Terms of Reference

for a rulemaking task

Oxygen fire hazard in gaseous oxygen systems

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Applicability		Process map	
Affected regulations and decisions:	ED Decision 2003/14/RM (CS-23); ED Decision 2003/02/RM (CS-25)	Rulemaking lead:	R4
		Concept Paper:	No
		Rulemaking group:	No
Affected stakeholders:	TC and STC applicants for CS-23 and CS-25 aeroplanes	RIA type:	Light
		Technical consultation during NPA drafting:	No
Driver/origin:	Safety	Publication date of the NPA:	2014/Q1
Reference:	Safety Recommendation CHIN-2011-005 and FRAN-2012-030	Duration of NPA consultation:	3 months
		Review group:	No
		Focussed consultation:	No
		Publication date of the Opinion:	N/A
		Publication date of the Decision:	2016/Q1

1. Issue and reasoning for regulatory change

1.1. Description of the issue

In an oxygen-enriched environment most materials ignite at lower temperatures than in the air. Combustion rates are also greater in an oxygen-enriched environment. The equipment used to store and distribute gaseous oxygen on board an aircraft consists of pressurised cylinders, regulators, valves, tubing and fittings which are made of metallic and non-metallic materials. All of these materials, including metallic parts, can combust in a pressurised oxygen-enriched environment.

Ignition within an oxygen-enriched environment can be triggered by different contributing factors. Some factors may be related to the system, for instance contamination (e.g. by grease), compression heating or migration of oxygen in a non-suitable zone where temperature may be too high (e.g. internal leakage). Ignition is also possible due to outside sources, such as arcing from electrical equipment when combined with an external leakage.

Furthermore, pressure shocks may provide enough energy to cause auto-ignition. Any gas can produce a considerable amount of heat if rapidly compressed. This happens when a gas is quickly released through a hose to a dead end or from a higher pressure to a lower pressure location and then the gas encounters a restriction such as a pressure regulator. Temperature rise is associated with the compression of oxygen in this location. Since oxygen is necessary to support combustion, the temperature rise associated with the compression of oxygen can readily ignite polymers or flammable contaminants. Thus, lubricants, tapes and gaskets increase the possibility of ignition in oxygen systems.

1.2. History of accidents/incidents and related safety recommendations

The above-mentioned hazard was illustrated by a serious incident to an Airbus A319 on 19 June 2008 in China[1]. The flight was diverted because of a fire detected in the aft cargo compartment. The investigation concluded that a pressure reducer (PR#1) was in failure condition (exact type of failure unknown), that the heat produced by rapid leakage of oxygen ignited the parts in PR#1 which subsequently caused fire in the oxygen cylinder compartment.

The following safety recommendation was released by CAAC:

'SR CHIN-2011-005: It is recommended that EASA, FAA and CAAC perform HP oxygen shock tests to oxygen regulation device equipped on civilian aircraft.'

On 1 July 2010 another incident occurred to a Bombardier CRJ 700 (F-GRZF) during landing roll in Paris Charles de Gaulle airport, France[2]. The investigation confirmed that the flight crew oxygen system pressure transducer exploded.

The following safety recommendation was released by BEA:

SR FRAN-2012-030: 'Le BEA recommande: que l'AESA s'assure que la conception des systèmes d'oxygène gazeux ne permette pas une concentration d'oxygène sous pression dans des zones non prévues à cet effet.'

Unofficial translation: 'The BEA recommends that EASA ensure that oxygen system design does not allow a high concentration of oxygen in areas not designed for this purpose.'

[1] Serious incident to A319/B-6167 on 19 June 2008, flight MU2261 from Chongqing to Wenzhou operated by China Eastern Airlines Corporation Limited Northwest Branch. Refer to Aircraft Serious Incident Report CAAC-AS/AIR-2011001 from the Civil Aviation Administration of China (CAAC), dated 9 April 2011.

[2] Incident to Bombardier CRJ700 registered F-GRZF on 1 July 2010 in Paris Charles de Gaulle airport, France. Refer to BEA report f-zf100701, dated June 2012.

1.3. Existing certification specifications

For CS-25 aeroplanes

Fire protection related to oxygen systems is specified in CS 25.869(c). However, CS/AMC 25.869(c) do not sufficiently address oxygen system design and precaution to be taken in the design to minimise the risk of fire originating from the oxygen system itself.

In addition, CS 25.1453(e) requires that pressure limiting devices be provided to protect parts of the oxygen system from excessive pressure. Experience has shown that such devices are not necessarily checked when installed on a complete system and may not release the pressure quickly enough to avoid unacceptable pressure build-up in the oxygen system.

For CS-23 aeroplanes

Specifications equivalent, though not always identical, to the above CS-25 specifications are provided in CS 23.1451 (Fire protection for oxygen equipment), CS 23.1453 (Protection of oxygen equipment from rupture).

1.4. Existing Certification Review Items (CRIs)

Taking into account the experience gained from in-service aeroplane events, showing that unsafe conditions may develop, the Agency decided to create a new generic Certification Review Item (CRI) in order to clarify CS 25.869 and CS 25.1453 with respect to oxygen fire hazard in gaseous oxygen systems, centralised, decentralised or portable. This CRI provides for interpretative material and means of compliance. It addresses the need to demonstrate that the oxygen systems and associated components should be designed in such a way that the occurrence of an uncontrolled oxygen fire is extremely improbable and does not result from a single failure. Failure Mode Effect Analysis (FMEA), System Safety Assessment (SSA) and Oxygen Hazards Analysis (OHA) are expected to support this demonstration. Some design precautions guidelines are also provided. This CRI is raised systematically since 2012 on new applications.

Although it has been prepared for CS-25 large aeroplanes, its content is applicable to CS-23 aeroplanes equipped with gaseous oxygen systems. A similar CRI has been issued for CS-23 related applications.

Note: CS-29 (large rotorcraft) does not provide specifications for oxygen systems. The Agency is using a CRI with a Special Condition for certification of emergency medical service (EMS) helicopters that are equipped with liquid/gaseous oxygen system installations. It is proposed to continue using this process, i.e. the Agency to raise a CRI when necessary.

2. Objectives

The specific objective of this rulemaking task is to improve the certification specifications regarding the design of gaseous oxygen systems applicable to CS-23 and CS-25 aeroplanes so that all potential ignition mechanisms are identified and analysed for the systems and their components. This must ensure that no single failure can create an oxygen fire or explosion, and that this risk remains extremely improbable.

3. Specific tasks and deliverables

3.1. Task

Following the issues analysis in section 1, the task is to amend existing Certification Specifications and Acceptable Means of Compliance applicable to gaseous oxygen systems on board CS-23 and CS-25 aeroplanes based on the available Certification Review Item (CRI) clarifying CS 25.869 and CS 25.1453 with respect to oxygen fire hazard in gaseous oxygen systems, centralised, decentralised or portable.

The task will define requirements addressing the need to demonstrate that the oxygen systems and associated components should be designed in such a way that the occurrence of an uncontrolled oxygen fire is extremely improbable and does not result from a single failure. Failure Mode Effect Analysis (FMEA), System Safety Assessment (SSA) and Oxygen Hazards Analysis (OHA) are expected to support this demonstration.

The requirements will also provide some design precautions guidelines.

Lessons learnt from recent incidents should be taken into account to prevent similar occurrences on new designs.

3.2. Deliverables

— ED Decision with amendments to CS-23 and CS-25.

3.3. Focussed consultation

N/A

4. Profile and contribution of the rulemaking group

Not applicable: Agency task.

5. Annex I: Reference documents

5.1. Affected regulations

— CS-23 (paragraphs 23.1441, 23.1451, 23.1453);

— CS-25 (paragraphs 25.869, 25.1441, 25.1453).

5.2. Affected decisions

— ED Decision 2003/14/RM (CS-23);

— ED Decision 2003/02/RM (CS-25).

5.3. Reference documents

— Aircraft Serious Incident Report CAAC-AS/AIR-2011001 from the Civil Aviation Administration of China (CAAC) dated 9 April 2011: ‘Serious incident to A319/B-6167 on 19 June 2008, flight MU2261 from Chongqing to Wenzhou operated by China Eastern Airlines Corporation Limited Northwest Branch’;

— BEA report f-zf100701 dated June 2012: ‘Incident to Bombardier CRJ700 registered F-GRZF on 1 July 2010 in Paris Charles de Gaulle airport, France’.