AEROSPACE RECOMMENDED PRACTICE

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Superseding ARP1523B

Air Mode Insulated Containers - Thermal Efficiency Requirements

RATIONALE

The SAE AGE-2A committee determined that the technology/practice defined in this standard has reached a level of maturity such that it is unlikely to change in the foreseeable future; therefore, it does not require regular 5-year reviews by the committee and it is appropriate for it to be stabilized.

STABILIZED NOTICE

This document has been declared "Stabilized" by the SAE AGE-2A Cargo Handling Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

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FOREWORD

This SAE Aerospace Recommended Practice (ARP) outlines supplementary requirements for air cargo insulated containers of all sizes.

Throughout this ARP the minimum essential criteria are identified by use of the key word “shall”. Recommended criteria are identified by use of the key word “should” and, while not mandatory, are considered to be of primary importance in providing thermal efficiency. Deviation from recommended criteria should only occur after careful consideration, extensive testing and thorough service evaluations have shown alternate methods to be satisfactory.

Nothing in this ARP shall in any way cancel or reduce the status of the specifications which determine airworthiness, industry, ground handling or any other characteristics of the units.

This ARP refers to the thermal efficiency of all insulated air cargo containers irrespective of their size and designation. It does not provide details concerning refrigerated or heated containers and/or the methods and equipment used to obtain the required thermal effect, such as cryogenic, gaseous or liquid fluids, or mechanical compressors.

In preparing this ARP, for compatibility and guidance purposes, the requirements of ISO 1496-2:1996, Series 1 freight containers - Specification and testing - Part 2: Thermal containers, have been taken into account as far as procedures for measuring the thermal efficiency are concerned (see clause 6).

TABLE OF CONTENTS

1. SCOPE:

1.1 This SAE Aerospace Recommended Practice (ARP) delineates the minimum operational requirements that will ensure that perishable cargoes in insulated standard airborne containers are kept in prime condition during the ground handling and air transportation cycle for a maximum period of 36 h.

1.2 The term "perishable cargo" refers, for example, to dairy produce, fruit, vegetables, flowers, frozen foods, meat, fish, etc., requiring maintenance of specific temperature ranges during door-to-door transportation involving air transport.

1.3 The overall temperature range for perishable commodities may be anywhere between +20 °C (+68 °F) and -25 °C (-13 °F) during the transport cycle.

1.4 During this period of door-to-door transportation, the container may be subjected to outside ambient temperature with extremes of +45 °C (+113 °F) and -50 °C (-58 °F) and a relative humidity of up to 100%.

1.4.1 For design purposes - and to allow for temperature drops and rises occurring between origin and destination in the air transport cycle - the container shall perform its protective function within an outside temperature variation, ΔT, of 53 units of temperature interval Celsius (95 units of temperature interval Fahrenheit) within the range of temperature exposure extremes stated in 1.4.

NOTE 1: It should be noted that throughout this document environmental (atmospheric) temperatures are expressed in commercial values of degrees Celsius/Fahrenheit (°C/°F) and technical (scientific) temperatures are expressed in kelvin (K). A temperature conversion table is given for convenience in Appendix C.

2. APPLICABLE DOCUMENT:

The document listed below contains provisions that, through reference in this text, constitute provisions of this Aerospace Recommended Practice. At the time of publication, the edition indicated was valid. As all publications are subject to revision, parties to agreements based on this ARP are encouraged to apply the most recent edition of the document.

2.1 ISO Publication:

Available from American National Standards Institute, 11 West 42nd Street, New York, NY, 10036.

ISO 11242:1996 Aircraft - Pressure equalization requirements for cargo containers

3. DESIGN CONSIDERATIONS:

3.1 In the design of the container, careful consideration shall be given to the contribution of conduction, convection, radiation and air leakage to the overall thermal efficiency of the unit. At the same time, an optimum balance between insulation, structure, cost and weight shall be a constant design goal.

3.2 Although no specific test is specified in clause 6 for thermal radiation, it is expected that consideration will be given to commonly encountered environments wherein radiant energy exchange can be minimized.

3.3 The container shall be free of sharp corners and/or crevices that might collect dirt, spillage or odors. No pockets shall exist in the cargo loading space that cannot be reached by conventional cleaning methods.

3.4 The construction shall be such that spillage collects during the transport cycle but runs off during flushing and/or washing. Adequate provision shall be made to ensure that cleaning water can satisfactorily drain from the inside of the container in normal operational conditions.

3.5 Materials used for the container structure, the interior surfaces and the insulation shall absorb neither moisture nor odors and shall not be functionally affected by daily washing, and shall be non-nutrient for fungi.

3.5.1 Methods of washing shall include flushing using a pressure hose at 689 kPa (100 lbf/in^2), 70 °C (158 °F) temperature and strong detergents. Washing may also be carried out by steam cleaning at 110 °C (230 °F).

3.5.2 When "washed", the container shall not require the use of odor-neutralizing chemicals.

3.5.3 The container shall withstand freezing temperatures while wet immediately following washing. All valves, seals, doors and controls shall remain operative.

3.5.4 Material used on the inside of the container, thus potentially coming in contact with foods and/or pharmaceutical goods, shall be neutral to these cargoes and shall meet applicable sanitary standards.

4. PRESSURIZATION:

4.1 General Conditions:

Containers shall be closed at differing terminal altitudes. The critical condition shall be at sea level. Operationally, the container could be subjected to either internal positive or negative pressure. Careful attention to the design of equalization devices (if any) and all seals is important in the control of air leakage heat transfer.

4.2 Pressure Equalization:

If the design of door seals is not adequate to relieve pressure, a pressure equalization device should be installed for two-way equalization. This pressure relief device should be set to operate at 3.45 to 6.89 kPa (0.5 to 1 lbf/in^2) pressure differentials.

4.3 Blow-out Panel:

To compensate for the unique exposure to rapid decompression of a container transported by air, a blow-out panel, or equivalent device, conforming to ISO 11242:1996, shall be provided. It shall be installed in such a manner that it will not damage aircraft structure or systems or cause injury in event of its operation.

NOTE 2: The decompression parameter is based on an event lasting 1 s, involving an ambient pressure change from 81 kPa (11.80 lbf/in^2) to 15 kPa (2.14 lbf/in^2).

5. AIR TIGHTNESS TESTS:

5.1 The container shall be subjected to tests to determine the air leakage rate. These shall be carried out after completion of the applicable operational or limit load tests (if any) required in other specifications related to the specific container involved.

5.2 The temperature inside and outside the container shall be stabilized within 3 °C (5.4 °F) of each other and shall both be within the range of 15 °C (59 °F) to 25 °C (77 °F). The container shall be empty and in its normal operational condition with the access doors closed in the normal manner. Any drain openings shall be closed.

5.3 Air shall be introduced into container through an accurate leakage-metering device and a suitable manometer shall be connected to the container by a leak proof connection. The manometer shall not be part of the air supply system. The flow-measuring device shall be accurate to ±3% of the measured flow rate, and the manometer on the container shall be accurate to ±5%.

5.4 Air shall be admitted to the container to raise its internal pressure to 0.25 kPa ± 0.01 kPa (0.036 lbf/in^2 ± 0.0015 lbf/in^2) and the air supply regulated to maintain this pressure.

5.4.1 The air leakage rate, corrected to standard atmospheric conditions, should be no more than the values given in Appendix A, Table A1, i.e., 40% of the internal volume per hour. If the measured air leakage is equal to or less than the values given in Appendix A, Table A1, the heat transfer results determined in the thermal test (see clause 6) shall be reported without correction for air leakage.

5.4.2 If the measured air leakage exceeds the values given in Appendix A, Table A1, but is no more than the values given in Appendix A, Table A2, then the U values measured in the thermal test shall be increased by the correction values given in Appendix A, Table A3.

5.5 The air pressure shall be increased to between 3.45 kPa and 6.89 kPa (0.5 to 1 lbf/in^2) internal pressure. The pressure relief device, or door seal expulsion, shall operate within the positive differential range of 3.45 to 6.89 kPa (0.5 to 1 lbf/in^2).

5.6 Upon completion of the tests (clauses 5.2 through 5.5) there shall be no permanent deformation and the container shall be fully operational. Closures, seals and pressure equalization device shall be intact and functional.

6. THERMAL TEST:

6.1 The test is performed to establish the overall heat transfer rate (U) and thermal transmission factor (K) of the container. The container shall be tested in the exact configuration intended for use. Any options or component configuration alternatives shall be tested in a separate test and appropriately specified, when applicable, in the container performance data on the marking plate described in clause 7.

6.1.1 The U factor applies to only one type of container, and allows the user to easily determine the thermal transfer rate by multiplying the factor by the temperature differential between inside and outside the container. The K factor allows comparison of the insulation performance of a variety of containers with different sizes and contours.

6.1.2 The heat leakage shall be expressed by the total heat transfer rate, U_θ, which is given by the formula

$$U_\theta = \frac{Q}{\theta_e - \theta_i} \qquad \text{(Eq. 1)}$$

where:

U_θ = Total heat transfer rate, expressed in watts per kelvin[1]

Q = Power dissipated or absorbed by the operation of internal heaters and fans or internal cooling units, in watts

θ_e = Average outside temperature, in kelvin, which shall be the arithmetic mean of the temperatures recorded at the end of each test interval (see 6.4.7) and measured 100 mm (4 in) from the walls, at least at the 12 points specified in 6.3.2 and shown in Appendix B, Figure B1

θ_i = Average inside temperature, in kelvin; which shall be the arithmetic mean of the temperatures recorded at the end of each test interval (see 6.4.7) and measured 100 mm (4 in) from the walls, at least at the 12 points specified in 6.3.1 and shown in Appendix B, Figure B2

[1] 1 W/K = 0.556 W/°F = 0.860 kcal/(h °C) = 1.895 Btu/(h °F).

6.1.3 The mean wall temperature, θ, shall be expressed in kelvin; by convention:

$$\theta = \frac{\theta_e + \theta_i}{2} \quad \text{(Eq. 2)}$$

6.1.4 The coefficient of heat transfer, K, expressed in watts per square meter kelvin, is such that

$$K = \frac{U_\theta}{S} \quad \text{(Eq. 3)}$$

where:

U_θ = Defined in 6.1.2
S = Mean surface area of the container, in square meters, which is the geometric mean of the inside surface area S_i and the outside surface area S_e; by convention:

$$S = \sqrt{S_i \times S_e} \quad \text{(Eq. 4)}$$

If areas are corrugated, the projected area shall be used.

6.2 The test shall be performed under steady-state conditions using the internal heating method. All measuring systems shall be selected and calibrated to result in the following root-mean-square average accuracy:

Temperatures: ±0.5 K
Power: ±2% of the quantity measured

6.3 The temperatures shall be measured in accordance with 6.3.1 and 6.3.2.

6.3.1 The inside air temperature shall be measured 100 mm (4 in) from the walls at least at the twelve (12) points shown in Appendix B, Figure B2:

a. the eight inside corners of the container;
b. the centers of the side walls, floor and ceiling.

6.3.2 The outside air temperature shall be measured 100 mm (4 in) from the walls at least at the twelve (12) points shown in Appendix B, Figure B1:

a. the eight outside corners of the container;
b. the centers of the side walls, underside and roof.

6.4 Test data for determining the heat leakage of the container shall be taken after an appropriate soak period to stabilize the wall temperature for the continuous period of not less than 8 h during which the following conditions shall be satisfied.

6.4.1 The test shall be performed with a mean wall temperature chosen between 293 K and 311 K, and a temperature difference between inside and outside of not less than 20 K.

NOTE 3: It should be noted that a standard mean wall temperature of 293 K should be used for rating thermal containers because it allows a better determination of all factors involved in the in-service conditions in which the containers will be operated, and facilitates comparison of different containers by owners and users. It also eliminates misunderstanding in applying the total heat transfer rate values for different mean wall temperatures. Appropriate correction factors may be employed for the specific insulation material employed using a curve relating to mean wall temperature; e.g., several testing laboratories use the formula:

$$\text{K factor (at } \theta_m = 293 \text{ K)} = \text{K (at } \theta_m \neq 293 \text{ K) times } \left[1 - \frac{(293 - \theta_m)}{200}\right] \quad \text{(Eq. 5)}$$

6.4.2 The maximum difference between the warmest and coldest points inside at any one time: 3 K.

6.4.3 The maximum difference between the warmest and coldest points outside at any one time: 3 K.

6.4.4 The maximum percentage difference between the lowest and the highest power dissipation values in watts shall not exceed 3% of the lowest figure.

6.4.5 The maximum difference between any two average inside air temperatures, θ_i, at different times: 1.5 K.

6.4.6 The maximum difference between any two average outside air temperatures, θ_e, at different times: 1.5 K.

6.4.7 All readings shall be recorded at intervals of not more than 30 min.

6.4.8 All temperature measuring instruments placed inside and outside the container shall be designed so as to render the effect of radiation negligible.

6.5 Calculate the total heat leakage, U, in watts per kelvin, from 17 or more sets of readings over a continuous test period:

$$U = \frac{1}{n} \sum_{1}^{n} U_\theta \quad \text{(Eq. 6)}$$

where:

$n \geq 17$

6.6 Calculate the mean of the mean wall temperature(s) (θ_m) for the test period:

$$\theta_m = \frac{1}{n}\sum_{1}^{n}\theta \qquad \text{(Eq. 7)}$$

6.7 During any test the outside air velocity shall not exceed 2 m/s (6.6 ft/s) at a distance of 100 mm (4 in) from the container.

6.8 No test method shall result in frost build-up that could affect the test result in any way.

7. MARKINGS:

7.1 The markings required for handling, as specified for the applicable container by an appropriate document, shall include on a plate adjacent to, or within, those markings the following particulars:

a. the total heat transfer rate, U, expressed in watts per degree Celsius (W/°C)and Btu/h per degree Fahrenheit (Btu/(h/°F)),

b. the applicable mean wall temperature, θ_m, expressed in degrees Celsius and degrees Fahrenheit.

7.2 The plate shall be 60 mm x 125 mm (2.5 in x 5.0 in) and permanently affixed to the container with black bold lettering 10 mm (0.4 in) high with the following format:

Heat transfer rate	W/ ^{0}C_____	Btu/(h / ^{0}F)	_____
Mean wall temperature	^{0}C _____	^{0}F	_____

FIGURE 1

PREPARED UNDER THE JURISDICTION OF
SAE SUBCOMMITTEE AGE-2A, CARGO HANDLING OF
COMMITTEE AGE-2, AIR CARGO AND AIRCRAFT GROUND EQUIPMENT & SYSTEMS