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Superseding AIR746A

Environmental Control for Civil Supersonic Transport

RATIONALE

This document has been reaffirmed to comply with the SAE 5-year Review policy.

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## SAE AIR746 Revision B

### 1. SCOPE:

This document supplements ARP85, to extend its use in the design of ECS for supersonic transports. The ECS provides an environment controlled within specified operational limits of comfort and safety, for humans, animals, and equipment. These limits include pressure, temperature, humidity, conditioned air velocity, ventilation rate, thermal radiation, wall temperature, audible noise, vibration, and composition (ozone, contaminants, etc.) of the environment. The ECS is comprised of equipment, controls, and indicators that supply and distribute conditioned air to the occupied compartments. This system is defined within the ATA 100 specification, Chapter 21. It interfaces with the pneumatic system (Chapter 36 of ATA 100), at the inlet of the air conditioning system shut-off valves.

#### 1.1 Purpose:

The purpose of this document is to provide information to assist in the design, installation, and analysis of environmental control systems (ECS) on supersonic transports. These transports operate at higher speeds and at higher altitudes than subsonic airplanes. These characteristics introduce certain environmental, operational, and design factors that are not considered in the design of systems for subsonic airplanes.

### 2. REFERENCES:

#### 2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

2.1.1 ARP85 Air Conditioning Systems for Subsonic Airplanes

2.1.2 AIR910 Ozone Problems in High Altitude Aircraft

#### 2.2 FAA Publications:

Available from FAA, 800 Independence Avenue, SW, Washington, DC 20591.

2.2.1 Federal Aviation Regulations, Part 25 "Airworthiness Standards: Transport Category Airplanes"

2.2.2 Advisory Circular AC No. 120-52 "Radiation Exposure of Air Carrier Crew Members"

2.2.3 Advisory Circular AC No. 120-38: "Transport Category Airplane Cabin Ozone Concentrations"

2.2.4 FAA-EQ-78-03 "Guidelines for Flight Planning During Periods of High Ozone Occurrence"

2.2.5 NPRM 89-31 "Standards for Approval for High Altitude Operation of Subsonic Transport Airplanes"

2.3 Other Publications:

2.3.1 Joint Airworthiness Requirements, Part 25: "Large Aeroplanes"

2.3.2 Wallace, R.W. and Sondhaus, C.A. "Cosmic Radiation Exposure in Subsonic Air Transport", Aviation Space Environmental Medicine 49: 610-623, 1978

3. REGULATIONS AND DESIGN PHILOSOPHY:

3.1 Regulations:

The regulations applicable to the ECS of supersonic transports are identical to the regulations applicable to the systems of subsonic airplanes. They are identified in 3.1 of ARP85. The regulatory agencies have not identified any additional regulations applicable to the supersonic transport. However, one should expect additional requirements, by means of Special Conditions or Issue Papers when negotiating the certification basis for a supersonic transport.

Notice for Proposed Rule Making, 2.2.5, has proposed amendment of certain current regulations and addition of some new rules. The NPRM 89-31 proposals relevant to the ECS are contained in Appendix A. An early check on the status of these proposals is suggested.

Control and indication, safety, reliability and maintainability, electrical power, and life cycle cost are important in the design of systems for supersonic transports. The guidelines and recommendations of 3.2 through 3.6 of ARP85 apply in their entirety. However, it should be recognized that reliability and safety goals generally accepted for subsonic airplanes may not be acceptable for supersonic transports which cruise at higher altitudes. Increased use of redundancy, separation of wiring, distributed controls, fault tolerant system concepts, microprocessors, artificial intelligence systems, etc., may be necessary to meet the supersonic transport's system reliability and safety goals. Also, to meet life cycle cost goals, use of an alternate compressed air supply (e.g., shaft driven compressor), heat sink (fuel, spent cabin air), materials (composites), signal transmission means (fiber optics), etc., may be necessary. The supersonic transport system may also require increased cabin air recirculation, increased filtration, and active cooling of recirculated cabin-air, and cabin-air humidification. These items have previously not been addressed in detail and the regulations that may be imposed are presently unknown.

3.2 Design Philosophy:

The ECS design philosophy is identical for subsonic airplane and supersonic transport: low life cycle cost, high reliability, and safety while providing a comfortable and safe environment for crew and passengers during normal and probable failure conditions. Operation at higher altitudes (in excess of 40 000 ft (12.2 km)) and higher speeds (Mach number greater than unity) cause certain environmental and operational factors to assume greater significance in the design of systems for supersonic transports. Important environmental factors are cosmic radiation, higher ozone concentrations and essentially constant ambient temperatures in the stratosphere. Operational factors cause aerodynamic heating of structure and large heat flux, high ram air temperatures or

3.2 (Continued):

reduction in available heat sink, high cabin-to-ambient pressure differentials, and a potential for rapid decompressions in the event of air-conditioning system, cabin pressure control system, or structural failure. These factors demand increased consideration of redundancy, distributed controls, fail-safe features, protective devices, etc. Aircraft design may impose restrictions on engine type or engine bypass ratio. This may impose design constraints and or penalty factors (e.g., engine bleed, shaft power, ram-air drag, etc.) different than those encountered on present subsonic commercial airplanes which use high-bypass ratio turbofan engines.

The data contained in ARP85, in its entirety, applies to the supersonic transports as they operate at subsonic speeds at lower altitudes. The limiting items of ARP85 are: Figure 3, ambient temperature versus altitude, and Figure 4, ambient humidity versus altitude. These figures do not provide data for operational altitudes of supersonic transports. Thermal management is of concern due to aerodynamic heating of structure and high ram-air recovery temperature during high speed cruise. These items are not addressed in ARP85. The former increases the heat load and the latter reduces the heat sink capability. Also, not discussed in ARP85 are radiation, low humidity, and high ozone concentrations normally found in the environment at high altitudes. These factors, in addition to the limited availability (or high cost) of bleed-air and heat sink, importance of higher reliability, and thermal management, make it essential to evaluate design solutions other than those that have proven successful in subsonic airplanes.

4. SYSTEM DESIGN REQUIREMENTS:

The ECS design requirements for the supersonic transport are the same as the requirements for the subsonic airplane, described in Section 4 of ARP85. The regulatory agencies reserve the right to impose additional or different requirements, see 3.1. System design requirements can only be finalized after the certification basis has been established with the regulatory agencies.

Transports operating at high altitudes are subject to increased cosmic radiation and it is of concern for the safety of equipment and personnel. In the contiguous United States, at ground level the average dose equivalent rate<sup>1</sup> from cosmic plus terrestrial radiation is 0.6 microsievert (0.06 millirem) per hour, see Advisory Circular AC No. 120-52. At an altitude of 35 000 ft (10.7 km), the dose equivalent rate from cosmic rays is about 6 microsievert (0.6 millirem) per hour. The dose equivalent rate substantially increases with increase in altitude. The dose equivalent rate also increases, by one to two orders of magnitude, during solar activity. The higher cosmic radiation may impose hardening requirements for microprocessors and other electronic components to ensure satisfactory operation. Instrumentation may also be required to warn crew of hazardous radiation levels, see 2.3.2.

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<sup>1</sup> The dose equivalent is a measure of the biological harmfulness of ionizing radiation and takes into account that equal amounts of absorbed energy from different types of ionizing radiation are not necessarily equally harmful. The present international unit of dose equivalent is the sievert. [1 sievert = 100 rem]