U.S. Department of Transportation
Federal Aviation Administration

Policy Statement

Subject: Mitigating Fire Hazards in Gaseous Oxygen Systems

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Initiated By: ANM-112

Summary

This policy statement provides methods to address potential fire hazards within gaseous oxygen systems and to comply with Title 14, Code of Federal Regulations (14 CFR) 25.1441(b). Specifically, this policy addresses design features and considerations for protection from potential ignition sources in typical gaseous oxygen system designs.

Definition of Key Terms

In the text below the terms “must,” “should,” and “recommend” have a specific meaning that is explained in Attachment 1.

Current Regulatory and Advisory Material

Section 25.869(c) states “Oxygen equipment and lines must- (1) Not be located in any designated fire zone, (2) Be protected from heat that may be generated in, or escape from, any designated fire zone, and (3) Be installed so that escaping oxygen cannot cause ignition of grease, fluid, or vapor accumulations that are present in normal operation or as a result of failure or malfunction of any system.”

Section 25.1441(b) states “The oxygen system must be free from hazards in itself, in its method of operation, and in its effect on other components.”

Advisory Circular (AC) 25-22, *Certification of Transport Airplane Mechanical Systems*, dated March 14, 2000, contains general methods of compliance to § 25.1441. This AC also refers to the “1992 SAE Aircraft Oxygen Equipment Handbook,” published by the Society of Automotive Engineers (SAE) Aerospace Committee A-10, for useful information.

Section 25.1453 states “Oxygen pressure tanks, and lines between the tanks and the shutoff means, must be-(a) Protected from unsafe temperatures; and (b) Located where the probability and hazards of rupture in a crash landing are minimized.

Section 25.1707(a) states that each electrical wiring interconnection system (EWIS) must be designed and installed with adequate physical separation from other EWIS and airplane systems so that an EWIS component failure will not create a hazardous condition. Unless otherwise stated, for the purposes of this section, adequate physical separation must be achieved by separation distance or by a barrier that provides protection equivalent to that separation distance.

Section 25.1707(g) states “Except to the extent necessary to provide electrical connection to the oxygen systems components, EWIS must be designed and installed with adequate physical separation from oxygen lines and other oxygen system components, so that an EWIS component failure will not create a hazardous condition.”

Advisory Circular (AC) 25.1701-1, *Certification of Electrical Wiring Interconnection Systems on Transport Category Airplanes*, dated December 4, 2007, provides guidance for certification of EWIS on transport category airplanes to comply with §§ 25.1701 through 25.1733.

Although guidance materials do exist for general requirements for oxygen systems, the FAA currently has no existing policy on methods to address potential fire hazards within gaseous oxygen systems.

Relevant Past Practice

In 2007, the FAA added EWIS rules to part 25, along with related requirements in parts 26, 121, and 129 to enhance the safety of airplane wiring systems. These new rules treat airplane wiring as an airplane system to ensure that wiring is properly considered when assessing system safety.

AC 25.1701-1 contains guidance for certification of EWIS on transport category airplanes and should be considered for certification of oxygen system installations. It contains a section on physical failure analysis that states it should be assumed that wires are carrying electrical energy and in the case of an EWIS failure, this energy may result in hazardous or catastrophic effects directly or when combined with other factors (e.g., fuel, oxygen, hydraulic fluid, or damage by passengers).

AC 25-22 refers to the “1992 SAE Aircraft Oxygen Equipment Handbook” as a source of information. However, this SAE handbook has not been updated for several years and is no longer considered current. Using currently maintained documents published by SAE is generally considered an industry best practice. For example, SAE currently maintains a set of 14 general information documents related to oxygen systems used on aircraft. AIR825/1, *Introduction to Oxygen Equipment for Aircraft*, is the first document in the series and contains general introductory information as well as references to other documents related to oxygen systems. Although SAE documents are not regulatory in nature, applicants frequently use them in project-specific certification plans. It is acceptable for applicants to use information in SAE documents for certification, but applicants are responsible for showing that the information is applicable for their specific project and that the installation meets the applicable regulations.

Background

Although oxygen is not considered to be flammable by itself, it is a necessary element of combustion. An ignition source, flammable material, and oxygen are all necessary to support combustion. Airplane oxygen systems either contain or produce high concentrations of oxygen. When high oxygen concentrations are introduced to a fire, the fire will burn hotter, propagate significantly faster, and readily burn most materials, including metal and other materials not generally considered flammable.

Oxygen systems are required on airplanes that fly at altitudes which can make the flight crew or passengers susceptible to the potential effects of hypoxia. Since oxygen systems are necessary, emphasis should be placed on reducing the possibility of ignition sources within the oxygen system or in areas near oxygen system components that could contribute to a fire if ruptured. Removing potential ignition sources increases the level of safety associated with oxygen system installations.

Policy

This policy statement provides guidance for developing a process to conduct a hazard analysis of the oxygen system to comply with § 25.1441(b) as part of the certification process for new type certificates, changes to type certificates, and supplemental type certificates. The guidance provided in this policy statement is in addition to guidance associated with conducting a system safety assessment for compliance to § 25.1309. There are various types of oxygen systems typically referred to by their supply source such as chemical, gaseous, or liquid. Liquid oxygen systems are rarely used in commercial operations and require special considerations not covered in this policy.

SAE document AIR825/13, *Guide for Evaluating Combustion Hazards in Aircraft Oxygen Systems*, may be used as a guideline for how to conduct an oxygen systems hazard analysis.

The hazard analysis should include the following areas, as applicable:

1. **Identification of Potential Ignition Sources.** The hazard analysis should identify all potential ignition sources and the strategy used to mitigate the potential risk of fire associated with each ignition source.

1.1. In accordance with § 25.869(c)(3), oxygen equipment and lines must be installed so escaping oxygen cannot cause ignition of grease, fluid, or vapor accumulations that are present in normal operation or as a result of failure or malfunction of any system.

1.2. To support compliance to 25.869(c)(3), the hazard analysis should identify potential oxygen system leakage locations and show that ventilation in the area surrounding the oxygen installation is sufficient so that oxygen concentrations would not reach unsafe levels. If there are areas of potential high oxygen concentrations, the hazard analysis should show that the area is void of potential ignition sources, such as electrical equipment or sources of heat. Typical materials used in airplane design, such as insulation, sidewalls, wiring and even metallic components can sustain a fire in an oxygen-enriched environment.

1.3. The hazard analysis should also identify potential internal ignition sources. The identification of potential internal ignition sources should include possibilities such as adiabatic compression, frictional heating, particle impact, mechanical stress, corrosion, and static discharge. In an oxygen-enriched environment, most materials can ignite more easily. Oxygen heats up when compressed, which can make the oxygen component under consideration susceptible to ignition. Components that are generally most vulnerable include pressure regulators, fill valves, or flow control units used to either reduce the system pressure or control the flow of oxygen.

1.4. The hazard analysis should identify potential external ignition sources. The analysis should include possibilities such as electrical arcing onto the oxygen system itself or potential leaks from adjacent equipment that could lead to contamination or deterioration of the oxygen system.

2. Identification of Components and Materials. The hazard analysis should include component descriptions and construction materials, specifically highlighting the use of non-metallic materials.

2.1. For compatibility of oxygen system components and materials within an oxygen-enriched environment, the hazard analysis should include the assumption of a 100% oxygen environment.

2.2. The hazard analysis should include the choice of materials and method of operation for oxygen system components, such as high-pressure regulators and shut-off valves that are used to reduce the potential of fire. For example, aluminum should be used with caution in these types of components, as it is particularly susceptible to ignition in an oxygen environment.

2.3. The hazard analysis should describe the use of construction materials that are compatible with oxygen and intended for use in an oxygen-enriched environment. For example, some materials, such as titanium, exhibit chemical reactions and become extremely flammable in an oxygen-enriched environment. Other materials, such as cadmium coatings, oxidize rapidly in a pure oxygen environment and release toxic compounds. Also, the use of oil, grease or other hydrocarbon material is particularly hazardous in the presence of oxygen and should be avoided.

2.4. The hazard analysis should also identify lubricants or thread sealants that may be used during assembly or maintenance of the oxygen system. Use of hydrocarbon based lubricants can be a source of system contamination and should be avoided.

3. High-Pressure Oxygen Areas. Typical airplane oxygen systems contain one or more oxygen storage cylinders containing oxygen near 2000 psi. This high pressure oxygen is then typically reduced to pressures below 100 psi for use at the dispensing equipment. The hazard analysis should include evaluation of components used with high pressure oxygen systems.

3.1. The hazard analysis should discuss specific design considerations made to mitigate the risk of fire in components which contain high-pressure oxygen, used to reduce oxygen pressure, or control the flow of oxygen with pressures which exceed 100 psi.

4. Flexible Hoses. Flexible hoses are often used within various oxygen system designs to accommodate system installation or maintenance. Flexible hoses are typically made of non-metallic materials that degrade over time, depending on the specific materials and installation environment. The hazard analysis should discuss the use of flexible hoses and specific design features incorporated to mitigate the risk of fire.

4.1. The hazard analysis should include potential hazards that may develop over the service life of the product, such as degradation of materials over time. When non-metallic materials are used, the hazard analysis may include documented component life limits and/or information provided in instructions for continued airworthiness (ICAs) prepared in accordance with § 25.1529. ICA's should describe how flexible hoses should be inspected to maintain their continued airworthiness and the frequency of those inspections.

4.2. The hazard analysis should include mitigation steps taken to reduce the probability of ignition and resulting damage that may occur if oxygen hoses inadvertently contact electrical current, such as from a chafed wire or electrical short.

4.3. The hazard analysis should describe specific oxygen hose design features incorporated to prevent the hose from allowing electrical current between the end fittings. If the oxygen hose design allows inadvertent electrical current between the fittings, the hazard analysis should describe any additional mitigating features intended to prevent a potential fire, such as ground straps.

5. <u>Protection of Oxygen Systems from Electrical Systems.</u>

5.1. In accordance with § 25.1707(g) and the associated guidance in AC 25.1701-1, *Certification of Electrical Wiring Interconnection Systems on Transport Category Airplanes*, dated December 4, 2007, EWIS components and oxygen systems components must be designed and installed with adequate physical separation from each other so that an EWIS component failure will not create a hazardous condition. The oxygen hazard analysis should include a description of component design and system installation features that are intended to maintain separation of oxygen and electrical components throughout the service life of the airplane.

5.2. The hazard analysis should describe protection provided in case the oxygen system comes into contact with electrical currents. This may include using non-conductive materials to protect the oxygen system from damage or installing ground straps throughout the oxygen system installation.

Effect of Policy

The general policy stated in this document does not constitute a new regulation. Agency employees and their designees and delegations must not depart from this policy statement without appropriate justification and concurrence from the FAA management that issued this policy statement. The authority to deviate from this policy statement is delegated to the manager of the Transport Standards Staff.

Whenever a proposed method of compliance is outside this established policy, the project aircraft certification office must coordinate it with the policy-issuing office and initiate an issue paper if determined necessary. Similarly, if the project aircraft certification office becomes aware of reasons that an applicant's proposal that meets this policy should not be approved, the office must coordinate its response with the policy-issuing office. Applicants should expect that certificating officials would consider this information when making findings of compliance relevant to new certificate actions. In addition, as with all guidance material, this policy statement identifies one means, but not the only means, of compliance.

Implementation

This policy discusses compliance methods that should be applied to type certificate, amended type certificate, supplemental type certificate, and amended supplemental type certification programs. The compliance methods apply to those programs with an application date that is on or after the effective date of the final policy. If the date of application precedes the effective date of the final policy, and the methods of compliance have already been coordinated with and approved by the FAA or its designee, the applicant may choose to either follow the previously acceptable methods of compliance or follow the guidance contained in this policy.

Conclusion

The FAA has concluded that it is necessary to provide guidance on procedures for conducting a hazard analysis of the oxygen system to comply with § 25.1441(b). This policy statement provides new guidance on mitigating fire hazards in gaseous oxygen systems. If other data were to be presented which demonstrated otherwise, the FAA might reconsider the intent and content of this policy.

Original signed by Jeffrey E. Duven

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Attachment

Terms

Table A-1 defines the use of key terms in this policy statement. The table describes the intended functional impact.

Table A-1 Definition of Key Terms

	Regulatory Requirements	**Acceptable Methods of Compliance (MOC)**	**Recommendations**
Language	Must	Should	Recommend
Meaning	Refers to a regulatory requirement that is mandatory for design approval	Refers to instructions for a particular MOC	Refers to a recommended practice that is optional
Functional Impact	No Design Approval if not met	Alternative MOC has to be approved by issue paper.	None, because it is optional