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AEROSPACE RECOMMENDED PRACTICE

ARP 85D

AIR CONDITIONING EQUIPMENT, GENERAL REQUIREMENTS FOR SUBSONIC AIRPLANES

Issued 1-1-43
Revised 8-15-61

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1. PURPOSE:

1.1 "ARP - This recommended practice is based on sound engineering principles and intended as guides for future standard engineering practices for civil aircraft industry."

1.2 This recommended practice is to be considered as being currently applicable and necessarily subject to revision from time to time, due to rapid development of the aircraft industry.

1.3 The following recommendations are based on practical engineering requirements for the design and testing of such types of air conditioning equipment as is now used on airplanes and for such as may be developed to meet the demand imposed in the field of service.

2. SCOPE:

2.1 Air Conditioning System - General - Dealing with Design Features

2.2 Air Conditioning Equipment - Commercial Passenger - Dealing with features. Applicable only to commercial passenger carrying aircraft.

2.3 Desirable Design Features - General information for use of those concerned in meeting requirements contained herein.

3. AIR CONDITIONING SYSTEM - GENERAL:

3.1 Definition:

3.1.1 The basic aircraft air conditioning system should consist of the following:

a. A source of fresh air (at least two sources independent of each other).
b. A source of heat.
c. A cooling unit (air or vapor cycle machine with associated heat exchangers).
d. An air distribution system.
e. A waste and vitiated air exhaust system.
f. A temperature control system.

3.1.2 Cabin Pressurization: See ARP 367, Airplane Cabin Pressurization.

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3.1.3 The system may also include one or more of the following:

a. Filters
b. Recirculation provisions
c. Humidity control
d. Germicidal control
e. Individual passenger cool air outlet system
f. System instrumentation, including
   1. Cabin temperature indicators
   2. Duct temperature indicators
   3. Cabin humidity indicators
   4. Cabin airflow indicators
   5. Bleed air duct pressure indicators
   6. Other miscellaneous instrumentation as may be required for proper operation of the equipment involved.

3.2 General Recommendations:

3.2.1 The design of the air conditioning system should be such as to preclude the possibility of introduction of harmful concentrations of any toxic, combustible or objectionable fluids or gases from the aircraft or engine such as exhaust gases, de-icer fluids, gasoline or the fumes therefrom.

3.2.2 The air conditioning system should provide adequate ventilation to avoid an objectionable odor level and smoke concentration for all normal flight conditions.

3.2.3 The duct distribution system including the air inlets to the occupied space should be such as to provide for a minimum of temperature variation and air movement in accordance with values hereinafter recommended, within the air conditioned space.

3.2.4 Adequate exhaust should be provided to remove smoke or other contaminants resulting from equipment malfunction or fire.

3.2.5 A temperature control system should be provided which will provide a means for regulating the temperature within the air conditioned space independent of engine or airplane operation. The system should also provide for independent cabin and cockpit temperature control.

3.2.6 Aircraft air conditioning requirements should be met during all normal regimes of engines and airplane speeds and airplane altitudes.

4. AIR CONDITIONING EQUIPMENT:

4.1 Component Equipment Design:

4.1.1 Component parts of the air conditioning equipment should be constructed of materials which are considered acceptable for the particular use, and should be made and furnished with the degree, uniformity and grade of workmanship generally accepted in the aircraft industry.

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4.1.2 Component equipment should be designed to start and operate satisfactorily at design atmospheric temperatures of -65°F to +160°F local environmental conditions and -65°F to +120°F ambient temperatures. Specific installations may require consideration of a broader range of temperatures. This broader range should be stipulated in the detailed specification.

4.1.3 Equipment should be designed fail-safe as may be required by the function of the component or system.

4.1.4 High energy equipment must be capable of self-containment in the event of catastrophic failure. Protection from rotating machinery, such as fans and compressors, should be provided for personnel during ground maintenance and operating checks.

4.2 Component Equipment Installation:

4.2.1 Component equipment installation should be designed for reasonable accessibility for maintenance requirements. Time to remove and install any functional component should not exceed 20 minutes, or 30 minutes for assembled packages of functional components.

4.2.2 The following equipment temperatures should be maintained during flight:

a. Air driven instruments should be maintained at a minimum of 40°F.
b. Batteries should be maintained between 40°F and 110°F.

4.2.3 High energy and high temperature equipment should be adequately protected against overload and overheat with consideration for other vital equipment or structure in close physical proximity.

4.2.4 Pertinent instrumentation should be employed to facilitate not only inflight operation but maintenance and troubleshooting with matching ground test equipment.

5. AIR CONDITIONING SYSTEM DESIGN REQUIREMENTS:

5.1 Ventilating Requirements:

5.1.1 Air Quantities:

5.1.1.1 Ventilation requirements for odor control varies upward from 1.0 #/min per passenger, depending on the volume of cabin per occupant, and degree of recirculation used. If the ventilation is accomplished in part by recirculation, the recirculated air should be purified by adequate filters and/or air washers. In the absence of adequate filters and/or air washers, a minimum of 1.0 #/min per passenger of outside air is required for odor control.
Note: These ventilation requirements have been found satisfactory with volumes of cabins per occupant between 40 and 60 cubic feet.

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5.1.1.2 In addition to the minimum quantity of fresh air stipulated, an additional quantity of cabin air may be recirculated in order to provide proper temperature distribution and to allow cooling or heating load reduction.

5.1.1.3 During warm weather unpressurized operation (when no mechanical cooling is available) a minimum of 40 CFM of fresh air should be provided for each occupant.

5.1.1.4 Sources of outside air should be capable of supplying a minimum of 30 CFM of fresh air per occupant in the crew compartment. The air should not be recirculated, but when exhausted, can be used for windshield heat, equipment cooling, etc.

5.1.1.5 If the air conditioning system is used for defogging and defrosting cockpit transparent areas then the system should be capable of maintaining adequate visibility for all conditions of aircraft operation.

5.1.1.6 Toilets and galleys should be provided with an exhaust system, the capacity of which will exceed the air supply in order to preclude the possibility of any air supplied to such spaces moving into any other occupied portion of the airplane, either through doors or recirculation systems.

5.1.1.7 Air Velocity in Occupied Spaces:

5.1.1.7.1 During heating or mechanical cooling, velocity over occupant should not exceed 40 FPM, except for individual seat air outlets.

5.1.1.7.2 Air velocity during ground cooling "pull-down" through the use of bypass duct systems should not exceed 200 FPM over the occupant and 600 FPM elsewhere.

5.1.1.7.3 Individual seat air inlet flow velocities should be at least 600 FPM at seated head level with all units open.

5.1.2 Air Inlets:

5.1.2.1 General air supply to occupied spaces should be through inlets which are adjustable only for the purpose of balancing the system but are not to be controllable by the occupants.

5.1.2.2 All crew stations or points of localized heating and cooling should have inlets controllable as to quantity or temperature. Such adjustment should not affect the overall balance of the distribution system.

5.1.2.3 Sleeper airplanes with enclosed berths should be provided with an inlet to each berth partially controllable by the occupant.

5.2 Design Requirements for Heating, Cooling and Temperature Control:

5.2.1 General:

5.2.1.1 Ambient Conditions:

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5.2.1.1.1 For particularly localized operations, the average maximum humidity and temperature values for the warmest month of the year, averaged over the last 10 years, in that area should be used for design cooling conditions; the average maximum humidity and minimum temperature values for the coldest month of the year, averaged over the last 10 years, in that area should be used for design heating condtions.

5.2.1.1.2 For operation within continental United States and similar international areas, humidity and temperature conditions for design hot and cold days should be as shown on Figures 1 and 2.

5.2.1.1.3 System design considerations should also be taken for the environmental factors of solar intensity, surface emissivity and aircraft airspeed.

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5.2.1.2 Cabin Conditions:

5.2.1.2.1 Cabin design temperature should be expressed in terms of effective temperature, provided the relative humidity is within the limits of 20 - 70%.

5.2.1.2.1.1 Effective temperature is an experimentally determined index of the degree of warmth experienced on exposure to different combinations of temperature, humidity and air movement. See Figure 3 for effective temperature versus humidity and wet and dry bulb temperatures.

5.2.1.2.2 At normal cruise altitude, except for full cooling conditions, cabin temperature gradients for uniform loading steady state conditions should not exceed 3°F measured in a vertical plane from 2" above floor level to seated head height; centerline temperature gradients should not exceed 5°F.

5.2.2 Cooling Requirements:

5.2.2.1 The cooling load should, in addition to all normal existing loads, in the case of pressurized airplanes, include the heat of compression from the pressure source in order to permit use of the pressurizing system to control the rate of cabin pressure change from take-off during warm weather operation.

5.2.2.2 The cold air discharge temperature should be not less than 35°F in order to prevent icing in the discharge duct, except when auxiliary means are provided to preclude the possibility of such ice formation.

5.2.2.3 The system should have the capability of maintaining an effective cabin temperature not in excess of 75°F below 20,000 ft. altitude and an effective temperature not in excess of 70°F in normal cruise with a normal full passenger load.

5.2.2.4 Suspended water vapor should not normally appear in the passenger compartments as a result of cooling system operation.

5.2.2.5 Ground "pull-down" time to reach 85% of design temperature differential on a design hot day should not exceed 30 minutes for aircraft equipped with self-sustaining equipment using an external power cart, aircraft closed and 100% passenger loading.

5.2.2.6 All cold air ducting should be insulated to prevent "sweating" wherever moisture collection from condensation would have a deteriorating effect on other components or aircraft structure.

5.2.3 Heating Requirements:

5.2.3.1 The aircraft heating requirements should be met at all associated aircraft speeds from sea level to the aircraft maximum design cruise altitude with a 20% passenger load.

5.2.3.2 The heating system should be capable of producing a 75°F dry bulb cabin.

5.2.3.3 Cargo compartments should be maintained above freezing but do not particularly require ventilation unless otherwise stipulated in the detailed specification.

5.2.3.4 The ground "pull-up" time to reach 60% of design temperature differential on a design cold day should not exceed 30 minutes for aircraft equipped with a heating system operable with an external power cart only, aircraft closed up and 20% passenger loading.

5.2.3.5 The maximum supply steady state air temperature from the cabin inlets should not be in excess of 140°F.

5.2.3.6 For systems employing the use of radiant panels, panel temperatures should not be in excess of 105°F.

5.2.4 Temperature Control:

5.2.4.1 A sytem of automatic temperature control should be provided for all commercial passenger transport airplanes. The system should be provided with simple means for manually overriding the automatic temperature controls for emergency operation.

5.2.4.2 Emergency backup, such as electrical or manual override or bypass, should be provided to prevent the failure of any one component from rendering either the main cabin or cockpit air conditioning system uncontrollable from a normal crew station.

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5.2.4.3 The temperature control system should be capable of controlling the temperature with cyclic variation of not more than plus or minus 1°F at the cabin temperature sensor. If the system is of the proportioning or modulating type, the proportioning range shall not exceed 10°F over the entire range of heating and cooling.

5.2.4.4 An adjustable setting should be provided which will permit selecting a cabin temperature at any point within the range of 65°F to 85°F.

5.2.4.5 For aircraft utilizing mixed configuration passenger loading means should be incorporated for providing zone temperature control sufficient to allow compartmental temperatures within allowable full cabin temperature gradients.

6. DESIRABLE DESIGN FEATURES:

6.1 General:

6.1.1 Means should be provided to minimize noise originating from air conditioning ducts, main air inlets and individual cool air outlets.

6.1.2 A ground air conditioning system connection should be provided.

6.2 Heating:

6.2.1 All surfaces should be kept as close as practical to cabin air temperature.

6.2.2 Floor surface temperature should be maintained at a temperature approximately the same as the cabin temperature; special attention should be given to floor areas over wheel well and wing areas.

6.2.3 Suitable duct overheat protection should be provided.

6.3 Cooling:

6.3.1 It should be a point of consideration to obtain the maximum practicable cooling flight from primary air to air heat exchangers so that duty time of the mechanical cooling equipment is minimized.

6.3.1.1 Where air to air heat exchangers are used, it should also be a point of consideration that total system cooling capacity be sufficient to allow 50% of the mechanical cooling system to be inoperative and still maintain a cabin temperature of 80°F effective temperature or less during normal cruise flight.

6.3.2 Special consideration for low altitude, slow speed flight should be given to systems using ambient ram air as a heat sink.

6.4 Ventilation

6.4.1 Individual air inlets should be provided and they should be controllable by the occupant for both direction and quantity of air only within the zone of the controlling occupant.

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6.4.2 Air intakes should be so located that:

a. The flow characteristics will not be materially affected by the attitude of the airplane.
b. Rain will not enter the opening. When such location is impractical, then a water separator should be installed in the duct system immediately after the ram inlet.

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