New oxygen sources for passengers of transport aircrafts

Henri Marotte
AsMA
May 16, 2013
Abstract #442
I have the following financial relationships to disclose:
• Consultant for: Zodiac Aerospace

I will not discuss off-label use and/or investigational use in my presentation
Transport aircrafts, composite materials
3 275 dm$^3$ of oxygen,
Empty weight: 8,2 kg
Total weight: 12,6 kg
h=0,91 m, Ø=0,229 m.
O$_2$ weight = 35% of total weight

On-board oxygen (existing technologies): gaseous oxygen

current materials: 
O$_2$ weight = (about) 10% of total weight
On-board oxygen (existing technologies): gaseous oxygen

**Advantages**
- simplicity,
- reliability,
- everywhere in the world,
- not expensive,
- all the systems supplied with GOX are compatible with this technology (supply pressure close to 5 bars (350 psi))
- A tight cylinder keeps its oxygen for a very long time.
Disadvantages

- operational: heavier and larger than other means of storage, because
- the logistics is everywhere limited to 127 bars (1,850 psi).
- But, instead of this limitation, there is a risk of burst; in consequence:
  - the maintenance is expensive,
  - and it is anticipated legal limitations on the in-flight transport and use of gaseous systems, at least over a certain volume.
On-board oxygen (existing technologies): gaseous oxygen

**Applications**: large!

- for all flight desk crewmembers,
- for passengers against the risk of depressurization (half of the aircrafts),
- other oxygen sources for passengers,
- **MEDEVAC**.
On-board oxygen (existing technologies): liquid oxygen

**Principle:**
2 concentric envelops, with a strong thermal insulation (convective and radiative)

**Advantages:**
smaller weight and size (compared to GOX).

**Example:** a 10 liter converter contains 8 m³ (STPD) of gaseous O₂
empty weight: 8 kg, total weight: 19.5 kg
382 x 372 x 314 mm

**Various Disadvantages**
...
- Risk of degradation of the materials of the cabin structure in case of contact with cryogenic liquid.
- Replenishment not possible everywhere.

**Very few applications for MEDEVAC (in civilian applications)**
On-board oxygen (existing technologies): chemical generators

Based on the exergonic degradation of the sodium chloride

\[ 2 \text{Na ClO}_3 \rightarrow 2 \text{Na Cl} + 3 \text{O}_2 + 105 \text{kJ} \]

with undesirable or utilitarian reactions (examples):

\[ \text{Fe} + \frac{1}{2} \text{O}_2 \rightarrow \text{FeO} \]
\[ 3 \text{Na ClO}_3 + \frac{3}{2} \text{O}_2 \rightarrow 3 \text{Na ClO}_4 \]
\[ 2 \text{Na ClO}_3 \rightarrow \text{Na}_2 \text{O} + \text{Cl}_2 + \frac{5}{2} \text{O}_2 \]
\[ \text{Cl}_2 + \text{BaO}_2 \rightarrow \text{BaCl}_2 + \text{O}_2 \]

with 1 g Na ClO\(_3\) : 0.45 g O\(_2\) = 0.32 dm\(^3\) STPD O\(_2\)

Applications:
only for the passengers, in case of depressurization (half of the transport aircrafts)
No application for MEDEVAC.
On-board oxygen: oxygen concentrators

Terminology

Historic

Physical principles

Current products

Advantages / Disadvantages

Proposals for MEDEVAC.
On-board oxygen: oxygen concentrators

Terminology

Aeronautics:
OBOGS = On-Board Oxygen Generating System
MSOC = Molecular Sieve Oxygen Concentrator
PSA = Pressure Swing Absorber

Medical (sometimes):
oxxygen extractors
On-board oxygen: oxygen concentrators

Terminology

Historic

Physical principles

Current products

Advantages / Disadvantages

Proposals for MEDEVAC.
Historic (aviation):

1970’s: (mainly) request from the US Navy

1978: first prototype with good performances (Bendix, USA)

then tests of OBOGS on AV-8B « Sea Harrier » and EA-6B « Prowler »,
then on F-16 of USAF
On-board oxygen: oxygen concentrators

Historic (aviation):

1970’s : (mainly) request from the US Navy

1978 : first prototype with good performances (Bendix, USA)
then tests of OBOGS on AV-8B « Sea Harrier » and EA-6B « Prowler »,
then on F-16 of USAF

in France:
1981 : beginning of the French « OBOGS » program
for (initially) Mirage 2000, then Rafale

1990’s : flights on two-seats test-aircrafts in Flight Test Center
(α-Jet and Mirage 2000)
then OBOGS was defined as standard equipment for Rafale
On-board oxygen: oxygen concentrators

Terminology

Historic

Physical principles

Current products

Advantages / Disadvantages

Proposals for MEDEVAC.
The functioning of an oxygen concentrator is based on the separation of gases on a zeolite (complex aluminosilicate) column. The gaseous mixture is injected under pressure at the input of the column. The first part of the output gas is directed to the crew. The remaining part is rejected.
About the gas separation: it is impossible to obtain pure oxygen with standard OBOGS, because the noble gases of the atmosphere are concentrated as well (better?) as oxygen. Theoretically: 95 % oxygen. Practically: 92 % oxygen.
Comment on the output gas pressure: low!
On-board oxygen: oxygen concentrators

Terminology

Historic

Physical principles

Current products

Advantages / Disadvantages

Proposals for MEDEVAC.
On-board oxygen: oxygen concentrators

some military aircrafts (with French OBOGS)

L-159

JSF (F-35)

A400M
OBOGS for Airbus A 380
170 kg – to supply 600 passengers after cabin depressurization, without duration limitation.
On-board oxygen: oxygen concentrators

Terminology

Historic

Physical principles

Current products

Advantages / Disadvantages

Proposals for MEDEVAC.
On-board oxygen: oxygen concentrators

Advantages / Disadvantages

Advantages:
- Unlimited production of oxygen-enriched gas, when energy is available.
- No on-board oxygen storage;
- No on-board high-pressure lines.

Disadvantages:
- Oxygen available only when (at least one) engine turns,
- (very) low supply pressure at the output of the OBOGS, with the need to adapt all the oxygen systems supplied by the OBOGS.
- «oxygen-enriched» gas only - and not pure oxygen.
On-board oxygen: oxygen concentrators

Terminology

Historic

Physical principles

Current products

Advantages / Disadvantages

Proposals for MEDEVAC.
On-board oxygen: oxygen concentrators

Proposals for MEDEVAC

2 OBOGS were built for usual aviation applications
- built and/or proposed by Zodiac Aerospace (France);
- this company knows the requests of medicine,
- and proposed an adaptation of these 2 OBOGS for an on-board medical use.
On-board oxygen: oxygen concentrators

SeQual (Z. in France)
- manufacturer of medical oxygen concentrators,
- with a model « aviation » for US-Army, dedicated to helicopter operations,
- target in altitude: 15-18 000 ft
- gas flow: 3 l/min (ATPD)
- enrichment: 90 %
- available « pulse » function
- electrical supply on vehicle (multistandard) or on battery
- 5,5 kg, l = 68 cm, Ø = 11 cm
- 100 W
OBOGS in development by AVOX systems (Zodiac group) for general aviation

performance:
- 6 l/min at > 90 % O₂
- 8 l/min at 70 % O₂

12 kg, 72 x 20 cm
28 V x 15 A
New oxygen sources for passengers of transport aircrafts

2 OBOGS were developed for general aviation purposes, certified for aeronautic use, (very) interesting for on-board oxygen therapy.

The manufacturer is ready to adapt them for medical use aboard an aircraft.

- Are You Buck Danny, the airman?
  
- No, I’m George, the asthmatic!

Thank you for your attention!