

Australian Standard™

**Thermal performance of refrigerated
transport equipment—Specification and
testing**



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Thermal performance of refrigerated transport equipment—Specification and testing

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Thermal performance of refrigerated transport equipment—Specification and testing

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee ME-006, Refrigeration.

The term ‘informative’ has been used in this Standard to define the application of the appendix to which it applies. An ‘informative’ appendix is only for information and guidance.

Statements expressed in mandatory terms in Notes to Tables are deemed to be requirements of the Standard.

This Standard incorporates a Commentary on some clauses. The Commentary is set directly following the relevant clause and is designated by ‘C’ preceding the clause number and printed in italics in a panel. The Commentary is for information only and does not need to be followed for compliance with the Standard.

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FOREWORD

Logistically, Australia presents challenges in the daily functions of distributing perishable food products nationally. Refrigerated transport equipment is required to effectively and efficiently maintain the appropriate temperature environment around the load, whilst often coping with extreme external temperature environments.

This Standard was developed by Standards Australia Committee ME-006 with the active input from the refrigerated transport industry to address the need for nationally recognized and endorsed performance-based specifications for equipment used to road transport refrigerated food products in Australia. The Standard is a result of the preliminary testing conducted under the guidance of the Refrigerated Transport Manufacturers Forum (RTMF), an organization with members drawn from the two national industry organizations that are involved in the refrigerated distribution of perishable food products—the Australian United Fresh Transport Advisory Committee Limited and the Refrigerated Warehouse and Transport Association, and with the involvement of recognized consultants and industry experts in the area of refrigerated transport, both within Australia and internationally.

The development of this Standard forms part of a multistage process. The first phase of the project covered mostly preliminary equipment testing and the initial drafting of the Standard and was jointly funded by industry and the Federal Department of Transport and Regional Services. A task for preparing an Australian Standard was assigned to a new Standards Australia Subcommittee ME-006-03 involving experts from a wide industry base including equipment manufacturers, distributors, truck builders and installers, operators, users, consulting engineers, associations and government organizations.

This Australian Standard is particularly timely given the current emphasis on food safety and quality systems. National performance-based specifications enable the verification of equipment based on performance, in line with the implementation of correct operational procedures.

STANDARDS AUSTRALIA

Australian Standard

Thermal performance of refrigerated transport equipment— Specification and testing

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard covers the thermal performance of insulated equipment fitted with any type of refrigeration system and intended for the transport of perishable products by road, whether as individual packages or as unit loads (e.g., palletized). Trailers and vehicle bodies are included; refrigerated tankers and all insulated but unrefrigerated vehicle bodies are excluded.

NOTES:

- 1 Product temperature may differ from air temperature and is not addressed by this Standard. Recommendations for maintaining appropriate product temperatures can be found in publications listed in Appendix A.
- 2 Appendices C, D and E provide guidance on relevant bibliography and metric conversions.

1.2 OBJECTIVE

The objective of this Standard is to set down specifications and testing procedures for the thermal performance of refrigerated equipment intended for the transport of perishable goods by road. It is based on heat balance between the insulating ability of the body and the refrigerating power of the refrigeration unit.

1.3 APPLICATION AND TRANSITIONAL ARRANGEMENTS

1.3.1 Inclusions

The following are covered by this Standard:

- (a) Insulated bodies, trailers, trucks and van bodies fitted with any form of refrigeration systems.
- (b) Insulated compartments of multi-compartment bodies.
- (c) All types of mechanical refrigeration equipment (i.e., refrigeration equipment using compressors or absorption devices) including those powered by their own internal engine, those powered from the vehicle's engine, and those fitted with stand by electric motors.
- (d) All types of refrigeration systems using an expendable refrigerant (e.g., liquefied carbon dioxide and liquefied nitrogen).
- (e) All types of refrigeration systems using heat storage devices (e.g., eutectic systems, that store 'cold' by means of a phase change material).
- (f) Hybrid refrigeration systems (that is, those that combine two or more of the above types of refrigeration).

1.3.2 Exclusions

The following are excluded from this Standard:

- (a) Freight containers conforming to ISO 1496-2 not older than 8 years.
- (b) Insulated but non-refrigerated bodies and other devices.
- (c) Refrigerated tankers intended for the transport of liquids.
- (d) Curtain-sided bodies.

1.3.3 Structural performance

The structural performance of the body or refrigeration equipment is not specified by this Standard.

1.3.4 Compliance

Checks for conformity to the Standard shall be made—

- (a) before the equipment is put into service;
- (b) after a period of 6 years;
- (c) after any major repair or modification (that is, a repair or modification of a type which might affect the thermal performance of the equipment).

NOTE: It is expected that the industry, in cooperation with the competent authority, will develop guidelines as to what constitutes a major repair or modification.

1.3.5 Transitional provisions for existing equipment

Existing equipment, and equipment built to current specifications, may be certified by the provisions specified in this document for existing equipment (see Clause 4.6).

1.4 REFERENCED DOCUMENTS

ISO

1496 Series 1 Freight containers—Specifications and testing

1496-2 Part 2: Thermal containers

5801 Industrial fans—Performance testing using standardized airways

ADR

43/04 Australian Design Rules ADR 43/04

ARI

1110 Mechanical transport refrigeration units

1.5 DEFINITIONS

1.5.1 Airflow floor

A profiled floor, usually consisting of aluminium extrusions, intended to allow some airflow beneath a load stowed directly onto the floor (as opposed to a flat floor).

1.5.2 Air circulation rate

Volume of air circulating through the cooling system, measured in cubic metres per second.

1.5.3 Bulkhead

A partition providing a passage for air to return from the lower part of the loadspace to the refrigeration unit, which may be formed by a solid panel or by mesh.

1.5.4 Calorimeter box

An insulated enclosure with known heat transfer characteristics, to which a refrigeration unit can be fitted for the determination of its refrigeration capacity. A calorimeter box is used in a test room. A calibrated trailer body, truck body, or freight container may be used as a calorimeter box.

1.5.5 Ceiling duct

A rigid or flexible duct attached to the ceiling intended to distribute air from the refrigeration unit throughout the loadspace.

1.5.6 Coefficient of insulative effectiveness, K (also known as K coefficient)

Heat leakage, under test conditions, divided by the product of the mean surface area of the body and the difference between the outside and inside air temperatures (W/m^2K).

$$K = Q / (S_m (T_o - T_i))$$

1.5.7 Heat leakage

Transfer of heat through the structure of an insulated body or calorimeter box resulting when the outside and inside are maintained at different temperatures.

1.5.8 Hybrid refrigeration system

A combination of two or more types of refrigeration (for example, a mechanical refrigeration system to handle the background heat load plus a liquid nitrogen system to re-cool after each door opening).

1.5.9 Insulated body

Insulated structure that encloses the load space, and that may be load-bearing (for example, carrying meat rails, and all or part of the refrigeration unit).

1.5.10 Loadspace

That part of the body intended for the transport of product.

1.5.11 Major modification

Modifications or repairs that have the potential to substantially alter the heat transfer balance of the transport equipment.

NOTE: Changing the type of door or refrigeration unit constitutes a major modification.

1.5.12 Mean inside temperature (T_i)

The mean inside temperature (T_i), calculated as an arithmetic mean of temperatures inside the body (see Clause 4.4.7.2.5).

1.5.13 Mean surface area (S_m)

The geometric mean of the outside surface area (S_o) and the inside surface area (S_i) of the body, measured in square metres:

$$S_m = \sqrt{(S_o \times S_i)}$$

1.5.14 Mean wall temperature (T_m)

Arithmetic mean of outside air temperature (T_o), and the inside air temperature (T_i), measured in degrees Celsius.

$$T_m = (T_o + T_i) / 2$$

1.5.15 Multi-compartment body

Body having more than one load compartment capable of independent temperature control.

1.5.16 In-service test

A transient test to estimate compliance with a specified thermal rating. Need not be conducted in a testroom.

1.5.17 Reference equipment

Equipment that has been tested and certified, and which is then referred to in granting approval to other similar equipment. The test of reference equipment may be referred to as a 'Type-test'.

1.5.18 Refrigerated body

An insulated body fitted with a means of creating and automatically maintaining temperatures inside the body.

1.5.19 Refrigerated equipment

Includes all functional aspects of both insulated body and refrigeration unit associated with its thermal performance.

1.5.20 Refrigerating power (Q)

Net refrigerating power of a refrigeration unit at specified outside and inside conditions, measured in watts.

1.5.21 Refrigeration unit

A device that is capable of modifying the temperature within the loadspace (by cooling and/or by heating). Includes any fans supplied with the unit.

1.5.22 Reserve power

The additional refrigerating power over that required to remove body heat leakage through the refrigerated body, expressed as percentage of heat leakage.

1.5.23 Transient test

Test made under non-steady-state conditions (see also 'In-service Test').

1.5.24 Test room or test chamber

A room in which the temperature, and sometimes the humidity, can be controlled at standard values for the purpose of testing the thermal performance of a piece of equipment.

1.5.25 Testing station

A testing laboratory authorized to perform specified types of test, and subject to third-party verification.

1.5.26 Type-test

A reference test, the results of which may be applied to other equipment of a substantially identical construction (see also reference equipment).

1.5.27 Secondary doors

Inner doors, fitted to an insulated body, intended to reduce air exchange.

SECTION 2 THERMAL PERFORMANCE AND CLASSIFICATION

2.1 GENERAL

Refrigerated transport equipment shall be classified in accordance with the requirements of this Section.

Refrigerated transport equipment shall comply with the thermal performance requirements of this Section.

Refrigerated transport equipment shall deliver specific thermal outcomes to ensure perishable goods loaded at appropriate temperatures are maintained within a given temperature range during transport.

C2.1 *Effective and efficient transport refrigeration, to keep the cargo temperatures within the given range at economic power consumption and emission of greenhouse gases requires co-optimization of three systems, as follows:*

- (a) *Refrigeration—to maintain a temperature difference against ambient air in a loadspace.*
- (b) *Insulation—to reduce the heat load to the loadspace, which serves three purposes —*
 - (i) *to keep power consumption and pollution of refrigeration low;*
 - (ii) *to check temperature rise in periods without refrigeration; and*
 - (iii) *in combination with air circulation, to hold air and product temperatures within given ranges.*
- (c) *Air circulation and distribution—to keep the air and cargo temperature range within given limits, influenced by the dimensions of load and loadspace. Necessary fan power adds to head load and power consumption but should not fall below a necessary limit.*

Insulation to protect cargo from temperature rise is limited in time, depending on the thermal properties of insulation and cargo. Maximum safe protection times are reached with cargo at uniform initial temperature. When starting from temperature distributions, safe protection times depend on the minimum unaccomplished temperature difference.

These principles reflect best practice and maximum energy efficiency and emission control along with product protection within the constraints of external factors such as weight considerations, pallet width, overall dimensional regulations.

2.2 CLASSIFICATION CATEGORIES

Refrigerated equipment shall be classified into one of four categories according to the thermal performance of the equipment, in accordance with Table 2.1.

TABLE 2.1
CLASSIFICATION CATEGORIES FOR
REFRIGERATED VEHICLES

Category	Outside air temperature	Mean inside air temperature
A	+38°C	+12°C
B	+38°C	0°C
C	+38°C	−18°C
D	+38°C	−28°C

NOTE: Due to current vehicle width regulation (ADR 43/40), generally category D is only achievable in special purpose vehicles.

SECTION 3 DESIGN REQUIREMENTS

3.1 GENERAL

The temperature within the loadspace shall be controlled by ensuring that the refrigeration capacity of the refrigeration system exceeds the heat leakage.

3.2 RESERVE POWER

The refrigerating capacity shall be adequate to offset heat leakage into the body, and shall have reserve capacity, sufficient to allow for additional heat loads, including the following:

- (a) Deterioration of the thermal performance of both body and refrigeration unit with age ('ageing').
- (b) Differences between operational conditions and test conditions.
- (c) Removal of the heat of respiration from live produce.
- (d) Removal of heat entering while doors are open during intermediate deliveries.
- (e) Removal of heat added during defrosting.

NOTE: The reserve capacities should be in accordance with the provisions of Table 3.1.

3.3 AIR CIRCULATION RATE

Air shall be circulated sufficiently to achieve a minimum of one air change per minute (empty body).

TABLE 3.1
RECOMMENDED REFRIGERATING POWER
(AS A PERCENTAGE OF WALL HEAT LOAD)

Number of 'drops' during each eight hour period	Recommended refrigerating power (see Notes 1 and 2)
1	25%
2–5	50%
6–10	75%
11–15	100%
16–20	125%
21–25	150%
26–30	175%
31–35	200%

NOTES:

- 1 Insulation should be aged 30 days prior to testing.
- 2 The use of appropriate secondary doors may reduce the reserve capacity required for particular service, e.g., by moving one place up the table.

CTable 3.1 *Table 3.1 is a guide for reserve capacity (as a percentage of wall heat load) required for various types of service, which has historically proved to be of an acceptable level.*

Additional reserve capacity is required for products categorized with high rate of respiration.

Doors and door seals should be designed in such a way as to minimize heat leakage.

Doors and their frames and fastenings are major sources of heat leakage because metals and other non-insulating materials are used for their strength.

Because doors are sites of heat leakage, allowance shall be made for the heat load contributed by additional doors (e.g., side doors) or less well-insulated types of doors (e.g., roller doors).

Two-part seals are preferred, with an outer dust seal, and an inner seal to control air leakage.

With non-palletized cargo, airflow floors help direct the return airstream beneath the load. They are of limited thermal benefit when carrying palletized cargo loaded from end doors, but are recommended for side-loaded vehicles.

Return air bulkheads improve the uniformity of temperature within the loadspace. They help gather return air from floor level, so reducing ‘short-circuiting’ of air from delivery to return airstream. Solid return air bulkheads are more effective in doing this than open mesh bulkheads.

Like return air bulkheads, ceiling ducts improve temperature uniformity by reducing short-circuiting. Fabric ceiling ducts are less prone to damage than rigid ducts, but are still susceptible to tearing.

If temperature indicators and/or recorders are not fitted to the refrigeration unit, they should be fitted to the body. The temperature sensor is usually located so as to measure the temperature of the return airstream.

SECTION 4 TESTING

4.1 GENERAL

Multi-compartment bodies with adjustable partitions shall be tested as a single full body compartment to the most severe category applicable.

Multi-compartment bodies with fixed partitions shall have individual compartments tested and certified separately.

4.2 FREQUENCY OF TESTING

Equipment shall be tested in accordance with the following:

- (a) *Type test* Before equipment is put into service, a certificate valid for an initial period of 6 years is issued.
- (b) *In-service test of equipment previously certified:*
 - (i) At the expiry of the initial certificate, then after every 3 years;
 - (ii) After any major modification or substantial repair, a certificate for 3 years or until the expiry of the initial certificate (whichever is later) is issued.

4.3 AIRTIGHTNESS TESTS

4.3.1 General

Either of two types of test may be used, the steady-state test or the pressure-decay test.

C4.3.1 *Airtightness is an indicator of potential air exchange between the equipment and surroundings. It is usual to carry out this test prior to the heat leakage test.*

4.3.2 Conditions of test

Temperatures inside and outside the body shall be stabilized within 3 K of each other and both shall be between 10°C to 30°C.

Tests shall be conducted under cover, away from direct sunlight.

4.3.3 Procedure (steady-state method)

The body shall be in its normal operating condition and shall be closed in the normal manner. If the refrigeration equipment is not in place, the opening to which it is fitted shall be sealed with a 'plug'. All drain openings shall be closed.

The procedure shall be as follows:

- (a) Connect an air supply through a metering device and a suitable manometer to the body by leak-proof connections in such a way that the incoming airstream does not interfere with the reading of the manometer. The flow-measuring device shall be accurate to $\pm 3\%$ of the measured flow rate, and the manometer shall be accurate to $\pm 5\%$.
- (b) Admit air to the body to raise the internal pressure by 250 ± 10 Pa and the air supply regulated to maintain this pressure.
- (c) Once steady test conditions have been established, record the airflow rate required to maintain this pressure.

4.3.4 Requirement

For bodies with a single door opening, the air leakage rate, expressed in standard atmospheric conditions, shall not exceed 30% of the inside volume of the body per hour. For each additional door opening, an extra air leakage rate of 15% of the inside volume is allowed.

4.3.5 Alternative test (pressure-decay method)

The pressure decay method may be used as an alternative. Where the pressure decay method is used, a correlation should be established between the constant pressure method and the pressure decay method for the particular type of structure being tested.

4.4 HEAT LEAKAGE TESTS

4.4.1 Components of initial certification

For initial certification, the insulating ability of the body and the performance of the refrigeration unit shall be measured separately under standard conditions.

4.4.2 Level of insulation

The level of insulation of the body shall be measured under standard conditions by a steady-state heat leakage test using the internal heating method. The result shall be expressed as the coefficient of insulative effectiveness. The body may be tested with the refrigeration unit in place, or without. If tested without the unit, the opening of the unit shall be filled with a 'plug' of similar thermal properties to the wall in which it is fitted.

4.4.3 In-service tests

For reassessment of a body after a service period, an in-service test, which calculates an approximate value for the coefficient of insulative effectiveness, shall be used.

4.4.4 Type testing and individual testing

Equipment shall be certified by individual or type testing.

A type test certificate obtained for one piece of equipment (the reference equipment) may be applied to further units built in the same way, within a period of 2 years, subject to confirmation that materials and method of construction are substantially identical. To be covered by the certificate of such a 'type-test', the design of insulated bodies may be varied only in such ways as are likely to improve the thermal performance (for example, inside fittings may be simplified, the thickness of insulation may be increased).

4.4.5 Age of foam insulation

Insulated bodies shall not be tested until the insulation material is at least 30 days old.

This requirement shall apply unless it has been shown that the performance of a particular type of insulation does not decline with age.

***C4.4.5** It is generally recognized that the performance of insulation materials deteriorates with time. There are various reasons for this, including the exchange of blowing agent with air, mechanical damage, and the ingress of moisture. During the first 30 days after manufacture, foam insulation ages especially quickly.*

4.4.6 Types of test

Two forms of heat leakage test are allowed, as follows:

- (a) The reference method, to be used for certifying new equipment, is a steady-state test using the internal-heating method, and conducted under standard conditions, in a testroom. Heat leakage is measured as the electrical heat load required to maintain a constant temperature difference between the inside and the outside.
- (b) Equipment already in service may be checked using a less rigorous in-service test, conducted under cover away from direct sunlight. The interior is heated or cooled, and then allowed to return to its initial temperature. The heat leakage characteristics are calculated from the thermal response.

4.4.7 Reference (steady-state) heat leakage test

4.4.7.1 General

This test shall be carried out to establish the heat leakage of the body. It shall be carried out after successful completion of the airtightness test. It shall be performed with the refrigeration equipment in place, or the opening for this equipment sealed. All drains shall be sealed.

The inner heating method shall be used. This test requires the establishment of a heat balance. A heating device shall be placed inside the body, and thermal equilibrium shall be established between the power of the heating device(s) and associated fan(s), and the heat flowing out through the insulation. All instruments and devices shall be selected and calibrated as follows:

- (a) Temperature measuring devices:..... $\pm 0.5^{\circ}\text{C}$.
- (b) Power-measuring device: $\pm 2\%$ of quantity measured.

The heat leakage shall be expressed by the coefficient of insulative effectiveness (K), as follows:

$$K = Q / (S_m (T_i - T_o))$$

where

Q = electrical power dissipated inside the body by the heater(s) and fan(s), in watts

S_m = mean surface area of the body, in square metres

T_i = mean inside temperature, in degrees Centigrade

T_o = mean outside temperature, in degrees Centigrade

4.4.7.2 Procedure

4.4.7.2.1 Test data conditions

Test data for determining the heat leakage of the body shall be taken for a continuous period of not less than 8 h during which the following conditions shall be satisfied (see Figure 4.1):

- (a) The test shall be performed with a mean wall temperature T_m ($T_m = (T_o + T_i)/2$) chosen between 20°C and 32°C and a temperature difference between the inside and outside of not less than 20 K ;
- (b) The maximum difference between the warmest and coldest inside points at any one time shall be 3 K ;
- (c) The maximum difference between the warmest and coldest outside points at any one time shall be 3 K ;