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T HR RS 08001 ST

Standard

Climate Comfort and HVAC on Passenger Rolling Stock

Version 1.0

Issued Date: 09 September 2014

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Standard governance

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Document history

Version	Summary of change
1.0	First issue

For queries regarding this document, please email the ASA at standards@asa.transport.nsw.gov.au or visit www.asa.transport.nsw.gov.au

Transport Asset Standards Authority

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Preface

The Asset Standards Authority (ASA) is an independent unit within Transport for NSW (TfNSW) and is the network design and standards authority for defined NSW transport assets.

The ASA is responsible for developing engineering governance frameworks to support industry delivery in the assurance of design, safety, integrity, construction, and commissioning of transport assets for the whole asset life cycle. In order to achieve this, the ASA effectively discharges obligations as the authority for various technical, process, and planning matters across the asset life cycle.

The ASA collaborates with industry using stakeholder engagement activities to assist in achieving its mission. These activities help align the ASA to broader government expectations of making it clearer, simpler, and more attractive to do business within the NSW transport industry, allowing the supply chain to deliver safe, efficient, and competent transport services.

The ASA develops, maintains, controls, and publishes a suite of standards and other documentation for transport assets of TfNSW. Further, the ASA ensures that these standards are performance based to create opportunities for innovation and improve access to a broader competitive supply chain.

This standard covers the requirements for climate comfort and heating, ventilation, and air conditioning (HVAC) for passenger rolling stock owned by Transport for NSW (TfNSW).

This standard is a first issue.

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1. Introduction

This standard specifies the requirements for climate comfort and heating, ventilation, and air conditioning (CC-HVAC) for passenger rolling stock owned by Transport for NSW (TfNSW).

This Asset Standards Authority (ASA) standard applies the principles of climate comfort science as presented in referenced international standards ISO 7730 and ASHRAE 55-2013 within the limits for climate parameters prescribed in European standards for railway applications. Using this approach, the interior climate control on passenger rolling stock will deliver a high level of climate comfort throughout the range of operating conditions experienced in NSW whilst maximising energy efficiency. In line with these principles, interior climate comfort levels will be monitored and optimised by fine-tuning the control algorithm in response to customer and crew survey.

2. Purpose

The purpose of this standard is to ensure that an appropriate standard of interior climate comfort for passengers and crew and other personnel is maintained on TfNSW passenger rolling stock assets in service on the NSW and interstate rail network.

This standard specifies the requirements for climate comfort and heating, ventilation, and air conditioning for passenger rolling stock used primarily on NSW rail networks and owned by TfNSW. The standard is for use by engineers involved in the design, manufacture, testing, maintenance, and operation of passenger rolling stock on behalf of TfNSW. This standard includes guidance notes to assist in meeting the requirements.

2.1. Scope

This ASA standard applies to heavy rail passenger rolling stock for service primarily in NSW including interstate services that traverse parts of interstate rail networks. It specifies the minimum operating standards for CC-HVAC on TfNSW assets. This standard references and requires compliance with several international standards. Should there be conflict between requirements, then the requirements providing the higher level of safety and climate comfort takes precedence.

2.2. Application

This standard is applicable to TfNSW rolling stock assets intended for use on the NSW rail network as follows:

- new heavy rail passenger rolling stock assets acquired by TfNSW
- currently excludes light rail (trams)
- currently excludes rapid transit rolling stock

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3. Reference documents

International standards

ASHRAE 55-2013 Thermal Environment Conditions for Human Occupancy

BS 6853 Railway applications - Code of practice for fire precautions in the design and construction of passenger carrying trains

EN 779 Particulate air filters for general ventilation - Determination of the filtration performance

EN 13129-1 Air conditioning for mainline rolling stock - Part 1: Comfort parameters

EN 13129-2 Air conditioning for mainline rolling stock - Part 2: Type tests

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 45545 Railway applications - Fire protection on railway vehicles

EN 50126 Railway applications - The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)

IEC 61133 Railway applications - Rolling stock - Testing of rolling stock on completion of construction and before entry into service

ISO 7730 Ergonomics of the thermal environment - Analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria

ISO 15288:2008 Systems and Software Engineering - System life cycle processes

Australian standards

AS 1324.1 Air filters for use in general ventilation and airconditioning - Application, performance and construction

AS 1324.2 Air filters for use in general ventilation and airconditioning - Methods of test

AS 1668.2 The use of ventilation and airconditioning in buildings - Part 2: Mechanical ventilation in buildings

AS 4260 High efficiency particulate air (HEPA) filters - Classification, construction and performance

AS 4292.3 Railway Safety Management - Part 3: Rolling Stock

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AS 7513.3 Railway Rolling Stock - Interior Environment - Part 3: Passenger

AS 7522.3 Railway Rolling Stock - Access Egress - Part 3: Passenger

AS 7529.3 Railway Rolling Stock - Fire Safety - Part 3: Passenger

HB 40 Australian Air Conditioning and Refrigeration Code of Good Practice

TfNSW standards

ESR 0001 Minimum Operating standards for Rolling Stock

T HR HF 00001 ST Human Factors Integration - Rolling Stock

T MU AM 01001 ST Life Cycle Costing.

T MU AM 01002 MA Maintenance Requirements Analysis Manual.

T MU HF 00001 GU AEO Guide to Human factors Integration

T MU HF 00001 ST Human Factors Integration - General Requirements

T HR RS 00117 ST Electric Circuits and Equipment for Passenger Rolling Stock

T HR RS 00126 ST Electronic Equipment Supplied for Passenger Rolling Stock

T HR RS 00164 ST Electrical Cable for Passenger Rolling Stock

T HR RS 01701 ST Mounting and Installation of Electrical Equipment

T HR RS 10001 ST EAPS and Battery System for Passenger Rolling Stock

TS 20001 System Safety Standard for New or Altered Assets

TS 10752 Railway Asset Product Configuration Information Requirements

Legislation

Ozone Protection and Synthetic Greenhouse Gas Management Act 1989 and all related legislation and Amendments

Rail Safety (Adoption of National Law) Act NSW 2012 and Regulations

Safe Work Australia: Workplace Exposure Standards for Airborne Contaminants

Work Health and Safety Act 2011 and Regulations

Publications

AIRAH (Australian Institute of Refrigeration, Airconditioning and Heating) Handbook DA09

ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) Applications Handbook

Safe Work Australia: Workplace Exposure Standards for Airborne Contaminants

UNIFE Railway Industry Substance List

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4. Terms and definitions

The following terms and definitions apply in this document:

AEO Authorised Engineering Organisation

ASA Asset Standards Authority

CC-HVAC climate comfort, heating, ventilation, and air conditioning

contractual specification the contract between rolling stock purchaser and supplier

EAPS electrical auxiliary power supply

FMECA failure modes, effects, and criticality analysis

HVAC heating, ventilation, and air conditioning

interior climate comfort satisfaction associated with temperature and atmosphere of the interior environment (based on 'six climate parameters' defined in ASHRAE 55-2013 and ISO 7730)

PMV predicted mean vote

PPD predicted percentage dissatisfied

RAMS reliability, availability, maintainability, and safety

SFAIRP so far as is reasonably practicable

TfNSW Transport for New South Wales

vestibule normally occupied space that may include a combination of standing and seating areas, may be in proximity of the passenger bodyside doors, and may be separate from the main seating area

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5. Passenger and crew comfort requirements

5.1. Vehicle and crew cab classification

Except where varied by this ASA standard, heavy rail passenger rolling stock for use in TfNSW assets shall comply with the performance standards listed in Table 1.

Table 1 - Interior Climate Comfort Performance Standards for heavy rail passenger services

Climate Comfort Area	Service Type A Total journey time not exceeding 1.5 hours (e.g. urban, suburban)	Service Type B Total journey time exceeding 1.5 hours (e.g. Inter-city, country, inter-state)
Passenger, Passenger / Crew shared areas and Non Cab Crew areas	EN 14750 Category A or EN 13129	EN 13129
Occupied Crew Cabs	EN 14813 Category A	EN 14813 Category A

Guidance Note: the applicable vehicle journey time or service type should be stated in the Contractual Specification or determined from the operational requirements.

Interior climate comfort for all passengers and crew shall meet the climate comfort requirements of the applicable performance standard of Table 1, for the full range of climatic and environmental operating conditions in the relevant parts of the rail network and not limited by the climatic zones defined in the various Euronorm standards.

The regulation temperature curves shall be within the limits defined by the applicable figure from Appendix B.

The range of mean interior temperature with respect to the interior temperature setting shall comply with the limits in Table 2.

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Table 2 - Limits for the range of mean interior temperature with respect to the interior temperature setting as defined in the applicable EN standard from Table 1

Service Type	Comfort Envelope	-10ºC ≤ Ta ≤ 40ºC 'Normal' Operating Range	40ºC < Ta ≤ 46ºC 'High Ambient'	46ºC < Ta 'Extreme High Ambient'
(A) Urban / Suburban	Passenger / crew	± 2 °C	± 2 °C and Tim ≤ 30 °C	± 3 °C and Tim ≤ 30 °C
(B) Intercity / Country / interstate	Passenger / crew	± 1 °C	± 2 °C and Tim ≤ 30 °C	± 3 °C and Tim ≤ 30 °C
All	Occupied Crew Cabs	± 1 °C	± 1.5 °C and Tim ≤ 28 °C	± 1.5 °C and Tim ≤ 28 °C
All	Occupied Crew Cabs with local controls per Section 9	± 1.5 °C	± 1.5 °C and Tim ≤ 28 °C	± 1.5 °C and Tim ≤ 28 °C

In Table 2, the three columns on the right together give the ambient temperature range (fresh air inlet temperature)

The climate comfort limits defined in the applicable EN standards, including fresh air supply rates, shall cover all vehicle areas normally occupied by passengers or crew.

Unless varied by the contractual specification, the CC-HVAC system shall deliver a climate comfort performance level of 90% satisfied for 90% of travel time as defined in Appendix C and determined by passenger and crew survey.

5.2. Fresh air rates and air quality

Fresh air supply rates for all passenger areas shall be not less than the normal operational limits given in the applicable standard from Table 1 for all operating conditions and for the number of passengers stipulated in the contractual specification. The rates shall apply equally for seated and standing passengers.

Fresh air supply rates for crew cabs shall be not less than the normal operational limits given in the applicable standard from Table 1 for all operating conditions and for the number of cab occupants stipulated in the contractual specification.

Guidance note: in some applications it may be acceptable for fresh air supply rates to be lower than the rates given in the referenced standards for limited periods, providing a detailed risk assessment has been conducted verifying that the associated risk has been reduced to so far as is reasonably practicable (SFAIRP) level and the risk has been accepted by TfNSW.

Special areas such as toilets and kitchens shall have ventilation and exhaust air provision complying with an internationally recognised standard and be designed to prevent fumes, odours, fire, or smoke from reaching other occupied parts of the vehicle.

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Air supplied to occupied areas shall be substantially free of dust, contaminants, and impurities.

Air quality shall comply with *Safe Work Australia: Workplace Exposure Standards for Airborne Contaminants*.

6. System performance requirements

6.1. Climate and operating conditions

Equipment shall be designed to operate under the full range of climatic operating conditions in the relevant parts of the rail network, including the local environment where the equipment is installed on the rolling stock.

Equipment mounted on the outside of the rolling stock shall be designed to allow for higher local ambient temperatures than the ambient air temperatures prevailing in the rail corridor.

> *Guidance note: Sources of NSW climate data and operating conditions are given at Appendix A for reference. Temperatures in the rail corridor may be higher than recorded by the Bureau of Meteorology (BoM) weather stations.*

6.2. System cooling and heating capacity

The CC-HVAC system shall have sufficient cooling and heating capacities to establish and maintain the specified interior climate comfort levels for all passenger loading, exterior climate, and operating conditions.

The CC-HVAC system shall have sufficient cooling and heating capacities to establish the specified interior climate comfort levels with zero passenger loading from a stabled condition under all exterior climate conditions within the time limits stated in the contractual specification.

> *Guidance note: Programmable control systems can be used to effect scheduled automatic 'start-up', 'stabled mode' and 'shut-down' routines to prevent operational delays.*

6.3. Interior noise

The CC-HVAC system shall generate minimal noise and vibration in the occupied interior areas of the vehicles, and comply with the vehicle interior limits specified in the applicable standard from Table 1 or as stated in the contractual specification. Vibration shall not exceed the limits stated in AS 7513.3 *Railway Rolling Stock - Interior Environment - Part 3: Passenger*.

> *Guidance note: Higher air speeds at higher interior temperatures are likely to result in higher noise levels and this should be allowed for in the contractual specification.*

> *Guidance note: CC-HVAC system design should apply aerodynamic principles for airflows, fans, and ducts. Noise minimisation can be achieved by applying engineering*

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techniques for managing equipment noise performance, mounting and damping, sound absorption, attenuation, and transmission paths.

6.4. Fresh air inlets

Fresh air shall be drawn from an area where there is no possibility that the air has been heated by Set borne equipment.

The CC-HVAC system shall minimise exterior smoke and fumes entering the vehicle interior.

The CC-HVAC system shall minimise the ingress or accumulation of dust, water, contaminants, and debris.

6.5. Internal pressure

The static pressure inside each Car shall be maintained at a positive pressure relative to atmosphere to prevent uncontrolled ingress of fumes, dust, or unconditioned air.

The CC-HVAC system shall maintain passenger comfort when entering and exiting tunnels by controlling the rate of pressure change in the Trains.

6.6. Air purification and filtration

Air supplied by the HVAC system shall be filtered or purified to remove particles, contaminants, and impurities to an acceptable air quality standard by suitable filters or other means.

Particle filters shall comply with AS 1324.1 *Air filters for use in general ventilation and airconditioning - Application, performance and construction* or EN minimum Grade G3 or otherwise as stated in the contractual specification.

High efficiency particle filters (HEPA) filters shall comply with AS 4260 *High efficiency particulate air (HEPA) filters - Classification, construction and performance* or equivalent international standard.

Other types of air purifiers or filters shall meet the appropriate international standard.

The CC-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.

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6.7. Operating modes

The CC-HVAC control system shall control HVAC operating modes to match the vehicle operating modes including, but not limited to, the following:

- normal service operation with door open-close cycles as stipulated in the contractual specification
- service operation, stationary with passenger doors open for extended periods (automatic detection and control)
- out-of-service train operation (train operating without passengers)
- stabled - night time and day time
- start-up (train preparation)
- presentation / cleaning (restricted access)
- maintenance (restricted access)
- degraded and emergency modes - refer to Section 8

6.8. System efficiency

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

6.9. System design and general requirements

Human factors shall be integrated into the design of the CC-HVAC system in accordance with the following standards:

- T HR HF 00001 ST *Human Factors Integration - Rolling Stock*
- T MU HF 00001 ST *Human Factors Integration - General Requirements*
- T MU HF 00001 GU *AEO Guide to Human Factors Integration*

The CC-HVAC system shall comply with Handbook HB 40 *Australian Air Conditioning and Refrigeration Code of Good Practice*.

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7. Power supply and system requirements

The CC-HVAC system shall be compatible with and powered from the vehicle electrical auxiliary power supply (EAPS) complying with T HR RS 10001 ST *EAPS and Battery System for Passenger Rolling Stock*.

The CC-HVAC system shall incorporate suitable power supply and circuit protection equipment complying with the referenced standards.

In the event of loss of the vehicle main power supply, emergency mode functions including emergency ventilation shall continue to operate from the vehicle EAPS.

On demand, emergency ventilation shall be provided for the period required to meet operational safety requirements as stated in the contractual specification, and not less than the period stated in Section 8 of this document, below.

The CC-HVAC system and all related components shall comply with the applicable requirements of the following ASA standards:

- T HR RS 00117 ST *Electric Circuits and Equipment for Passenger Rolling Stock*
- T HR RS 01701 ST *Mounting and Installation of Electrical Equipment*
- T HR RS 00126 ST *Electronic Equipment Supplied for Passenger Rolling Stock*
- T HR RS 00164 ST *Electrical Cable for Passenger Rolling Stock*

8. System safety requirements and failure modes

8.1. Emergency ventilation

If the CC-HVAC system fails to provide ventilation, then the emergency ventilation system shall provide ventilation for all vehicle occupants at a rate not less than the rates specified in the applicable standard from Table 1 for normal operation, for a period of a least 1.5 hours, or otherwise as stipulated in the contractual specification.

If the forced ventilation system fails, then adequate ventilation shall be provided to all vehicle occupants by alternative means.

The CC-HVAC system shall be integrated with the vehicle fire and emergency system, and designed to prevent or restrict fire propagation, such as by shutting-down ventilation, or air conditioning, or both, when and where appropriate.

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The CC-HVAC system shall manage system faults, failures, and degraded and emergency operating modes, including but not limited to the following:

- degraded and emergency modes
- emergency ventilation
- fire and smoke external to vehicle
- fire and smoke internal to vehicle
- tunnel operation
- system failures and redundancy
- system safety and protections

The CC-HVAC system and ducting shall provide suitable access for cleaning to limit the accumulation of dust or other combustible materials that could aid fire propagation.

The CC-HVAC system shall comply with either BS 6853 *Railway applications - Code of practice for fire precautions in the design and construction of passenger carrying trains* or EN 45545 *Railway applications - Fire protection on railway vehicles* for the applicable categories of service duty and risk as stated in the contractual specification.

> *Guidance note: Fire and emergency requirements for passenger rolling stock are provided by AS 7529.3 Railway Rolling Stock - Fire Safety - Part 3: Passenger*

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

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9. Communication, monitoring, and control

9.1. General

The interior climate shall be regulated by a programmable control system.

Control of individual HVAC units shall be integrated and units shall not work against each other.

9.2. Interior climate comfort regulation

The control of the CC-HVAC system shall be optimised for each operating mode and allow for intercar door and passenger bodyside door operation as well as coupling and uncoupling of units in the consist.

The interior climate comfort control shall have sensor and algorithm inputs to monitor in real time the relevant climate parameters including interior and exterior air temperatures, surface radiant temperatures, humidity, passenger loading, and air speeds.

Values for clothing factor and metabolic rate shall be taken from ASHRAE 55-2013 or ISO 7730 and adjusted for NSW population and crew preferences and seasonal variations.

The interior climate comfort control shall monitor and control the six climate comfort parameters (defined in ASHRAE 55-2013 and ISO 7730), optimise the climate comfort envelopes for the prevailing conditions, minimise local discomfort factors, and minimise the energy consumption.

The interior climate comfort control system shall record internal and external conditions in real time. The data shall be available for analysis and continual improvement, including adjustment of the control program and interior climate comfort algorithm.

The initial basis for optimising interior climate comfort envelopes shall be the predicted mean vote (PMV) / predicted percentage dissatisfied (PPD) scale as defined in ISO 7730 and ASHRAE 55-2013.

Customer surveys shall be used to validate the interior climate comfort performance and to generate local preference data for adjustment and optimisation of the control algorithm. The performance standard shall be 90% satisfied (PMV between -0.5 and +0.5) for 90% of the operating time or otherwise as stated in contractual specification.

Guidance note: refer to Appendix C for guidance.

9.2.1. Interior climate comfort regulation for occupied crew cabs

Crew shall be provided with local climate comfort controls for heating, cooling, airflow rate and direction, ventilation, and control of local discomfort factors, such as local heating or cooling.

Design of crew cab climate control shall ensure that local climate controls are adequate to meet the climate comfort performance requirements under all local conditions.

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Guidance note: due to the high solar radiation levels in Australia and NSW in summer, and low overnight temperatures in winter, crew cabs are subject to steep temperature gradients, high local heating factors, and large temperature transients.

Climate control of occupied crew areas shall be independent of passenger areas, and there shall not be interference between the two areas.

Guidance note: meeting this requirement does not mandate separate HVAC units for passenger and crew areas, but requires that the control of one area does not cause a system imbalance resulting in local discomfort in another area.

Control settings and sensor readings shall be recorded for analysis.

Crew surveys shall be used to validate the interior climate comfort performance and to generate local preference data.

9.3. Crew monitoring and controls

Normal operation of the passenger CC-HVAC system shall be automatic and maintain optimum conditions with minimal need for crew intervention.

Crew controls shall be minimised and designed with appropriate human factors integration and cab design principles in accordance with Section 6.

Operating modes and status shall be indicated to crew.

Modes other than for train service operation (such as presentation and maintenance, programming, and so forth) shall have appropriate access restrictions.

Faults shall be indicated to crew with clear indication of vehicle, consist, and train serviceability.

Manual override controls shall be provided for degraded and emergency modes including the following:

- close of external ventilation
- emergency shutdown

Local controls shall be provided for the crew to adjust climate comfort of occupied cabs.

Guidance note: crew cab local climate controls should include air conditioning on and off, air temperature, flow rate and direction, ventilation on and off and air flow rate and direction, local heating on and off and temperature, air flow rate and direction.

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10. Vehicle and network integration requirements

The CC-HVAC system shall interface with other vehicle systems including but not limited to the following:

- vehicle interior design
- train communications, monitoring, and control systems
- fire and emergency systems (refer to AS 7529.3 for guidance)
- door systems
- access and egress (refer to AS 7522.3 *Railway Rolling Stock - Access Egress - Part 3: Passenger* for guidance)
- condensation control system
- coupling and uncoupling of vehicles, units, and consists
- electrical system including the electrical auxiliary power supply (EAPS)
- vehicle operating modes

The CC-HVAC system shall comply with ESR 0001 *Minimum Operating Standards for Rolling Stock* including but not limited to the following sections:

- ESR 0001 - 000 *Common requirements*
- ESR 0001 - 100 *General interface standards*
- ESR 0001 - 200 *Common interface requirements*
- ESR 0001 - 500 *Locomotive hauled passenger vehicle specific interface standards*
- ESR 0001 - 600 *Multiple unit train specific interface standards*
- ESR 0001 - A1 to 0001 - I *Appendices*

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11. RAMS, asset management, and through life support

11.1. Reliability and availability

The reliability and availability of the CC-HVAC system shall be maximised in accordance with EN 50126 *Railway applications - The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)* and shall meet the availability and reliability requirements stated in the contractual specification.

The CC-HVAC system for the train shall have suitable level of redundancy so that failure of individual components has minimal effect on the train interior climate and system availability.

The reliability and availability performance of the CC-HVAC system shall be independent of ambient operating conditions. Note: meeting the overall reliability and availability performance requirements (aggregated over all operating hours) shall not justify low reliability and availability performance aggregated over operating periods having adverse conditions. ('adverse conditions' being periods of extreme weather such as high or low ambient temperature, humidity, dust level, precipitation, wind speed, and so forth)

11.2. Maintainability

The maintainability of the CC-HVAC system shall be maximised in accordance with EN 50126 and meet the maintainability requirements stated in the contractual specification.

11.3. Safety

The safety of the CC-HVAC system shall be maximised in accordance with EN 50126. All hazards to people and environment for all stages of the life cycle (including design, manufacture, installation, testing, service operation, maintenance, and disposal) shall be identified and reduced to so far as is reasonably practicable (SFAIRP) level in accordance with ASA standard TS 20001 *System Safety Standard for New or Altered Assets*.

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Safety functions related to the CC-HVAC system shall be identified and included in the failure modes, effects, and criticality analysis (FMECA) conducted for the sets, including but not limited to the following:

- safe operating environment for crew
- air quality
- emergency ventilation
- smoke and fire and emergency modes
- isolation and safety of each individual CC-HVAC unit for maintenance
- safety in service and maintenance operations

11.4. Asset management and through-life support

11.4.1. Technical maintenance plan (TMP)

A Technical maintenance plan (TMP) for the CC-HVAC system shall be provided complying with the principles defined in T MU AM 01002 MA *Maintenance Requirements Analysis Manual*.

The TMP for the CC-HVAC system shall include the following items:

- service and planned maintenance schedule (for whole of life)
- RAMS performance monitoring
- configuration items list
- parts list
- obsolescence management plan
- mid and late-life overhaul and upgrade management plan
- in-service support plan

11.4.2. Manuals

Detailed manuals of the CC-HVAC system shall be provided to TfNSW to support the whole of life asset management of the system covering the following:

- installation
- operation
- climate control, monitoring, and adjustment
- service, maintenance, and overhaul instructions
- performance and condition monitoring and fault identification and correction

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- end-of life recycling and disposal
- system and circuit diagrams
- parts list

12. Environmental and sustainability requirements

The CC-HVAC system shall generate minimal noise and the vehicle shall comply with the environmental requirements of ESR 0001 *Minimum Operating Standards for Rolling Stock* including RSU 150.

The CC-HVAC system shall be designed for minimum life cycle cost in accordance with T MU AM 01001 ST *Life Cycle Costing*.

Labels shall be clearly legible from the expected viewing positions in large font, permanent, indelible for the life of the rolling stock, and appropriately positioned for service personnel.

12.1. Refrigerants

The refrigerant used in the CC-HVAC system shall be selected to meet the following requirements:

- compliance with Australian legislation including the *Ozone Protection and Synthetic Greenhouse Gas Management Act* 1989 and all related legislation and amendments

  For guidance, refer to the website http://www.environment.gov.au/protection/ozone/rac
- system safety, environment, capacity, performance, and reliability requirements
- maximised energy efficiency and minimised energy consumption over the life of the vehicle
- the system shall use the most environmentally friendly refrigerant within the constraints of zero ozone depleting potential and low global warming potential balanced with whole of life energy consumption
- consideration of future technology and legislation trends, options for upgrading at mid and late-life stages and end-of-life recycling and disposal

12.2. Restricted and prohibited materials

Materials likely to cause damage to the environment or human health shall not be used during the life cycle of the vehicles.

The supplier shall provide adequate evidence to the purchaser that materials likely to cause damage to the environment or human health are not used, by following the UNIFE *Railway Industry Substance List*, or equivalent internationally accepted guidance on prohibited and restricted materials.

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The Australian Government Department of Health publishes guidance on materials that are prohibited or restricted by legislation in Australia at www.nicnas.gov.au.

13. Verification, validation, and documentation requirements

13.1. Configuration management and systems engineering

The AEO, or design authority, or both, shall provide asset configuration information to TfNSW in accordance with ASA standard TS 10752 *Railway Asset Product Configuration Information Requirements* and as detailed in the contractual specification.

> *Guidance note: details of the ASA Authorised Engineering Organisation system are described on the ASA website - refer to www.asa.transport.nsw.gov.au*

The CC-HVAC system shall be integrated with the rolling stock using 'systems engineering' methodology following the principles of ISO 15288:2008 *Systems and Software Engineering - System life cycle processes*.

13.2. Testing and verification

The AEO or design authority shall develop a detailed inspection and test plan to cover all requirements that need verification or validation by testing. The type testing shall include the following:

- system functions and integration requirements
- testing in accordance with the referenced EN standards (Table 1) with provision for extended climate range for NSW (Appendix B) including higher temperature and solar radiation levels
- Control algorithm based on ASHRAE 55-2013 climate comfort envelopes with adjustments if needed to suit the NSW climate and passenger and crew preferences
- in-service interior climate comfort monitoring, data logging, and data analysis
- customer and crew survey, satisfaction performance assessment, and system optimisation
- in-service overall system performance monitoring, and assessment including the following:
    - system safety
    - climate comfort
    - energy consumption and efficiency
    - reliability and availability
    - whole of life cost

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In each case, the performance shall be plotted with the design baseline on a time-base showing current and past-to-date performance at agreed time intervals for whole of life.

13.3. Documentation deliverables

CC-HVAC system documentation shall be managed in accordance with the AEO's configuration management requirements and the requirements of the contractual specification.

Guidance Note: refer to www.asa.transport.nsw.gov.au

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Appendix A - Climate data and operating conditions for the NSW network

The following are references for climate data and operating conditions for the NSW rail network

- Australian Government - Bureau of Meteorology (BoM)

  www.bom.gov.au

- Australian Institute for Refrigeration, Air Conditioning and Heating - AIRAH Guideline DA09

  www.airah.org.au

- American Society of Heating Refrigeration and Air Conditioning Engineers ASHRAE Climate Data

  www.ashrae.org

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Appendix B - Temperature regulation curve limits for passenger rolling stock for NSW

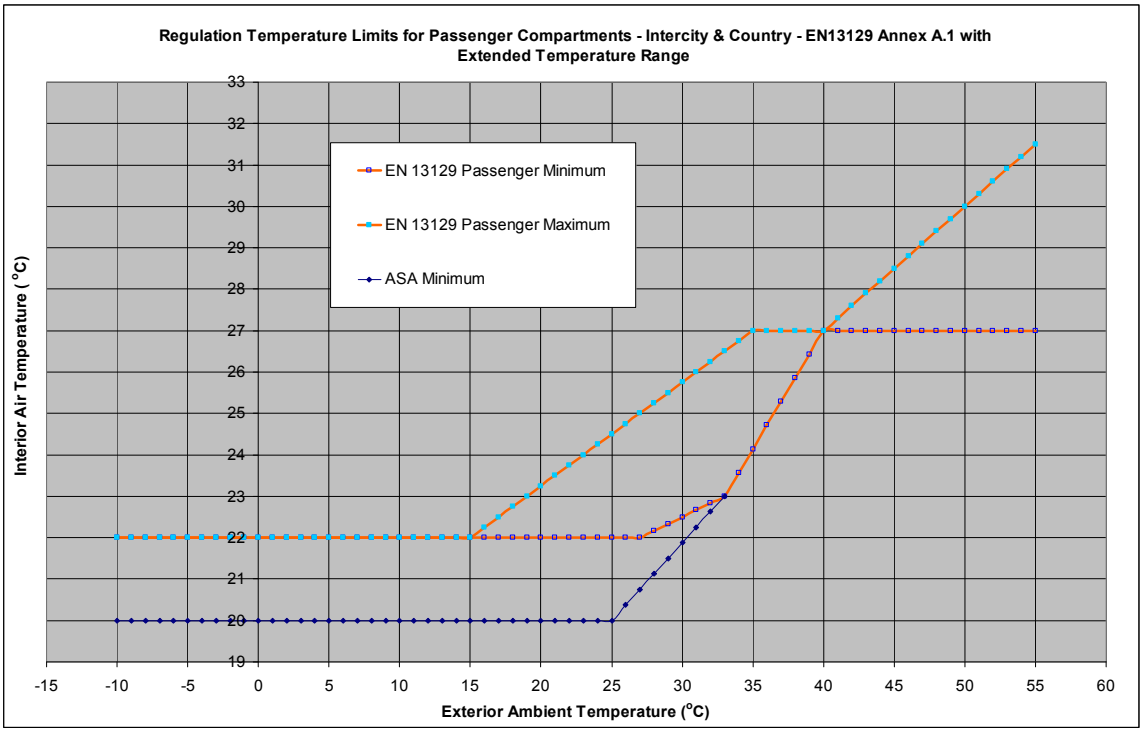

Figure 1 - Regulation temperature limits of EN 13129-1 Annex A.1 (inter-city, country and inter-state services) modified to suit the NSW climate

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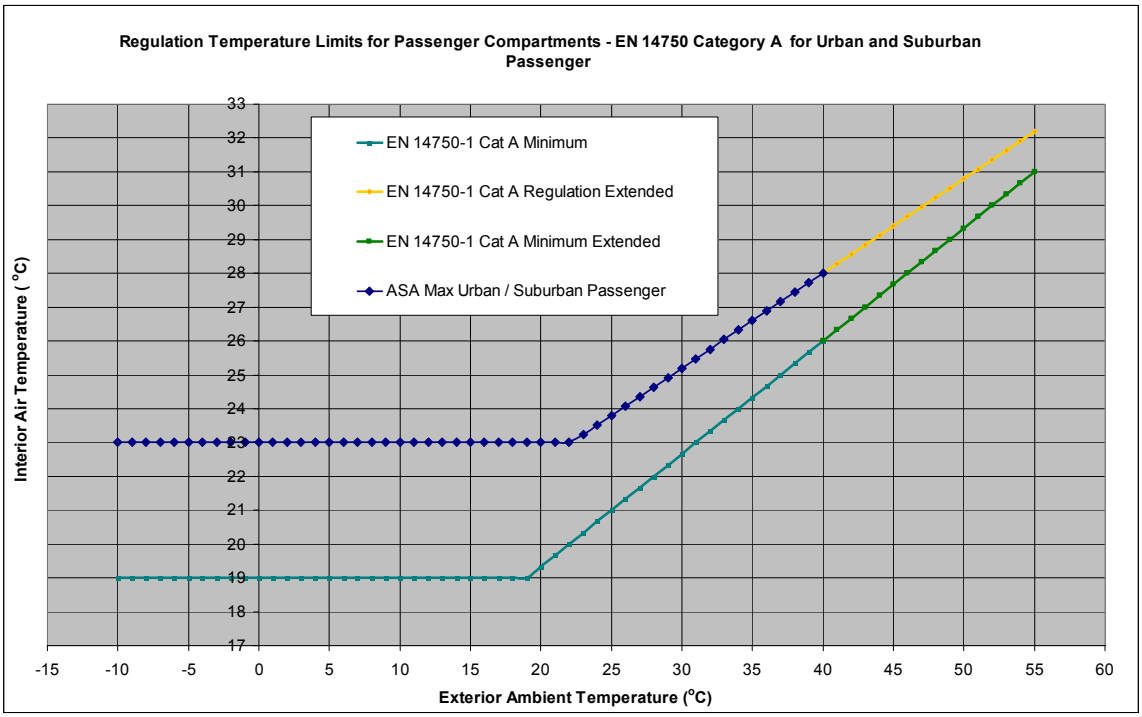

Figure 2 - Upper and lower regulation temperature limits for passenger areas of urban and suburban passenger trains, taken from EN 14750-1 Annex A.1 and modified to suit the NSW climate

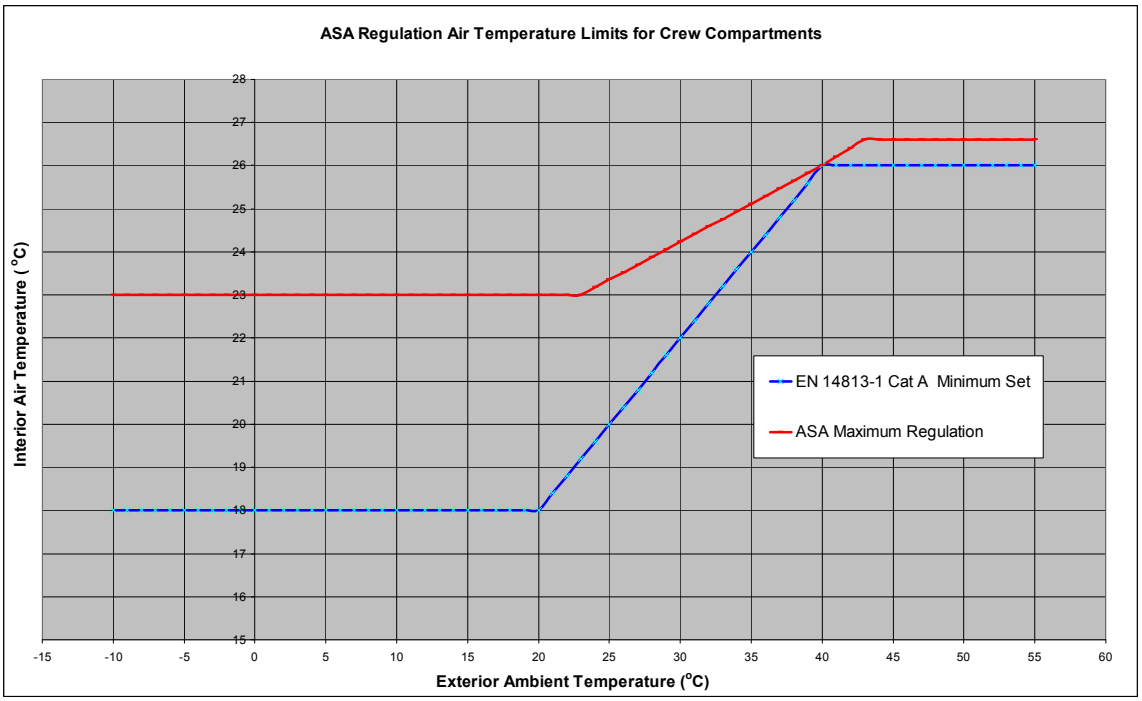

Figure 3 - Upper and lower regulation temperature limits for crew occupied cabs of passenger trains, taken from EN 14813-1 Annex A.1 and modified to suit the NSW climate

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Appendix C - Process logic and climate comfort performance standard

C.1 Process logic for CC-HVAC design

The following are steps to carry out the CC-HVAC design:

1. Determine applicable EN standard in accordance with Table 1

   Guidance Note: this should be stated in the contractual specification or determined from the operating requirements of the rolling stock.

2. Determine climate comfort limits in accordance with the applicable EN varied by Appendix B and Table 2.

   Guidance Note: the referenced EN standards and Appendix B provide upper and lower limits for temperature regulation curves but not the actual temperature regulation curve, which is to be determined by the Supplier at steps 4 and 5 below

3. Design the rolling stock interior and CC-HVAC system - integrate vehicle systems

4. Program the CC-HVAC regulation using ASHRAE 55 / ISO 7730 to maintain PMV between - 0.5 and + 0.5 for all exterior conditions

   The control algorithm should maintain the comfort envelopes within the limits provided by the PMV scale subject to the constraints of temperature regulation given in Appendix B. For optimisation, other inputs can be used such as previous experience with existing rolling stock and knowledge of passenger and crew preferences and seasonal variations (refer to step 6 below). If the Appendix B limits for temperature regulation conflict with the PMV requirements then the Appendix B limits shall be maintained pending survey results (refer to step 6 below).

5. Monitor climate comfort parameters in-service

   Some parameters can be measured in real time using sensors such as air temperatures, humidity, and passenger loading. Input parameters such as clothing factor and metabolic rate shall be taken from ASHRAE 55 or ISO 7730. Other parameters such as air speeds and surface radiant temperatures can be determined indirectly from measurements, type test, and design data.

6. Monitor and optimise climate comfort satisfaction levels in-service (passenger and crew survey)

   Passenger and crew climate comfort surveys shall be used to assess the performance level of the system. A satisfaction scale of 1 to 5 can be used where score 4 to 5 corresponds approximately to a PMV score between - 0.5 and + 0.5. The control algorithm

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should be adjusted (fine-tuned) until optimum satisfaction levels are sustained. Survey design and frequency shall be agreed between purchaser and supplier. Guidance on suitable survey design can be obtained by references such as ASHRAE 55 and other publications. If the survey results require the Appendix B temperature regulation limits or the PMV requirements to be exceeded, then notify ASA so the limits in this standard can be reviewed.

C.2 Climate comfort performance standard

For thermal comfort scale, refer to ISO 7730.

Unless varied by the contractual specification, passenger and crew areas shall meet the target performance for climate comfort of 90% satisfied for 90% of travel time.

Table 3 shows the target performance standard (90% satisfied 90 % of travel time) for the columns having a PMV value of -0.5, 0, or +0.5 (all of these also have a Descriptor value of 'Comfortable').

Table 3 - Target performance standard for climate comfort

PMV Scale:	-3	-2	-1	**-0.5**	**0**	**+0.5**	+1	+2	+3
Survey Score:	1	2	3	**4**	**5**	**4**	3	2	1
Descriptor	Cold	Cool	Slightly Cool	**Comfortable**	**Comfortable**	**Comfortable**	Slightly Warm	Warm	Hot

Guidance Note: deviation from the PMV scale may be needed to meet NSW passenger crew preferences and an exact correspondence between survey score and PMV scale is not required.

For local discomfort, refer to ISO 7730 Annex A.

Unless varied by the contractual specification, occupied crew cabs shall meet the local discomfort limits of Category A thermal environments as defined in Table A.1 of the referenced standard.

Unless varied by the contractual specification, passenger, and crew shared areas shall meet the local discomfort limits of category B thermal environments as defined in Table A.1 of the referenced standard.

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