

Safety first

The Airbus Safety Magazine

Edition February 2010

CONTENT:

- ▶ A320 Family/
Evolution of ground spoiler logic
- ▶ Incorrect pitch trim setting
at takeoff
- ▶ Technical Flight Familiarization
- ▶ Oxygen safety



Issue 9

New Standards. Together



AIRBUS

Safety First

The Airbus Safety Magazine

For the enhancement of safe flight through
increased knowledge and communications

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Yannick MALINGE

Vice President
Flight Safety

Editorial

Dear Customers and Aviation
Safety Colleagues,

We have now started a new year, and looking back at 2009, statistics confirm that runway excursions remain the main category of accidents in air transport.

In the last issue of this magazine, we presented two new system features developed by Airbus to help flight crews during the critical landing and takeoff phases: the Runway Overrun Protection System (ROPS) and the TakeOff Securing function (TOS).

In this issue we have as well two articles devoted to these flight phases:

- “A320 Family/ Evolution of ground spoiler logic”.
- “Incorrect pitch trim setting at takeoff”.

The other two articles of this magazine concentrate on topics for which the specific environment requires to reinforce awareness of either pilots or mechanics.

- Technical flights.
- Maintenance work on aircraft oxygen systems.

These topics, and many others, will be reviewed during our next Flight Safety Conference in Brussels on March 15th to 18th, where we look forward to meeting the representatives of all our operators.

Yannick MALINGE
Vice President Flight Safety

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Magazine distribution

If you wish to subscribe to Safety First, please fill out the subscription form that you will find at the end of this issue.

Please note that the paper copies will only be forwarded to professional addresses.

Your articles

As already said, this magazine is a tool to help share information.

Therefore, we rely on your inputs. We are still looking for articles from operators that we can help pass to other operators through the magazine.

If you have any inputs then please contact Nils Fayaud at:

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Safety Information on the Airbus websites

On the different Airbus websites we are building up more and more safety relevant information for you to use.

The present and previous issues of Safety First can be accessed to in the Flight Operations Community- Safety and Operational Materials chapter-, at <https://w3.airbusworld.com>

Other safety and operational expertise publications, like the Getting to Grips with...brochures, e-briefings etc...are regularly released as well in the Flight Operations Community at the above site.

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Erratum

In the article titled « Fuel spills during refuelling operations » published in issue #8 of Safety First, the second paragraph of chapter 3/ Guidance Material should read:

“Under normal circumstances the auto-refuel will close the refuel valve at the requested fuel-on-board preselected value. High-level sensors within the fuel tank will also automatically close the valve if high-level is reached.

On later programmes (A330/A340/A380) if the high level sensors fail, then an additional overfill sensor in the surge tanks, if wet, will automatically close the valve.

However the basic step requested in the AMM for all aircraft refuel procedures is the high level / overfill sensor test via the dedicated pushbutton on the refuel panel.”

News

16th Flight safety conference

Brussels, 15-18 March 2010

The preparation for this year's conference is well underway. It will be held from the 15th to the 18th of March 2010 in Brussels. A provisional agenda has been defined and the invitations have been sent out in December 2009.

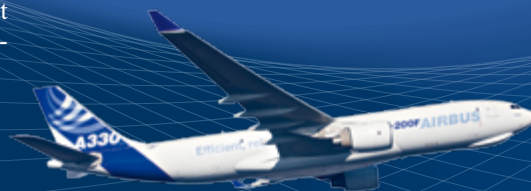
Please note that this is a conference for Airbus and our customers only. We do not accept outside parties into the conference so as to ensure that we can have an open forum for everybody to share information.

If you are an Airbus customer and have not yet received an invitation or if you would like to receive information regarding registration and logistics, please contact Nuria Soler at:
e-mail: nuria.soler@airbus.com
fax: +33 (0) 5 61 93 44 29

As always we welcome presentations from you. The conference is a forum for everybody to share information, so if you have something you believe will benefit other operators and/or Airbus, please contact Christopher Courtenay at:

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We look forward to meeting you all at the conference !



**Stéphane BOISSEININ**

Engineer, Handling Qualities
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Engineer, Flight Control Systems
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A320 Family/ Evolution of ground spoiler logic

1. Introduction

Ground spoilers reduce the lift produced by the wings and hence transfer the weight of the aircraft to the landing gear, allowing a more effective wheel braking action.

Their non or untimely extension has been a factor in the following types of A320 Family events:

- The absence of spoiler extension contributed to increase the stopping distance during landing.
- The untimely spoiler extension contributed to a number of hard landings.

In both cases, the cause could be traced back to non arming of the ground spoilers and/or inappropriate thrust levers positions during the flare.

To reduce the frequency of these events, Airbus has modified the spoiler extension logic.

The new logic is now tolerant to inappropriate speed brake and/or thrust levers positions.

This modification applies to the complete as well as to the partial ground spoiler extension.

It was achieved by creating a new standard of Spoiler Elevator Computer (SEC), which is in charge of spoiler control, the SEC standard 120.

This article will describe:

- The current ground spoiler extension conditions.
- The identified causes of runway excursion and hard landings.
- How the new SEC standard will reduce the number of these occurrences.

2. Current ground spoiler extension conditions

2.1. Full extension

Depending on whether the ground spoilers have been armed or not, the following conditions must be met for their full automatic extension (as outlined in FCOM 1.27.10 p12):

- Ground spoilers armed (**fig. 1**)
 - Both main landing gears seen on ground.
 - Both thrust levers at or below Idle notch (**fig. 2**).

Figure 1

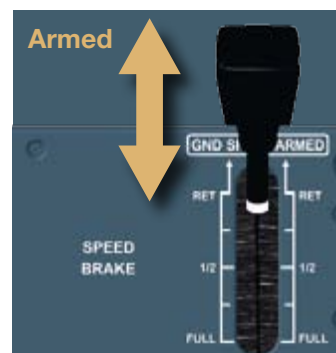


Figure 2



- ▶ Ground spoilers not armed (fig. 3)
 - Both main landing gears seen on ground.
 - Reverse is selected on at least one engine (the other thrust lever must be at or below Idle notch, fig. 4).

2.2 Partial extension

The Phased Lift Dumping function allows the ground spoilers to deploy with a reduced deflection and serves to accelerate the full spoiler extension when landing in crosswind conditions or on contaminated runways.

The necessary conditions to trigger the partial ground spoiler extension, independently of the position of the ground spoiler lever are:

- ▶ One main landing gear seen on ground.
- ▶ Reverse is selected on at least one engine (the other thrust lever must be at or below Idle notch).

3. In-service events

The genesis of this flight control computer modification is coming from two types of events:

3.1. Longitudinal runway excursion

Runway excursions resulted from the spoilers not extending during the landing.

This was traced to the following two causes:

- ▶ The speed brake lever was in a non retracted position (fig. 5).
- ▶ One engine throttle was not in the area that authorized ground spoiler extension (fig. 6).

3.2. Hard landings

Among hard landings, one specific category has been identified where by the hard landing occurred after a bounce. They fit to the following scenario (fig. 7):

- ▶ ❶ No engine throttle reduction (retard) during the flare → No ground spoiler extension.
 - ▶ ❷ Bounce induced by a too high energy level and by the lack of lift destruction.
 - ▶ ❸ Engine throttle reduction performed during the bounce → Ground spoiler extension if the retard is performed within 3 seconds following the first touchdown.
 - ▶ ❹ Severe hard landing due to sudden loss of lift leading to a fall from a height of about 5ft to 15 ft.
- It has been established that most of the hard landings occurring after a bounce are severe.

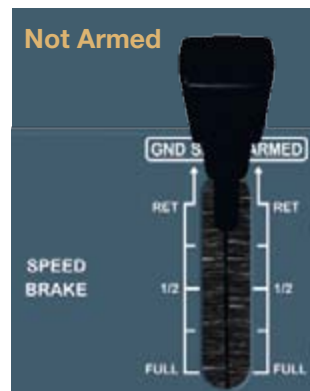


Figure 3



Figure 4



Full ground spoiler extension

Figure 5
The ground spoilers were not armed

Figure 6
The spoilers could not extend

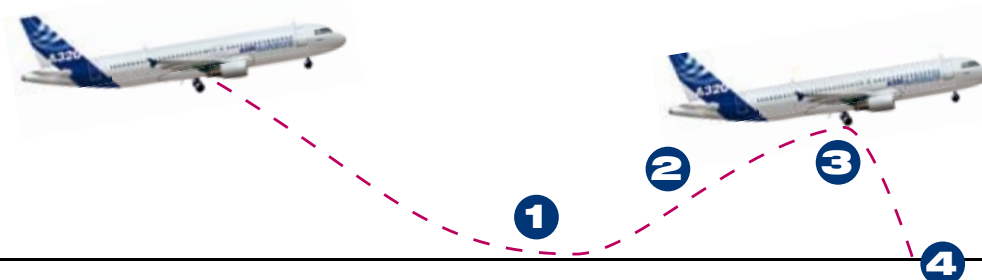


Figure 7

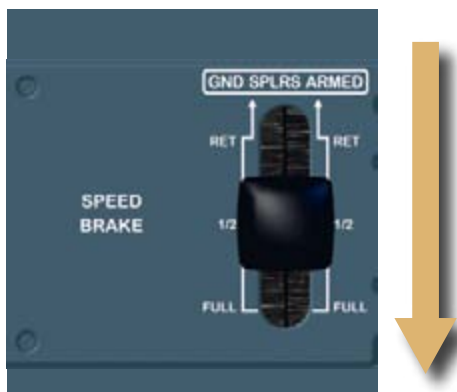


Figure 8
Expanded ground spoiler arming condition based on more tolerant speed brake lever position.

4. Expanded ground spoiler extension conditions

4.1. General philosophy

The Airbus philosophy regarding the ground spoiler activation logic is still based on the achievement of the following three conditions:

- ▶ Arming
- ▶ Ground detection
- ▶ Thrust lever position

The arming and thrust lever position conditions have been expanded to be more tolerant to inappropriate speed brake and thrust lever positions.

The ground detection condition has been expanded as well, albeit only for the partial ground spoiler extension, to address failures of ground detection sensors.

4.2. Changes introduced to limit runway excursions

The changes introduced by the new SEC 120 standard are highlighted in bold.

Complete ground spoiler extension conditions

- ▶ Ground spoilers armed or **speed brake lever in non retracted position (fig. 8).**
 - Both main landing gears seen on ground.
 - Both thrust levers at or below Idle notch **or Reverse is selected on at least one engine (the other thrust lever must be below the Maximum Continuous - MCT- notch).**

- ▶ Ground spoilers not armed (fig. 9)
 - Both main landing gears seen on ground.
 - Reverse is selected on at least one engine **(the other thrust lever must be below the Maximum Continuous - MCT - notch, fig. 10).**

Partial ground spoiler extension conditions

The partial ground spoiler extension conditions have been expanded to mirror the full spoiler extension conditions.

- ▶ Ground spoilers armed or **speed brake lever in non retracted position**
 - One main landing gear seen on ground.
 - **Both thrust levers at or below Idle notch.**
- ▶ Ground spoilers not armed
 - One main landing gear seen on ground.
 - Reverse is selected on at least one engine **(the other thrust lever must be below the Maximum Continuous - MCT - notch).**

note
All combinations that would trigger the full ground spoiler extension hide the partial ground spoiler extension.

4.3. Changes introduced to limit bounces at landing

A new spoiler extension logic is proposed on the SEC 120 to minimize the magnitude of the bounce in the event of an inappropriate thrust lever position during the flare.

Figure 10
Expanded ground spoiler extension condition based on more tolerant thrust lever position

Figure 9

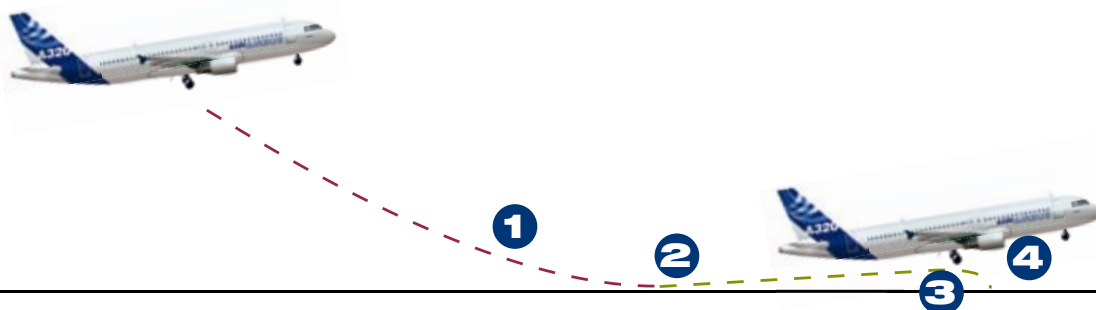
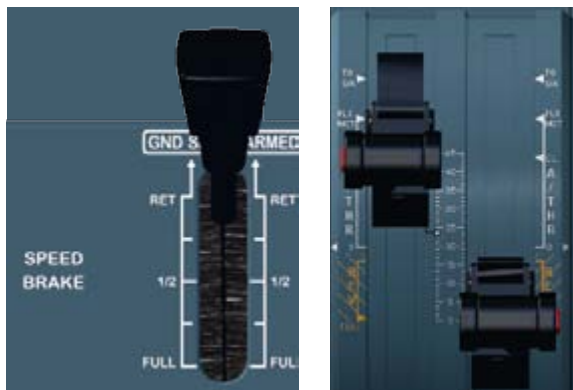


Figure 11

This logic provides some lift destruction through the partial extension of ground spoilers as soon as ground conditions are detected on both landing gears, as long as both thrust levers are at or below the Climb notch (ATHR).

New ground spoiler partial extension conditions:

- ▶ **Ground spoilers armed.**
- ▶ **Both main landing gears seen on ground.**
- ▶ **Both thrust levers at or below the Climb notch (ATHR).**

Landing scenario with SEC 120 (fig. 11):

- ▶ ❶ No engine throttle reduction (retard) during the flare → No ground spoiler extension.
- ▶ ❷ With the SEC 120 modification, the ground spoilers will extend partially at touchdown, as long as both engines levers are at or below the Climb notch (ATHR). Lift is decreased and the bounce is reduced or cancelled.
- ▶ ❸ As soon as the thrust lever conditions are fulfilled (for instance engine throttle reduction to Idle), the ground spoilers extend fully (if achieved within 3 seconds of the initial touchdown).
- ▶ ❹ As the height of the bounce is significantly reduced, the vertical speed at the second touchdown is largely reduced as well.

5. Conclusion

Runway excursion and hard landing events have prompted Airbus to develop a new standard of Spoiler Elevator Computer, the SEC 120.

Expansion of the ground spoiler extension conditions means that the spoilers will extend even when the speed brake and/or thrust levers are in inappropriate positions, thereby improving the aircraft's deceleration on ground.

In addition, a new ground spoiler partial extension logic has been developed to limit bounces that may lead to hard landings.

To summarize, the SEC standard 120 provides means to reduce:

- ▶ **Runway excursions by enabling:**
 - **Arming of the ground spoilers even when the speed brake lever is not retracted.**
 - **Extension of the ground spoilers even with a thrust lever above the Idle position.**
- ▶ **Hard landings by minimizing:**
 - **The number and amplitude of bounces by triggering partial spoiler extension at touchdown even with both thrust levers in the ATHR position.**

Annexe

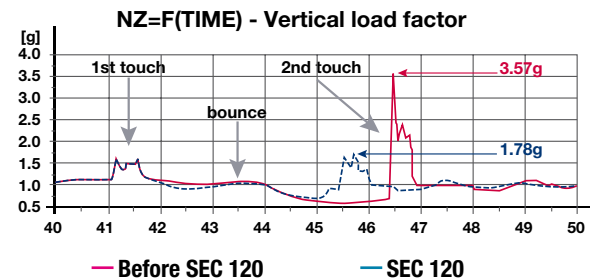
Hard landing effect following bounce is reduced by 50%.

The modification proposed to reduce bounce occurrences at landing has been validated using a back to back approach. A dozen of major hard landing occurrences following a bounce have been simulated with Airbus flight dynamics simulations tools with and without the partial ground spoiler extension at touchdown.

Without the partial spoiler extension at the first touchdown, the average vertical load factor at the second touchdown is about 3.2g.

With the SEC 120 modification allowing partial ground spoiler extension on ground even with thrust levers on Climb (ATHR) notch, the average load factor at the second touchdown is reduced to about 1.7g.

Example of typical hard landing event



Hard landings statistical breakdown

A statistical analysis has revealed that a significant bounce ($Nz > 1.6g$) occurs in about 50% of the hard landing events. In about half of those cases (i.e. 25% of all hard landings), the second impact is harder than the first one.

More globally, the ground spoiler extension during a bounce has been identified as the root cause of the hard landing in 15% to 20% of the cases. Moreover, those events also represent 40% of the cases with costly issues (aircraft grounded, structural damages, landing gear changes ...).

Computer hardware	Modification number	Service Bulletin number
B	150471	27-1198
B'	150857	27-1201

The SEC 120 will become production standard on A320 Family from MSN 4472 on.



Catherine BONNET

Group Manager Weight and Balance
Operational Performance
Customer Services

Incorrect pitch trim setting at takeoff

1. Introduction

In 2008, an A330 flight crew was surprised by the rapid rate of rotation of the aircraft at takeoff.

Analysis of the flight revealed that the crew selected an erroneous takeoff pitch trim setting. This trim setting was based on a Takeoff Center of Gravity (TOCG) determined through a simplified load and trim sheet calculation method. This TOCG did not correspond with the aircraft's CG at takeoff.

This event highlights three issues:

- ▶ The AFTER START procedure, which calls for the setting of the pitch trim according to the CG indicated on the ECAM, was not properly applied.
- ▶ The pitch trim setting was set according to a load and trim sheet TOCG instead of the ECAM CG.
- ▶ The TOCG on the load and trim sheet was erroneous, because of the simplified TOCG calculation method.

The aim of this article is to:

- ▶ Explain why this simplified TOCG calculation method can lead to differences between the calculated TOCG and the real TOCG at brake release.
- ▶ Propose an improved simplified TOCG calculation method.
- ▶ Highlight the existing Standard Operating Procedures (SOP) relating to the TOCG.

2. TOCG calculation methods

2.1. Complete calculation

To determine the TOCG (expressed in percent of the Mean Aerodynamic Chord, %MAC) it is necessary to determine the Takeoff Weight (TOW) and the Takeoff Index (TOI) (fig. 1).

The TOW and TOI are calculated with the following formulae:

$$\text{TOW} = \text{Zero Fuel Weight} + \text{Ramp Fuel weight} - \text{Taxi Fuel Weight}$$

$$\text{TOI} = \text{Zero Fuel Index} + \text{Ramp Fuel Index} - \text{Taxi Fuel Index}$$

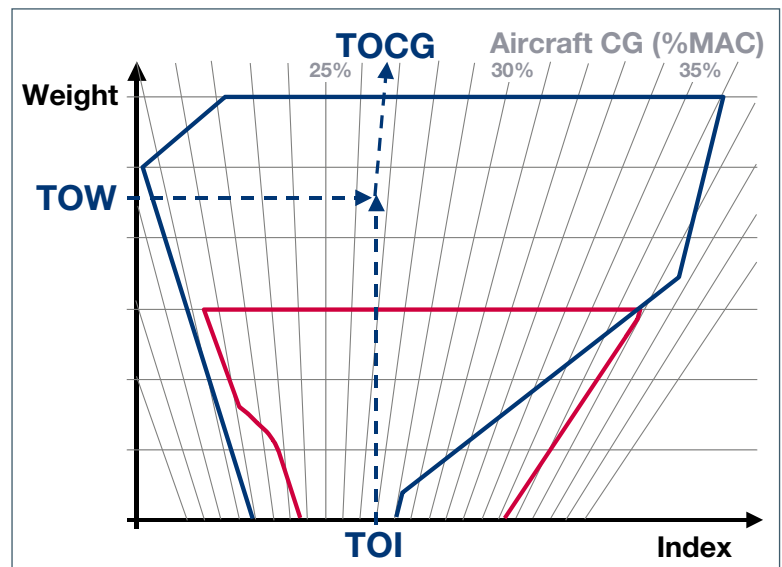
For TOW, airlines use a standard value for taxi fuel weight. This is an acceptable simplification. However for TOI, the determination of the Taxi Fuel Index is complex because it depends both on the amount and the location of the fuel consumed during taxi. Therefore airlines often prefer to use the simplified calculation method described here below.

2.2. Simplified TOCG calculation

(As used during the 2008 A330 event.) The TOI is calculated with the following formula:

$$\text{TOI} = \text{Zero Fuel Index} + \text{Takeoff Fuel Index}$$

Figure 1
Determination of the TOCG



The Takeoff Fuel index is taken from the ramp fuel index table, which gives for each fuel weight the corresponding total fuel index. The table assumes a pre-determined tank refueling sequence, (fig. 2).

Fuel Weight	Index
...	...
37500	- 6
38000	0
38500	+ 5
39000	+ 10
...	...

The utilization of the ramp fuel index table to calculate the takeoff weight index is possible as long as the taxi fuel burn sequence is the reverse of the tank refueling sequence, i.e. if the taxi fuel is consumed from the last refueled tank.

If the taxi fuel is not consumed from the last refueled tank, the distance between the CG after refueling and the aircraft's CG at takeoff is:

- Negligible if the taxi fuel quantity is low or if the tank used for taxi is near the last refueled tank.
- Large if the fuel used for taxi is high and if the tank used for taxi is far from the last refueled tank.

On the A330 example mentioned in the introduction, the Ramp Fuel was 39 tons and the Taxi Fuel was 2.6 tons. In this configuration, the last refueled tank is the trim tank, and the taxi fuel is burnt from the inner tanks, as shown in fig.3.

The simplified TOCG calculation gives a TOCG at 22.2%MAC, that corresponds to a pitch trim setting of 6.4 degrees NOSE UP. The complete calculation taking into account the taxi fuel burn gives a TOCG at 26.7%MAC, that corresponds to 4.1 degree NOSE UP.

The aircraft CG moves backward during the taxi-out, whereas the simplified method considers that the CG moves forward.

The respective TOCG positions are shown in fig.4.

The cause of the rapid rate of rotation of the aircraft was the difference in pitch trim settings.

3. Improved simplified TOCG calculation

To avoid any large CG discrepancy, Airbus recommends an improved simplified method where the TOI is calculated with the following formula:

$$\text{TOI} = \text{Zero Fuel Index} + \text{Ramp Fuel Index}$$

The Ramp Fuel Index replaces the Takeoff Fuel Index of the original simplified calculation because, on all Airbus aircraft, the taxi fuel is burnt in the tanks located near the aircraft's CG position.

On Airbus aircraft the taxi fuel is consumed from:

- The inner/wing tanks on the A300/A310/A318/A319/A320/A321/A330/A340.
- The feed tanks on the A380.

As a consequence, the taxi fuel index can be considered to be negligible.

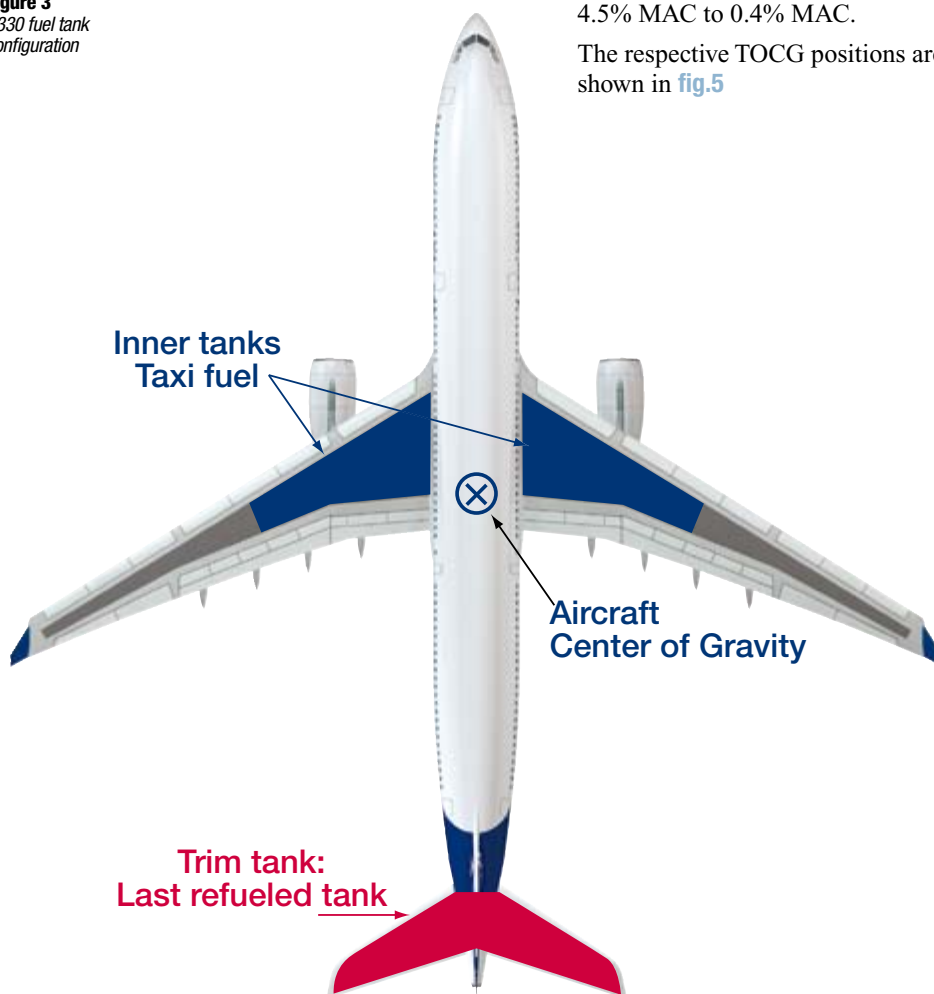
On the A330 used to illustrate our article, the calculation of the TOCG by means of the improved simplified calculation would have given a TOCG at 26,3% MAC, corresponding to a pitch trim setting of 4.3 degrees NOSE UP. This is very close to the TOCG at 26,7% MAC and the pitch trim setting of 4.1 degree NOSE UP that would have resulted from calculation using the complete calculation.

With the improved simplified TOCG calculation, the difference between the calculated TOCG and the real TOCG decreases from 4.5% MAC to 0.4% MAC.

The respective TOCG positions are shown in fig.5

Figure 2
Excerpt from an A330
ramp fuel index table

Figure 3
A330 fuel tank
configuration



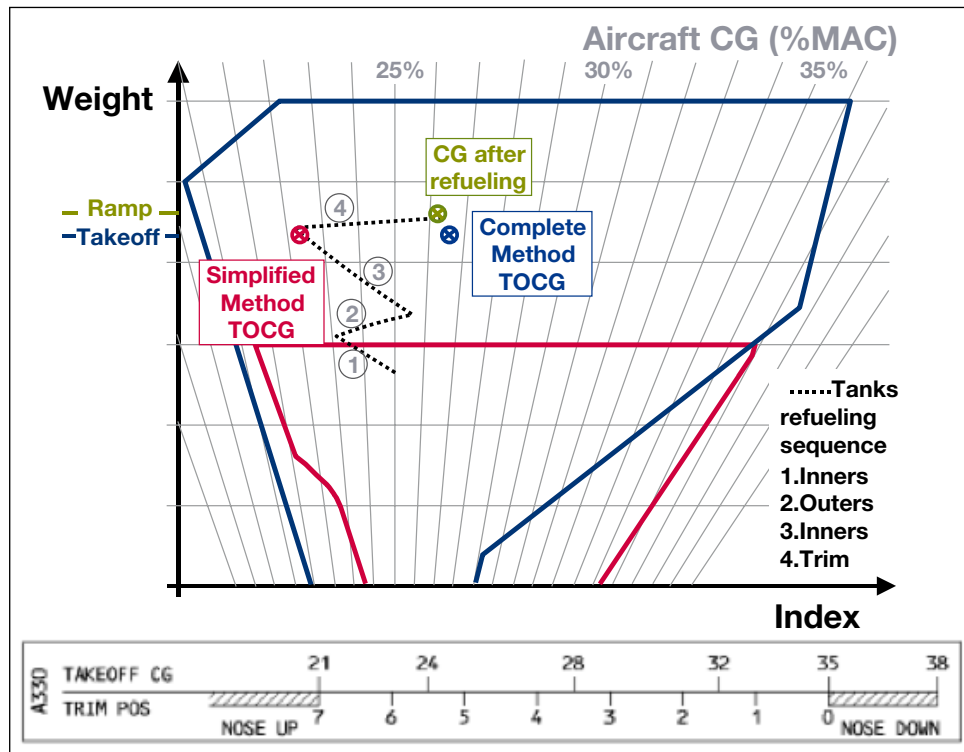


Figure 4
TOCG positions using the simplified and complete calculations

4. Standard Operating Procedures

4.1. BEFORE PUSHBACK OR START procedure

(FCOM 2.03.07 on A300-600/A310, FCOM 3.03.07 on A318/A319/A320/A321/A330/A340, FCOM > Procedure > Normal Procedure > Standard Operating Procedure > Before Pushback or Start on A380).

The loadsheet check in the BEFORE PUSHBACK procedure requires the Captain to :

- ▶ Ensure that the load and trim sheet is filled properly.
- ▶ Control that the ZFW/CG data is entered in the FMS correctly.
- ▶ Verify that the TOCG is within the load and trim sheet operational limits.

In addition, on the aircraft types where the ECAM displays the Gross Weight (GW) and CG (A300-600R/A310-300/A330/A340/A380), the loadsheet check calls for the comparison of the load and trim sheet CG against the ECAM CG.

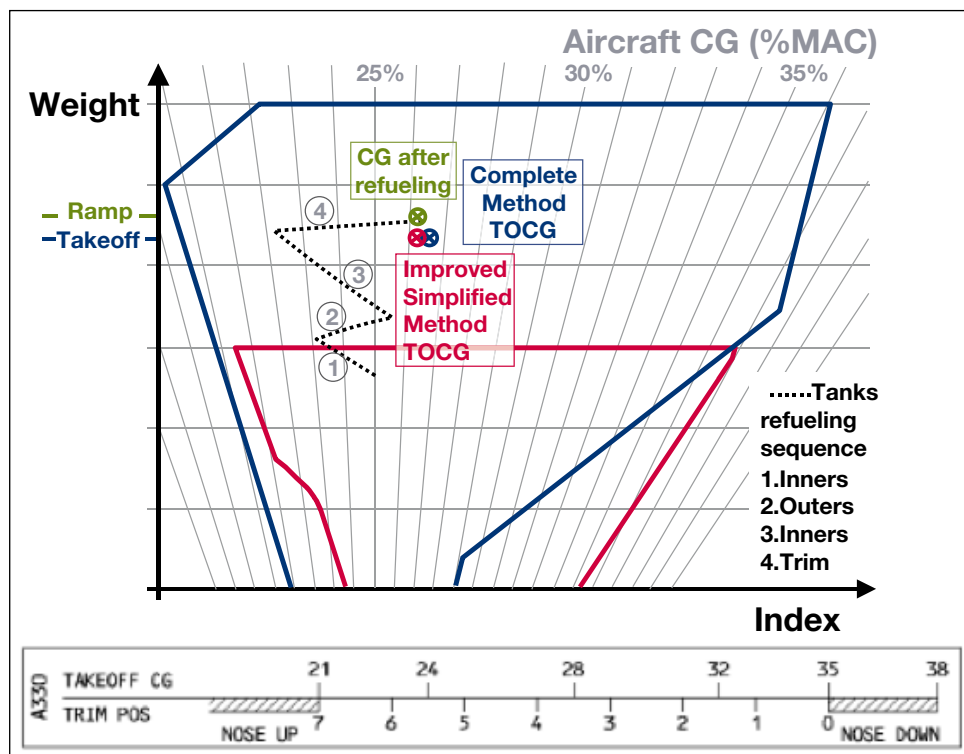
A significant difference may be due to:

- ▶ An error in the load and trim sheet
- ▶ An erroneous ZFW/ZFWCG entry in the FMS.
- ▶ A non standard fuel distribution on board, which may be caused by an inoperative part of the fuel system.
- ▶ An erroneous TOCG on the load and trim sheet, calculated with the simplified TOCG calculation.

On these aircraft types, the pitch trim must be set according to the ECAM CG:

- ▶ Manually on A300-600R/A310-300/A330/A340.
- ▶ Automatically on A380, A340-500/A340-600 and A330/A340 equipped with takeoff automatic pitch trim setting.

Figure 5
TOCG positions using the improved simplified and complete calculations



4.2. AFTER START procedure

The A300-600/A310-200 procedures (FCOM 2.03.09) are as follows:

PITCH TRIM.....SET for T/O

The flight crew uses the TOCG from the load and trim sheet, which is close to the TOCG at brake release if the improved simplified TOCG calculation method is used.

The A300-600R/A310-300 procedures (FCOM 2.03.09) are as follows:

PITCH TRIM.....SET for T/O

The flight crew uses the CG displayed on the ECAM, which is close to the TOCG at brake release.

The A320 family procedures (FCOM 3.03.09) are as follows:

PITCH TRIM.....SET

Set takeoff CG on pitch trim wheel.

The flight crew uses the TOCG from the load and trim sheet, which is close to the TOCG at brake release if the improved simplified TOCG calculation method is used.

The A330/A340 procedures (FCOM 3.03.09) are as follows:

PITCH TRIM.....SET

Set CG on pitch trim wheel. For this purpose use CG indicated on ECAM.

The flight crew uses the CG displayed on the ECAM, which is close to the TOCG at brake release.

The A340-500/A340-600 and A330/A340 equipped with takeoff automatic pitch trim setting procedures (FCOM 3.03.09) are as follows:

PITCH TRIM..... CHECK

Check the takeoff CG on the pitch trim wheel using the ECAM'S CG indication.

The flight crew checks that the pitch trim is correctly set.

The A380 procedures (FCOM>Procedure>Normal Procedure>Standard Operating Procedure>After Start) are as follows:

PITCH TRIM..... CHECK

Check that the pitch trim is at the takeoff target on the pitch trim position indication of the PFD.

The flight crew checks that the pitch trim is correctly set.

5. Conclusion

Caution must be exercised when determining the TOCG value on the load and trim sheet through a simplified calculation method. This may lead to erroneous results, particularly on aircraft equipped with trim tanks and/or Auxiliary Center Tanks (ACT).

Airbus therefore recommends the use of either the complete or improved simplified calculation for the TOCG value. This insures that the TOCG values always remain as close as possible to the real aircraft CG at takeoff.

The AFTER START Standard Operating Procedures call for the pitch trim to be set according to:

- The CG displayed on the ECAM on the A300-600R/A310-300/A330/A340/A380.
- The calculated TOCG value on the load and trim sheet on the A300-600/A310-200/A318/A319/A320/A321.

note

The FCOM 2.01.40 for A318/A319/A320/A321/A330/A340 has been updated with the improved simplified TOCG calculation method in the revision released in SEPT09.

The FCOM 2.06.40 for A300-600/A310 will be updated at next revision in MAY10.

The subject was presented at the IATA Load Control and Aircraft Messaging Working Group in Geneva in SEPT09.



Jean Michel ROY

Test Pilot

Technical Flight Familiarization

1. Introduction

Airline pilots are trained to deliver safety, efficiency and comfort in line operations.

However, in addition to normal revenue flights, operators may perform technical flights following aircraft maintenance visits or major repairs.

Non-revenue flights after maintenance are only required by Airbus after very specific actions and if some items cannot be properly ground tested, to verify that the aircraft's operational characteristics have not been adversely affected.

These technical flights require a different mindset compared to normal line operation.

To fill this need, Airbus has created the Technical Flight Familiarization course (TFF).

2. Sharing experience

Airbus' Flight Test Division has developed over the years an expertise in aircraft flight testing. Beyond the development of new aircraft types, the test crews have to support the acceptance of hundreds of production aircraft each year.

During the acceptance phase, these crews take the aircraft to the limits of the flight envelope and validate the proper operation of aircraft, engines and systems.

They are made of test pilots and flight test engineers working together to check that the airplanes, released by the assembly lines, are ready to be delivered to the customers and to start line operations.

The goal of the TFF is to share expertise with the operators by training crews, selected by their airline, to safely perform technical flights.

3. Technical flight crews

Technical flights necessitate technical flight crews made of:

- ▶ Two pilots, qualified and current on the type (Airbus recommends at least 6 months experience).

▶ One technical flight engineer who may be:

- A third pilot qualified on the type.
- A maintenance engineer, who has followed the maintenance type rating course.
- A flight operations engineer, who has followed an aircraft type familiarization course.

4. Presentation of the TFF

The Technical Flight Familiarization course is available for the A320 family, A330, A340 and A380.

The TFF lasts 5 days and is divided into 3 phases:

- ▶ Ground school
- ▶ Full flight simulator training
- ▶ Actual aircraft flight training

3.1. Ground school

This first part of the course lasts for 2 days and covers:

- ▶ The concept of Technical Flight Crew and the associated task sharing.
- ▶ The preparation of a technical flight and the writing of a Technical Flight Order.
- ▶ The recording of in-flight parameters and the utilization of Airbus' on-board Aircraft Integrated Data System (AIDS) and Central Maintenance System (CMS).

The course includes the following key aircraft checks:

- ▶ Taxi
- ▶ Flight controls
- ▶ Pressurization
- ▶ Systems (fuel, electrical, hydraulic etc...)
- ▶ High speed
- ▶ Low speed
- ▶ Engine shutdown and relight
- ▶ Rejected take-off

3.2. Full flight simulator training

This phase includes 2 sessions lasting 4 hours each and includes training on:

- ▶ The key checks performed in normal operations.
- ▶ The knowledge, skills and attitude needed to deal with abnormal situations.

3.3. Actual aircraft flight training

This last phase of the course is made of a 4-hour-flight (2 hours per pilot) to allow trainees to perform normal operations checks in a real operating environment.

4. Conclusion

During their flying careers, airline crews may have to perform technical flights for which they have never been prepared for. Technical flights require knowledge, skills and attitudes which are different from that required for normal revenue flights. This is why Airbus encourages operators to pay specific attention to this type of operations.

To fill this need for a specific technical flight training, Airbus created the Technical Flight Familiarization course.

The first TFF took place September 2009 in Toulouse, France with two airline Technical Flight Crews. The feedback was positive and the TFF course is now offered on a monthly basis.





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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.

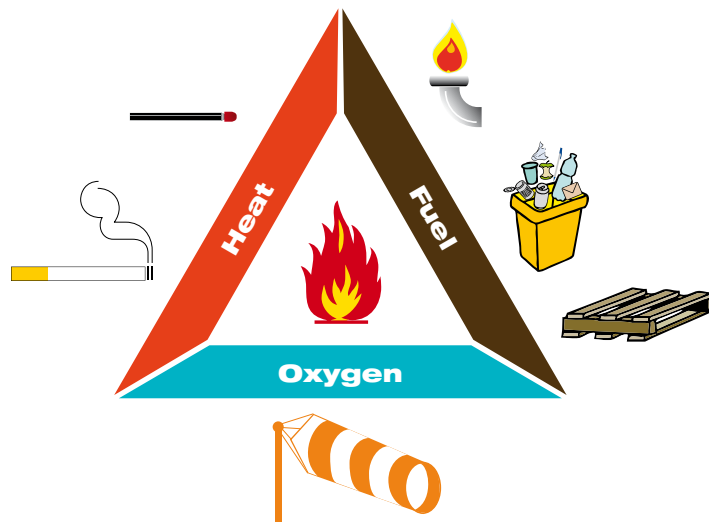
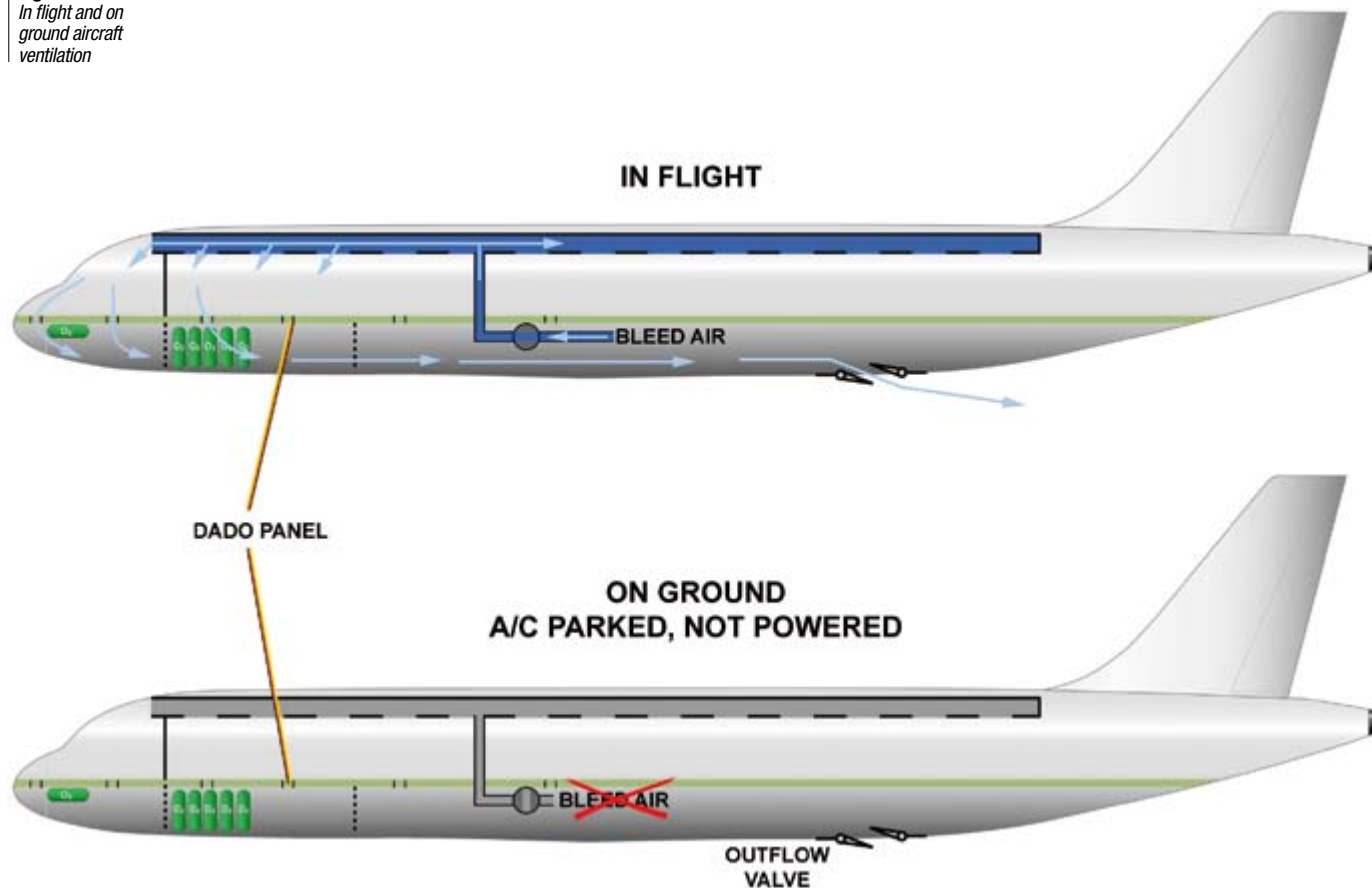


Figure 1
The fire (chemical reaction) can start if there is enough heat, fuel and oxygen.

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 oxygen enriched 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 O₂ 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**

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