AMC 25.1436(b)(3) Pneumatic Systems

ED Decision 2003/2/RM

1 In systems in which the air pressure of the supply sources is significantly greater than the system operating pressure (e.g. an engine bleed-air tapping) due account should be taken of the consequences of failure of the pressure-regulating device when assessing the strength of the system, downstream of the device relative to the values of P_W, P_L and P_R.

2 Such devices should be protected as necessary against deleterious effects resulting from the presence of oil, water or other impurities, which may exist in the system.

AMC 25.1436(c)(2) Pneumatic Systems

ED Decision 2003/2/RM

The loads due to vibration and the loads due to temperature effects are those loads, which act upon the elements of the system due to environmental conditions.

CS 25.1438 Pressurisation and low pressure pneumatic systems

ED Decision 2016/010/R

(See AMC 25.1438)

Pneumatic systems (ducting and components) served by bleed air, such as engine bleed air, air conditioning, pressurisation, engine starting and hotair ice-protection systems, which are essential for the safe operation of the aeroplane or whose failure may adversely affect any essential or critical part of the aeroplane or the safety of the occupants, must be so designed and installed as to comply the CS 25.1309 In particular account must be taken of bursting or excessive leakage. (See AMC 25.1438 paragraph 1 for strength and AMC 25.1438 paragraph 2 for testing.)

[Amdt 25/18]

AMC 25.1438 Pressurisation and low pressure pneumatic systems

ED Decision 2003/2/RM

1 *Strength*

1.1 Compliance with CS 25.1309(b) in relation to leakage in ducts and components will be achieved if it is shown that no hazardous effect will result from any single burst or excessive leakage.

1.2 Each element (ducting and components) of a system, the failure of which is likely to endanger the aeroplane or its occupants, should satisfy the most critical conditions of Table 1.

TABLE 1

Conditions 1	Conditions 2
1·5 P_1 at T_1	3·0 P_1 at T_1
1·33 P_2 at T_2	2·66 P_2 at T_2
1·0 P_3 at T_3	2·0 P_3 at T_3
–	1·0 P_4 at T_4

P_1 = the most critical value of pressure encountered during normal functioning.

T_1 = the combination of internal and external temperatures which can be encountered in association with pressure P_1.

P_2 = the most critical value of pressure corresponding to a probability of occurrence 'reasonably probable'.

T_2 = the combination of internal and external temperatures which can be encountered in association with pressure P_2.

P_3 = the most critical value of pressure corresponding to a probability of occurrence 'remote'.

T_3 = the combination of internal and external temperatures which can be encountered in association with pressure P_3.

P_4 = the most critical value of pressure corresponding to a probability of occurrence 'extremely remote'.

T_4 = the combination of internal and external temperatures which can be encountered in association with pressure P_4.

1.3 After being subjected to the conditions given in column 1 of Table 1, and on normal operating conditions being restored, the element should operate normally and there should be no detrimental permanent distortion.

1.4 The element should be capable of withstanding the conditions given in column 2 of Table 1 without bursting or excessive leakage. On normal operating conditions being restored, correct functioning of the element is not required.

1.5 The element should be capable of withstanding, simultaneously with the loads resulting from the temperatures and pressures given in the Table, the loads resulting from –

a. Any distortion between each element of the system and its supporting structures.

b. Environmental conditions such as vibration, acceleration and deformation.

1.6 The system should be designed to have sufficient strength to withstand the handling likely to occur in operation (including maintenance operations).

2 *Tests*

2.1 *Static tests*. Each element examined under 1.2 should be static-tested to show that it can withstand the most severe conditions derived from consideration of the temperatures and pressures given in the Table. In addition, when necessary, sub-systems should be tested to the most severe conditions of 1.2 and 1.5. The test facility should be as representative as possible of the aircraft installation in respect of these conditions.

2.2 *Endurance tests*. When failures can result in hazardous conditions, elements and/or sub-systems should be fatigue-tested under representative operating conditions that simulate complete flights to establish their lives.

CS 25.1439 Protective breathing equipment

ED Decision 2007/020/R

(a) Fixed (stationary, or built in) protective breathing equipment must be installed for the use of the flight crew, and at least one portable protective breathing equipment shall be located at or near the flight deck for use by a flight crew member. In addition, portable protective breathing equipment must be installed for the use of appropriate crew members for fighting fires in compartments accessible in flight other than the flight deck. This includes isolated compartments and upper and lower lobe galleys, in which crew member occupancy is permitted during flight. Equipment must be installed for the maximum number of crew members expected to be in the area during any operation.

(b) For protective breathing equipment required by subparagraph (a) of this paragraph or by the applicable Operating Regulations, the following apply:

(1) The equipment must be designed to protect the appropriate crewmember from smoke, carbon dioxide, and other harmful gases while on flight deck duty or while combating fires.

(2) The equipment must include –

(i) Masks covering the eyes, nose and mouth, or

(ii) Masks covering the nose and mouth, plus accessory equipment to cover the eyes.

(3) Equipment, including portable equipment, while in use must allow communication with other crew members while in use. Equipment available at flight crew assigned duty stations must enable the flight crew to use radio equipment.

(4) The part of the equipment protecting the eyes must not cause any appreciable adverse effect on vision and must allow corrective glasses to be worn.

(5) The equipment must supply protective oxygen of 15 minutes duration per crew member at a pressure altitude of 2438 m (8000 ft) with a respiratory minute volume of 30 litres per minute BTPD. The equipment and system must be designed to prevent any inward leakage to the inside of the device and prevent any outward leakage causing any significant increase in the oxygen content of the local ambient atmosphere. If a demand oxygen system is used, a supply of 300 litres of free oxygen at 21°C (70°F) and 760 mm Hg pressure is considered to be of 15-minute duration at the prescribed altitude and minute volume. If a continuous flow open circuit protective breathing system is used a flow rate of 60 litres per minute at 2438 m (8 000 ft) (45 litres per minute at sea level) and a supply of 600 litres of free oxygen at 21°C (70°F) and 204 kPa (760 mm Hg) pressure is considered to be of 15-minute duration at the prescribed altitude and minute volume. Continuous flow systems must not increase the ambient oxygen content of the local atmosphere above that of demand systems. BTPD refers to body temperature conditions, that is 37°C (99°F), at ambient pressure, dry.

(6) The equipment must meet the requirements of CS 25.1441.

[Amdt 25/4]

CS 25.1441 Oxygen equipment and supply

ED Decision 2019/013/R

(a) If certification with supplemental oxygen equipment is requested, the equipment must meet the requirements of this paragraph and CS 25.1443 through 25.1453.

(b) The oxygen system must be free from hazards in itself, in its method of operation, and in its effect upon other components. (See AMC 25.1441(b))

(c) Except for oxygen chemical generators and for small sealed, one-time use, gaseous oxygen bottles, there must be a means to allow the crew to readily determine, during flight, the quantity of oxygen available in each source of supply.

(d) The oxygen flow rate and the oxygen equipment for aeroplanes for which certification for operation above 12192 m (40 000 ft) is requested must be approved. (See AMC 25.1441(d).)

[Amdt No: 25/18]
[Amdt No: 25/21]
[Amdt No: 25/23]

AMC 25.1441(b) Risk assessment related to oxygen fire hazards in gaseous oxygen systems

ED Decision 2018/005/R

1. Purpose

This AMC provides guidance material and acceptable means of compliance for demonstrating compliance with CS 25.1441(b), which requires an oxygen system to be free from hazards in itself, in its method of operation, and in its effect upon other components.

This AMC applies to centralised, decentralised or portable oxygen systems. Those systems may be installed in an occupied compartment or in a remote inaccessible area.

2. Related certification specifications

CS 25.869(c) Fire protection: systems — Oxygen equipment and lines

CS 25.1301 Function and installation

CS 25.1309 Equipment, systems and installations

CS 25.1441(b) Oxygen equipment and supply

CS 25.1453 Protection of oxygen equipment from rupture

3. Installation

CS 25.869(c) specifies that oxygen system equipment and lines must:

(1) not be located in any designated fire zone;

(2) be protected from heat that may be generated in, or may escape from, any designated fire zone; and

(3) be installed so that escaping oxygen cannot cause the ignition of grease, fluid, or vapour accumulations that are present in normal operation or as a result of a failure or malfunction of any system.

In addition, the following analysis and precautions should be considered.

3.1. External ignition sources

An analysis should be performed to identify all possible external ignition sources and their mechanisms. If an ignition source exists in the vicinity of the oxygen system installation, it should be demonstrated that in normal operation or in conditions that result from a failure or malfunction of any system, the risk of ignition is minimised and that all design precautions have been taken to minimise this risk.

3.2. Contamination

The compartments in which oxygen system components are installed should provide adequate protection against potential contamination by liquids, lubricants (grease, etc.), dust, etc.

3.3. Ventilation

The compartments in which oxygen system components are installed should be ventilated in such a way that, if a leak occurred or oxygen was discharged directly into the compartment (not overboard) from any protective device or pressure-limiting device, the likelihood of ignition of the oxygen-enriched environment would be minimised. The applicant should substantiate that the ventilation rate of the compartment is adequate. Analytically determined ventilation rates should be validated by flight test results or their equivalent.

CS 25.1453(f) provides additional specifications related to ventilation.

This paragraph does not apply to portable oxygen systems, such as systems used to provide first-aid oxygen to passengers or supplemental oxygen for cabin crew mobility, usually stowed in overhead bins, provided that it is confirmed that the shut-off means mounted on the oxygen container is always closed when the system is stowed and not used.

3.4. Routing

The installation of the system should be such that components and pipelines are:

— adequately separated from electrical and fluid systems;

— routed so as to minimise joints and sharp bends;

— clear of moving controls and other mechanisms.

CS 25.1453(b) provides additional specifications related to oxygen pressure sources and the installation of tubing.

4. Oxygen hazards analysis (OHA)

The applicant should demonstrate that the oxygen systems and their components are designed so that the occurrence of an uncontrolled oxygen fire at the aircraft level is extremely improbable and does not result from a single failure.

To assess the consequences of system/component failures, the applicant should conduct an oxygen hazards analysis (OHA) in either a qualitative or a quantitative manner, and include the conclusions of the OHA in the oxygen systems system safety analysis (SSA).

The applicant should provide an OHA with a detailed assessment of the potential ignition and combustion mechanisms. In the OHA, the applicant should do the following:

4.1. Equipment failures

The applicant should use a detailed failure modes and effects analysis (FMEA) at the component level as the input for the OHA. The OHA should not include quality/production issues or human errors during assembly in.

The applicant should take into account all single failures, and any failure combinations that are not shown to be extremely improbable.

4.2. Operating conditions

The applicant should consider the worst-case operating conditions, including any failures determined from paragraph 4.1 that are not shown to be extremely improbable.

4.3. Components and materials

The analysis should cover all component designations and the materials of construction, including compounds and non-metallic material.

Most materials ignite at lower temperatures in an oxygen-enriched environment than in air. The applicant should therefore establish the auto ignition temperature assuming a 100 % oxygen-enriched environment, and evaluate the materials used to determine whether they are flammable under the conditions specified in paragraph 4.2.

4.4. Ignition mechanisms

The assessment should address the identification of the possible internal ignition mechanisms. As a minimum, the following mechanisms should be assessed:

— adiabatic compression (pneumatic impact) (see Note 1 below)
— frictional heating
— mechanical impact
— particle impact
— fresh metal exposure
— static discharge
— electric arc
— chemical reaction
— resonance.

The applicant should evaluate each ignition mechanism under the conditions specified in paragraph 4.2 to determine whether it exists in the component and in the system considered.

Note 1: in calculating the temperature elevation due to oxygen compression, the applicant should use the transient peak pressures measured under paragraph 5.2, unless other values are duly demonstrated.

4.5. Kindling chain

The applicant should evaluate the ability of a fire to propagate and burn through a component, i.e. the kindling chain. The ignition and burning of a single component may produce sufficient heat to ignite the surrounding materials, leading to a burn-through of the component.

Therefore, if any of the ignition mechanisms assessed under paragraph 4.4 exists, the applicant should conduct an analysis to assess the kindling chain, based on the ability of the materials of construction to contain a fire.

5. Design considerations

5.1. High-pressure shut-off

As required by CS 25.1453(c), the applicant must keep to a minimum the parts of the system that are subjected to high-pressure oxygen, and must locate those parts so they are remote from occupied compartments to the extent that is practicable.

High-pressure shut-off valves should be designed to open and close slowly enough so as to avoid the possible risk of fire or explosion.

5.2. Pressure-limiting devices (e.g. relief valves)

As required by CS 25.1453(e), the applicant must design the pressure-limiting devices (e.g. relief valves), which protect parts of the system from excessive pressure, so that in the event of a malfunction of the normal pressure-controlling means (e.g. a pressure reducing valve), they prevent the pressure from exceeding the applicable maximum working pressure multiplied by 1.33.

In addition, the performance of pressure-limiting devices should be tested on a complete system under the conditions specified in paragraph 4.2, but limited to failures that are not shown to be extremely improbable.

For testing purposes, oxygen can be replaced by an inert gas (e.g. nitrogen). However, the relationship between the pressure and the temperature would not be simulated by the inert gas and should be analysed separately. The transient pressure level (TPL) should be measured at various locations, and each component of the oxygen system exposed to the TPL should be demonstrated to sustain the pressure level.

The analysis detailed in paragraph 4.1 may identify single failures that affect the pressure regulation device. These failures could include poppet/shaft/diaphragm blockages or ruptures, seal leakages, etc. of a pressure reducer. If the applicant excludes any of these single failures from the TPL assessment due to

— design considerations, such as a safety factor on the yield strength, the size of damage, etc. or

— a low estimated probability of the failure occurring,

they should provide a detailed rationale for this in the certification documents and agree it with EASA.

CS 25.1453(d) provides additional specifications related to the protection of oxygen pressure sources (e.g. tanks or cylinders) against overpressure.

5.3. Isolation

When the system includes multiple bottles as oxygen sources, each source should be protected from reverse flow or reverse pressure if a failure occurs on one source. Such isolation can be achieved by installing check valves or an equivalent means in an appropriate manner.

5.4. Non-metallic hoses

Except for flexible lines from oxygen outlets to the dispensing units, or where shown to be otherwise suitable for the installation, non-metallic hoses should not be used for any oxygen line that is normally pressurised during flight.

If non-metallic hoses with anti-collapse springs are used due to installation constraints, it should be ensured that inadvertent electrical current cannot reach the spring, as this could cause the hose to melt or burn, leading to an oxygen-fed fire. As an example, correctly grounded metallic braid may be considered to prevent inadvertent electrical current from reaching the spring.

In addition, non-metallic oxygen distribution lines should not be routed where they may be subjected to elevated temperatures, electric arcing, or released flammable fluids that might result from normal operation, or from a failure or malfunction of any system.

5.5. Grounding

All the oxygen lines and hoses should be grounded as appropriate.

5.6. Joints

Joints should, as far as possible, be assembled dry. However, where compounds are used for sealing, they should be approved for that purpose.

5.7. Recharging systems

Recharging systems, if installed, should be provided with means to prevent excessive rates of charging, which could result in dangerously high temperatures within the system. The recharging system should also provide protection from contamination.

Where in situ recharging facilities are provided, the compartments in which they are located should be accessible from outside the aircraft and be as remote as possible from other service points and equipment. Placards should be provided, located adjacent to the servicing point, with adequate instructions covering the precautions to be observed when the system is being charged.

[Amdt 25/21]

AMC 25.1441(c) Oxygen chemical generators and small sealed, one-time use gaseous oxygen bottles

ED Decision 2019/013/R9/013/R

For chemical generators and for small, sealed, one-time use, gaseous oxygen bottles distributed throughout the cabin for passenger use, the following precautions should be considered in order to ensure that oxygen is actually available:

1. The oxygen supply source should be designed and tested to ensure that it will retain the required quantity of oxygen or chemicals throughout its expected life under the foreseeable operating conditions;
2. A means should be provided for maintenance personnel to readily determine when oxygen is no longer available in the supply source due to inadvertent activation;
3. The life limit of the oxygen supply source should be established by test and analysis;
4. Each oxygen supply source should be labelled such that the expiration date can be easily checked by maintenance; and

5. Instructions for continued airworthiness should be provided to ensure that the oxygen supply sources:

    a. are removed from the aeroplane and replaced whenever they have been used, and before they reach their expiration dates; and

    b. are not installed on the aeroplane beyond their expiration dates.

[Amdt No: 25/23]

AMC 25.1441(d) Oxygen equipment and supply

ED Decision 2003/2/RM

In assessing the required oxygen flow rates and equipment performance standards, consideration should be given to the most critical cabin altitude/time-history following any failure, not shown to be Extremely Improbable, which will result in the loss of cabin pressure taking into account the associated emergency procedures.

CS 25.1443 Minimum mass flow of supplemental oxygen

ED Decision 2003/2/RM

(a) If continuous flow equipment is installed for use by flight-crew members, the minimum mass flow of supplemental oxygen required for each crew member may not be less than the flow required to maintain, during inspiration, a mean tracheal oxygen partial pressure of 149 mmHg when breathing 15 litres per minute, BTPS, and with a maximum tidal volume of 700 cm^3 with a constant time interval between respirations.

(b) If demand equipment is installed for use by flight-crew members, the minimum mass flow of supplemental oxygen required for each crew member may not be less than the flow required to maintain, during inspiration, a mean tracheal oxygen partial pressure of 122 mmHg, up to and including a cabin pressure altitude of 10668 m (35 000 ft), and 95% oxygen between cabin pressure altitudes of 10668 m (35 000) and 12192 m (40 000 ft), when breathing 20 litres per minute BTPS. In addition, there must be means to allow the crew to use undiluted oxygen at their discretion.

(c) For passengers and cabin crew members, the minimum mass flow of supplemental oxygen required for each person at various cabin pressure altitudes may not be less than the flow required to maintain, during inspiration and while using the oxygen equipment (including masks) provided, the following mean tracheal oxygen partial pressures:

    (1) At cabin pressure altitudes above 3048 m (10 000 ft) up to and including 5639 m (18,500 ft), a mean tracheal oxygen partial pressure of 100 mmHg when breathing 15 litres per minute, BTPS, and with a tidal volume of 700 cm^3 with a constant time interval between respirations.

    (2) At cabin pressure altitudes above 5639 m (18 500 ft) up to and including 12192 m (40,000 ft), a mean tracheal oxygen partial pressure of 83·8 mmHg when breathing 30 litres per minute, BTPS, and with a tidal volume of 1100 cm^3 with a constant time interval between respirations.

(d) If first-aid oxygen equipment is installed, the minimum mass flow of oxygen to each user may not be less than 4 litres per minute, STPD. However, there may be a means to decrease this flow to not less than 2 litres per minute, STPD, at any cabin altitude. The quantity of oxygen required is based upon an average flow rate of 3 litres per minute per person for whom first-aid oxygen is required.

(e) If portable oxygen equipment is installed for use by crew members, the minimum mass flow of supplemental oxygen is the same as specified in sub-paragraph (a) or (b) of this paragraph, whichever is applicable.

CS 25.1445 Equipment standards for the oxygen distributing system

ED Decision 2012/008/R

(a) When oxygen is supplied to both crew and passengers, the distribution system must be designed for either –

(1) A source of supply for the flight crew on duty and a separate source for the passengers and other crew members; or

(2) A common source of supply with means to separately reserve the minimum supply required by the flight crew on duty.

(b) Portable walk-around oxygen units of the continuous flow, diluter demand, and straight demand kinds may be used to meet the crew or passenger breathing requirements.

[Amdt 25/12]

CS 25.1447 Equipment standards for oxygen dispensing units

ED Decision 2017/015/R

(See AMC 25.1447)

If oxygen-dispensing units are installed, the following apply:

(a) There must be an individual dispensing unit for each occupant for whom supplemental oxygen is to be supplied. Units must be designed to cover the nose and mouth and must be equipped with a suitable means to retain the unit in position on the face. Flight crew masks for supplemental oxygen must have provisions for the use of communication equipment.

(b) If certification for operation up to and including 7620 m (25 000 ft) is requested, an oxygen supply terminal and unit of oxygen dispensing equipment for the immediate use of oxygen by each crew member must be within easy reach of that crew member. For any other occupants the supply terminals and dispensing equipment must be located to allow use of oxygen as required by the operating rules.

(c) If certification for operation above 7620 m (25 000 ft) is requested, there must be oxygen dispensing equipment meeting the following requirements (See AMC 25.1447(c)):

(1) There must be an oxygen-dispensing unit connected to oxygen supply terminals immediately available to each occupant, wherever seated. If certification for operation above 9144 m (30 000 ft) is requested, the dispensing units providing the required oxygen flow must be automatically presented to the occupants before the cabin pressure altitude exceeds 4572 m (15 000 ft) and the crew must be provided with a manual means to make the dispensing units immediately available in the event of failure of the automatic system. The total number of dispensing units and outlets must exceed the number of seats by at least 10%. The extra units must be as uniformly distributed throughout the cabin as practicable. (See AMC 25.1447(c)(1).)

(2) Each flight-crew member on flight deck duty must be provided with demand equipment. In addition, each flight-crew member must be provided with a quick-donning type of oxygen dispensing unit, connected to an oxygen supply terminal, that is immediately