

A SYSTEM FOR ENVIRONMENTAL QUALIFICATION TESTING

FIELD OF INVENTION

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The invention relates to a system for environmental qualification testing.

BACKGROUND

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In most aircraft the interior avionics bays can reach relatively high temperatures due to heat build up from the heat generating avionics, engine heat and/or air friction. In order to avoid damage or failure due to overheating, avionics or other electronic systems typically have some form of cooling system. Depending on the aircraft an auxiliary air conditioning unit may supply cooled airflow, either into the avionics bays, or ducted

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It is known in the art of environmental chambers to provide simulated conditions, for example to provide simulated altitude conditions. It is also known to employ such a chamber to test aircraft components at simulated altitude conditions. For example aircraft avionics or electronics must undergo rigorous Environmental Qualification Testing (EQT) before commercial deployment.

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An EQT chamber for avionics must therefore be configured to simulate an avionics cooling system simultaneously with altitude conditions. Such a combination produces a conflict in prior art EQT systems, as the test chamber is operating at a vacuum and the simulated avionics cooling system introduces an external cooling airflow. This external airflow is equivalent to a leak in the chamber, and requires extra vacuum pumps to maintain the correct vacuum to simulate altitude conditions.

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A need therefore exists to address at least one of the above problems.

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SUMMARY

In accordance with a first aspect of the invention there is provided a system for environmental qualification testing of a heat generating device, said system comprising:

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a chamber having an interior for locating a heat generating device during testing,
a chamber conditioner communicating with said interior and adapted to condition
air within said interior, and

5 a device conditioner for conditioning the heat generating device located within said
interior during testing, said device conditioner having an inlet communicating with said
interior and an outlet adapted to direct conditioned airflow towards the heat generating
device within said interior during testing.

10 The chamber conditioner may be adapted to condition air in said interior towards a
predetermined pressure and/or temperature condition(s).

15 The system may be adapted to simulate high altitude for testing heat generating
devices designed for aircraft, and said predetermined pressure condition is an interior
pressure lower than atmospheric pressure at standard sea level conditions.

The device conditioner may be adapted to condition said airflow towards a
predetermined mass flowrate and/or temperature condition(s).

20 The device conditioner may be adapted to cool said airflow to a lower temperature
than the temperature of air within said interior.

The outlet of said device conditioner may be adapted to be directly connected to
an inlet of said heat generating device during testing.

25 The outlet of said device conditioner may alternatively be adapted to be provided
adjacent to a fan forced inlet of a heat generating device during testing.

The chamber may be in use substantially sealed.

30 In accordance with a second aspect of the invention there is provided a method of
environmental qualification testing of a heat generating device, comprising the steps of:
providing conditioned air to the interior of a chamber;
testing a heat generating device within said chamber;
extracting air from said interior;

conditioning said extracted air;
directing said conditioned extracted air towards the heat generating device during testing.

5 The air within said chamber may be conditioned to a predetermined pressure lower than atmospheric pressure at standard sea level conditions.

The extracted air may be conditioned to a predetermined temperature below the temperature of said air within said chamber.

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The flow of said extracted air may be regulated to a predetermined mass flow rate.

The conditioned extracted air may be directed directly into an inlet of said heat generating device.

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The conditioned extracted air may alternatively be directed toward to a fan forced inlet of said heat generating device.

BRIEF DESCRIPTION OF THE DRAWINGS

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Example embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

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Figure 1 shows a schematic of a system for environmental qualification testing.

Figure 2 shows a schematic of a conditioning unit for the EQT chamber.

Figure 3 shows a schematic of connections from a conditioning unit to a heat generating device under test.

Figure 4 shows a schematic of a conditioning unit for the test device.

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Figure 5 shows a flow chart of the system in operation.

DETAILED DESCRIPTION

Figure 1 exemplifies an example embodiment of a system for environmental qualification testing (EQT) 100. A sealable chamber 102 has a hollow interior 108 in which a heat generating device 104, such as an avionics box, undergoes environmental qualification testing. A chamber conditioning unit (CCU) 106 is connected to the chamber to condition the pressure, temperature and/or humidity of the chamber interior 108. The test device 104, or more particularly the test device interior, is subjected to separate conditioning by a test device conditioning unit (DCU) 110.

The test device 104 may be avionics or any other form of heat generating device requiring testing. In order to test operational robustness of the device, typically the device is subjected to extremes of expected conditions in aircraft. Examples of such extremes include high and low temperatures, and/or high altitude.

Typically the device includes an assembly of avionics components housed in a box, with an inlet and outlet for the conditioned airflow from the DCU.

In order to avoid additional strain or unnecessary capacity of the CCU 106, the DCU 110 effectively operates in a closed cycle with respect to the chamber interior 108. An inlet to the DCU 110 takes air from the chamber interior 108, conditions the airflow 112 accordingly and directs the conditioned airflow 114 into or towards the inlet of the test device 104. In this example no external air is added to the chamber interior by the DCU 110, hence the CCU 106 does not require additional capacity to maintain the vacuum.

Generally the chamber interior 108 will simulate above sea level altitude, and accordingly CCU 106 may at least be capable of reducing the pressure in the chamber interior below atmospheric pressure at standard sea level conditions. Referring to Figure 2 the CCU 106 includes a vacuum pump 200, heater/cooler 202, humidifier/dehumidifier 204, sensor(s) 206 and chamber controller (CC) 208. The CC 208 may automatically operate each of the vacuum pump 200, heater/cooler 202, humidifier/dehumidifier 204 in response to the sensor(s) 206 output to achieve predetermined values for pressure, temperature and/or humidity. A user input may be provided to vary the pressure, temperature and/or humidity. Alternatively the CC 208 may interface with other systems to automate the testing procedure.

The chamber 102 includes a mount for the test device, connections for the CCU, DCU test equipment and sensors, and an opening to insert and remove the test device. The chamber must be capable of withstanding the conditions within the chamber interior, and typically includes comprehensive sealing and insulation. Typical conditions include a collapsing pressure of 14.7 psi and a temperature range of -55°C to 95°C.

Depending on the type of heat generating device, different connections to the DCU may be required.

Referring to Figure 3a a test device 104 is shown according to a first embodiment, incorporating a fan for generating airflow through the device. An outlet 300 of the DCU is located within the chamber interior 108 so as to direct a conditioned airflow 302 towards an inlet 304 to the test device 104. The inlet 304 of test device includes an inlet fan 306, to induce the cooled airflow 302 into the interior 308 of test device. An outlet 310 of the test device discharges exhaust airflow 312 into the chamber interior 108.

Referring to Figure 3b a test device 104 is shown according to a second embodiment, that is adapted to be directly coupled to the DCU outlet. An outlet 314 of the DCU is connected directly to the inlet 316 of the test device 104. Conditioned airflow 318 flows from the DCU directly into the test device interior 308. The outlet 310 of the test device 104 discharges exhaust airflow 312 into the chamber interior 108.

Generally the DCU conditioned airflow 114 directed towards the test device will be colder than the chamber interior 108 (simulating actual conditions in an aircraft), and accordingly DCU 110 may at least be capable of reducing the airflow 114 temperature below the chamber interior air temperature. Referring to Figure 4 the DCU 110 includes a blower 400, cooler 402, sensor(s) 405,406 a DCU inlet 410, a DCU outlet 412, ducting 414 between each of the DCU components and a test device controller (DC) 408. The DC 408 may automatically operate each of the blower 400 and cooler 402 in response to the sensors 405,406 output(s) to achieve predetermined values for airflow and/or temperature at the output. A user input may be provided to vary the airflow and/or temperature. Alternatively the DC 408 may interface with other systems to automate the testing procedure.

Manual shutoff valves 416,418 are provided at the DCU connections to the chamber, to allow for connection and disconnection of the DCU. This allows CCU to operate with DCU disconnected.

5 The DC 408 may be a temperature and mass flow rate controller. For example the sensor outputs relating to flow rate 405 through the ducting and air temperature 406 at the DCU outlet, provide input data to the DC and based on set values for the airflow and temperature, output signals are generated by the DC to operate the cooler and blower to achieve the set values. Typically feedback control is used although simpler or more
10 complicated control schemes may also be used.

The blower 400 may be a variable speed fan with inverter speed control to regulate the airflow in the ducting 414 between the DCU inlet 410 and DCU outlet 412. The speed and therefore mass flow rate of the airflow may be varied according to a
15 control signal supplied by the DC. Alternatively varying the fan power supply, or adjusting a series valve to restrict the flow from a constant speed fan may be used to achieve manual control.

The cooler 402 may be a heat exchanger, in series with the blower, to refrigerate
20 (or heat) the airflow in the ducting 414 between the DCU inlet 410 and DCU outlet 412. The level of cooling (or heating) supplied to the airflow may be varied according to a control signal supplied by the DC. Alternatively varying the compressor power supply or restricting the coolant flow may be used to achieve manual control. If sub zero cooling is required liquid nitrogen cooling may also be incorporated.

25 The ducting 414 must be capable of withstanding the conditions within the chamber interior and typically includes comprehensive sealing and insulation. Typical conditions include a collapsing pressure of 14.7 psi and a temperature range of -55°C to 95°C.

30 Referring to Figure 5 the operation of the system is shown in a flow diagram. In step 500 the predetermined set points for the chamber pressure and chamber temperature are set. In step 502 the CCU runs to steady state conditions approximating the predetermined set points for the chamber pressure and chamber temperature. In step

504 the predetermined set points for the DCU mass flow rate and the DCU outlet temperature are set. In step 506 the DCU runs to steady state conditions approximating the predetermined set points for the DCU mass flow rate and the DCU outlet temperature. In step 508 the test device is operated under steady state conditions. In step 510
 5 measurements are made of the test device. In step 512 if further tests are required, the process restarts, or otherwise the process is stopped.

Example embodiments of the invention may have one or more of the following advantages:

- 10 1. avoids the need for the DCU to include dehumidifying capacity; high precision valves to control the flow of air from a high pressure ambient to low pressure chamber; and complex anti-icing capacity.
2. avoids extra CCU vacuum pumps to extract the additional air pumped in (equivalent to leakage from ambient into the chamber) by a prior art (non closed cycle)
- 15 DCU. For example testing up to an altitude of 50000ft (the lowest limit for most fighter aircraft) requires a relatively high vacuum.
3. avoids icing problems, since humidity is controlled by the CCU.
4. reduction in the complexity of the system.
5. reduction in the cost of the system.
- 20 6. smaller overall system footprint.
7. quieter system operation.
8. simpler system operation.

It will be appreciated by a person skilled in the art that numerous variations and/or
 25 modifications may be made to the present invention as shown in the example embodiments without departing from the spirit or scope of the invention as broadly described. The example embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

CLAIMS:

1. A system for environmental qualification testing of a heat generating device, said system comprising:

5 a chamber having an interior for locating a heat generating device during testing,
a chamber conditioner communicating with said interior and adapted to condition air within said interior, and

a device conditioner for conditioning the heat generating device located within said interior during testing, said device conditioner having an inlet communicating with said
10 interior and an outlet adapted to direct conditioned airflow towards the heat generating device within said interior during testing.

2. The system as claimed in claim 1 wherein said chamber conditioner is adapted to condition air in said interior towards a predetermined pressure and/or temperature
15 condition(s).

3. The system as claimed in claim 2 wherein said system is adapted to simulate high altitude for testing heat generating devices designed for aircraft, and said predetermined pressure condition is an interior pressure lower than atmospheric pressure at standard
20 sea level conditions.

4. The system as claimed in any one of claims 1 to 3 wherein said device conditioner is adapted to condition said airflow towards a predetermined mass flowrate and/or temperature condition(s).
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5. The system as claimed in claim 4 wherein said device conditioner is adapted to cool said airflow to a lower temperature than the temperature of air within said interior.

6. The system as claimed in any one of the preceding claims, wherein said outlet of
30 said device conditioner is adapted to be directly connected to an inlet of said heat generating device during testing.

7. The system as claimed in any one claims 1 to 4, wherein said outlet of said device conditioner is adapted to be provided adjacent to a fan forced inlet of a heat generating device during testing.

5 8. The system as claimed in any one of the preceding claims wherein in use said chamber is substantially sealed.

9. A method of environmental qualification testing of a heat generating device, comprising the steps of:

10 providing conditioned air to the interior of a chamber;
testing a heat generating device within said chamber;
extracting air from said interior;
conditioning said extracted air;
15 directing said conditioned extracted air towards the heat generating device during testing.

10. The method as claimed in claim 9 wherein said air within said chamber is conditioned to a predetermined pressure lower than atmospheric pressure at standard sea level conditions.

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11. The method as claimed in claim 9 or 10 wherein said extracted air is conditioned to a predetermined temperature below the temperature of said air within said chamber.

12. The method as claimed in any one of claims 9 to 11 wherein the flow of said
25 extracted air is regulated to a predetermined mass flow rate.

13. The method as claimed in any one of claims 9 to 12 wherein said conditioned extracted air is directed directly into an inlet of said heat generating device.

30 14. The method as claimed in any one of claims 9 to 12 wherein said conditioned extracted air is directed toward to a fan forced inlet of said heat generating device.