AS 7482:2022

Railway rolling stock- Heating ventilation and air conditioning (HVAC)

Rolling Stock Standard

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This Australian Standard® AS 7482 Heating Ventilation and Air Conditioning (HVAC) was prepared by a Rail Industry Safety and Standards Board (RISSB) Development Group consisting of representatives from the following organisations:

Transport for NSW	Metro	Queensland Rail
Keolis Downer	Public Transport Authority of Western Australia	Auckland One Rail
Department of Transport(Vic)		

The Standard was approved by the Development Group and the Rolling Stock Standing Committee in Select SC approval date. On Select Board approval date the RISSB Board approved the Standard for release.

This standard was issued for public consultation and was independently validated before being approved.

Development of the Standard was undertaken in accordance with RISSB's accredited process. As part of the approval process, the Standing Committee verified that proper process was followed in developing the Standard

RISSB wishes to acknowledge the positive contribution of subject matter experts in the development of this Standard. Their efforts ranged from membership of the Development Group through to individuals providing comment on a draft of the Standard during the open review.

I commend this Standard to the Australasian rail industry as it represents industry good practice and has been developed through a rigorous process.

Deb Spring
Exec. Chair / CEO
Rail Industry Safety and Standards Board

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AS 7482:2022

Heating Ventilation and Air Conditioning (HVAC)

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This Standard was prepared by the Rail Industry Safety and Standards Board (RISSB) Development Group AS 7482 Railway rolling stock - Heating ventilation and air conditioning (HVAC). Membership of this Development Group consisted of representatives from the organisations listed on the inside cover of this document

This Standard supersedes Sections 5 – 9 of AS 7513.3.

Objective

The objective of this Standard is to is to provide requirements, recommendations, and guidance for rolling stock heating ventilation and air conditioning (HVAC) and establish industry standards for these systems.

Compliance

There are four types of provisions contained within Australian Standards developed by RISSB:

1. Requirements.
2. Recommendations.
3. Permissions.
4. Constraints.

Requirements – it is mandatory to follow all requirements to claim full compliance with the Standard. Requirements are identified within the text by the term 'shall'.

Recommendations – do not mention or exclude other possibilities but do offer the one that is preferred. Recommendations are identified within the text by the term 'should'.

Recommendations recognise that there could be limitations to the universal application of the control, i.e. the identified control is not able to be applied or other controls are more appropriate or better.

Permissions – conveys consent by providing an allowable option. Permissions are identified within the text by the term 'may'.

Constraints - provided by an external source such as legislation. Constraints are identified within the text by the term 'must'.

For compliance purposes, where a recommended control is not applied as written in the standard it could be incumbent on the adopter of the standard to demonstrate their actual method of controlling the risk as part of their WHS or Rail Safety National Law obligations. Similarly, it could also be incumbent on an adopter of the standard to demonstrate their method of controlling the risk to contracting entities, or interfacing organisations where the risk may be shared.

RISSB Standards address known hazards within the railway industry. Hazards, and clauses within this Standard that address those hazards, are listed in Appendix A

This Standard includes a commentary on some of the clauses. The commentary directly follows the relevant clause is designated by 'C' preceding the clause number and is printed in italics in a box. The commentary is for information and guidance, it does not form part of the requirements and recommendations of this Standard.

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Appendix Contents

1 Scope and general

1.1 Scope

This document applies to new and modified locomotive, freight, passenger and infrastructure maintenance rolling stock.

This document is applicable for rolling stock operating up to 160 km/h nominal maximum speed. The document covers the design, construction, and maintenance of rolling stock.

Operation of rolling stock is not covered.

The Standard is not specifically intended to cover tourist/heritage rolling stock, rolling stock used on light rail, cane railway, and monorail networks, but items from this Standard may be applied to such systems as deemed appropriate by the relevant railway infrastructure manager (RIM).

For avoidance of doubt, risks to safety must be eliminated so far as is reasonably practicable in accordance with the Rail Safety National Law.

1.2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document:

- AS 1668.2 The use of ventilation and air conditioning in buildings Mechanical ventilation in buildings
- AS 5149.1 Refrigerating systems and heat pumps – Safety and environmental requirements. Part 1: Definitions, classification, and selection criteria
- AS 5149.2 - Refrigerating systems and heat pumps—Safety and environmental requirements - Part 2: Design, construction, testing, marking and documentation
- AS 7722 EMC management
- AS 7530 - Electrical Systems
- Australia and New Zealand Refrigerant Handling Code of Practice Part 2 - Systems other than self-contained low charge systems
- EN 378 Refrigerating systems and heat pumps - Safety and environmental requirements - Part 1
- EN 13129 Air conditioning for mainline rolling stock
- EN 14750-1 Railway applications – Air conditioning for urban and suburban rolling stock – Part 1: Comfort parameters
- EN 14750-2 Railway applications – Air conditioning for urban and suburban rolling stock – Part 2: Type tests
- EN 14813-1 Railway applications – Air conditioning for driving cabs – Part 1: Comfort parameters
- EN 14813-2 Railway applications – Air conditioning for driving cabs – Part 2: Type tests

- EN 50126 Railway applications – Railway applications – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS) -- Part 1: Basic requirements and generic process
- IEC 60571 Railway applications – Electronic equipment used on rolling stock
- IEC 61373 Railway Applications - Rolling Stock Equipment - Shock And Vibration Tests
- ISO 16890 Air Filters For General Ventilation - Part 1: Technical Specifications, Requirements And Classification System Based Upon Particulate Matter Efficiency (EPM)
- ASHRAE Guideline 23 - Guideline for the Design and Application of Heating, Ventilation, and Air-Conditioning Equipment for Rail Passenger Vehicles

NOTE: Documents for informative purposes are listed in a Bibliography at the back of the Standard.

1.3 Terms, definitions, and abbreviated terms

For the purposes of this document, the following terms and definitions apply:

1.3.1

vehicle main power supply
the main source of power for vehicle propulsion, control, and auxiliary purposes (e.g. overhead catenary electrical supply, diesel engine, etc.)

1.3.2

vehicle electrical auxiliary power supply
the onboard supply of electrical power for auxiliary equipment, which could be derived from the vehicle main power supply or a separate supply (e.g. auxiliary generator)

1.3.3

interior temperature setting
target temperature to be achieved by the room air

1.3.4

mean exterior temperature
arithmetic mean of the exterior air temperatures measured at minimum 0.1m away from car body

1.3.5

mean interior temperature
arithmetic mean of the interior air temperatures measured in the locations specified in EN 13129-1 for main line rollingstock, EN14750-2 for urban and suburban rollingstock, and EN 14813-2 for crew cabs

1.3.6

HVAC

heating, ventilation and air conditioning

1.3.7

HVAC unit

Heating ventilation air conditioning equipment packaged into an integrated unit (could form a complete HVAC system or part thereof)

1.3.8

HVAC system
system comprising all onboard equipment specific to heating, ventilation, and air conditioning this could include HVAC Units, auxiliary heaters, exhaust fans, dampers, ducting, vents, sensors, control equipment, electrical supply equipment, etc.

1.3.9

fresh air
air taken from outside the vehicle

1.3.10

conditioned air
air that has been filtered; it is possible the air can have had energy exchanged as it passed through the air handling unit

1.3.11

reliability block diagram

diagrammatic method for determining the reliability of a system comprised of multiple components or systems with individual reliabilities, e.g. as described in IEC 61078

1.3.12

regulation curve

curve defining a relationship between the interior temperature setting and mean exterior temperature. Refer to EN 14750-1:2006 Section 8.2 or EN 13129-1:2016 Section 9.2

General rail industry terms and definitions are maintained in the RISSB Glossary: https://www.rissb.com.au/products/glossary/

2 Design principles

2.1 General design

The HVAC system must be designed and manufactured in accordance with the Australia and New Zealand Refrigerant Handling Code of Practice.

Material and manufacture should be in accordance with AS/NZS 5149.2.

Marking and documentation shall be performed in accordance with AS/NZS 5149.2.

The HVAC system should be designed in accordance with the guidelines detailed in ASHRAE Guideline 23.

2.2 Shock and vibration

The installation and vibration isolation of the HVAC equipment should preclude the transmission of uncomfortable vibrations to the passengers through the carbody structure. The vibration isolation design should limit the vibration levels to the maximum levels as stated in ASHRAE Guideline 23.

Unless otherwise specified in the customer specification, the equipment shall be designed and tested to meet the requirements of IEC 61373.

2.3 Electrical component design

The electrical equipment within the HVAC system shall be accessible for servicing.

Electrical control and switchgear should be accessible from within the vehicle without the need for roof access or removal of the HVAC.

Electrical equipment design should be in accordance with AS 7530.

The HVAC system electronic components shall comply with IEC 60571.

2.4 Power supply and system requirements

The HVAC system shall be compatible with, and powered from, the vehicle electrical auxiliary power supply.

The HVAC system shall be protected by suitable power supply and circuit protection equipment complying with the referenced standards.

The HVAC system shall comply with EMC requirements as defined in AS 7722.

C2.4 Commentary
The car builder are expected to provide key interface parameters, including but not limited to: minimum voltage tolerance, frequency tolerance dV/dT, harmonics, and neutral-earth voltage deviation.

Some HVAC equipment can be supplied downstream of the vehicle electrical auxiliary supply, e.g. from vehicle battery supplies or via vehicle inverters/converters.

2.5 Refrigerants

The refrigerant used in the HVAC system must comply with Australian legislation and all related legislation and amendments including:

(a) the Ozone Protection and Synthetic Greenhouse Gas Management Act 1989

(b) Ozone Protection and Synthetic Greenhouse Gas Management Regulations 1995 Australian Government

2.6 Reliability & availability

Unless otherwise specified in the customer specification, reliability and availability of the HVAC system shall be developed in accordance with EN 50126.

Reliability and availability requirements shall be specified in the customer specification.

Compliance with reliability and availability targets shall be demonstrated by FMECA and reliability block diagram, or fault tree analysis.

C2.6.2 Commentary

Reliability targets for new urban rollingstock with an MTBF of 2,300 hours have been apportioned a HVAC system MTBF of 92,000 hours per set (for service-affecting failures).

This is for guidance only, customer specific RAMS targets, quantities, requirements, or solutions for specific railway applications will result in different values and apportionments.

2.7 Maintainability

Unless otherwise specified in the customer specification, the maintainability of the HVAC system shall be designed and developed in accordance with EN 50126.

Maintenance requirements shall comply with Australia and New Zealand Refrigerant Handling Code of Practice.

Cleaning of the condenser and evaporator coils and condensate drain pans shall be achievable in situ without the removal of major components.

2.8 Safety

The design of the HVAC system shall minimize all safety hazards SFAIRP in accordance with processes defined in EN 50126 throughout the asset lifecycle.

System safety protections, isolations and security shall be provided for individual HVAC units and the complete system protecting all people that interact with the system including passengers, crew, cleaning, maintenance, testing and commissioning personnel at all stages of the life cycle.

The HVAC system shall detect system faults, including but not limited to the following:

(a) Degraded and emergency modes.

(b) Emergency ventilation.

(c) System failures and redundancy.

(d) System safety and protections.

HVAC system protective device design and methods should be developed and applied in accordance with ASHRAE Guideline 23.

The quantity of refrigerant that can enter the occupied space shall not exceed the limits stated in AS 5149.1.

2.9 Fire safety

The HVAC system shall respond to inputs from the vehicle fire and emergency system to prevent or restrict fire propagation in case of detection of fire or smoke within the vehicle.

The HVAC system should respond to inputs from the vehicle fire and emergency system to prevent or restrict ingress of smoke into the vehicle in case of fire or smoke external to the vehicle.

C2.9 Commentary

Suitable methods to restrict fire propagation include:

(a) shutting down ventilation, air conditioning or both;
(b) restricting fresh air intake.

Refer to AS 7529 for requirements relating to vehicle fire safety.

Refer to the Efficiency section for other automatic and manual functions of fresh air dampers.

2.10 Efficiency

In managing all operating modes, the HVAC control system shall optimize climate comfort and energy consumption over the life of the vehicle.

The total equivalent warming impact (TEWI) of the HVAC system shall be calculated in accordance with EN 378 Refrigerating systems and heat pumps - Safety and environmental requirements - Part 1 considering annual temperatures, passenger loading and operating profile.

For applications where a single non-compartmentalized zone is serviced by multiple HVAC units:

The units should not operate in contradictory modes, such that one unit negates the efficacy of the other(s), e.g. one heating, another cooling.

The difference in cooling or heating power delivered between HVAC units should be minimized.

Automatic fresh air dampers should be employed for one or any combination of the following purposes:

(a) To reduce pull-down or pull-up time.

(b) To close the fresh air intakes in the event of an exterior or tunnel smoke condition.

(c) To reduce the equipment thermal load in extreme temporary conditions, thus preventing it from shutdown, by modulating the fresh air volume.

(d) To adjust the required fresh air flow rate, based on the number of passengers and/or operation mode, for energy saving.

(e) For high-speed operations, to minimize the effects of pressure waves as the result of entering tunnels or passing trains.

HVAC systems should enable fresh air intake to be temporarily stopped while operating in tunnels.

Where HVAC systems enable closing of fresh air intakes, continuous indication shall be provided to crew whilst the fresh air intakes are restricted.

Where HVAC systems enable closing of fresh air intakes from automatic inputs (e.g. GPS, transponders), they shall reopen after a fixed period of time to ensure occupant safety.

To minimize the infiltration of unconditioned air, a positive pressurisation of the passenger and cab areas should be maintained.

Static exhaust (e.g., damper/duct assembly) or dynamic exhaust (i.e., fan) provisions should be incorporated into the vehicle design to allow for final adjustment of the car pressurisation.

Adjustable exhaust provision should be incorporated into the carbody design to allow adjustment of car pressurisation during validation and train level tuning.

C2.10 Commentary

Examples of non-compartmentalized zones serviced by multiple HVAC units include:

(a) A double-deck commuter carriage fitted with two HVAC units;
(b) A single-deck regional carriage fitted with two HVAC units;
(c) A single-deck metro train with open gangways, with one or more HVAC units per carriage.

Minimising intake of external air when in tunnels minimizes the intake of smoke and fumes that can be present in the tunnel (e.g. from diesel rail vehicles), improving occupant comfort. Typically, closing of fresh air intake is activated on approach to a tunnel by crew and/or automatic controls (e.g. GPS, transponders), and closed for a fixed period of time (e.g. 5 minutes). It is not generally desirable to close fresh air dampers for tunnels where only electric rolling stock operate.

A stationary pressurisation of 25 Pa is shown to be sufficient. ASHRAE Guideline 23 recommends a range of 12.5 – 37.4 Pa. Exceeding this can interfere with door operations. The cab will have a higher pressurisation than the passenger area to prevent the ingress of undesirable airborne material (e.g. odour, pathogens, products of fire).

2.11 Noise

The HVAC system design shall support the achievement of the overall vehicle interior noise requirements in accordance with AS 7513.

Unless otherwise specified in the customer specification, HVAC systems shall support achievement of the vehicle internal and external noise requirements under all HVAC system operating modes, and all ambient conditions including:

(a) all compressors running;

(b) evaporator and condenser fan speed at the design condition;

(c) supply air fan and damper settings (highest noise condition);

(d) fresh air intake (highest noise condition);

(e) manually adjustable diffuser settings (highest noise condition).

The HVAC unit design should apply the noise reduction principles as described in ASHRAE Guideline 23.

C2.11 Commentary
The recommended air velocities in supply ducts are within the range of 4 - 8 m/s with the duct cross-section being progressively reduced as it extends away from the air conditioning unit to maintain the air velocity in the duct local to the point of discharge. This is to minimize noise and distribute the air evenly.

3 Comfort parameters

3.1 General

Passenger comfort parameters shall be in accordance with either EN 14750 - 1 or EN 13129 as per the defined vehicle classification, except as specified in this standard.

For crew cab areas the comfort parameters shall be in accordance with EN 14813 Category A, except as specified in this standard.

The vehicle classification shall be specified in the customer specification.

3.2 Fresh air

Fresh air shall be able to be maintained within non-cab occupiable enclosed areas normally occupied by passengers if part of the forced ventilation system or its normal power supply fails or deteriorates for a duration determined by the hazard control process.

Fresh air inlets should be positioned to minimize the intake of engine exhaust gases, cooling system exhaust air and other contaminants, particularly in tunnels.

The fresh air inlets shall be designed and positioned in such a way as to prevent negative pressure formation at the fresh air inlet.

C0 Commentary

An emergency inverter could be required to power ventilation fans from emergency (typically vehicle battery) supplies to meet Clause 0.

Systems where ventilation fans operate directly from vehicle battery/DC supplies can avoid the need for an emergency inverter.

3.3 Air purification and filtration

Fresh air intakes and return air grilles shall be fitted with filters or other air cleaning devices.

Filter performance for fresh air intakes and return air grilles shall have a minimum filter grade of ePM10 50% to ISO 16890 or better.

The HVAC system shall manage the effects of condensation and water ingress to prevent issues of safety, discomfort to passengers and crew, negative impacts on other parts of the rolling stock, corrosion, maintainability, and system integrity for whole-of-life.

3.4 Air velocity

The crew cab air velocity shall be able to be controlled incrementally between the allowable ranges defined in the referenced standard.

Where adjustable vents are provided the minimum fresh air quantity shall be maintained in accordance with the referenced standards.

Air velocities in crew and passenger areas shall be measured and maintained in the comfort envelope as defined in the referenced comfort standards.

To minimize noise and pressure loss, the average air face velocity at the return air grille should not exceed 2 m/s as per ASHRAE Guideline 23.

Occupiable compartments containing kitchens, toilets, showers, or equipment shall have exhaust ventilation at or above the flow rates given in Table B1 of AS 1668.2.

C3.4 Commentary

Note the air velocity measurement location in the comfort envelope is to be selected at the most unfavourable seats head, shoulder, knee, and foot area as detailed in EN 13129.

Where the extreme exterior conditions are exceeded, the maximum air velocity limits can be exceeded.

3.5 Service conditions

The customer specification shall nominate the design, extreme and operational limiting exterior conditions. In absence of customer specification, conditions as defined for Zone I in EN13129:2016 Section 7.1 shall be used.

The comfort parameters shall be satisfied within the specified design exterior conditions.

Where the design exterior conditions exceed those defined for Zone I, the maximum interior comfort limits shall apply up to the specified limits nominated in clause 3.5.1 of this standard.

In summer extreme exterior conditions as defined in clause 3.5.1 of this standard, HVAC systems should comply with requirements of the referenced standards for cooling (EN 13129:2016 Section 8.4, EN 14750-1 Section 7.3, EN 14813-1:2006 Section 7.3).

Where the nominated summer extreme condition exterior temperature exceeds 45 ºC, above 45 ºC the HVAC system may operate at reduced capacity.

There shall be no condensate or rainwater leaks into the vehicle from the HVAC system.

C3.5. Commentary

Refer to AIRAH DA09 for comfort and critical design conditions for different climatic zones across Australia. Note the critical and comfort data set is based on an exceedance of one day in two years for critical conditions and 10 days exceedance per year for comfort conditions.

Below is an example of modified design, extreme and operational limiting conditions for an Australian climate:

Exterior condition	Winter	Summer		
	Minimum exterior temperature	Maximum exterior temperature	Relative humidity [%]	Equivalent solar load W/m 2
Design	5	45	70	1000
Extreme	0	50	30	1000
Operating Limiting	-5	55	30	1000

3.6 Control and regulation

3.6.1 General

The customer specification should define a regulation curve for the interior temperature setting.

The regulation curve should be within the allowable range of Figure 1.

If not specified in the customer specification the regulation curve detailed in Figure 1 shall apply.

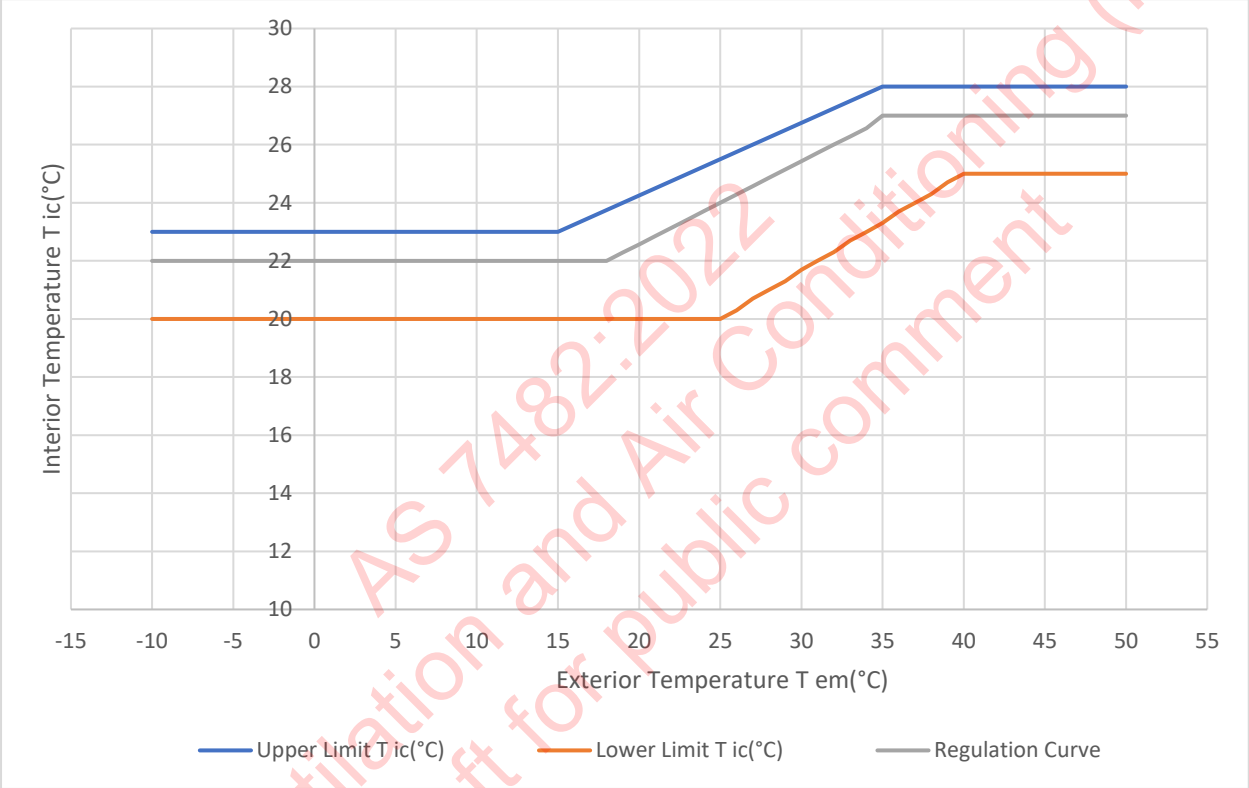

Figure 1: Allowable range for regulation curve.

3.6.2 Crew cab

The crew cab shall have a temperature selection control where the cab interior temperature setting can be selected.

The customer specification should define a default setpoint for the crew cab when the train is powered.

The temperature selection control should allow selection of the cab interior temperature setting in a range from +18 °C to +26 °C, in 0.5° C increments.

Windshields should be fitted with defogging/defrosting system.

Defogging/defrosting systems should clear at least 85 percent of the interior and exterior windshield surface area of surface moisture or frost within 20 minutes. The use of the windshield wiper (if provided) is allowed to help meet the relevant requirement on the outside surface.

C3.6.2 Commentary

Minimising necessary interaction with the HVAC controls is desirable to avoid crew distraction.

Cab HVAC systems with automatic modes (i.e. operating to a temperature regulation curve, and automatically adjusting supply air speed) help to reduce need for crew to adjust HVAC controls with changing exterior temperature conditions, and can reduce energy usage.

Complementarily, after being manually adjusted, systems preferably do not revert to an automatic mode unless there is clear indication the operator is no longer present (e.g. have removed keys or logged out, the vehicle or HVAC system is powered down, etc.).

Defogging/demisting and the specific regions of the windshield which it clears contributes to the vehicle meeting required exterior vision for crew. Refer to AS7533:2021 Section 9 for requirements relating to exterior vision.

4 Test requirements

The HVAC unit level type testing should be performed in accordance with ASHRAE Guideline 23.

The vehicle level type testing for medium and long distance rollingstock should be performed in accordance with EN 13129.

The vehicle level type testing for commuter rollingstock should be performed in accordance with EN 14750-2.

The vehicle level type testing for driving cabs should be performed in accordance with EN 14813-2.

ASHRAE Guideline 23 should be used for supplementary guidance on vehicle level testing.

Where vehicle level type testing under controlled conditions is impracticable, substitution with testing in alternative environments should be at the approval of the customer assuring the measured HVAC system performance is consistent with meeting the performance required by the substituted test scenario.

C4 Commentary

Where functional limit tests are described (e.g. EN13129-1:2016 section 13.5), HVAC unit level testing can be applied in place of vehicle level testing, ensuring all vehicle interfaces and interdependencies are considered (e.g. environmental performance of power supplies or other external equipment).

Substitution of vehicle level type testing under controlled conditions with outdoor environments should only be made by prior agreement with the customer.

Customer specifications could reduce the scope of performance tests required, or specify specific test regimes suitable for their jurisdiction, risk management process and operating environment.

Appendix A ARRM risk table

Hazard number	Hazard
4.1.1.15	Greenhouse gas emissions
5.3.1.13	The environment being too cold causing thermal stress
5.3.1.14	The environment being too hot causing thermal stress
5.3.1.34	Blocked fresh air filters leaving insufficient fresh air creating poor air quality and causing nausea
5.3.1.35	Overcrowding leaving insufficient fresh air creating poor air quality and causing nausea
5.3.1.36	Poor design leaving insufficient fresh air creating poor air quality and causing nausea
5.3.1.43	Harmful exposure to released pressured gas or fluid
5.5.1.19	Non-compliance with Gas legislation
5.5.1.20	Non-compliance with Environmental legislation
5.5.1.39	Non-compliance with OHS/WHS legislation when air-conditioning plant and associated OH&S mandated plant or designs are not registered
5.20.1.9	Poor air quality
5.20.1.10	Uncomfortable temperature
5.36.1.20	Condensation causing wet surfaces (Slippery access path surface)
5.38.1.10	Chemical spills (Breathing in hazardous substance)
5.38.1.5	Combustion engine emissions (Breathing in hazardous substance)
5.38.1.6	The leakage of refrigerants (Breathing in hazardous substance)
5.38.1.12	Fire (Breathing in hazardous substance)
5.42.1.27	Dust creating contaminates (Degradation of insulation properties - Insufficient voltage withstand level - Insulation)
5.53.1.7	Being unable to achieve desired test conditions

Appendix B Bibliography

The following referenced documents are used by this Standard for information only, or could be relevant to users of the standard:

(a) AIRAH DA09 Air Conditioning Load Estimation

(b) IEC 61078 Reliability block diagrams

(c) AS 7529 Australian Railway Rolling Stock- Fire Safety – Passenger

(d) AS 7533 Driving Cabs

(e) EN 50125-1 Railway Applications - Environmental Conditions for Equipment - Part 1: Rolling Stock and On-Board Equipment

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The Standards development process is rigorous and transparent.

Authors work with RISSB's Standards Development Managers and Development Groups to ensure that products are acceptable to industry. Standing Committees oversee this work and ensure that proper governance and process is followed. The products are exposed to the public and industry for comment and validated by an independent validator.

Once agreed by the Development Groups, Standing Committees and Validator, the drafts are passed to the RISSB Board for approval.

The same process is used in developing other RISSB products, although Guidelines are not exposed to the public for comment or validated, given their non-binding nature.

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The Standards Development and Accreditation Committee audits RISSB annually to ensure that RISSB's processes are in accordance with SDAC accreditation requirements.

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