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AEROSPACE INFORMATION REPORT

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# ENVIRONMENTAL CONTROL* FOR CIVIL SUPERSONIC TRANSPORT



## TRANSPORT:

Due to the significant step increase in speed and altitude of the supersonic transport above present (1961) jet transports (from Mach No. about .85 to 2.4 - 3, altitude from 40,000 to 70,000 feet) and decrease in average time spent by passengers in aircraft (from about 5 to 2 hours), a careful review of the environmental system from a safety and comfort point of view is needed.

This document supplements and in some cases supersedes the recommendations presented in ARP 85D which refers to subsonic civil transports.

The limits and design goals suggested in this document are as seen by SAE Committee A-9 and should not be interpreted as a definite specification.



## 1. COMFORT:

### 1.1 Fresh Air Supply:

1.1.1 Cabin atmosphere has to be maintained within specified comfort and safety limits. A minimum amount of external fresh air per passenger is not specified and can be selected at any value (including 0) by the designer providing cabin air temperature, pressure, ventilation rate** composition, odor level and other factors are kept within passenger comfort limits.

### 1.2 Pressure:

1.2.1 Under normal operating conditions the stabilized cabin pressure should be no lower than the equivalent of 6,000 feet*** altitude nor higher than the equivalent of the sea level pressure plus .5 inches of mercury.

1.2.2 Under normal operating conditions the rate of change of cabin pressure should not exceed .3 psi/minute decrease of pressure or .1 psi/minute pressure increase.

* Environmental control is defined as follows: It is a system which provides an environment controlled within specified limits of comfort and/or safety operation for humans, animals and/or equipment. These limits may include one or more of the following factors: composition of surrounding medium, pressure, temperature, humidity, velocity of medium, thermal radiation, wall temperature, noise vibration, etc. The definition of environmental control system encompasses the air conditioning system but is broader and does not necessarily rely on air alone as the controlled medium.

** Rate of air entering compartment regardless of source.

*** Present FAA regulations permit 8,000 feet cabin.



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1.3 Temperature:

1.3.1 The environmental system should be capable of maintaining any stabilized dry bulb temperature which combined with air movement, humidity, radiation, cabin altitude and other factors will provide comfort for the majority of passengers. (This temperature will be within D.B. 60° - 90°F limits.)

1.3.2 Under normal operating conditions the rate of change of cabin air temperature should not exceed 2°F per minute.

1.3.3 The air temperature difference in occupied area between foot and head of sitting passenger should not exceed 3°F.

1.3.4 Horizontal temperature gradients should be no more than 1°F per foot, with maximum difference from one extreme to the other of one compartment no more than 5°F.

1.3.5 If gaspers (personal vents) are used, the air temperature delivered through them in general should be lower than cabin average temperature. However, air delivered from gaspers should be no lower than 10°F below cabin dewpoint temperature and not lower than 35°F.

1.3.6 It is desirable that wall surfaces should have temperatures within 60°F to 100°F.

1.4 Humidity:

1.4.1 Acceptable cabin relative humidity is between 5% and 70%. Recommended optimum comfort value about 35%.

1.4.2 Air supplied to the cabin should not cause fogging of the cabin. Short (less than one foot) "fog steamers" in the vicinity of inlets are permissible.

1.5 Air Movements:

1.5.1 The recommended maximum air velocity (except using gaspers) to which a passenger should be exposed is 40 feet per minute.

1.5.2 The maximum allowable velocity of the air leaving the gaspers should be the function of the gasper size, location, distance from the passenger, noise level prevailing in the aircraft, etc.

1.5.3 Air delivered from gaspers should not cause undue drafts to adjacent passenger.

1.5.4 The system should be capable of providing air velocity at the head level of sitting passenger not less than 500 feet per minute with all gaspers in operation.

1.5.5 Complete shutoff of the gaspers and variations of the flow direction should be provided in line with present day practices.

1.6 Air Composition:

1.6.1 The recommended limits of partial pressures for oxygen, nitrogen, carbon dioxide, carbon monoxide and ozone in the cabin air are as follows:

Oxygen Partial Pressure - 118 mm Hg Min, 180 mm Hg Max
Carbon Dioxide Partial Pressure - 7.6 mm Hg Max
Ozone - .000076 mm Hg Max (See Para. 1.6.4)
Nitrogen Partial Pressure - The partial pressure required to make up the balance of the total cabin pressure.

The oxygen partial pressure limits represent, as a minimum, the partial pressure of oxygen in air at 8,000 feet and a maximum 20 mm Hg higher than the sea level pressure of 160 mm Hg. To go lower than the minimum would tend to result in hypoxia in some passengers; to go higher than the recommended maximum would result in excessively rapid burning of cigarettes and in rapid deterioration of food products and excessive use of oxygen.

The carbon dioxide recommendations are intended to avoid undesirable symptoms for either passengers or crew. It is not essential to reduce the carbon dioxide content to zero, and overruns up to 3% by volume or (22.8 mm Hg P. P. at sea level pressure) for short time (less than 30 min.) are acceptable.

Carbon monoxide, and ozone, are based on American Conference of Governmental Industrial Hygiene, (see 1.6.3 and 1.6.4)

1.6.2 In addition to maintaining the composition of the air within the limits specified in 1.6.1, contaminants such as dust, odors, tobacco smoke, ozone, decomposition products from oils or fuels, water, pollens, and bacteria must be maintained below levels of concentrations that can adversely affect the safety or comfort of the aircraft crew or passengers.

1.6.3 Under no condition should any contaminant in the cabin air reach a concentration greater than maximum acceptable concentration established per industrial 8 hour working day by American Conference of Governmental Industrial Hygiene (ACGIH). In a case where there is no value established by ACGIH, concentration should not be greater than 50% of harmful concentration. Harmful concentration implies exposures where measurable adverse effects on crew and passengers are encountered.

1.6.4 Since ACGIH data is for 8 hours per day exposure - overruns in case of short time exposure no doubt are permissible. There is no information available to what extent overruns can be tolerated. Until competent agency will release safe values for conditions compatible with exposure of crew and passengers of supersonic transport, it is advisable to comply with ACGIH.

1.6.5 The following table gives Maximum Acceptable Concentrations established for industrial 8 hour working day by American Conference of Governmental Industrial Hygiene (ACGIH) for some contaminants.

| Material | Maximum Acceptable Concentration Parts Per Million by Volume (ACGIH) |
|---|---|
| Ammonia | 100 |
| Carbon Dioxide | 5000 |
| Carbon Monoxide | 100**** |
| Chlorine | 1 |
| Freon 12 | 1000 |

**** CAR 4b.371 and proposed MIL-E-8593A recommend concentration of CO below 50 parts per million.

| Material | Maximum Acceptable Concentration Parts Per Million By Volume (ACGIH) |
|---|---|
| Methyl Alcohol | 200 |
| Benzene ($C_6H_6$) | 35 |
| "Gasoline Vapors" | 500 |
| Ozone | 0.1 |
| Aerolein (from cooking fats) | 0.5 |

1.6.6 Toxic gases may be liberated from various products which are normally totally harmless except when heated to high temperatures (such as the ram air stagnation temperature of 630°F and skin temperature of 450°F to 550°F of a Mach 3 aircraft). If there is lack of previous experience, materials which will be exposed to those temperatures should be heat-checked in laboratory tests. In systems where fresh air is admitted from the outside, a means of assuring the concentration of ozone in the fresh air below one-tenth of a part per million should be provided.

1.6.7 In systems which introduce external air at rates lower than .1 pounds per minute per person, instrumentation should be provided to measure in compartment at least partial pressure of oxygen and carbon dioxide.

1.6.8 In open loop systems admitting fresh air from the outside, a warning device of a high concentration of ozone should be provided.

1.7 Air Conditioning Equipment Noise:

1.7.1 Noise generated by equipment as measured inside the occupied compartment at head level of occupants should be kept to minimum.

1.7.2 The noise level should not exceed values specified in the following table. Values from the table can be interpolated between points by straight line proportions.

| Frequency Cycles per second | Noise Sound Pressure Level $L = 20 \log_{10} \frac{P}{.0002}$ Where P is in dynes per $cm^2$ |
|---|---|
| 20 - 75 | 91 |
| 75 - 150 | 81 |
| 150 - 300 | 72 |
| 300 - 600 | 66 |
| 600 - 1200 | 63 |
| 1200 - 2400 | 60 |
| 2400 - 4800 | 58 |
| 4800 - 10000 | 57 |

1.7.3 Noise generated outside of the airplane, with engines not running, (if applicable) at the distance of 50 feet from equipment location should not exceed S.I.L. 80 where S.I.L. is speech interference level. Defined as an arithmetic average of noise level expressed in decibels for the octaves of frequency 600-1200, 1200-2400, 2400-4800, cycles per second.

2. FLIGHT DECK:

2.1 Flight deck temperature should be controlled independently of main cabin control.

3. CARGO COMPARTMENT:

3.1 The cargo compartment should be maintained at a recommended temperature between 60°F and 85°F. (Never at normal operation to exceed limits of 32° to 120°F.) In emergency operation cargo compartment temperature should be below 200°F.

3.2 The cargo compartment should have the same pressure schedule as the cabin. However, no air from the cargo compartment should be recirculated through the cabin or flight deck. Pressure equalizing grills and openings are permissible.

3.3 In case of fire or other contamination of air in cargo compartment, there should be no possibility of contamination to main cabin or flight deck.

4. SAFETY:

4.1 Design Philosophy - Due to the hostile environment surrounding the airplane, utmost reliability of the environmental system is required.

4.2 The reliability should be based on high reliability of components and be supplemented by sufficient redundancy.

4.3 No single component failure should result in need for immediate change in flight plan.

4.4 Further failure of second component should not result in danger to the passengers and crew but should allow tolerable cabin conditions if flight plan is changed.

4.5 Failure of one redundant component should not induce damage to the other components, systems or subsystems.

4.6 Emergency systems can be either separate or constitute part of the normal system so long as reliability and failure considerations are compiled with, as stated above.

4.7 Emergency system must be capable of providing tolerable (although not necessarily comfortable) surroundings until airplane can descend to habitable altitude, proceed and reach a safe landing field.

4.8 Emergency system should not require change of flight plan penalizing the airplane to the point that it cannot reach emergency landing field.

4.9 Under emergency conditions the cabin temperature should not be above 105°F, or below 40°F; the cabin pressure (for extended time flights) should not be above 15,000 feet altitude.

4.10 If the emergency cabin pressure exceeds the equivalent of 10,000 feet altitude, individual oxygen for passengers should be provided. It is expected that at least 10% of passengers will need oxygen above 10,000 feet and 100% passengers above 14,000 feet.