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29 West 39th Street
New York City

AERONAUTICAL RECOMMENDED PRACTICE

ARP 217

Issued 3-15-51
Revised

TESTING OF PROTOTYPE AIRPLANE AIR CONDITIONING SYSTEMS

1. PURPOSE:

1.1 This recommended practice is applicable to current design. It will therefore be subject to revision from time to time, due to rapid development of aircraft industry.

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

2. SCOPE: These recommendations are written to cover the testing of air conditioning equipment as installed in the prototype aircraft for the purpose of:

A. Demonstrating safety of the installation.
B. Demonstrating performance of the installation.
   a. Aircraft ducting and distribution system.
   b. Component parts (i.e., vendors equipment)
C. Obtaining data for future design.

3. GENERAL EQUIPMENT REQUIREMENTS FOR TESTING AIR CONDITIONING SYSTEMS:

3.1 Suitable instrumentation should be installed to determine the weight flow of air, the temperature differential and the pressure drop through each of the major components of the air conditioning system. The accuracy of these measurements should be within ± 5%.

3.2 Final acceptance tests should be conducted with a minimum of 75% of passenger and crew accommodations occupied during cooling tests and a maximum of 10% of the passenger accommodations occupied during heating tests.

3.3 Provisions should be made for determining the CO concentration in each closed compartment of the aircraft if occupied by passengers or crew.

3.4 Equipment should be provided to determine the temperature distribution from forward to rear and top to bottom of all spaces occupied by passenger or crew personnel and all cargo and accessory compartments.

3.5 Equipment should be provided to determine the direction of flow and the air velocities in all compartments of the aircraft under all conditions of flight.

3.6 Equipment should be provided to indicate the position of valves or actuators which are remotely installed and not available for visual observation during flight.

3.7 Equipment should be located in each compartment of the aircraft or provisions made for determining the presence in each compartment of CO_2 or any hazardous concentrations of fire extinguishing agents carried aboard the airplane for extinguishing engine, cargo compartment or cabin fires when the maximum allowable quantity is discharged to one or more points of discharge.

3.8 Equipment should be provided to determine the moisture content of the ambient air, the air in crew, passenger, cargo and equipment compartments.

4. GENERAL OPERATIONAL REQUIREMENTS FOR TESTING AIR CONDITIONING SYSTEMS:

4.1 Tests should be conducted to demonstrate safe and proper operation of the system and component parts under the following conditions:

4.1.1 Ground operation
4.1.2 Pressurized flight
4.1.3 Unpressurized flight

4.2 Smoke or gas removal procedures should be demonstrated to prove conclusively that proposed methods of elimination are adequate to clear all areas occupied by passengers and crew of hazardous concentrations of smoke or gas within a safe period of time.

4.3 Final acceptance tests on refrigeration equipment should be conducted during the daytime to determine the adequacy of the system with full sun effect and with maximum daylight electrical load within the fuselage applied.

4.4 Final acceptance tests on heating equipment should be conducted during night time to eliminate sun effect. Tests should be conducted with maximum and minimum electrical load applied within the aircraft cabin to determine the adequacy of the system under both conditions.

4.5 In the event temperatures representing the extreme heating and cooling requirements of the aircraft cannot be encountered, sufficient data should be obtained at a minimum of three conditions requiring heat and three conditions requiring cooling so that accurate extrapolations can be made. The moisture content of the ambient air should be determined and corrections made to determine the true cooling load encountered.

4.6 The following SAE specifications should be complied with where applicable:

ARP 85B
ARP 367
AS 143
AIR 30

5. INSTRUMENTATION:

5.1 Air Flow Measurement:

5.1.1 Sections of duct in the normal ducting system, calibrated in place in the aircraft, should be used to determine the air flow in each component part of the air conditioning system wherever possible.

5.1.2 Calibrated orifices or venturis may be used in ducting systems where added pressure drop does not affect distribution or restrict air flow.

5.1.3 In the event calibrated sections of duct or orifices cannot be used, the use of calibrated pitot-static tubes is permissible. Icing of the pitot heads and resulting erroneous data may occur if this type of instrumentation is used downstream of refrigeration units, however.

5.1.4 All pressures should be recorded simultaneously at regular intervals. A common reference pressure should be used for all pressures recorded.

5.2 Temperature Measurements:

5.2.1 All true air temperatures should be measured by use of thermocouples. Cabin and cargo compartment temperatures should be determined by use of unshielded thermocouples in order to include the effect of radiation. Duct temperatures should be determined by use of shielded thermocouples to minimize the effect of radiation.

5.2.2 All temperatures should be recorded as near simultaneously as possible at regular intervals.

5.2.3 Thermocouples should be so located as to determine the following air temperatures:

a. Outside free air.
b. Inlet to supercharger (s).
c. Outlet from supercharger (s).
d. Inlet to refrigeration unit (s). (Cabin air and coolant)
e. Outlet from refrigeration unit (s). (Cabin air and coolant)
f. Inlet to heater (s) and/or heat exchanger (s).
g. Outlet from heater (s) and/or heat exchanger (s).
h. Inlet to recirculating fan (s).
i. Outlet from recirculating fan (s).
j. Inlet to wall or window panels if used.
k. Outlet from wall or window panels or air entry to cabin.
l. Head level (standing), head level (sitting) and floor level at forward, center and rear of all passenger and crew compartments.
m. Air passing over thermostat sensing element.
n. Forward, center and rear at top and bottom of all cargo and accessory compartments.
o. Floor temperatures at several points throughout the airplane.
p. Heated panel surface temperature at several points throughout the airplane.
q. Inner surface temperature of cabin and cockpit windows.
r. Other pertinent and desirable locations.

5.3 Pressure Measurements:

5.3.1 All pressure taps should be so located as to minimize to effect of turbulence caused by valves, elbows or orifices installed in the system.

5.3.2 Pressure taps should be so located as to determine the following pressure indications:

a. Cabin rate of pressure change ft. per min.
b. Cabin altitude.
c. Airplane rate of climb or descent.
d. Airplane altitude.
e. Airplane indicated air speed.
f. Inlet to supercharger (s).
g. Outlet from supercharger (s).
h. Inlet to refrigeration unit (s). (Cabin air and coolant)
i. Outlet from refrigeration unit (s). (Cabin air and coolant)
j. Inlet to heater (s) and/or heat exchanger (s).
k. Outlet from heater (s) and/or heat exchanger (s).
l. Inlet to recirculating fan (s).
m. Outlet from recirculating fan (s).
n. Duct pressure drop through each separate branch system.
o. At other points that affect appreciable pressure drop in the system.

5.4 Humidity Measurement: Humidity measurements should be taken within the cabin at regular intervals using a reliable type of psychrometer. Equipment for determining the humidity of the ambient air should be available for use during periods of operation of the refrigeration system.

5.5 Air Velocities:

5.5.1 A suitable velometer should be used to determine air velocities in passenger and crew compartments during pressurized and unpressurized flight as specified in SAE ARP 85B.

5.5.2 Air velocities across the cabin thermostat sensing element and temperature indicating instrument should be determined by use of a suitable velometer during pressurized and unpressurized flight.

6. TEST PROCEDURE:

6.1 Ground Tests:

6.1.1 Safety Tests:

6.1.1.1 Inspect the aircraft to determine that all air entries are so located that no normal drain or vent of inflammable fluid can enter the scoop during flight or on the ground during cross wind conditions.

6.1.1.2 With an adjustable external power source connected to the airplane, adjust the voltage to that normally supplied by the aircraft system.

6.1.1.3 If the aircraft equipment does not include blowers required for ground operation, external equipment required to supply in-flight conditions should be attached.

6.1.1.4 With blowers in operation the aircraft system should be turned on and checked for normal operation. System should be adjusted as required.

6.1.1.5 With system operating normally the combustion air source should be disconnected or deactivated, to determine that no unsafe condition will be created by loss of combustion air through failure of combustion air blower or icing of combustion air scoop in flight.

6.1.1.6 With system operating normally the ventilating air source should be disconnected or deactivated to determine that no unsafe condition will be created by loss of ventilating air through failure of equipment or icing of air inlet in flight.

6.1.1.7 With system operating normally deactivate or bypass the normal temperature control system to allow heater outlet air temperature to increase to overheat switch setting. (Reduce ventilating air flow if required) Determine that no unsafe condition exists at the temperatures encountered and that the overheat circuit functions properly.

6.1.1.8 With the system operating normally gradually decrease the voltage supplied to the aircraft until all of the components of the system cease to operate. Determine that no unsafe condition is created due to low voltage operation.

6.1.1.9 With the system turned on and all electrical power disconnected from the aircraft (external blowers operating if used) reduce the voltage to 50% of the normal aircraft system voltage and reconnect to the aircraft. Gradually increase the voltage until all components are operating normally and determine that no unsafe condition is created by low voltage condition.

6.1.1.10 Conditions required to cause the aircraft heater to backfire should be created to determine that combustion air and exhaust systems are secure and adequate for the heater. These conditions may be created by reduction of combustion air flow on disconnecting the ignition system for a brief period of time. At least three substantial backfires should be created before considering the system adequate. Inspect ducting and heater for damage after test.

6.1.2 Performance Tests:

6.1.2.1 Ground tests should be conducted on aircraft equipped with ground conditioning equipment to determine if specified temperatures and air flow rates have been met.

6.1.2.2 Pressurized aircraft should be pressurized to design differential to determine if air flow and leakage requirements as specified in ARP 367 have been met. Pressure controls, flow controls and pressure relief valves should be checked to ascertain that the units are operating properly.

6.1.2.3 During unpressurized and pressurized condition the air distribution should be observed and flow rates measured to determine proper balance of the system.

6.1.2.4 All temperatures, pressures and air velocities and humidity specified in Section 5 should be recorded.

6.1.2.5 On pressurized aircraft ground operation should be tested or otherwise analyzed with or without pressurization and/or refrigeration equipment functioning in order to determine the optimum configuration for comfort in hot weather while the airplane is taxiing or waiting take off clearance with full passenger load.

6.2 Flight Tests:

6.2.1 Safety Tests:

6.2.1.1 With the cabin pressurized (on pressurized aircraft) to maximum differential pressure prepare the airplane and crew members for discharge of fire extinguishing agent to the cargo compartments if Carbon Dioxide or a toxic fluid is carried for that purpose. With the airplane in the most critical flight attitude discharge the maximum permissible quantity of the extinguishing agent into each compartment or group of compartments and measure the concentration in the compartment and the contamination in all areas occupied by passengers and crew members. It should be demonstrated that the air conditioning system does not interfere with the retention characteristics of the cargo compartment and prevents contamination of areas occupied by crew or passengers. It is recommended that all occupants of the airplane be equipped with full face coverage type masks supplied with undiluted oxygen. Use of a demand type regulator on each mask is also recommended.

6.2.1.2 Repeat the above test in the unpressurized condition.

6.2.1.3 With the cabin unpressurized and wing flaps set for landing approach condition, the flight station clear vision panels should be opened and tests for carbon monoxide contamination made in the cabin and flight station areas. The approach attitude should be maintained for a minimum period of fifteen minutes. Contamination should not exceed .005 per cent (one part in 20,000) at any location within the aircraft.

6.2.1.4 Pressurize the cabin to maximum differential pressure. Protect all crew members and observers with suitable protective masks and discharge or manufacture sufficient smoke to fill the airplane cabin. Carry out smoke removal procedures and record time required to remove smoke from crew and passenger compartments.

6.2.1.5 Unless depressurization of the cabin was required in 6.2.1.3 the cabin should be depressurized and the smoke removal procedure repeated under these conditions.

6.2.2 Performance Tests:

6.2.2.1 Pressurized Flight Condition:

6.2.2.1.1 The following test should be conduoted in addition to any other tests deemed necessary to demonstrate performance of the air conditioning system.