BEA
Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile

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SYNOPSIS

OXYGEN FIRE IN COCKPIT - STUDY

Context

Following the accident on 19 May 2016 over the Mediterranean Sea, involving an Airbus A320 registered SU-GCC, the first factual information collected (CVR and FDR recorders, debris from the wreckage) revealed that a fire had broken out on board the aeroplane and had been identified by the crew.

In coordination with its international counterparts, the BEA identified several prior occurrences where there had been fires in the presence of an oxygen leak in the cockpit producing a noise comparable to that on the CVR recording of SU-GCC.

The BEA therefore carried out a study on oxygenated fires in the cockpit, convinced that a detailed analysis of this accident on 19 May 2016 and previous occurrences could provide safety lessons to be shared with the international aviation community.

Scope and aim of study

In the event of depressurisation or in the presence of smoke, the pilots may need to use oxygen. For this eventuality, they have quick-donning masks at their disposal, stowed in storage boxes on both sides of the cockpit.

Quick-donning oxygen mask

Oxygen mask storage boxes on commercial air transport aeroplane

The study carried out by the BEA focused on fires fed by pressurised oxygen from this system in the cockpit. It particularly looked at the fire breakout mechanisms, how it spread and the possibilities of extinguishing this type of fire.

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The fire breakout mechanisms studied focused on:

- external sources of heat (lithium batteries in electronic devices or glowing cigarettes);
- internal ignition of the hoses;
- ignition of grease or dust in an oxygen-enriched environment.

For all the tests, the noise was recorded using acquisition equipment identical to that present in a cockpit, so as to be able to carry out an acoustic characterisation of the various phenomena and compare them with CVR recordings from pre-identified accidents.

Note: The oxygen system for passengers and cabin crew is of a different design, and is not the subject of this study, the events having occurred solely in the cockpit.

Fire fed by pressurised oxygen - Test results

All the work and results are available in the complete study and its appendices. Details of the tests and results obtained are also summarized in several videos.

The main results show that a source of heat in a mask storage box (in a potentially oxygen-enriched environment) or actually within the distribution system can lead to a fire causing a rupture in the supply hoses, resulting in a pressurized oxygen-fed fire that becomes difficult to control. The noise produced is comparable to that of a blowtorch.

In this case, the flames are large and the fire spreads rapidly to the surroundings of the storage box. The protective and extinguishing equipment in the cockpit are then not sufficient to bring it under control.

The video on how the fire spreads in the environment of the oxygen distribution system in a cockpit show the consequences of such a phenomenon.

A specific video concerning the use of a halon fire extinguisher shows its ineffectiveness on a fire fuelled by a pressurised oxygen leak.

The presence of the oxygen distribution system has two cumulative impacts on fire risks: (1) increasing the risk of a fire starting; (2) reducing the possibilities of controlling the fire or facilitating its propagation.

(1) Micro-leaks, mask testing or the failure of a system component can lead to an increase in oxygen concentration in the storage box. When there is a heat source and a fuel, the presence of oxygen in high concentration makes a fire more likely to start in the system in the event of contamination, or in the storage box.

(2) When a fire occurs in this environment with oxygen in high concentration, the distribution system, and in particular the supply hoses, become the fuel and, if ruptured, release oxygen under high pressure, feeding the pre-existing fire and facilitating its spread.

Study's safety recommendations

Certification requires that the occurrence of an uncontrolled oxygen fire is extremely unlikely. Given the occurrence of several in-flight and on-ground incidents, the study considered not only the means of preventing these fires, but their propagation and the means of fighting them. The results led to the following recommendations.

Further work taking into consideration the effects of overpressure in the oxygen system

The tests carried out by the BEA in the scope of this study were based on the assumption that the pressure in the system was 5 bar. Internal ignition mechanisms such as particle impact, grease oxidation or ignition by electrostatic discharge may depend on the oxygen pressure. Similarly, the fragility created by a nearby external source of ignition could be greater in the event of a high-pressure leak.

Consequently, the BEA recommended that EASA, in collaboration with the manufacturers, carry out additional risks analyses to take into account the hypothesis of an overpressure in the distribution system and its consequences in terms of failure mechanisms. The results should be analysed with regard to the potential factors explaining the scenario of flight MS804. These analyses may require additional testing as part of a research program. [FRAN-2023-024]

Propagation of a fire fed by an oxygen leak

The events and the tests carried out have highlighted the size of the fire and the speed at which it spreads in the case of a fire fuelled by an oxygen leak. These fires produce a characteristic sound, comparable to that of a blowtorch, and significant heat (recognisable by the whiteness of the flame).

Two on-ground occurrences and the tests showed that halon fire extinguishers are not suitable for treating fires fuelled by an oxygen leak.

In the events on the ground, the crews were unable to control the fires and evacuated the cockpit. In flight, fighting an oxygen-enriched fire requires the oxygen supply to be immediately cut off.

Consequently, the BEA recommended that EASA assess the appropriateness of cockpit fire/smoke procedures incorporating the recognition of an oxygen fire (identifiable by a characteristic noise comparable to that of a blowtorch) and the immediate cutting off of the oxygen supply in this case, and if necessary review the requirements for installing and carrying protective equipment independent of the oxygen distribution system. [FRAN-2023-025]

Risks linked to the use of cigarettes in the cockpit

International regulations are not explicit about banning smoking in the cockpit of commercial air transport aeroplanes. While there are warnings about smoking near oxygen in the passenger compartment, there are no similar warnings with respect to the cockpit. The decision seems to rest with the captain.

No systematic and obvious danger has been established from smoking near an oxygen mask storage box, even with a mask in the EMERGENCY position or when the box has not been reset. However, if a cigarette is introduced into the storage box - an unlikely but nevertheless possible scenario - a

fire, accompanied by an oxygen leak, may start. In this case the flames are large and the fire spreads rapidly to the surroundings of the storage box.

Consequently, the BEA recommended that EASA ensure that the danger represented by a glowing cigarette in the cockpit be taken into account, the associated risks assessed and that certification and operational regulations be amended where applicable. [FRAN-2023-026]

The BEA investigations are conducted with the sole objective of improving aviation safety and are not intended to apportion blame or liabilities.