Evaluation of systems size and systems consumption
  - Comparison with power and fluid availability on board long range aircraft
- **Progress report n°3 - OBOGS** - *In Progress*
  - Certification issues
- **Final report** - *End of 2001*
  - Technical synthesis
  - Commercial issues
  - Introduction to TSO for OBOG systems under responsibility of DGAC

ON SITE OXYGEN GENERATION TECHNOLOGIES

TECHNOLOGY TRADEOFF - OXYGEN

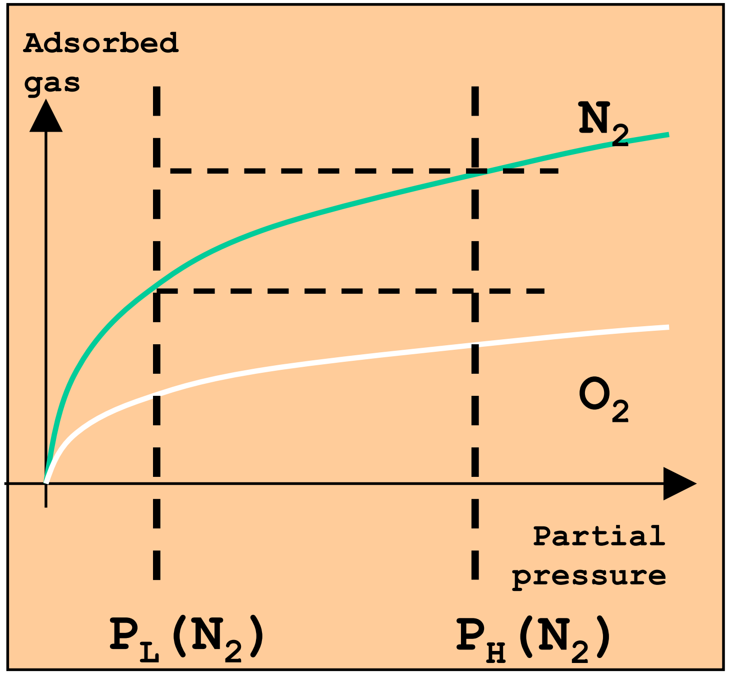


MOST SUITABLE TECHNOLOGY FOR LARGE AIRCRAFT OBOGS

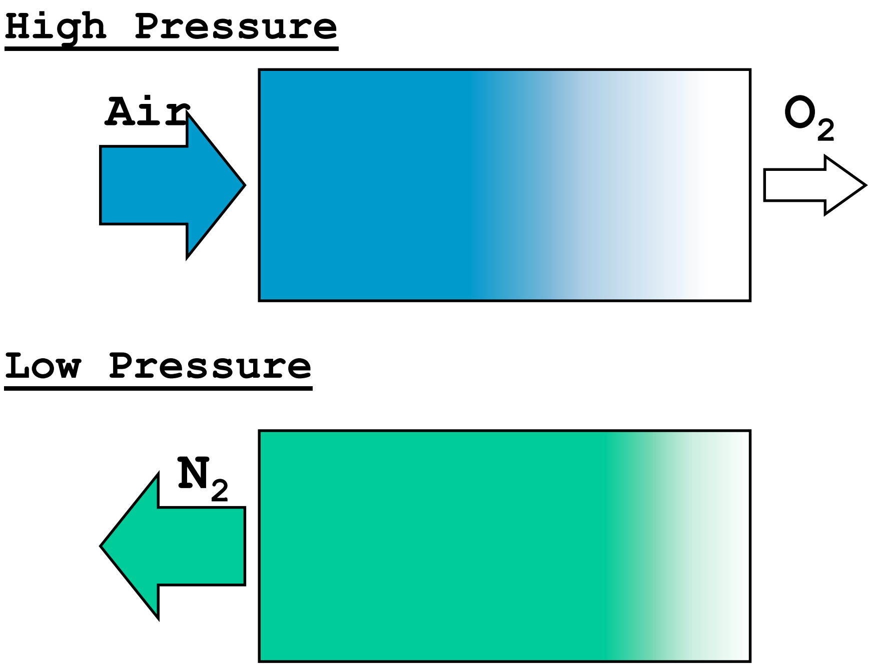
⇒ **Molecular sieve technology:**

- Technically : Best trade-off quantity / quality of oxygen
- Economically : Cost effective solution for on-site oxygen separation
- Historically : Years of experience of Air Liquide in on-site systems for the industry and the aeronautics
- Reliability and availability of molecular sieve based systems
- Compatibility with aircraft power and fluid availability

MOLECULAR SIEVES PRINCIPLE



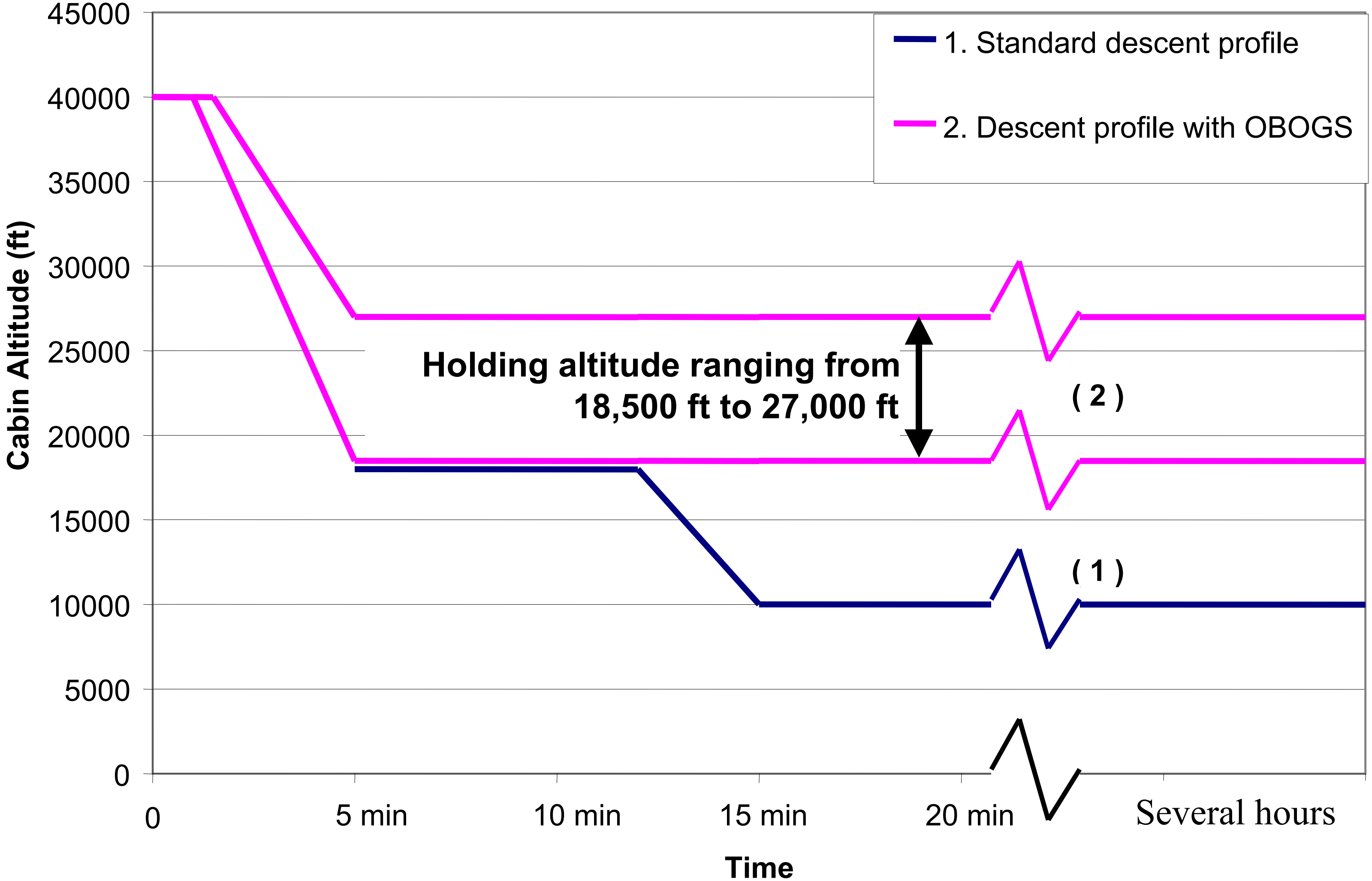
Pressure Vacuum Swing Adsorption



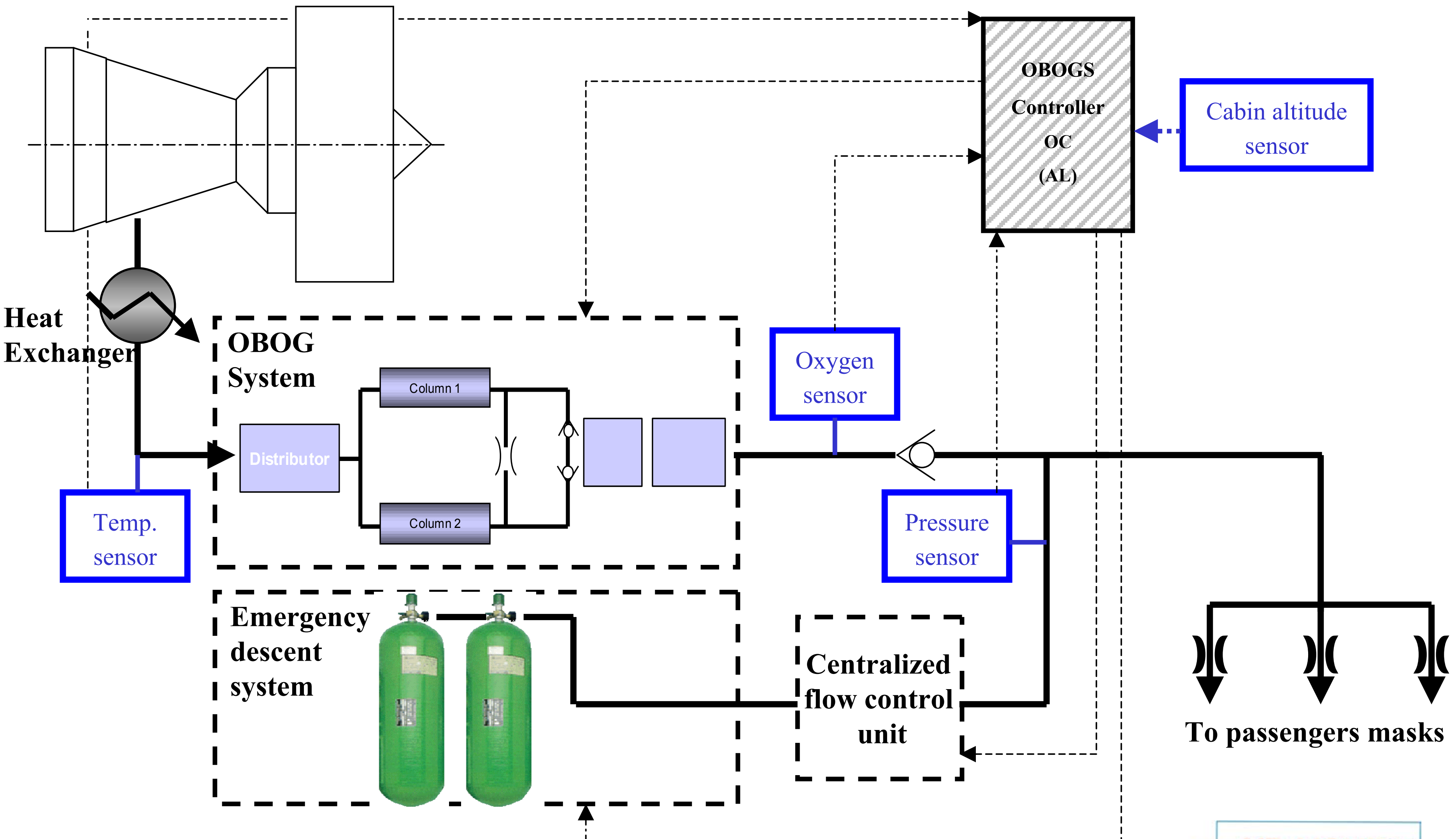
High Pressure : 1100 / 2000 mbar
Low Pressure : 300 / 500 mbar
Purity : 60 / 93 %

SYSTEM DESIGN AND INTEGRATION

DESCENT PROFILE WITH OBOGS



PROPOSAL OF ARCHITECTURE (PAX OBOGS)



BLEED AIR AND POWER AVAILABILITY

- **Power**

  Providing OBOGS with electrical power does not pose any difficulty due to the low electrical power required by the system

- **Bleed air**
  - **The OBOGS being a safety system, it is necessary to consider the possible failure of part of the engine bleed air system or conditioning pack.**
  - **For several long range aircraft, the air mass flow and the bleed air pressure available according to the number of bleeds and conditioning packs operative have been determined under normal and de-icing conditions.**
  - **It turns out that during a diversion flight, there is more than the minimal bleed air pressure and mass flow required by the OBOGS.**

AIR LIQUIDE TECHNIQUES AVANCEES

CERTIFICATION ISSUES

CONTENT OF CERTIFICATION STUDY

1. Availability of bleed air after decompression (Common mode) 2. Hazard analysis regarding fire risk in the cargo compartment and engine rotor burst	System installation
3. OBOG System reliability and system safety analysis (SSA)	System design
4. Compatibility of OBOGS with FAR/JAR requirements	Regulation

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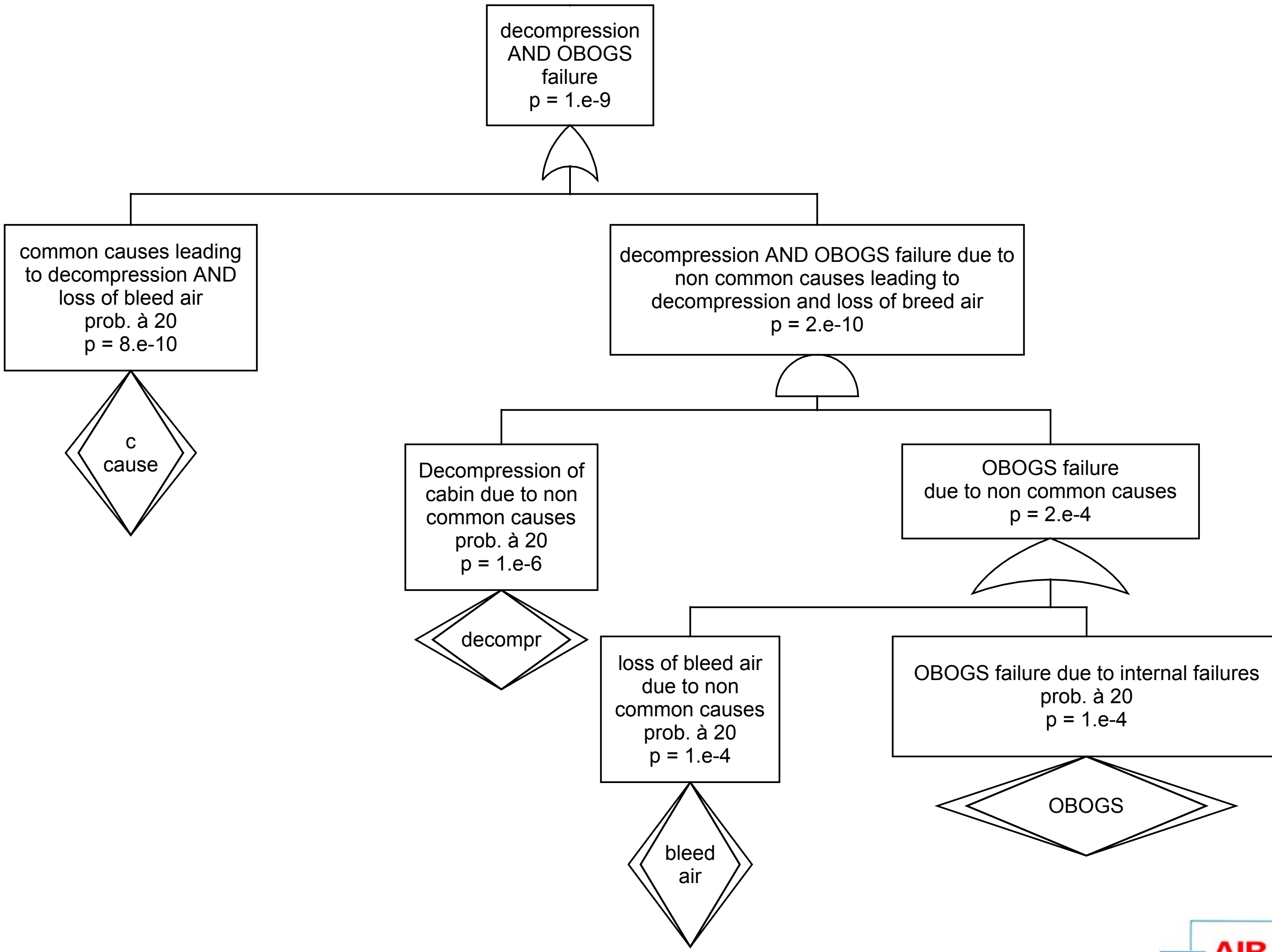
TECHNIQUES AVANCEES

1. AVAILABILITY OF BLEED AIR AFTER CABIN DECOMPRESSION

COMMON MODE


decompression AND OBOGS failure
p = 1.e-9
common causes leading to decompression AND loss of bleed air
prob. à 20
p = 8.e-10
c cause
decompression AND OBOGS failure due to non common causes leading to decompression and loss of breed air
p = 2.e-10
Decompression of cabin due to non common causes
prob. à 20
p = 1.e-6
decompr
OBOGS failure
due to non common causes
p = 2.e-4
loss of bleed air due to non common causes
prob. à 20
p = 1.e-4
bleed air
OBOGS failure due to internal failures
prob. à 20
p = 1.e-4
OBOGS

COMMON MODE - CONCLUSIONS

Analysis of the quantitative objective for « decompression AND OBOGS failure » leads to the following requirements:

- Probability of OBOGS internal failure after decompression < 10-4 per FH

  ⇒ Achievable for OBOGS

- Probability of common causes leading to decompression AND loss of bleed air (engine burst) < 8 10-10 per FH

  ⇒ Concerns bleed air system only and not OBOGS (OBOGS design has no impact on that undesirable event)

  ⇒ Necessity for the aircraft manufacturer to make bleed air system reliable (segregation of bleed air collected samples, use of isolation valves)

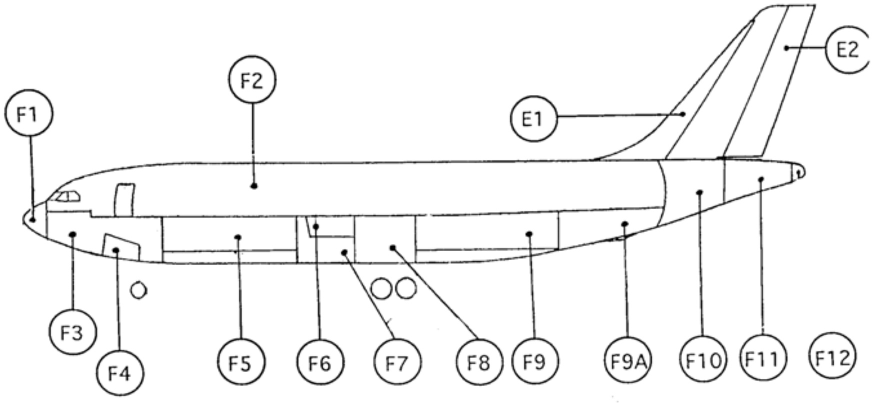
2. HAZARD ANALYSIS

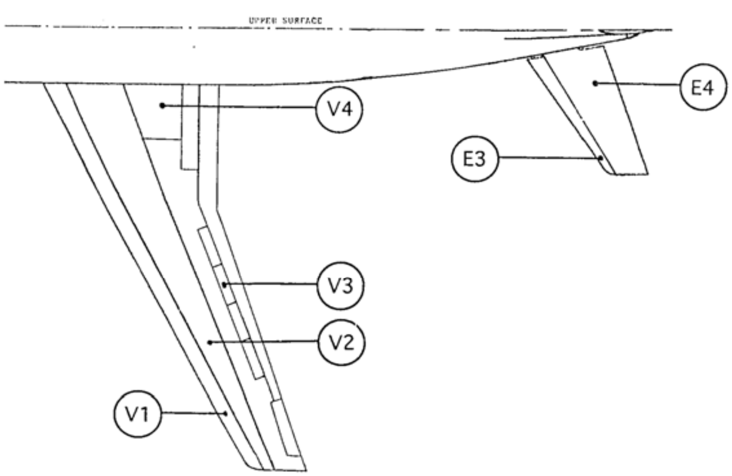
OBOG SYSTEM PARTICULARITIES

- **Oxygen production pipe**
  - ⇒ Similar to standard gaseous systems
- **Bleed air inlet pipe**
  - ⇒ Bleed air architecture must provide improved segregation against engine rotor burst events
- **Evacuation of nitrogen enriched air**
  - ⇒ Avoid long evacuation pipe susceptible to create dangerous leaks in the zones crossed through (a particular zone susceptible to house such an outboard port is the belly fairing) and to decrease the system efficiency

AIR LIQUIDE TECHNIQUES AVANCEES

FIRE EXPLOSION RISK ANALYSIS

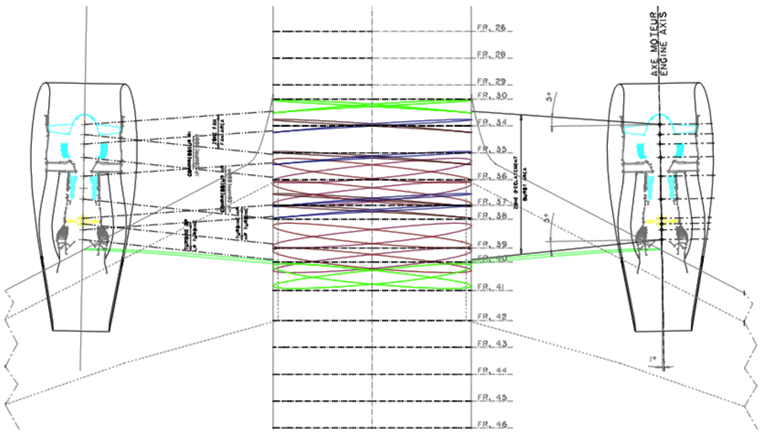


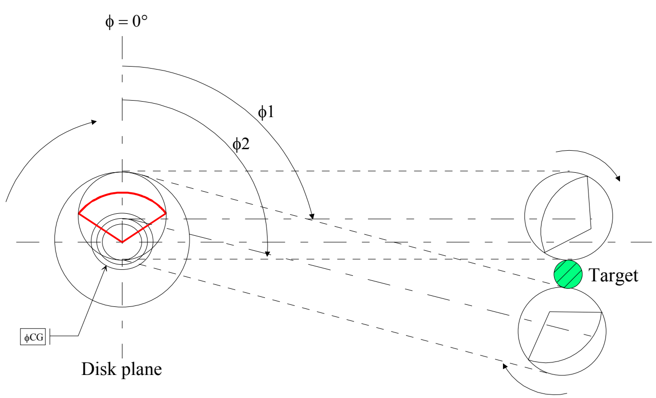


- Verification of the impact of the system on the global safety of the airplane from the fire risk standpoint

- Aircraft divided into various zones delimited by its frames

ENGINE ROTOR BURST ANALYSIS





- Analysis of the consequences on the system of an uncontained engine rotor failure
- Design precautions are required. They are addressed through specific electronic tools.

3. SYSTEM SAFETY AND RELIABILITY ANALYSIS

SAFETY ANALYSIS - APPROACH

- Three probabilistic objectives:
  - Probability that EVENT 1 (minimum required flow of breathing gas is not available)
  - Probability that EVENT 2 (minimum required oxygen concentration is not available)
  - Probability that EVENT 3 (purity requirements of AS8010C are not fulfilled for the breathing gas)
- Three fault trees to define the subsystems failures leading to each undesirable event
- Fault trees calculations on the basis of subsystems failure rates and corrective maintenance frequencies

MAINTENANCE POLICY

The following maintenance policy is proposed and taken into account in the safety objectives calculations :

- Electronics and valves : test before each takeoff
- Performance test : in-flight test

4. FAR/JAR REQUIREMENTS

PROTECTION AGAINST HYPOXIA

- **Hypoxia is defined as any state in which the oxygen in the lung, blood and/or tissues is abnormally low compared wih that of a normal resting person breathing air at sea level.**

- **Protection against hypoxia (FAR/JAR 25.1443 § c.2)**

  For passengers and cabin attendants, the minimum mass flow of supplemental oxygen required for each person at cabin pressure altitudes above 18,500 ft may not be less than the flow required to maintain a mean tracheal oxygen partial pressure of 83,8 mmHg when breathing 30 LPM BTPS.

  ⇒ It shall be demonstrated that the OBOGS oxygen output concentration (ranging from 60 to 93%) can meet the requirement provided that the flow rate is increased

CONCLUSIONS

CONCLUSIONS

- OBOGS permits to increase aircraft flexibility as well as to reduce the hazards related to stored oxygen when long diversion times are considered

- Status of OBOGS study :
  - System architecture, system size and system integration parts of the study are completed
  - System certification part of the study is in progress

- Study will permit to give to the DGAC the elements to eventually work on a TSO for OBOG systems in the near future.