AEROSPACE STANDARD

AS8040™	REV. C

Issued 1988-02
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Reaffirmed 2024-10

Superseding AS8040B

(R) Heater and Accessories, Aircraft Internal Combustion Heat Exchanger Type

RATIONALE

The standard's title and body have been revised to reflect its use as minimum performance requirements for both heater and heater accessories.

AS8040C has been reaffirmed to comply with the SAE Five-Year Review policy.

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1. SCOPE

This SAE Aerospace Standard (AS) covers combustion heaters and accessories used in, but not limited to, 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)

d. Aircraft deicing

1.1 Purpose

This document details the minimum safety, performance, design, and testing requirements for combustion heaters and accessories that are considered necessary for the utilization of heaters in any category of aircraft. This standard is to be considered currently applicable and necessarily subject to revision from time to time due to advances in the aircraft industry. This standard is based on practical engineering requirements for aircraft heaters currently in use and is applicable to aircraft heaters that will be developed to meet future requirements.

The requirements of this standard are primarily intended to be applicable to civil aircraft whose primary function is transporting passengers or cargo. For additional information regarding military applications, refer to MIL-H-5484.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 EASA Publications

Available from European Aviation Safety Agency, Ottoplatz, 1, D-50679 Cologne, Germany, Tel: +49 221 8999 000, www.easa.europa.eu.

CS-Definitions	Definitions and Abreviations used in Certification Specifications for Products, Parts, and Appliances
CS-23	Certification Specifications for Normal, Utility, Aerobatic and Commuter Category Aeroplanes
CS-25	Certification Specifications for Large Aeroplanes
CS-27	Certification Specifications for Small Rotorcraft
CS-29	Certification Specifications for Large Rotorcraft

2.1.2 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

AC 20-135	Advisory Circular: Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria
14 CFR Part 23	Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes

14 CFR Part 25 Airworthiness Standards: Transport Category Airplanes

14 CFR Part 27 Airworthiness Standards: Normal Category Rotorcraft

14 CFR Part 29 Airworthiness Standards: Transport Category Rotorcraft

2.1.3 U.S. Government Publications

Copies of these documents are available online at https://quicksearch.dla.mil.

MIL-H-5484 Heater; Aircraft, Combustion Type

2.1.4 NASA Publications

NASA Technical Services, NASA STI Program STI Support Services, Mail Stop 148, NASA Langley Research Center, Hampton, VA 23681-2199, 757-864-9658, Fax: 757-864-6500, http://ntrs.nasa.gov/.

NASA-TM-X-74335 U.S. Standard Atmosphere, 1976, United States National Oceanic and Atmospheric Administration

2.1.5 RTCA Publications

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

DO-160 Environmental Conditions and Test Procedures for Airborne Equipment

2.2 Definitions

COMBUSTION HEATER: A device that utilizes the heat produced by combustion of a fuel within the heater for the purpose of heating air being supplied to various aircraft systems.

FIREPROOF: The capability to withstand, as well as (or better than) steel, application of heat by a flame for 15 minutes minimum, while still fulfilling its ability to confine the flame. The flame shall have a temperature of 1100 °C ± 80 °C (2012 °F ± 176 °F) and a heat flux density 116 KW/m^2 ± 10 KW/m^2 (10.2 BTU/s·ft^2 ± 0.88 BTU/s·ft^2), as defined in AC 20-135.

PRESSURIZED HEATER: A combustion heater that heats pressurized fuselage air.

3. GENERAL REQUIREMENTS

3.1 Heater Components

A combustion heater shall include:

a. Combustion chamber and heat exchanger assembly

b. Casing or shroud

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(s)

A typical installation of an aircraft combustion heater is shown in Figure 1 with all heater components identified.

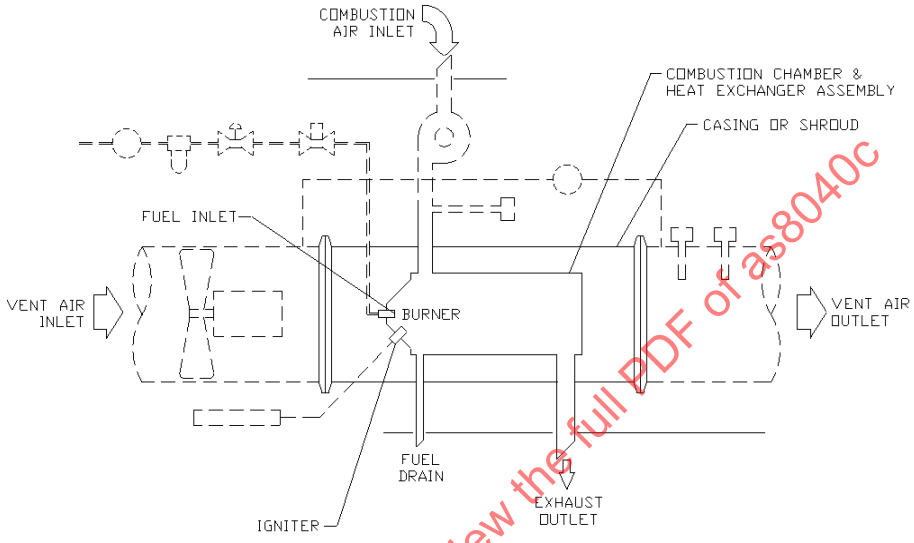

Figure 1 - Typical aircraft installation, combustion heater elements labeled

3.2 Accessories

There are several accessory devices that may be utilized when installed on an aircraft to improve the safety and performance of the heater. These devices may be furnished separately or as part of the heater. Those accessories considered necessary to the safety and performance shall be required and will be covered in that respect by this standard. This standard does not cover all tests necessary on these devices, but only those relevant to the heater. Not all of the following accessories are required for a combustion heater installation and there may be additional accessories included that are not listed in this section.

A typical installation of an aircraft combustion heater is shown in Figure 2 with some heater accessories (including required safety accessories) identified.

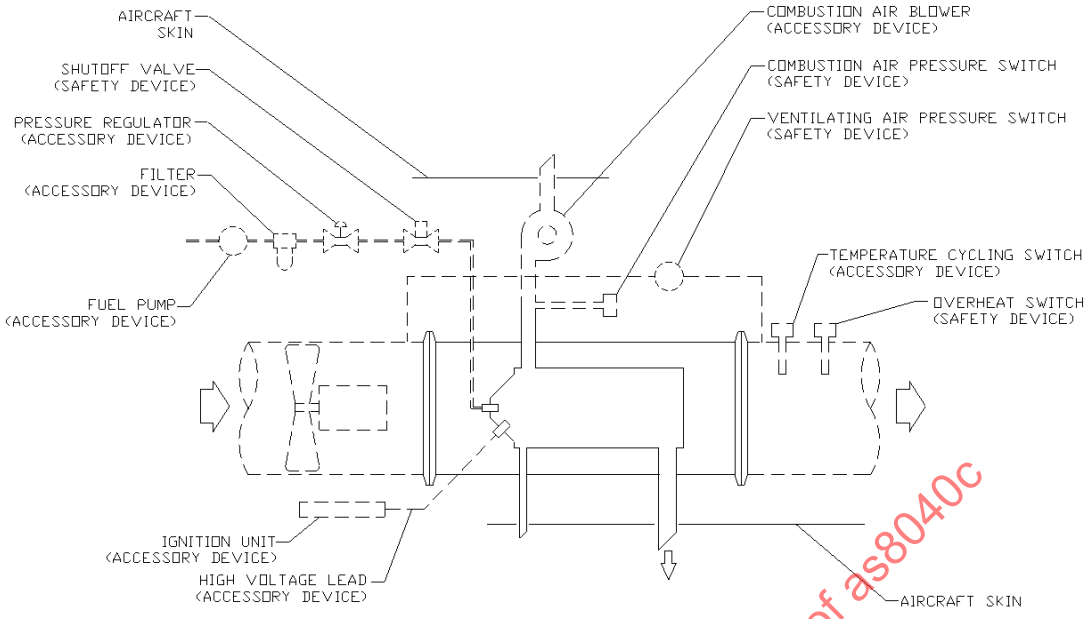

Figure 2 - Typical aircraft installation, examples of combustion heater accessories labeled

The following accessories are discussed to the extent that they are relevant to heater design and operation:

a. Fuel System: The fuel system supplies fuel to the heater at the correct pressure, temperature, and flow rate. Examples of accessory devices that may be utilized in a heater fuel system include, but are not limited to:

   1. Fuel nozzle, restrictor, orifice, or equivalent (required)
   2. Fuel shutoff valve (required)
   3. Fuel filter (required)
   4. Fuel pressure regulator
   5. Fuel pump
   6. Fuel/air ratio controller
   7. Fuel lines
   8. Preheater

b. Spark Ignition System: The spark ignition system uses aircraft electrical power to generate a high-temperature electric discharge across an air gap within the combustion chamber of the heater. Components of the spark ignition system include:

   1. Device to provide high voltage power (required for spark ignition only)
   2. High-voltage ignition lead assembly or equivalent electrical linkage between high voltage device and igniter (required for spark ignition only)
   3. Radio interference shielding; radio interference suppression and test method shall be specified by the procuring and/or regulatory entity

c. Air Supply System: The air supply system provides both air for the combustion process and air (usually referred to as ventilation air) to be heated and distributed to various aircraft systems. Air supply components may be required to be fireproof, especially in fire zones, and should comply with applicable FAA, EASA, or other local civil aviation authority regulations (see 3.7). Examples of accessory devices that may be utilized in an air supply system include, but are not limited to:

1. Ducting/tubing
2. Combustion air blower
3. Combustion air inlet scoop
4. Ventilation air blower
5. Combustion air flow sensor
6. Air flow/pressure regulator

d. Temperature Control System: The heater shall be supplied with a temperature control system to maintain the desired heater downstream temperature. Examples of accessory devices that may be utilized in a temperature control system include, but are not limited to:

1. A cabin or compartment temperature sensor
2. A cycling switch located on or just downstream of the heater that limits heater air discharge temperature
3. An overheat switch, located on the heater, that prevents overheating
4. Cabin temperature controls

e. Safety Controls: Heater controls shall be provided to prevent hazardous or unsafe operation of the heater. Unsafe conditions include excessive heat exchanger temperature, insufficient combustion air to support complete combustion of the fuel, and insufficient ventilating airflow. Examples of accessory devices that may be utilized to prevent unsafe operating conditions include, but are not limited to:

1. A device that senses heat exchanger temperature (required)
2. A device that senses combustion airflow, inlet pressure, or deferential pressure across the combustion chamber (inlet to outlet)
3. A device that senses excessive downstream air temperature
4. A device that senses heater ventilating air pressure differential
5. A device that senses combustion
6. A device that senses excessive combustion byproducts in the ventilating air
7. A device that shuts off fuel flow to the heater (required)
8. A device that alerts crew that a safety system is engaged

3.3 Materials and Workmanship

3.3.1 The heater and auxiliary equipment shall be constructed throughout of materials that 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.

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

3.4 Design Features

3.4.1 The design shall preclude the possibility of discharging harmful concentrations of carbon monoxide or other combustion byproducts into the ventilating air stream. See 5.2.2.2 and 5.2.2.3.

3.4.2 Where specified, the design shall preclude the excessive loss of pressurized fuselage air. See 5.2.2.4.

3.4.3 The design may include protection against excessive radio interference as specified by the procuring and/or regulatory entity.

3.4.4 The design shall include protection against overheating that may arise from lack of sufficient ventilating airflow through the heater. See 5.2.10.6.

3.4.5 The design shall preclude harmful effects on construction or performance due to vibration. See 5.2.9.

3.4.6 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 5.2.10.

3.5 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 or trademark, or both

b. Manufacturer’s part number

c. Manufacturer’s serial number

d. Rated output (Btu/h or W)

e. Type of fuel

f. Rated fuel pressure (pound-force per square inch gage or kPa gage)

g. Electrical characteristics (such as nominal operating voltage)

h. Specification number (such as technical standard order number)

i. Approvals: unpressurized cabin, pressurized cabin, wing, or others (may be abbreviated; for example, Unpr. Cabin, Press. Cabin)

j. Minimum fuel temperature

k. Design altitude

3.6 Preventive Maintenance and Inspection

The heater manufacturer shall specify the preventive maintenance and inspection requirements necessary to ensure the continued airworthiness of the heater throughout the useful life of the heater. A heater maintenance manual shall be provided by the manufacturer. It is best practice to set inspection, maintenance, and/or replacement intervals based on field history. Inspection, maintenance, and/or replacement intervals for new components with no field history can be derived from endurance qualification testing. The heater components and related accessories addressed in the heater manual shall consist of, as a minimum, the following:

a. Combustion chamber/heat exchanger integrity (such as pressure decay test); cracks in the heater combustion chamber shall not be welded as either a temporary or permanent repair

b. Fuel pressure regulator

c. Fuel nozzle

d. Fuel pump

e. Safety controls

f. Ignition system

3.7 Aircraft Installation

This document is primarily intended to specify heater design and test requirements irrespective of the particular aircraft installation. However, it should be emphasized that the heater installation within the aircraft should comply with applicable FAA, EASA, or other local civil aviation authority regulations including, but not limited to:

a. 14 CFR/CS 23.859 Combustion Heater Fire Protection

b. 14 CFR/CS 23.863 Flammable Fluid Fire Protection

c. 14 CFR/CS 25.859 Combustion Heater Fire Protection

d. 14 CFR/CS 25.863 Flammable Fluid Fire Protection

e. 14 CFR/CS 25.869 Fire Protection: Systems

f. 14 CFR/CS 27.859 Heating Systems

g. 14 CFR/CS 27.863 Flammable Fluid Fire Protection

h. 14 CFR/CS 29.859 Combustion Heater Fire Protection

i. 14 CFR/CS 29.863 Flammable Fluid Fire Protection

The heater installation should also comply with the fire safety criteria specified by the aircraft manufacturer.

4. DETAIL REQUIREMENTS

4.1 Rating Conditions

Heater shall deliver rated output as specified by manufacturer at the following conditions:

a. Sea level ambient pressure/temperature

b. Specified type of fuel

c. Rated fuel pressure/flow

d. Rated sea level combustion air flow rate

e. Ventilating air temperature rise of 139 °C ± 3 °C (250 °F ± 5 °F)

f. Inlet temperatures of fuel, combustion air, and ventilating air at ambient sea level conditions

4.2 Air Supply

4.2.1 The heater ventilating and combustion air inlet and outlet ports shall be sized to provide the minimum possible pressure loss consistent with the aircraft system and installation requirements.

4.2.2 When sufficient combustion or ventilating air for safe operation is not available, the heater shall be made automatically inoperative. See 5.2.10.6.

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

4.3 Fuel Supply

4.3.1 The fuel supplied shall be aviation-grade fuel as specified by 4.1.b.

4.3.2 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.

4.3.3 A fuel drain outlet shall be provided to prevent accumulation of liquid fuel in the combustion chamber and heat exchanger assembly in the event that fuel flows into the combustion chamber without igniting. In addition, it is a best practice for consideration to be given to protecting all drains against hazardous ice accumulation under any operating condition.

4.3.4 All fuel lines, fittings, and other fuel containing components 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 1093 °C (2000 °F) flame for 5 minutes.

4.3.5 All gaskets, synthetic rubber seals, etc., shall be suitable for use with applicable fuels and shall be satisfactory for use at the temperatures encountered from initial low starting temperature limit of -54 °C (-65 °F) for gasoline or -29 °C (-20 °F) for kerosene to the overheating limits of the heater. Low starting temperature limits for other types of fuels need to be addressed on a case-by-case basis.

4.3.6 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.

4.4 Combustion Chamber and Heat Exchanger Assembly

4.4.1 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. Heater materials should be selected to withstand the deteriorating effects of high humidity, condensation, fungus, and abrasive particles in the air.

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

4.4.3 The accumulation of combustion deposits shall not cause functional failure before 500 hours of normal heater operation.

4.4.4 The heater combustion chamber and heat exchanger assembly shall be so designed that it shall not rupture under the most severe explosion conditions that can occur with any possible fuel air mixture as demonstrated by the test outlined in 5.2.8.

4.4.5 The heater combustion chamber and heat exchanger assembly shall be so designed that no permanent distortion of any part of the heater shall occur under negative pressure due to operation at altitude as demonstrated by the test outlined in 5.2.7.

4.5 Exhaust

The temperature of the exhaust gases at the point of discharge from the heater shall not exceed material capabilities in this section of the heater at the specified rating condition of 4.1. The point of discharge is defined as a point in the exhaust tube 0.30 m (12 inches) from the heater casing. Best practice is to ensure that the temperature at the point of discharge shall not exceed 649 °C (1200 °F). Consideration should also be given to the impact of heat impingement on the aircraft region surronding the combustion heater.

4.6 Ignition

4.6.1 Ignition shall be defined as having occurred when the exhaust temperature of the heater rises 83 °C (150 °F).

4.6.2 Ignition time shall be defined as the time from the instant the heat switch is actuated until ignition occurs.

4.6.3 Heaters of 11700 W (40000 Btu/h) capacity or less may be ignited by means of an electrically heated resistance wire or heated solid surface. Using resistance wires as an ignition source for power levels above 11700 W (40000 Btu/h) is not considered a best practice.

4.6.4 As a best practice, heaters of any capacity may be ignited by means of an electric high-voltage spark plug.

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

4.6.6 The ignition system shall be capable of functioning over a period of 167 heater operating hours without service for wing empennage heaters and 170 heater operating hours for cabin heaters. See the test specified in 5.2.10.

4.6.7 In the event of ignition delay for an indefinite period, either with or without fuel supply, no hazardous condition shall result. The heater should be designed to preclude violent explosions on being started.

4.6.8 Glow plug ignited heaters shall ignite within 200 seconds. Spark ignited heaters shall ignite within 15 seconds when burning gasoline type fuels, and within 60 seconds when burning kerosene type fuels. See 5.2.3. Other types of fuels need to be addressed on a case-by-case basis.

4.6.9 Heaters that are intended for wing-empennage heating shall ignite within 15 seconds when using gasoline, and 60 seconds when using kerosene type fuels, under conditions of 5.2.5. Other types of fuels need to be addressed on a case-by-case basis.

4.7 Safety Controls

Heater safety controls are covered in applicable FAA, EASA, or other local civil aviation authority regulations. Controls shall be provided to automatically shut off the ignition and fuel supply to the heater in the event any of the following occurs:

a. Heat exchanger temperature exceeds safe limits

b. Ventilating air temperature exceeds safe limits

c. Insufficient combustion airflow

d. Insufficient ventilating airflow

These safety controls shall be independent of the controls normally used to control heater operation. The shutoff of ignition and fuel shall occur at a point remote from the heater itself. The combustion heater shall have a means to warn the crew when any heater whose heat output is essential for safe operation has been shut off by the automatic means. The requirement to shut off ignition and fuel at a point remote from the heater until restarted by the crew may require a safety interlock relay and additional fuel shut off device be supplied in addition to the valve usually supplied with the heater as an accessory. This relay and valve are the responsibility of the installer. See 5.2.10.6 for tests conducted on safety controls.

4.8 Lines and Fittings

All lines and fittings shall comply with applicable regulations and aircraft standards.

4.9 Electrical Equipment

All electrical equipment shall conform to applicable aircraft standards. Heater electrical wiring shall be suitable for the intended application. Wiring shall be selected so that the maximum conductor temperature cannot be exceeded for any combination of electrical loading, ambient temperature, and heating effects of bundles, conduit, and other enclosures. Use electrical load analysis to show the worst-case situation is safe to operate.

Factors to consider in wire selection are voltage, current, electrical shielding, ambient temperature, mechanical strength, abrasion, flexure, flammability, and pressure altitude requirements.

Electrical connection to aircraft heaters shall conform to applicable aircraft standards, utilizing terminal strips, or connectors or receptacles, or both.

4.10 Vibration

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 Hz with a total excursion of 1.59 mm (0.062 inch), and from 45 to 53 Hz with an acceleration of 6 g. Unless otherwise specified in detail specifications, the equipment shall be mounted on the vibrating surface of the apparatus and normal to the direction of vibration.

4.11 High Temperature

The heater and its accompanying devices should not be adversely affected if subjected to ambient temperatures of 71 °C (160 °F) for indefinite periods.

4.12 Radio Interference

4.12.1 If the manufacturer elects to demonstrate compliance with standard radio interference requirements, best practice is to test the combustion heat exchanger per RTCA DO-160 and report the result in the aircraft flight manual supplement.

4.12.2 If the manufacturer elects not to demonstrate compliance with radio interference requirements, the manufacturer shall include in the aircraft flight manual supplement the following statement:

“This Combustion Heat Exchanger does not include protection against, nor has it been tested for, radio or avionics interference.”

5. DESIGN QULIFICATION TESTING

All testing required to show that the design meets minimum performance standards shall be conducted on a test unit that is typical of production hardware. Test units shall be inspected to applicable engineering drawings. Drawings shall be generated and maintained. Unless otherwise specified, all tests shall be conducted at ambient pressure and temperature. All test measurement equipment shall be calibrated prior to testing. Test procedures and reports shall be generated and retained for the life of the design. Reports shall include an introduction, a description of the test apparatus, instrumentation and test setup, the results, a discussion, and conclusions.

5.1 Test Sequence

Two test units shall be subjected to the tests described herein. The sequence of testing shall be as shown in Table 1 as follows:

Table 1 - Heater testing sequence

Test	Procedure Paragraph	Unit No. 1	Unit No. 2
Inspection	5.2.1	X	X
Rated Sea Level Performance	5.2.2	X	X
Ignition Envelope	5.2.3	X	
Low-Temperature Performance	5.2.4	X	
Altitude Performance	5.2.5	X	
Electrical Characteristics	5.2.6	X	
Collapsing Pressure	5.2.7	X	
Burst Pressure	5.2.8	X	
Vibration	5.2.9		X
Rated Sea Level Performance	5.2.2		X
Endurance	5.2.10		X
Rated Sea Level Performance	5.2.2		X
Inspection Teardown	5.2.1	X	X

5.2 Test Procedure

The following procedures describe the general test conditions, test inputs, and success criteria for various heater tests. Alterations to the procedures may be necessary depending on the particular heater undergoing test evaluation. When success criteria are not specified, they shall be mutually agreed upon by the manufacturer and purchaser. For all regulatory purposes, deviation from the following procedures will require approval of the applicable civil aviation authority.

5.2.1 Inspection

The heater shall be inspected for conformance to applicable engineering drawings. Critical dimensions shall be measured and recorded. The heater and accessories shall be weighed to determine conformance to weight requirements.

5.2.2 Rated Sea Level Performance

5.2.2.1 Rated Heater Output

Rated heater output test shall demonstrate compliance with 4.1 as follows:

The test unit shall be installed in a test set up capable of supplying the inputs specified in 4.1. The specified type of fuel at the rated pressure/flow and ambient sea level temperature shall be supplied to the heater fuel system. Combustion air at the rated sea level mass flow rate and ambient sea level temperature shall be supplied to the heater. Ventilation air shall be provided at the mass flow rate specified and ambient sea level temperature. The following test parameters shall be measured and recorded:

a. Barometric pressure

b. Fuel flow rate

c. Fuel inlet temperature

d. Fuel inlet pressure

e. Combustion airflow rate

f. Combustion air inlet pressure

g. Exhaust gas temperature

h. Combustion air pressure drop

i. Ventilating airflow rate

j. Ventilating air inlet pressure

k. Ventilating air inlet temperature

l. Ventilating air outlet temperature

m. Ventilating air pressure drop

Rated output shall be defined at a ventilating air temperature rise of 139 °C ± 3 °C (250 °F ± 5 °F). Output is defined as follows in Equation 1:

$$Q = W_v \times C_P \times (T_{vo} - T_{vi}) \text{ , kW} \quad \text{(Eq. 1)}$$

where:

Q = rated output, kW

W_v = ventilating airflow rate, kg/s

C_P = specific heat of air, kJ/kg - K

T_{vo} = ventilating air outlet temperature - °C

T_{vi} = ventilating air inlet temperature - °C

$T_{vo} - T_{vi}$ = 139 °C ± 3 °C (250 °F ± 5 °F)

5.2.2.2 Carbon Monoxide (CO) Contamination

Carbon monoxide contamination test shall demonstrate compliance with 3.4.1 as follows:

At rating conditions specified in 5.2.2.1 and with the burner operating, the heater downstream ventilating airstream shall be checked for the presence of CO. The 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 five times the diameter in length. A suitable instrument with a resolution no higher than 5 ppm, calibrated against a known standard, shall be used to determine CO concentration. The CO concentration shall not exceed 50 ppm.

5.2.2.3 Combustion Chamber Leakage

Combustion chamber leakage test shall demonstrate compliance with 3.4.1 as follows:

The test unit shall be removed from the performance test set up. Cap the fuel circuit, fuel drain lines, and the combustion air inlet tube. Apply air pressure at 55.1 kPa gage (8 lbf/in^2 gage) to the heater exhaust connection thereby applying internal pressure to the heater combustion chamber. Measure the airflow required to maintain the internal pressure. The air leakage shall not exceed 4.1 kg/h (9 pounds per hour) at sea level and 15 °C (59 °F). A pressure decay test may alternatively be used, provided that the decay rate can be determined to be equivalent to the requirements listed above.

In addition, a test shall be conducted to show that there will be no leakage of fuel into the ventilating air circuit in the event that the heater fails to ignite. For this additional test, the heater is to be mounted as normally installed, with all fuel drains open.

5.2.2.4 Pressurized Heater Leakage

Pressurized heater leakage test shall demonstrate compliance with 3.4.2 as follows:

Heaters intended for use in pressurized aircraft shall be checked for ventilation air circuit leakage. The heater ventilation air inlet and outlet shall be capped. Air pressure at 110 kPa gage (16 lbf/in^2 gage) shall be applied to the capped ventilation air circuit. Measure the air flow required to maintain the internal pressure. The air leakage shall not exceed 4.5 kg/h (10 pounds per hour) at sea level and 15 °C (59 °F).

5.2.2.5 Post-Endurance Test Output: Wing-Empennage Anti-Icing

When heater is to be used for wing-empennage anti-icing, the output shall be no less than 90% of the original output rating after the endurance test.

5.2.3 Ignition Envelope

Install the test unit into a test set up that simulates the aircraft installation as closely as possible. The test unit and mating duct work shall be installed in an altitude chamber (or equivalent) capable of simulating pressures from sea level to the specified design altitude and temperatures of -54 °C (-65 °F). Fuel at the rated pressure/flow shall be supplied to the heater at a temperature of -54 °C (-65 °F) for gasoline-type heaters and -29 °C (-20 °F) for kerosene-type heaters. Measure and record the operating parameters specified in 5.2.2.1. The ability of the heater to ignite repetitively within the time specified in 4.6.8 or 4.6.9 and burn continuously shall be determined for various combustion air differential pressures at various altitudes. The results shall be plotted as altitude versus combustion air differential pressure. Figure 3 shows a typical ignition envelope curve.

Ignition shall be defined as having occurred when the exhaust temperature rise reaches 83 °C (150 °F). The area under the curve shown in Figure 3 shall represent the envelope of operation where the heater can be repetitively restarted. The design altitude of the heater and its accompanying ignition devices shall be defined as the peak of the ignition characteristics curve. Typical design altitude for a combustion heater is at least 6100 m (20000 feet), and in order to ensure an adequate margin with this test being performed on only one heater, a safety margin of 5% shall be applied. Therefore, in order to set a design altitude of 6100 m (20000 feet), the peak of the ignition characteristics curve shall be no lower than 6405 m (21000 feet).

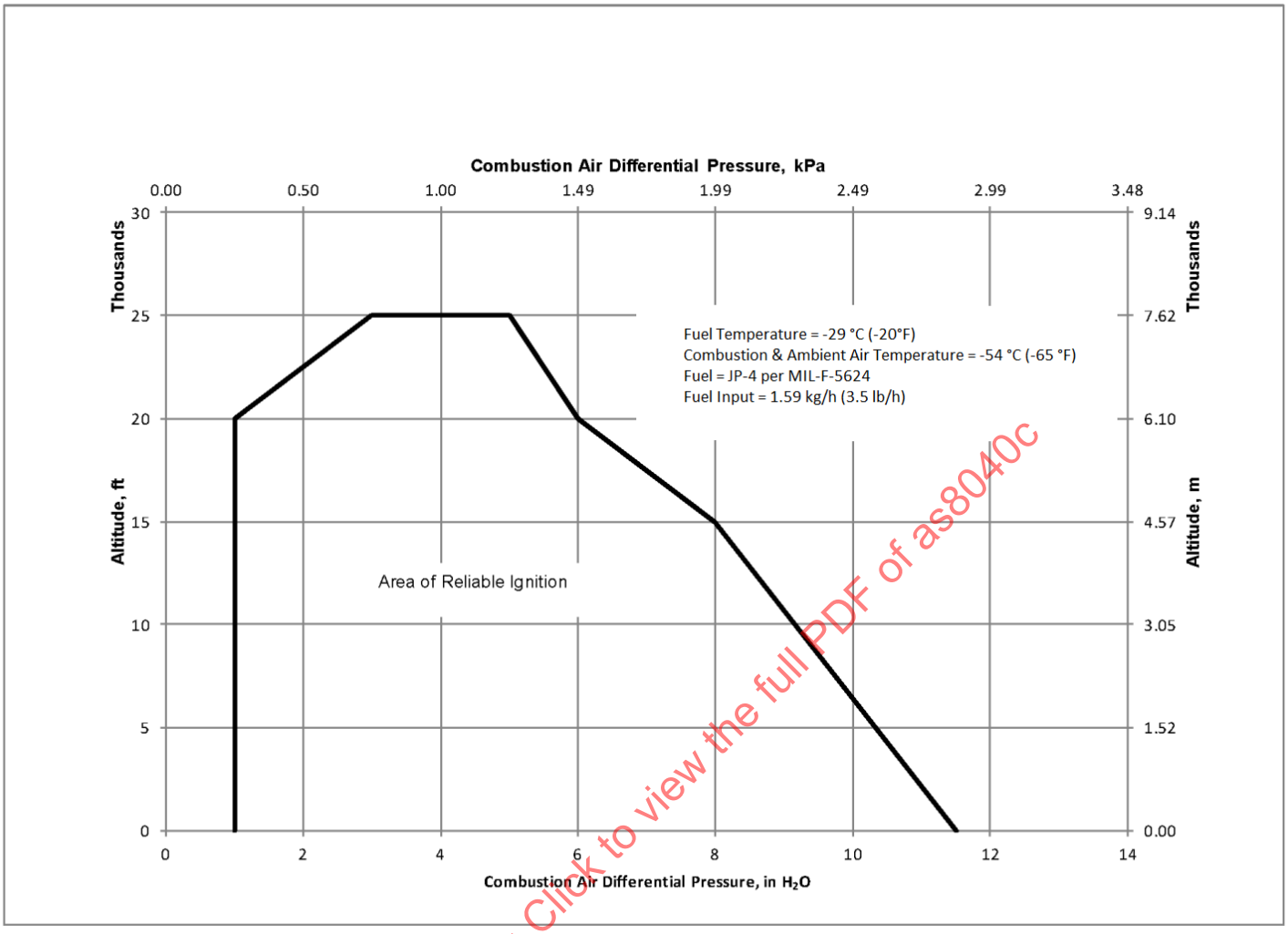

Figure 3 - Typical ignition characteristic curve

5.2.4 Low-Temperature Performance

Install the test unit into the test set up used in 5.2.2.1 and cold-soak the combustion heater assembly to -54 °C (-65 °F) for gasoline-type heaters and -29 °C (-20 °F) for kerosene-type heaters. Other types of fuels need to be addressed on a case-by-case basis. Fuel shall be supplied to the heater at the temperature specified in 5.2.3. The fuel valve internal leakage in the closed position at rated fuel pressure and minimum practical fuel pressure shall not exceed 2 mL (0.068 fluid ounce) of fuel in 10 minutes.

Install the test unit into the test set up used in 5.2.2.1 and cold-soak the combustion heater assembly to -54 °C (-65 °F). Supply combustion air and ventilating air to the heater at sea level pressure and -54 °C (-65 °F) temperature. Fuel at the rated pressure/flow shall be supplied to the heater at the temperature specified in 5.2.3. Combustion and ventilating air pressure levels and mass flow rates shall be the same as 5.2.2.1. Measure and record the parameters specified in 5.2.2.1.