AEROSPACE STANDARD

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HEATERS, AIRCRAFT, INTERNAL COMBUSTION HEAT EXCHANGER TYPE

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1. PURPOSE - The purpose of this standard is to specify minimum safety and performance requirements for internal combustion heaters and certain auxiliary devices which are considered necessary to the safety and performance of the heaters as used in fixed and rotary wing aircraft. These standards are to be considered currently applicable and necessarily subject to revision from time to time due to rapid development of the aeronautical industry. The following standards are based on practical engineering requirements for such internal combustion heat exchanger type heaters as are now used on aircraft and for such as may be developed to meet later requirements.

   The recommendations of this standard are primarily intended to be applicable to civil aircraft whose prime function is the transporting of passengers or cargo.

2. SCOPE - These standards are written to cover internal combustion heat exchanger type heaters used in the following applications:

   a. Cabin heating (all occupied regions and windshield heating)
   b. Wing and empennage anti-icing
   c. Engine and accessory heating (when heater is installed as part of the aircraft)

3. DEFINITION - An internal combustion heat exchanger type heater, as used for aircraft heating, is one that utilizes through a heat exchanger the heat produced by combustion of a fuel within the heater for the purpose of heating the air being supplied to the aircraft.

4. GENERAL REQUIREMENTS

4.1 Heater Components - An internal combustion type heater shall include:

   a. Combustion chamber and heat exchanger assembly
   b. Casing or shroud for combustion chamber and heat exchanger assembly
   c. Igniter
   d. Burner
   e. Ventilating air inlet
   f. Ventilating air outlet
   g. Combustion air inlet
   h. Exhaust outlet
   i. Fuel inlet
   j. Fuel drain

4.2 Additional Devices - In addition to the heater, the following devices are considered necessary to the safety and performance of the heater and will be covered in that respect by these standards. These devices may be furnished separately or as part of the heater. This standard does not cover all tests necessary on these devices, but only those relevant to the heater.

   a. Fuel system

      (1) Fuel nozzle, restrictor, orifice, or equivalent
      (2) Fuel shutoff valve
      (3) Fuel filter

   b. Safety controls

      (1) A device to prevent the heater from becoming overheated
      (2) A device to prevent fuel flow to the heater when combustion air is insufficient for safe operation

   c. Ignition system (required for spark ignition only)

      (1) Device to provide high voltage power
      (2) High-voltage ignition lead assembly or equivalent electrical linkage between high voltage device and spark plug

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(3) Radio interference shielding. Radio interference suppression and test method shall be specified by the procuring agency

4.3 Materials and Workmanship

4.3.1 The heater and auxiliary equipment shall be constructed throughout of materials which are considered acceptable for the particular use intended and shall be made and furnished with a degree, uniformity and grade of workmanship generally accepted in the aircraft industry.

4.3.2 The heater casing or shroud shall be constructed of fireproof material.

4.4 Design Features

4.4.1 The design shall be such as to preclude the possibility of discharging harmful concentrations of carbon monoxide into the ventilating air stream. See test, paragraph 6.3.4.1.

4.4.2 Where specified, the design shall be such as to preclude excessive loss of pressurized fuselage air. See test, paragraphs 6.3.4.2 and 6.3.4.3.

4.4.3 The design shall include protection against excessive radio interference as specified by the procuring agency.

4.4.4 The design shall be such as to preclude harmful effects on construction or performance due to vibration. See test, paragraph 6.2.

4.4.5 The design shall be such that the life of the heater and accompanying devices shall be comparable to other similar airframe components and accessories. See test, paragraph 6.3.

4.5 Heater Identification - The following minimum information shall be legibly and permanently marked on the heater or on a nameplate attached thereto:

a. Manufacturer's name and/or trademark
b. Manufacturer's part number
c. Manufacturer's serial number
d. Rated output, _____ Btu/hr (see paragraph 5.1)
e. Type of fuel
f. Rated fuel pressure, _____ psig
g. Electrical characteristics
h. Specification number
i. Approvals - unpressurized cabin, pressurized cabin, wing or others (may be abbreviated, e.g., unpr. cabin, press. cabin)

5. DETAIL REQUIREMENTS

5.1 Rating Conditions - Heater shall deliver rated output as specified by manufacturer at the following conditions:

a. Sea level ambient pressure
b. Specified type of fuel
c. Rated fuel pressure
d. Rated sea level combustion air rate
e. Ventilating air temperature rise of 250 F
f. Inlet temperature of fuel and air at ambient conditions

5.2 Air Supply

5.2.1 When sufficient combustion or ventilating air for safe operation is not available, the heater shall be made automatically inoperative. See tests, paragraphs 6.3.7.1 and 6.3.7.2.

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5.2.2 The combustion air and ventilating air inlets on the heater shall be separated from each other.

5.3 Fuel Supply

5.3.1 The fuel supplied shall be aviation-grade gasoline or aviation-grade kerosene, or both, as specified by paragraph 5.1.2.

5.3.2 The fuel lines and fittings under pressure in the heater shall be enclosed in such a manner as to prevent any fuel leakage from entering the ventilating air stream, and the enclosure shall have adequate provision for draining to the combustion chamber or to a fuel drain fitting.

5.3.3 A fuel drain outlet or equivalent safety device shall be provided to prevent accumulation of liquid fuel in the combustion chamber and heat exchanger assembly in case the fuel flows without igniting.

5.3.4 All fuel lines in the heater shall be constructed of steel or other fire-resistant material. Where flexibility is required in these lines, flexible fire-resistant coupled hose assemblies shall be used to eliminate the possibility of using hose clamp connections. Connections in metal fuel lines shall not employ solder or other relatively low-melting-point materials which cannot withstand a 2000 F flame for five minutes.

5.3.5 All gaskets, synthetic rubber seals, etc., shall be suitable for use with gasoline and kerosene-type fuels and shall be satisfactory for use at the temperatures encountered within the overheating limits of the heater.

5.3.6 The fuel system lines, fittings, and controls shall be sufficiently isolated from the combustion side of the heater to prevent their being damaged by flame, radiant heat, or backfire.

5.4 Combustion Chamber and Heat Exchanger Assembly

5.4.1 The combustion chamber and heat exchanger assembly shall be constructed from a corrosion and heat resistant material suitable for the intended use and in accordance with SAE Aerospace Material Specifications, or equivalent.

5.4.2 Means shall be provided to minimize malfunctioning due to lead or carbon deposits and to permit disassembly and cleaning of all parts affected by products of combustion.

5.4.3 The accumulation of lead scale or products of combustion deposits shall not cause functional failure before 200 hours of heater operation.

5.4.4 The heater combustion chamber and heat exchanger assembly shall be so designed that it will not rupture under the most severe explosion conditions that can occur with any possible fuel air mixture as demonstrated by test procedure outlined in paragraph 6.1.6.

5.5 Exhaust

5.5.1 The temperature of the exhaust gases at the point of discharge from the heater shall not exceed 1200 F at the specified rating conditions. (See paragraph 5.1)

5.6 Ignition

5.6.1 "Ignition" shall be defined as having occurred when the exhaust temperature of the heater rises 150 F, providing the heater continues to function normally.

5.6.2 "Ignition time" shall be defined as the time from the instant the heater switch is actuated until ignition occurs.

5.6.3 Heaters of 40,000 Btu/hr capacity or less may be ignited by means of an electrically heated resistance wire.

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5.6.4 Heaters of any capacity may be ignited by means of an electric high voltage spark plug.

5.6.5 Ignition power may be sustained during heater operation or discontinued if satisfactory combustion is assured.

5.6.6 The igniter shall be capable of functioning over a period of 200 hr without service. (See test, paragraph 6.3.5)

5.6.7 In the event of ignition delay for an indefinite period, either with or without fuel supply, no hazardous condition shall result.

5.6.8 Glow plug ignited heaters shall ignite within 200 sec. Spark ignited heaters shall ignite within 15 sec when burning gasoline type fuels, and within 60 sec when burning kerosene-type fuels. (See test, paragraph 6.1.1)

5.6.9 Heaters which are intended for wing-empennage heating shall ignite within 15 sec when using gasoline, and 60 sec when using kerosene-type fuels, under conditions of paragraph 6.1.2.3 except that the temperature shall not be higher than -20 F.

5.7 Safety Controls - The following automatic safety controls shall be furnished separately or as part of the heater. These controls shall be independent of and in addition to the normal operating controls.

5.7.1 A control to shut off the heater fuel flow in case combustion air supply is insufficient for safe operation.

5.7.2 A control to prevent the heater from becoming overheated under any condition of ventilating air flow.

5.8 Lines and Fittings - All lines and fittings shall comply with applicable aircraft standards.

5.9 Electrical Equipment - All electrical equipment, including wiring, instruments, motors, insulation, shielding, relays, etc., shall conform to acceptable aircraft practice.

6. TEST REQUIREMENTS AND METHOD - Unless otherwise specified, all tests shall be made at ambient pressure and temperatures. The manufacturer shall furnish reports, on request, covering tests. These reports shall include an introduction, a summary, a description of apparatus, instrumentation and tests, the results, a discussion and conclusions.

6.1 Performance Tests - Tests shall be conducted to establish the following:

6.1.1 Ignition characteristic curve, plotting altitude as the ordinate and combustion air pressure differential as the abscissa such that the area under the curve demonstrates the compatibility of repeative starting and continuous burning at -65 F for gasoline or -20 F for kerosene-type fuels. Include information on temperature of fuel and combustion air supplied to heater. The service ceiling of the heater and its accompanying ignition devices shall be defined as the peak of the ignition characteristic curve. A time record shall be kept on each test start.

6.1.2 Heat output, ventilating air pressure drop, combustion air pressure drop, exhaust temperature, ventilating air temperature rise, fuel rate at:

6.1.2.1 Sea level rating. (See Section 5.1)

6.1.2.2 Sea level rating, except with -65 F inlet ventilating air, combustion air, and fuel temperatures when using gasoline, or with -20 F inlet ventilating air, combustion air and fuel temperatures when using kerosene-type fuels.

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6.1.2.3 The specified altitude or at 20,000 ft altitude with:

a. Sea level rated weight of ventilating air at the inlet temperature as specified in paragraph 6.1.2.2.

b. Combustion air at the inlet temperature as specified in paragraph 6.1.2.2 and combustion air pressure differential midway between the ignition limits determined in paragraph 6.1.1 at 20,000 ft altitude or the specified altitude.

c. Sea level rated values of voltage and fuel pressure.

d. Fuel at -65 F (gasoline type) or -20 F (kerosene type) inlet temperature.

Note: Temperature measurements for output shall be made in a manner which will provide a representative average temperature of the discharge air. Temperature-sensing elements used in test shall be protected against effects of radiation from the heater.

6.1.3 Maximum starting and maximum running amperages required with normal voltage for operation of the heater and accompanying devices at sea level.

6.1.4 Voltage range within which the heater and accompanying devices will operate at sea level and service ceiling.

6.1.5 Collapsing Pressure Resistance - The heater shall be set up with an adjustable restriction on the combustion air inlet and a source of vacuum connected to the exhaust outlet. The ventilating air shall discharge freely to atmosphere (sea level). A static pressure tap shall be provided in the exhaust pipe within 12 in. of the connection to the heater.

Collapsing pressure test of the combustion chamber and heat exchanger assembly shall be as follows:

6.1.5.1 For a nonpressurized cabin heater or a wing-empennage heater, the heater shall be operated at sea level rating, except that the exhaust outlet pressure is to be maintained at a value which is at least 4 psi below the ventilating air outlet pressure. After operating the heater for at least 1 hr at these conditions, there must be no permanent distortion of any part of the heater, unless it can be demonstrated that such distortion does not affect the performance or life of the heater.

6.1.5.2 For pressurized cabin heaters, the test shall be the same as 6.1.5.1, except that the exhaust outlet pressure shall be maintained at a value which is at least 10 psi below the ventilating air outlet pressure.

6.1.6 Combustion Chamber Burst Pressure - Combustion chamber burst pressure test shall demonstrate compliance with paragraph 5.4.4 as follows:

6.1.6.1 With the combustion chamber and heat exchanger assembly at room temperature, introduce a gasoline fuel air mixture in a ratio of from .085 to .095. Purge the combustion chamber and heat exchanger assembly with this mixture to the extent of at least ten times the volume of the combustion chamber and heat exchanger assembly. Ignite the mixture with a spark plug. Repeat procedure to complete 25 explosions. The heater shall then meet the leakage requirements of paragraph 6.3.4.2.

6.2 Vibration Test - The heater and auxiliary equipment shall be capable of withstanding and satisfactorily operating when subjected to a steady vibration over a range of frequencies from 10 to 45 cps with a total excursion of 1/16 in., and from 45 to 53 cps with an acceleration not exceeding 6 g's. Unless otherwise specified in detail specifications, the equipment shall be mounted on the vibrating apparatus with the longitudinal axis of the heater in a plane parallel to the vibrating surface of the apparatus and normal to the direction of vibration.

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6.2.1 The heater shall be vibrated over a range of from 10 to 45 cps with a total excursion of 1/16 in. The frequencies at which resonance occurs, if any, shall be observed and noted.

6.2.2 The heater shall be vibrated over a range of from 45 to 53 cps with an acceleration of not less than 5 g's and not more than 6 g's. The frequencies at which resonance occurs (if any occurs) shall be observed and noted.

6.2.3 If resonance is observed under the test of either 6.2.1 or 6.2.2, a vibration test shall be conducted for 15 hr at the frequency showing the maximum resonance.

6.2.4 If no resonance is observed under the tests of 6.2.1 or 6.2.2, a vibration test shall be conducted for 15 hr at 45 cps with 1/16 in. total excursion.

6.2.5 At the conclusion of the vibration test, there shall be no evidence of structural failure and the heater and accompanying devices shall operate satisfactorily.

6.3 Endurance Tests - Endurance tests may be conducted in such manner as to qualify the heater and accompanying devices for cabin heating, wing-empennage anti-icing, or both. For cabin heating only, the duration of the test shall be at least 850 hr "on" time. For wing-empennage anti-icing only, the duration of the test shall be at least 500 hr "on" time. For qualification of the heater and accompanying devices under both cabin heating and wing-empennage classifications, the duration of the test may be 850 hr heater "on" time providing at least 500 hr "on" time is performed at wing-empennage conditions.

6.3.1 General Conditions - The general conditions applying to both cabin and wing-empennage heater endurance tests shall be as follows:

6.3.1.1 Tests shall be performed at sea level rated fuel pressure and sea level rated combustion air rate.

6.3.1.2 Inlet air temperature shall not exceed 125 F.

6.3.1.3 Approximately 50% of the endurance test shall be with "continuous" operation, and the remainder of the test with "rapid cycling" operation.

6.3.1.3.1 During "continuous" operation, the ventilating air rate shall be adjusted as required to give the specified temperature rise under steady conditions. At least once, and not more than twice, during each two hours of operating time, the fuel and ignition system shall be shut off and the heater permitted to cool for at least 10 minutes with continuous ventilating air and combustion air flow. In calculating total "on" time for the heater, the 10 minute cooling periods shall not be included.

6.3.1.3.2 During "rapid cycling" operation, a thermostatic switch in the ventilating air outlet stream shall cycle the fuel on and off or high to low input to maintain a specified outlet air temperature. The ventilating air rate shall be adjusted so that the average heat output (assuming that the setting of the cycling switch represents the average outlet air temperature) is between 60 and 75% of the rated output. At least once, and not more than twice during each 2 hr of operating time, the fuel and ignition system shall be shut off and the heater permitted to cool for at least 10 minutes with continuous ventilating air and combustion air flow.

For cycling operation "on" time is defined as the total elapsed time during which the rapid cycling switch controls the heater operation; it does not include the 10-minute cooling periods.

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6.3.2 Cabin Heater Endurance Tests - The cabin heater endurance tests shall be divided into four periods, as follows:

a. First period - 250 hr. Continuous operation, with the ventilating air rate adjusted to maintain a temperature rise of at least 200 F and an outlet air temperature of at least 250 F.

b. Second period - 250 hr. Rapid cycling operation, with the cycling switch set to control at 250 ± 10 F outlet air temperature.

c. Third period - 175 hr. Same conditions as first period.

d. Fourth period - 175 hr. Same conditions as second period.

6.3.3 Wing-Empennage Anti-Icing Heater Endurance Tests - Wing-empennage anti-icing heater endurance tests shall be divided into two periods, as follows:

a. First period - 250 hr. Continuous operation with the ventilating air rate adjusted to maintain a temperature rise of at least 300 F and an outlet air temperature of at least 350 F.

b. Second period - 250 hr. Rapid cycling operation with the cycling switch set to control at 350 ± 10 F outlet air temperature.

6.3.4 Performance After Tests - At the end of the endurance and vibration tests, the heater shall meet the following requirements.

6.3.4.1 Carbon Monoxide Contamination - At rating conditions and with the burner operating, carbon monoxide concentration in the heated ventilating air stream shall not exceed one part in 20,000 above the background level. This test shall be run with the heater exhaust discharging to atmosphere. The ventilating air samples shall be taken from an unrestricted duct fastened to the heater ventilating air outlet. The duct shall be the same diameter as the heater casing and at least 5 diameters in length. Use carbon monoxide detector assembly MSA model 08-91927, Bacharach Monoxor GDE, or equivalent, with length of stain detector tubes.

6.3.4.2 Combustion Chamber Leakage - With an air pressure of 8 psig inside the combustion chamber and heat exchanger assembly, leakage shall not exceed 9 lbs/hr (sea level and 59 F). There shall be no leaks which could allow liquid fuel to enter the ventilating air stream in event of ignition failures, when the heater is mounted in any normal operating position, with drains open.

6.3.4.3 Pressurized Heater Leakage - For pressurized cabin heaters, with pressurized jacket, air leakage through the ventilating air shroud or casing shall not exceed 10 lbs/hr at sea level and room temperature when air pressure of 16 psig is applied to the ventilating air passages.

6.3.4.4 Output After Test - When heater is to be used for wing-empennage anti-icing, the output shall be not less than 90% of the original rating after the endurance test. If the heater is to be used for cabin heating, the manufacturer shall record in the test report the heater output at the end of the life test.

6.3.5 Igniter - Whenever it becomes necessary due to ignition failure during the endurance test, the igniter may be cleaned, adjusted, or replaced. However, the igniter shall not require servicing or replacement more than twice during the endurance test of a wing-empennage heater or more than four times during the endurance test of a cabin heater.

6.3.6 Fuel System

6.3.6.1 Whenever necessary due to stoppage or failure, the fuel orifice or nozzle may be cleaned or replaced. Such servicing shall not be required more than once during a wing-empennage heater endurance test or twice during a cabin heater endurance test.

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