Jacques CHAVAGNE
Mechanical Instructor
Airbus Training Center
Customer Services

Oxygen safety

1. Introduction

Oxygen (O2) is vital for most forms of life on earth. Yet, at high concentration it may become hazardous. In the light of recent oxygen related aircraft incidents, it seems adequate to remind operators, flight crews, mechanics that the gas so commonly associated with survival may, in some circumstances, be dangerous.

This article will first present O2 characteristics in a normal environment, as found in the air around us. It will then show the potential dangers of oxygen at high concentration levels. The third part will describe where oxygen is to be found in aircraft.

Last but not least, the fourth part will present recommended safety precautions for working around oxygen systems.

2. Oxygen in the surrounding air

O2 is naturally present in the air we breathe at a concentration of approx 21%, the rest is mainly nitrogen.

One of the characteristics of oxygen is that it is an oxidant. In fact it is the most common oxidizing agent, hence the name.

This means that oxygen is one of three elements needed for fires to develop.

The second element is fuel, which may be solid, liquid or gaseous.

The third element, in the form of heat or spark, is needed to trigger the combustion (fig.1).

3. Oxygen enriched atmosphere

Fires in oxygen enriched environments are characterized by higher intensities and temperatures and by a more rapid combustion than their equivalents in normal environments. The higher the concentration of oxygen, the more explosive the result. Even a small increase in the oxygen level, from 21% to 24%, can create a dangerous situation. It becomes easier to start a fire, which will then burn hotter and more fiercely than in normal air.

Materials which will not ignite at normal oxygen concentration levels, may burn in an oxygen enriched environment.

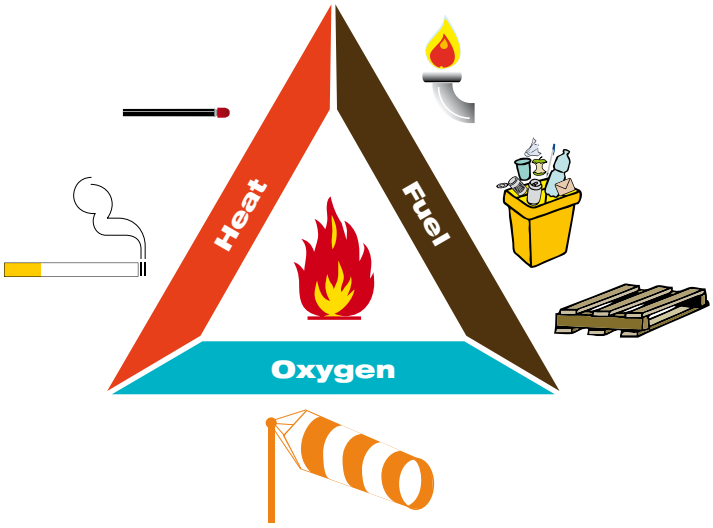
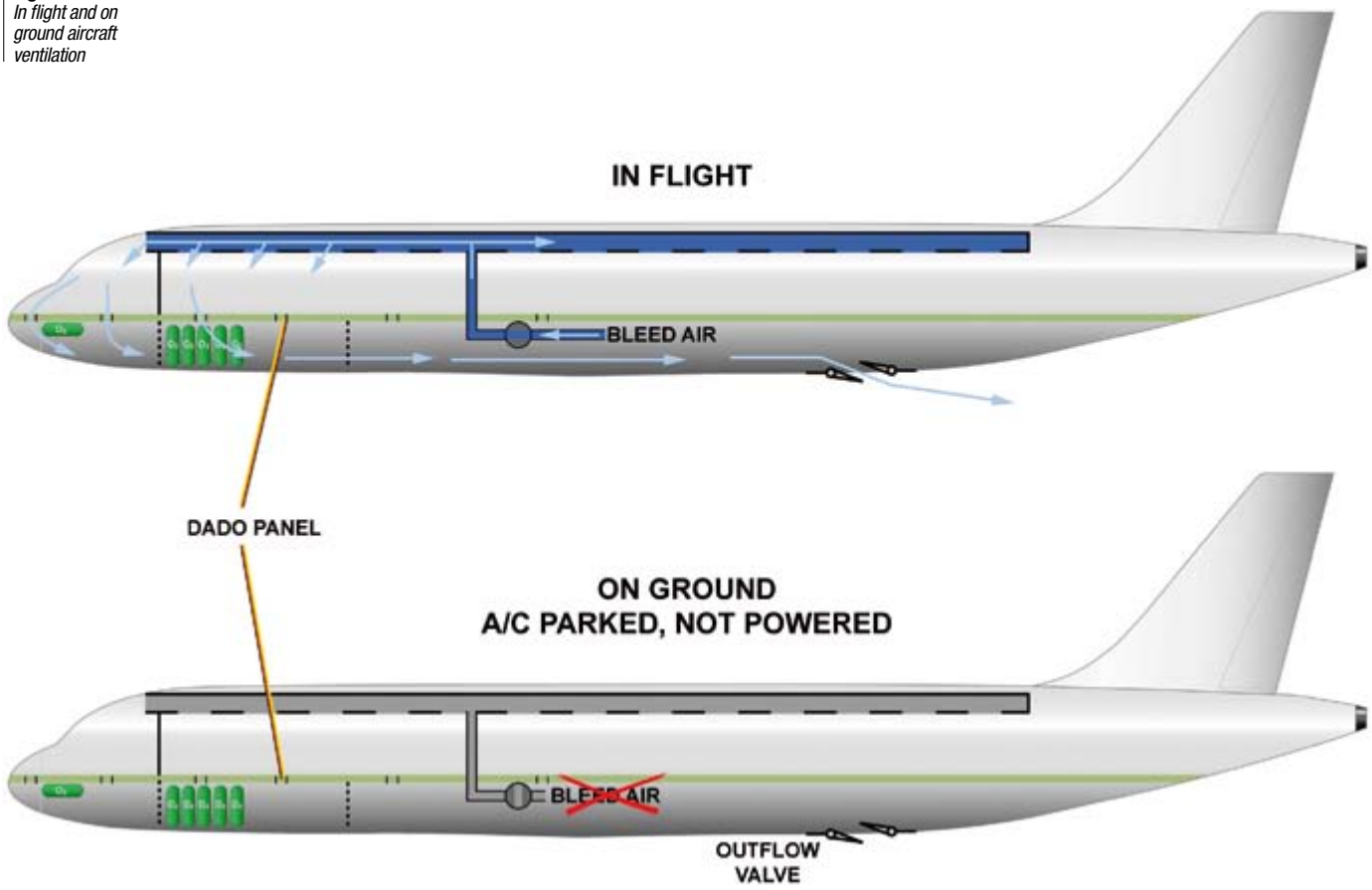


Figure 1
The fire (chemical reaction) can start if there is enough heat, fuel and oxygen.

Figure 2
In flight and on ground aircraft ventilation



Fire and explosion hazards may develop, even at ambient temperature and in the absence of sparks, when O2 at high concentration levels is set in contact with commonly found materials such as hydrocarbons, oil and grease.

4. Aircraft oxygen systems

Oxygen is present in Airbus aircraft in the following three systems:

- The flight crew O2 system, which is supplied by one (optionally two to four) cylinder(s).
- The passenger oxygen system, which is supplied by either O2 chemical generators or O2 gaseous cylinders (up to 18).
- The portable oxygen system, which includes first aid O2 cylinders.

The oxygen bottles are located in confined areas (avionics bay, vicinity of cargo compartments etc…). When the aircraft is flying, these areas are ventilated and leaking oxygen is expected to be evacuated by the aircraft's air conditioning system, through the outflow valve(s) (fig.2).

5. Safety precautions

5.1. Ventilate oxygen enriched environments

When the aircraft is on the ground, the confined areas containing the oxygen cylinders and distribution lines are not ventilated anymore, and oxygen leaks will lead to hazardous enriched oxygen environments.

A leaking valve or connector in a poorly ventilated space can quickly increase the oxygen concentration to a dangerous level. Personnel entering confined areas containing oxygen bottles should therefore be aware of the potential dangers of 02 enriched environments.

O2 being invisible and odourless, it is not detected by human senses. The only safe method to determine the level of oxygen in a confined zone is to use an oxygen detector before entering the area. High readings should lead the personnel to leave and ventilate the compartment.

5.2. Avoid ignition sources

When working on oxygen systems, whether during oxygen servicing or oxygen components removal and installation, beware of potential ignition sources.

This is important as oxygen leaks may go undetected or develop during maintenance actions.

Figure 3
Raw flame from cigarette

Figure 4
Clothes ventilation, at least 15 minutes

Figure 5
Electrical discharge from cell phone

Figure 6
Open the valves slowly

CAUTION TO OPEN BOTTLE

1 - OPEN THE VALVE SLOWLY 3-4 TURNS
2 - WAIT FOR PRESSURE STABILIZATION (90 SECONDS)
3 - FULLY OPEN VALVE

There are numerous potential sources of ignition, herewith a non-exhaustive list:

► Raw flames, from cigarettes for example. It is important to keep in mind that clothes and hair tend to absorb oxygen, consequently people exposed to an oxygen enriched atmosphere should refrain from smoking for at least 15 minutes after leaving the O2 enriched area (fig.3 & 4).

► Incandescent particles, from grinding or drilling for example. It is important to stop all operations that cause heat and flames. As a general rule, avoid all maintenance activities less than 5m (15ft) away.

► Electrical overheating (from electrical engines, poor contact…).

► Electrical discharge from static electricity or from a short circuit for example.

Remember to ground the aircraft and oxygen servicing equipment and to bond them together. Put a warning notice in the cockpit, the work area and the cabin to warn not to operate electrical switches during the oxygen filling procedure.

Do not use mobile phones. If there is a risk of lightning during thunderstorms, stop all oxygen servicing operations (fig.5).

Other non –obvious sources of ignition may be oxygen overheating due to:

► Too rapid pressure build-up when servicing the system. Ensure that the pressure in each oxygen cylinder increases smoothly.

► Too rapid opening or closure of oxygen valves can result in high oxygen velocities causing frictional heat. Open the hand-valves of the oxygen cylinders very slowly, and turn them to the fully open position (fig.6).

(if hand-valves are not fully opened before flight, the oxygen pressure readings on the ECAM page may be incorrect).

► Impacts on the oxygen bottles (heating by molecular agitation).

5.3. Avoid non-compatible materials

As mentioned above, oxygen will react to certain substances.

It is therefore important to watch for the following:

► The oxygen components, as well as the area around them, must always be cleaned with approved cleaner; before and after any work done on the system.

► Clothing, skin and equipment (tools, rags etc…) should be clean and free from oil, grease and hydrocarbons in general.

► Keep your hands clean (if possible, wear cotton gloves). Do not touch connection ends nor the inside of oxygen components with bare hands, as skin oil and bacteria are a source of contamination (fig.7).

► Stop all procedures that use flammable material such as cleaning and de-icing materials.

► Stop all refueling and all repairs on fuel and hydraulic systems.

► Keep all hydrocarbons (fuels, corrosion protection compounds, lubricants, etc.) away from sources of oxygen (fig.8).

5.4. Beware of non authorized procedures

Make sure that you use the correct Airbus documentations (tasks in AMM, Part number in IPC, SB...) and carefully follow the maintenance procedure instructions.

Keep the following recommendations in mind to avoid injury to people and damage to equipment:

► When servicing, only use aviator's breathing oxygen as defined by Airbus.

► Never use oxygen for other purposes such as tire or accumulator inflation, blowing of dust etc...

► During oxygen components removal and installation, make sure that the ground support equipment is approved for oxygen systems.

Figure 7
Keep Clothes, skin and equipment clean

WARNING: NEVER USE STANDARD OIL TO LUBRICATE THE CONNECTOR THREAD. ONLY USE LUBRICANTS AND THREAD COMPOUNDS SPECIFICALLY APPROVED FOR OXYGEN SYSTEMS.

Figure 8
Use only oxygen systems approved lubricant

Figure 9
Use two wrenches during disconnection/reconnection of connectors and torque at right value

► During leak detection, make sure that the leak detector and test equipment are approved for oxygen systems.

► When removing or installing oxygen components, make sure that all oxygen cylinder valves are closed. Due to possible residual pressure in the lines, disconnect the connectors carefully. Put dry, clean, metal or plastic plugs on all pipes or units removed temporarily. Put each pipe or unit in a sealed vinyl bag.

► During disconnection/reconnection of an oxygen line connector use two wrenches, one for the nut and one for the counter nut, to avoid force onto the material (risk of rupture and leakage) (Fig. 9).

► Make sure that the flexible hoses are not twisted or pulled tight. If the hoses are twisted or pulled tight, the connections will break and cause a leak.

► Torque the connection at the right value, given by the Maintenance Manual, and make sure there is no leak by using an oxygen leak detection spray.

► Open and close the spring-loaded clamps carefully to prevent damage to the electrical harnesses near the oxygen cylinders.

5.5. On-aircraft oxygen servicing recommendation

In order to maintain the oxygen system integrity it is recommended, if authorized by the local authorities, to perform the oxygen servicing on the aircraft using the external refilling port (optional for crew – standard for cabin).

Remember: each cylinder removal is an additional risk of leak.

6. Conclusion

To summarize, remember that higher concentrations of oxygen are dangerous and represent a risk of fire and explosion, especially when the aircraft is not flying and therefore not ventilated.

O2 is invisible and odorless and cannot be detected by human senses. The only safe method of determining the oxygen level is to use oxygen detectors.

Two safety precautions, among many others, deserve to be emphasized:

► Do not smoke where oxygen is being used.

► Never use oil or grease to lubricate oxygen equipment.

As a general rule, when working on oxygen systems, use only equipment approved for oxygen use, keep it clean and work carefully and safely by following the correct procedures, as specified in the Airbus documentation.

Safety First

The Airbus Safety Magazine

For the enhancement of safe flight through increased knowledge and communications

Safety First is published by the Flight Safety Department of Airbus. It is a source of specialist safety information for the restricted use of flight and ground crew members who fly and maintain Airbus aircraft. It is also distributed to other selected organisations.

Material for publication is obtained from multiple sources and includes selected information from the Airbus Flight Safety Confidential Reporting System, incident and accident investigation reports, system tests and flight tests. Material is also obtained from sources within the airline industry, studies and reports from government agencies and other aviation sources.

All articles in Safety First are presented for information only and are not intended to replace ICAO guidelines, standards or recommended practices, operator-mandated requirements or technical orders. The contents do not supersede any requirements mandated by the State of Registry of the Operator's aircraft or supersede or amend any Airbus type-specific AFM, AMM, FCOM, MEL documentation or any other approved documentation.

Articles may be reprinted without permission, except where copyright source is indicated, but with acknowledgement to Airbus. Where Airbus is not the author, the contents of the article do not necessarily reflect the views of Airbus, neither do they indicate Company policy.

Contributions, comment and feedback are welcome. For technical reasons the editors may be required to make editorial changes to manuscripts, however every effort will be made to preserve the intended meaning of the original. Enquiries related to this publication should be addressed to:

Airbus
Product Safety department (GS)
1, rond point Maurice Bellonte
31707 Blagnac Cedex - France
Fax: +33(0)5 61 93 44 29
safetycommunication@airbus.com

A380
Serial Number 004 cold weather trials in Iqaluit, Nunavut, Canada.

Safety First, #09 February 2010. Safety First is published by Airbus S.A.S.. 1, rond point Maurice Bellonte. 31707 Blagnac Cedex/France. Editor: Yannick Malinge, Vice President Flight Safety, Nils Fayaud, Director Product Safety Information. Concept Design by Airbus Multi Media Support Ref. 20100055. Computer Graphic by Quat'coul. Copyright: GSE 420.0010/10 Photos copyright Airbus. Photos by ExM Company: H. Berenger, P. Masclet, H. Goussé. Computer rendering by Abac Effect. Printed in France by Airbus Print Centre.