



AEROSPACE INFORMATION REPORT

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Ø AIR CONDITIONING OF SUBSONIC AIRCRAFT AT HIGH ALTITUDE

Ø TABLE OF CONTENTS

1. PURPOSE
2. SCOPE
3. GENERAL CONSIDERATIONS
 - 3.1 Physiological Factors
 - 3.2 Flight Procedures
4. PRESSURIZATION DESIGN GUIDELINES
 - 4.1 Pressure Altitude and Controls
 - 4.2 Redundant Pressure Sources
 - 4.3 Window Design
 - 4.4 Door and Hatch Design
 - 4.5 Structural Design
 - 4.6 Pressure Relief Systems
5. TEMPERATURE FACTORS
6. VENTILATION
7. HUMIDITY FACTORS
8. DETERMINATION OF CABIN LEAKAGE
9. NOTES

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1. PURPOSE

∅ This information report clarifies the special problems involved in the pressurization and air conditioning of civil subsonic transport aircraft during high altitude flight, as they relate to the physical and physiological limitations of the human body.

2. SCOPE

∅ This report is limited to the special problems of air quantity, purity, movement, pressure, temperature, and humidity which arise from the requirements of the human body during high altitude flight, together with the associated aircraft design problems.

2.1 Within the purpose of this report, high altitude is defined as altitudes above 25,000 ft. (7620m) and up to ∅ 45,000 ft. (13716m).

2.2 It is considered that all requirements for air conditioning of aircraft as presented in SAE ARP 367, ∅ Airplane Cabin Pressurization, and ARP 85, Air Conditioning Equipment, General Requirements for Subsonic Airplanes, exist in high altitude flight, in addition to the special requirements discussed in this AIR.

2.3 It is considered that medical aspects of the physiological problems will be treated only briefly in this ∅ report. It is anticipated that Aviation Medicine and Human Factors personnel will be consulted for detailed analysis of specific problems. Refer to 3.1.6 for hypoxia information.

3. GENERAL CONSIDERATIONS

3.1 Physiological Factors:

3.1.1 A loss of cabin pressure at high altitude encompasses possible physiological and physical hazards. ∅ The passengers may also react psychologically to rapid decompression in a manner contributing to the overall hazard.

3.1.2 Damage to ears and sinuses on rapid decompression is not likely due to the relative ease with which air can escape from the sinuses and inner ear except in individuals with upper respiratory ailments.

3.1.2.1 With rapid descent of the aircraft seeking lower altitude following decompression, ear and sinus difficulties may be experienced by many of the occupants of the airplane. Since the tolerance of individuals to recompression varies, the difficulties they experience may vary from none to temporary pain, temporary deafness, and possibly to rupture of the ear drum. This pain, which may be extreme, and the damage, which is usually repairable, must be accepted to prevent more serious impairment due to hypoxia (lack of oxygen).

3.1.3 Exposure to high altitude may result in decompression sickness, the liberation from solution within the body of nitrogen due to rapid and/or extreme pressure decreases.

3.1.3.1 The critical altitude at which decompression sickness is likely to occur, regardless of the rate of pressure change, is 30,000 ft. (9144m). Symptoms may arise, however, at altitudes as low as 23,000 ft. (7010m). The probability and severity of symptoms will increase with physical activity, age, and overweight. Usually several minutes of exposure are required before symptoms of decompression sickness begin.

3.1.3.2 The frequency of occurrence and/or severity of decompression sickness is not significantly ∅ affected by the use of oxygen during decompression.

3.1.4 Frostbite is a possible hazard after decompression, with possible uncontrolled ventilation at ∅ temperatures approaching -70°F (-57°C). Other physiological effects of decompression are hyperventilation and post decompression shock.

3.1.5 Personal injury may occur as a direct result of the sudden outrush of air during the decompression. The passage of air may hurl unattached objects about the cabin and, if sufficiently violent, may carry personnel through the decompression opening. Passenger injury may also occur as a result of the pilot's effort to produce rapid descent rates. This will diminish if seat belts are kept fastened and loose objects kept to a minimum.

3.1.6 Hypoxia will result from exposure to low barometric pressures of high altitudes. The low partial pressure of oxygen in the air under these conditions makes it impossible for the oxygen requirements of the body to be met. Unconsciousness and death will occur with marked rapidity if protective measures are not taken.

3.1.6.1 Hypoxia symptoms and consequences, together with the oxygen equipment and procedures required to protect against it, are detailed in the following documents:

AIR 822 - Oxygen Systems for General Aviation

AIR 825 - Oxygen Equipment for Aircraft

AIR 847 - Oxygen Equipment for Commercial Transport
Aircraft Which Fly Above 45,000 Feet

AIR 1069 - Crew Oxygen Requirements Up To a Maximum of
45,000 Feet

3.2 Flight Procedures:

3.2.1 With flight at physiologically critical altitudes, the times required for recognition of emergency condition, reaction, and eventual initiation of descent become vital factors.

3.2.2 In the event of accidental or intentional loss of cabin pressure at high altitude, it is essential that the airplane descend to an altitude of 8,000 ft. (2438 m). If terrain or other conditions do not permit continued flight at such low altitude, then the revised altitude schedule may be adjusted to a level where the available oxygen equipment will meet the needs of the passengers and crew. (Refer to F.A.R. 121.329 (c)). To prevent or alleviate the incidence of eardrum injuries due to high rate of descent, the descent rate should be reduced to less than 1500 f.p.m. (7.6 m/s) below 1500 feet (4,572m), consistent with other operational requirements.

3.2.3 With sudden decompression, (loud noises occur,) fog formation occurs which is often mistaken for smoke, unusual wind gradients are developed, and general confusion borne of fear is generated, particularly in untrained personnel.

4. PRESSURIZATION DESIGN GUIDELINES

The design of aircraft structure, including windows, doors, and hatches must be such as to make the possibility of an uncontrolled decompression in flight as remote as the possibility of a major structural failure.

4.1 Pressure Altitude and Controls:

4.1.1 The cabin pressure altitude should be no greater than 8000 ft. (2438m.) during normal flight at the maximum cruise altitude of the airplane. The cabin pressure control system should be designed so that no single failure results in a loss of control. Furthermore, the control system should include a means of automatically limiting cabin altitude to 15,000 ft. (4572 m) in the event of a failure or failures which causes the outflow valve (s) to open. Large outflow valves, required to minimize cabin pressure buildup on the ground, should be actively prevented from opening inadvertently during pressurized flight. Refer to ARP 1270 for further details on cabin pressure control system requirements.