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Preface

This standard was prepared by the Rolling Stock Passenger Seating and Appointments Development Group, overseen by the RISSB Rolling Stock Standing Committee.

Objective

The objective of this Standard is to provide best practice and performance-based outcomes in the design, manufacture and maintenance of rolling stock passenger seating, fittings and fixtures.

AS 7489 will form part of the Government's National Rail Action Plan (NRAP), a Ministerially sponsored programme of work being driven by the National Transport Commission (NTC) designed to stimulate domestic manufacturing, create local jobs, and shore up supply chains.

Compliance

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

(a) Requirements.

(b) Recommendations.

(c) Permissions.

(d) 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 recognize 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 C.

Appendices in RISSB Standards may be designated either "normative" or "informative". A "normative" appendix is an integral part of a Standard and compliance with it is a requirement, whereas an "informative" appendix is only for information and guidance.

Commentary

Commentary *C Preface*

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 and does not form part of the Standard.

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Tables

Section 1 Scope and general

1.1 Purpose

The purpose of this Standard is to provide best practice and performance-based outcomes in the design, manufacture and maintenance of rolling stock passenger seating and appointments.

1.2 Scope

This Standard is applicable to passenger seating and appointments for passenger rolling stock that operate on a network.

Crew seating is excluded from this Standard.

It is recognized that some RISSB products referenced in this Standard as either normative or informative do not specifically include light rail vehicles and/or metro rolling stock. However, for the purposes of this Standard, light rail vehicles and metro rolling stock are included and any referenced standards that do not specifically include light rail vehicles and/or metro rolling stock may be applied as deemed appropriate for this type of rolling stock.

This Standard does not specifically cover rolling stock used for heritage operations, crew cars, sleeper cars and dining cars. However, items from this Standard may be applied to such systems as deemed appropriate by the relevant rolling stock operator (RSO).

1.3 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 3000, *Electrical installations (known as the Australian/New Zealand Wiring Rules)*
- AS 7470, *Human Factors Integration Engineering Design - General Requirements*
- AS 7488, *Railway rolling stock – Locomotive and passenger vehicle flooring*
- AS 7521, *Interior Crashworthiness*
- AS 7522, *Access and egress*
- AS 7529.3, *Australian Railway Rolling Stock — Fire Safety, Part 3: Passenger*
- AS 7530, *Electrical systems*
- *Australian Government Disability Standards for Accessible Public Transport Guidelines (DSAPT)*
- BS EN 1335.1, *Office furniture. Office work chair – Dimensions. Determination of dimensions*
- BS EN ISO 7250.1, *Basic human body measurements for technological design, Body measurement definitions and landmarks*
- GMRT 2100, *Rail Vehicle Structures and Passive Safety*
- iMOVE 6-002, *Australian Size Variation for Design, M004: Detailed anthropometry dataset V2.0 30/06/2023*

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

1.4 Defined terms and abbreviations

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

1.4.1

accessibility
requirements to provide equivalent access to people with disabilities which are defined in the DSAPT for passenger rolling stock

1.4.2
anthropometric data
variety of human body measurements, such as weight, height, width, leg/arm length and circumference

1.4.3
biomechanical analysis
formal process of utilizing knowledge about the interfacing elements along with the design of the human body to fully integrate the two systems

1.4.4
design anthropometric data
static and dynamic measurement data of the human body

design anthropometric range
minimum range of the design anthropometric data being from the 5th percentile female or male (whichever has the smaller value) to the 95th percentile male or female (whichever has the larger value)

1.4.5
Disability Standards for Accessible Public Transport (DSAPT)
Australian government disability standards for accessible public transport guidelines

1.4.6
environmental management system (EMS)
tool for managing the impacts of an organisation's activities on the environment

1.4.7
ergonomics
process of designing or arranging spaces, products and systems so that they fit the people who use them

1.4.8
flip up seat
seat where the seat base raises to the vertical position allowing additional train standing capacity when required

1.4.9
footrest
fixed or moveable device typically mounted on the seat in front for the purpose of enabling a passenger to raise their feet off the floor or ground when sitting

1.4.10
general purpose outlet (GPO)
a 3-pin flat electrical socket that provides 240 VAC power

1.4.11
grab handle
short handrail device fitted to the seat back intended for supporting a single adjacent standing passenger and may also be used for assisting with seat back orientation for tip-over type seats

1.4.12
grab pole
predominantly vertical handrail provided for passenger support

1.4.13
headrest
padded fixed or moveable device typically mounted on the top of a seat for the purpose of supporting the passenger's head

1.4.14
human factors (HF)
discipline of applying what is known about human capabilities and limitations to the design of products, processes, systems, and human environments

1.4.15
human factors integration plan (HFIP)
plan that outlines how human factors are integrated into the overall engineering, assurance, and project management processes

1.4.16
lean seat
fixed padded or unpadded type seat typically installed near doorways or other space restricted areas allowing a passenger some ability to be partially seated

1.4.17
long distance trains
trains operating with journeys of long distance and duration (typically greater than several hours), for example on interstate journeys

1.4.18
longitudinal seat
seat or series of seats aligned with the longitudinal axis of a vehicle so that the occupant is sitting at 90° to the direction of travel

1.4.19
medium distance trains
trains operating with journeys of intermediate distance and duration (typically between one and several hours), for example between urban centres

1.4.20
reclining seat
passenger seat where the seat back and/or base can be manually adjusted by the passenger to enable better levels of comfort

1.4.21
reversible seat
passenger seat that can be reversed in direction of travel by unlocking and rotating the seat base assembly through 180 degrees

1.4.22
RTO
rail transport operator

1.4.23
passenger comfort
combination of physical and psychological factors affecting the well-being of an individual in relation to a particular environment

1.4.24
passenger rolling stock
rolling stock that carries people and facilities for these people

1.4.25
passenger seating appointments
features that make passenger seating comfortable and functional

1.4.26
pressure mapping analysis
use of sensors and software to measure the interface pressure between a person's body and a seating surface

1.4.27
priority seating
seating for passengers with disabilities and other groups in need of special assistance (for example, the aging) as defined in DSAPT

1.4.28
seat infotainment system
interactive screen with audio connection functionality for use by the passenger in the seat behind

1.4.29
seat mechanism
mechanisms for the adjustment of passenger seats including reclining, reversible and tip-up functionalities

1.4.30
seat pitch
a dimension between the back of one seat to the same point on the seat in front (or behind)

1.4.31
seat power outlet
seat-mounted GPO and/or USB charging outlet

1.4.32
seat width
the passenger seat width, typically at the base, not including armrests

1.4.33
short distance trains
trains operating with journeys of short distance and duration (typically under one hour)

1.4.34
S-N curve
a curve that defines the number of cycles to failure when a material is repeatedly cycled through a given stress range

1.4.35
table
tray surface for passengers to place items like drinks, food, books, or technology

1.4.36
tip-over seat
seat where the back can be tipped over to change the seating direction of travel of the passengers; also known as walk-over seats

1.4.37
transverse seat
seat, typically part of a group installed laterally across the vehicle so that the occupant is either sitting facing or back to the direction of travel

1.4.38
USB
universal serial bus

1.4.39
USB charging outlet
industry standard connection that allows data exchange and delivery of power between various types of electronics

1.4.40
wheelchair position flip-up seat
seat at a designated and marked wheelchair position where the seat base either through manual or automatic function, will raise to the vertical position allowing a person of restricted mobility in either a wheelchair or similar aid to be located

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

Section 2 Human factors

Human factors (HF) is essential for the design of passenger seating and appointments and shall be incorporated from the inception of the design process. Persons undertaking any human factors activities shall be competent in human factors at a level appropriate to the activity being undertaken.

For the design of the passenger seating and appointments, HF shall be applied for the following aspects at a minimum:

(a) identification of the full range of end users and the context of use (e.g., distance or duration of travel);

(b) specification of end user requirements for inclusion in the design process to support providing a fit-for-purpose outcome;

(c) provision of guidance on:

  (i) dimensions for seating and appointments with reference to appropriate anthropometric data to ensure that the designs accommodate appropriate anthropometric ranges;

  (ii) seating design considerations relating to comfort;

(d) identification of HF issues and management of those issues throughout the design process including an assessment of compliance with the above requirements and restrictions; and

(e) design and undertaking of passenger comfort and accessibility testing to evaluate options and determine final design.

Human factors integration (HFI) into these design elements shall be undertaken in accordance with AS 7470, with the HFI process documented in that standard applied.

Where passenger seating and appointments are being undertaken as part of broader rollingstock changes or designs, these activities shall be undertaken and documented in accordance with the human factors integration (HFI) process. Persons undertaking HF activities shall be competent in human factors at a level appropriate to the activity being undertaken.

An assessment of passenger seat comfort and accessibility shall be independently undertaken using a representative sample of end users (including persons with disabilities, parents with small children and the elderly), evaluating all seating and appointment options assembled in a mock up that represents their installation on the rail vehicle and its surrounding environment. This process shall include the development and use of a questionnaire by the end users surveyed. The results of the survey shall influence the final design and any changes shall be re-assessed by a similar methodology prior to design completion.

Commentary *C2*

The above process helps to ensure that the context of use and end users are appropriately identified, that HF requirements for the design are specified, that the required HF analyses are completed, that HF issues are systematically identified and managed throughout the design lifecycle, and that evidence of the HFI activities (through submission of a human factors integration plan (HFIP) and summary report) is documented.

RISSB Guideline: Integration of Human Factors in Engineering Design provides guidance on the human factors design process to assist in ensuring the asset is efficient and effective, meets its intended performance levels and is able to deliver the expected benefits to users and customers.

RISSB Guideline: Integration of Human Factors Across the Project Lifecycle provides guidance on the implementation and effectiveness of HF Integration into projects by providing guidance on scaling and managing HF activities across a project lifecycle.

Section 3 General requirements

3.1 Layout and configuration

The conceptual layout and configuration design of the passenger seats and appointments shall be defined early in the design process with the requirements detailed in this Standard applied to the detailed design.

Commentary *C3.1*

The passenger seating and appointments layout and configuration is influenced by many factors including:

– Existing layout and configuration on other trains being operated by the RTO.

– Asset owner expectations (e.g., passenger capacity)

– Passenger expectations.

– Type of rolling stock and operating regime.

– Length of travel.

– Dimensional limitations.

Dimensional limitations relate to the physical space allocation for the passenger seats and appointments and any other limitations of the car body or other attachment points.

Appendix B provides examples of passenger seats and appointments typically used in the Australian and New Zealand rail industry for the purpose of information only.

3.2 Priority seats for passengers with disabilities and/or mobility issues

Priority seats for the use of passengers with disabilities and/or mobility issues, shall be in accordance with DSAPT.

Priority seats should be of a contrasting colour to differentiate them from standard passenger seats for persons with visual impairment.

Priority seating should have handrail access between exterior doors and the priority seats and be located as near to exterior doors as practicable.

3.3 Design integration for passenger interface

The passenger seat and appointments design should incorporate the following attributes where applicable for passenger interfacing:

a) alignment with windows to provide external visibility (e.g., for the purpose of identification of external landmarks, station signage and the horizon to counteract the potential for motion sickness);

b) direct line of sight to a passenger information display;

c) direct line of sight to luggage storage areas (e.g., end of carriage vestibule luggage storage racks); and

d) direct line of sight to signage for amenities (e.g., passenger toilets, baby change facilities, buffet, etc).

3.4 Forces required to operate seats

The forces required for the operation of seats during normal use should not exceed:

a) 100 N for tip-over seats when applied perpendicular to the centre of rotation at the grab handle adjacent to the aisle;

b) 50 N for the raising or lowering of flip-up seats;

c) 50 N for the raising or lowering of wheelchair space flip-up seats;

d) 110 N for nominal slide forward for an in-shell seat recline;

e) 140 N for footrest (from up to down); and

f) 35 N for reversible seat rotation.

The operating range forces required for the operation of seats during normal use should be:

g) 20 N to 40 N for armrest operation; and

h) 30 N to 40 N for seat back table operation. For a force less than 30 N, the table will open itself.

Forces required to operate any other adjustable seat should be designed to incorporate the users within the design anthropometric range.

Section 4 Anthropometric data

The design anthropometric data to be used for the design of passenger seating and appointments shall be the NHS detailed anthropometry – adults 18-64 years old data as shown in *iMOVE 6-002 – Australian Size Variation for Design – M004: Detailed anthropometry dataset – V2.0 – 30/06/2023*, comprising of:

(a) standing measurements – heights and lengths;

(b) standing measurements – weight, circumferences, breadths, and widths; and

(c) sitting measurements.

The minimum design anthropometric range for adults shall be from the 5th percentile female or male (whichever has the smaller value) to the 95th percentile male or female (whichever has the larger value). The RTO may specify a broader anthropometric range where required.

The design anthropometric data does not include an allowance for clothing and footwear, therefore the design anthropometric data that shall be used for the design of the passenger seats and appointments shall add:

(d) 40 mm to stature to account for footwear; and

(e) 20 mm to widths and depths to account for clothing.

Commentary *C4*

It is recognized that providing smaller seats can result in increased passenger capacity within a train carriage in terms of basic numbers of passengers accommodated which can be desirable to meet other design or operational requirements. However, reducing seat size leads to a reduction in the proportion of people who can be physically accommodated within a seat. As the extent of this compromise is often poorly understood, the following tables provide guidance on the proportion of people dimensionally excluded when key seating variables are reduced.

The tables below detail the adult male and female population percentage accommodation against two critical seating dimensions for planning purposes. These are provided for general guidance on the proportion of people sizes who would be excluded when key seating dimension variables are reduced. These tables cannot be substituted for other requirements within this Standard.

Seat pitch (mm)	% Adult males accommodated	% Adult females accommodated
<550	0%	0%
550	0%	0%
570	0%	2%
590	1%	8%
610	5%	21%
630	12%	43%
650	31%	63%
670	58%	78%
690	77%	90%
710	89%	97%
730	96%	98%
750	98%	99%
770	99%	99% +

Seat backrest width (lateral spacing) (mm)	% Adult males accommodated	% Adult females accommodated
380	0%	0%
400	0%	2%
420	0%	13%
440	0%	35%
460	4%	60%
480	14%	76%
500	30%	87%
520	53%	95%
540	73%	97%
560	88%	98%
580	96%	99%
600	98%	99%+
620	99%	99%+

See Section 8 for optimized seating dimensions to comply with the design anthropometric range.

Section 5 Crashworthiness and occupant impact interfaces

Interior crashworthiness including occupant impact interfaces during normal operations, collision or derailment shall be in accordance with AS 7521.

Tip-over seats (if fitted) shall be designed to minimize the risk of occupants being propelled out of the seat due to the inertia of the moveable back rest.

Commentary *C5*

Body structural requirements for passenger rolling stock (including crashworthiness performance) are defined in AS 7520.3.

Section 6 Fire performance

Fire safety performance of passenger seats, materials, appointments and all associated components defined in this Standard shall be in accordance with AS 7529.3.

Test results from an appropriately certified testing laboratory demonstrating compliance with AS 7529.3 shall be provided as part of requirements verification.

Section 7 Accessibility, access and egress

Accessibility (including DSAPT requirements), access paths, access and egress shall be in accordance with AS 7522 and AS 7470.

The passenger seating and appointments design shall incorporate clearance allowances for passenger interfaces with components within the passenger space.

Clearances for access and egress for all persons shall be included in the design for movements around the seats and appointments whilst standing/walking, and when passengers transition from the sitting to the standing position and vice versa. The clearances shall be determined with reference to the design anthropometric range. The RTO may specify a broader design anthropometric range.

Section 8 Seat design

8.1 General

Passenger seat design requirements shall include the following:

(a) seat and seating configurations be designed to accommodate the majority (95%) of Australian body sizes in comfort (as per AS7470);

(b) be designed to support seated work with personal devices where feasible; and

(c) the level of seat comfort be appropriate for the length and type of travel.

Commentary *C8.1*

Seat design encompasses several interacting design features which combine to accommodate most user sizes in a comfortable posture. This section describes a suite of requirements that will promote compliance with the requirements above, such as:

– Minimum dimensional requirements: A set of seat dimensions that correspond to anthropometric measures for majority of Australian population (95%).

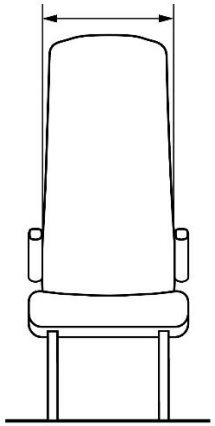
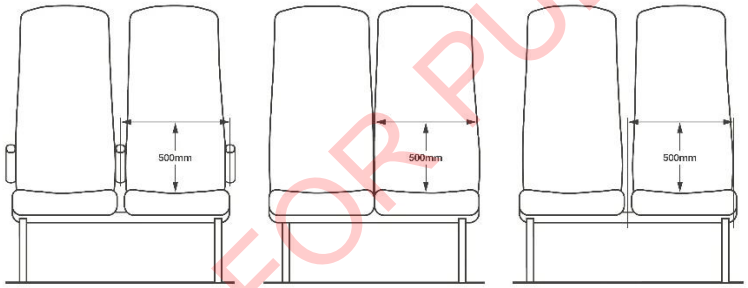
– Additional dimensions: Additional seat dimension features which are known to affect comfort and accommodation of users.

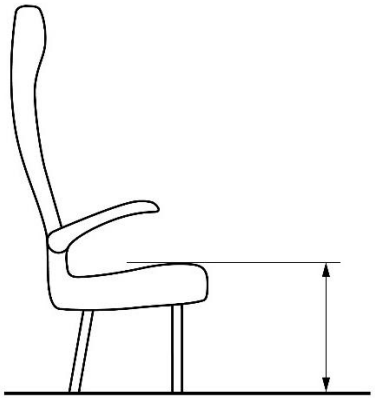
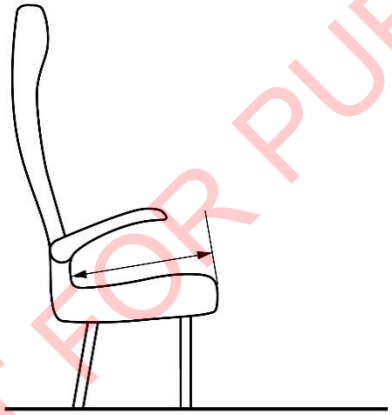
– User testing: Protocols to verify design decisions and validate against overarching requirements.

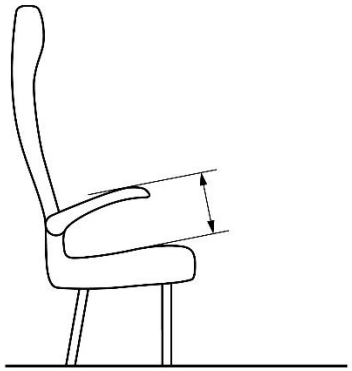
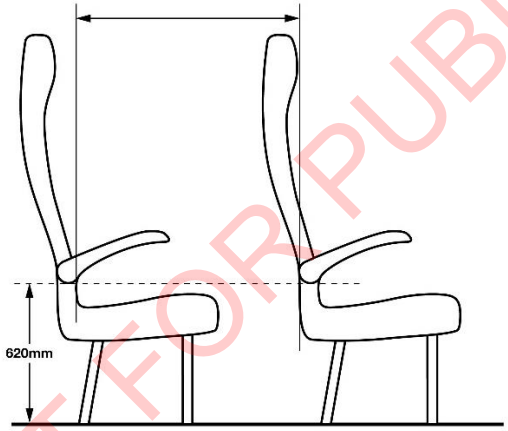
8.2 Dimensional requirements

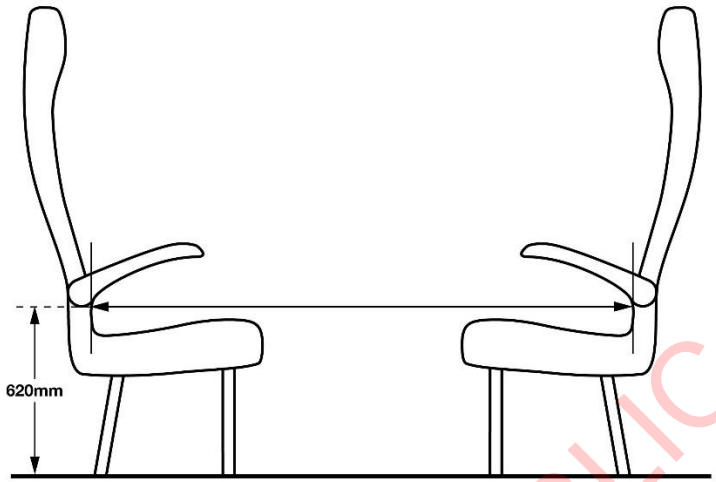
Table 8-1 details the dimensional requirements for passenger seating that shall be applied for the design anthropometric range. Additional space, adjustability and use of more comfortable finishes should be considered for longer duration services (e.g., medium and long-distance trains).

Table 8-1 Dimensional Requirements

Seat Dimension	Diagram	Anthropometric Measure	Value	Relevance to seating design
Seat pan width/ distance between armrests		Seated hip breadth (Female 95th percentile)	527 mm (includes clothing allowance of 20 mm)	Minimum design requirement for seat pan width and distance between armrests and other interior design constraints (e.g., walls, windows, handrails).
Seat backrest width		Bideltoid shoulder breadth (Male 95th percentile). Measured at 500 mm height from seat base.	576 mm (includes clothing allowance of 20 mm)	Minimum design requirement for seat back width and lateral spacing of seats. Three options shown: ○ With armrests ○ No armrests or spacers ○ No armrests with spacers

Seat Dimension	Diagram	Anthropometric Measure	Value	Relevance to seating design
Seat height		Knee height (also referred to as popliteal height) – vertical distance from standing surface to knee crease (Female 50th percentile)	480 mm +/- 10 mm (includes footwear allowance of 40 mm)	Minimum design requirement for vertical distance between seat surface and floor. This value includes compressibility of seat cushion materials if fitted.
Seat depth		Buttock popliteal length (Female 5th percentile) *NOTE: Refer to BS EN ISO 7250.1)*	435 mm +/-10 mm	Optimal requirement for depth from front of seat to rear of seat, as a function of the support offered by the seat back.

Seat Dimension	Diagram	Anthropometric Measure	Value	Relevance to seating design
Arm rest height		Elbow height sitting (Male 50th percentile). Measured parallel to the backrest line at a distance of 214 mm from the backrest line and with an allowance for seat compressibility where applicable.	230 mm ~ 250 mm	The armrest height is the distance from the top surface of the armrest to the top of the seat pad.
Seat pitch/legroom		Buttock Knee Length (Male 95th percentile). Measured 620 mm above the train floor.	722 mm (includes clothing allowance of 20 mm plus movement allowance of 30 mm)	Minimum design requirement for leg room, seat pitch spacing. NOTE: Measured at 620 mm height.

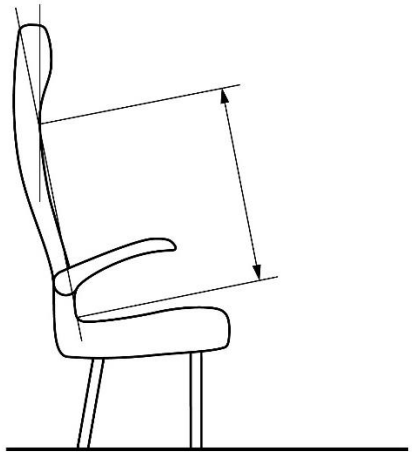
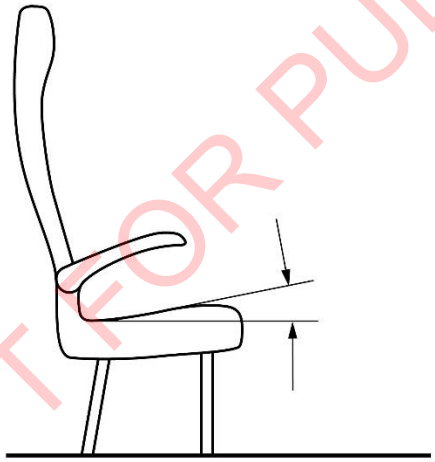
Seat Dimension	Diagram	Anthropometric Measure	Value	Relevance to seating design
Bay seating		A combination of leg measures. Measured 620 mm above the train floor.	1,390 mm ~ 1,531 mm	Distance is measured as the horizontal distance between the backs of the two facing seats (offset 120 mm from the median plane).

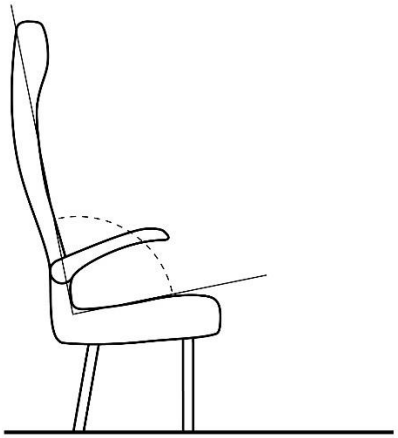
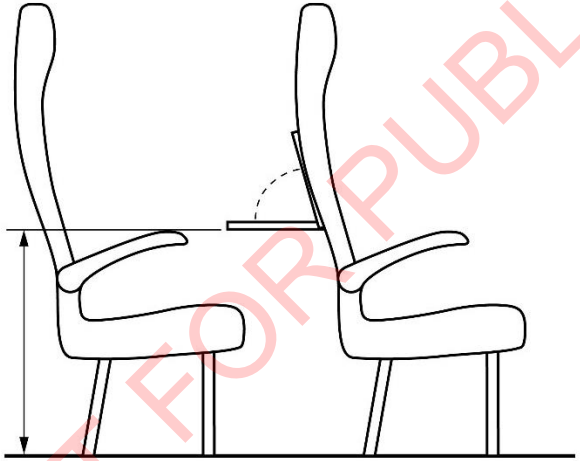
NOTE: Unless otherwise specified, anthropometric values are based on the design anthropometric data.

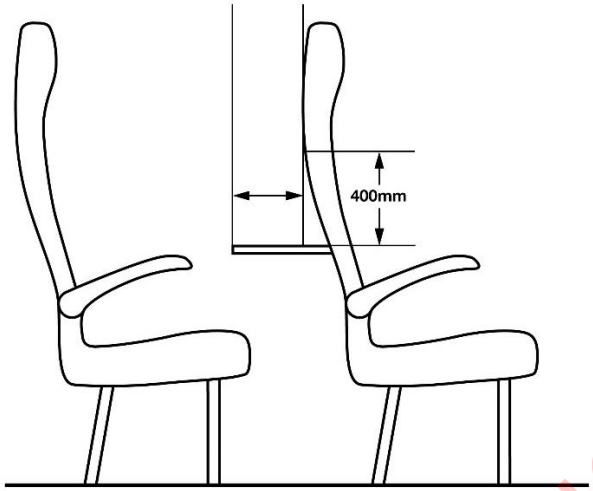
8.3 Additional recommended requirements

Table 8-2 details additional recommended requirements known to impact comfort and accommodation of users that should be applied for the design anthropometric range where applicable.

Table 8-2 Additional Dimensions

Seat Dimension	Diagram	Anthropometric Measure	Value	Relevance to seating design
Underside of headrest to seat		The dimension for the underside of the headrest (if fitted) to seat.	660 mm ~ 680 mm	The underside of headrest (if fitted) to seat dimension captures the body dimension for a passenger's shoulder height when seated, as defined in BS EN ISO 7250.1.
Angle of seat		The angle of the seat.	-2° to -12° Negative values of angles are given to show that the seats are rearwards inclined (i.e. not sloping forward).	Based on comfortable angles for back support and activities for work chairs, and measured train seats.

Seat Dimension	Diagram	Anthropometric Measure	Value	Relevance to seating design
Angle between seat and back		The angle between the seat and back.	95° to 110°	The angle between the seat and back is based on dimensions set out in the office seating standard BS EN 1335-1 This dimension specifies the angle between the loaded backrest and the loaded seat.
Table clearance		Knee height sitting (Male 95th percentile)	650 mm ~ 690 mm (includes footwear allowance of 40 mm)	The minimum vertical distance from the floor to the lowest point on the underside of the fold down tablet.

Seat Dimension	Diagram	Anthropometric Measure	Value	Relevance to seating design
Table depth		The table depth is defined as the horizontal distance measured from the edge of the tablet closest to the passenger to the rear of the seat back at a height of 400 mm above the table surface. This measurement is undertaken along the seat's centreline.	120 mm ~ 201 mm	

8.4 Seat comfort

The design of the passenger seating shall incorporate requirements for ensuring passenger seat comfort based upon the following factors:

(a) duration of travel;

(b) class of travel;

(c) ergonomics;

(d) human factors;

(e) customer expectations; and/or

(f) RTO expectations.

Commentary *C8.4*

Passenger comfort is paramount in the development of passenger seats encompassing a combination of physical and psychological factors affecting the well-being of a passenger and their experience in relation to passenger seat design. Parameters that can influence passenger comfort include vibration, noise, seat pitch, seat width, seat angle, adjustability of seat accessories (e.g., headrest, footrest, recline, etc) and seat cushioning.

Biomechanical analysis, pressure mapping analysis, seat pad compressibility analysis and the use of digital human models are useful tools that can assist in the evaluation of passenger comfort.

Refer to Appendix A for informative optional dimensions and other values that can be considered for enhanced passenger comfort.

8.5 User testing

In accordance with AS 7470, assurance shall be provided of the suitability of the passenger seating and standing arrangements. This can be provided through one of the following options:

(a) user trialling with a representative sample of end users. The trialling should replicate the layout and context as closely as possible; or

(b) for off the shelf solutions, documented evidence of use in comparable contexts accompanied by appropriate justification of its use.

8.5.1 User trialling

Where user trialling is adopted, the following method shall be applied:

(a) User sample – representative size range, numbers, male/female;

(b) User tasks - seat ingress/egress, seated position, footrest use, table use, etc;

(c) Method - time in seat, repeated measures; and

(d) Measures - standardized questionnaire.

Full details of the user trialling methodology and process should be captured in a documented trial plan.

Commentary *C8.5.1*

The following guidance is provided in relation to user trialling. It is recommended to incorporate the following:

1. User sample

- Recommended trial size and composition:
  - the required sample size may be obtained through statistical analysis; however, as general guide, it is recommended that a sample of at least 30 people is used;
  - ii. is evenly split between male and female;
  - iii. is representative of the age profile and mobility/accessibility characteristics of the general population;
  - iv. includes a broad size range commensurate with the 5th to 95th percentile values present in the Australian population;
  - v. is representative of the travelling user population (e.g., appropriate mix of commuter, leisure traveller, family groups, etc); and
  - vi. is inclusive of any items that may be expected to be carried on board for travel (e.g., bags, laptops, weather appropriate clothing, prams, etc).
- Incentives:
  - Payment of trial users is often necessary to achieve a reasonable sample for user trials. It is important to do this in such a way that it does not bias the trial. Payment can bias responses and task performance if the user perceives that payment is linked to providing a “favourable” response or outcome.

2. Replicating the layout and context

- Validity of user testing will be improved with greater fidelity of the testing environment, although this may be matched against the scale and complexity of the proposed seating change.
- Validity is also improved by testing seats with several subjects at a time to represent sitting close to other travellers in a real-life context.
- There are four typical configurations for representing seating for user testing purposes:

a) Train moving – Fitment of seating within active rolling stock running on the network. This has the highest fidelity and validity to actual usage as it incorporates real movement, lighting, vibration, temperature and other physical characteristics.

b) Carriage mock-up (static) – Accurate physical mock-up of the carriage interior, including all appointments and seating configuration. Whilst this lacks some environmental fidelity, all other physical characteristics are well represented.

c) Seat layout mock-up – A sub-set of seats (outside of a carriage mock-up) that represent a typical configuration, where seat layout captures the key physical space and constraints to user interaction. Fidelity is higher when there are multiple seats in rows to accurately represent the space allowance and tray table/footrest where applicable.

d) Individual seat – An individual seat, removed from any other surrounding contextual features that may affect usage and comfort. This is generally not recommended, except in cases of a minor change to a seat (e.g., a modification to headrest/armrest).

- The following table provides guidance on the types of tasks/activities that are recommended to be incorporated into user trialling, and also the applicability of the different testing configuration options noted above for assessing these items. The table is a generic list of tasks that may not apply in every context; therefore consideration should be given to tasks for a specific context of use such as sleeper train, or buffet car seating etc.

Task/measure		Train (moving)	Carriage mock-up (static)	Seat layout mock-up	Individual seat
Find seat	Access carriage	1	1		
	Use handholds	1	1	2	
	Navigate to seat	1	1		
	Stow personal items (luggage, prams, cycles etc)	1	1	2	
Take seat	Access seat	1	1	2	
	Adopt comfortable posture/adjust seat	1	1	2	2
	Impacts of adjacent passengers on personal space and comfort	1	1	2	
On journey	View PIDS/Information	1	1		
	View exterior	1			
	Use personal devices	1	1	1	2
	Access power points (if fitted)	1	1		
	Adjust table (if fitted)	1	1	1	
	Interaction with other passengers	1	1	2	
	Respond to moving and dynamic environment	1			
	Assess seat comfort in typical moving conditions	1			
Seat egress	Exit seat	1	1	2	2
	Use handholds	1	1	2	
	Navigate to aisle	1	1		
	Retrieve personal items	1	1	2	
	Exit Carriage	1	1		

NOTE: 1 = Fully met; 2 = Partially met

3. Method considerations

- In general, testing should be conducted in accordance with accepted experimental design principles that aim to increase validity and remove potential sources of bias and confounding variables that could affect the validity and reliability of results.
- It is recommended to determine how the results will be assessed in advance. The default position is to compare the proposed option(s) against existing seating as baseline.
- Methodological design – Within user design is preferred, so all users test all seating conditions and every user acts as their own control. It is recommended that users be sub divided into smaller equal groups and presentation of seating conditions should be randomised to counteract any influence of presentation order for example.
- It is recommended that trial exposure duration (i.e., how long a user should remain in a seat) be determined with reference to anticipated journey length and level of comfort sought.
- Other factors affecting perceptions of comfort should be controlled. For example:
  - Seating fabric and colour
  - Lighting
  - Thermal environment
  - Excessive noise
- It is recommended that consideration be given to the overall trial duration itself, particularly accounting for the potentially negative effects of subject boredom, fatigue or dropout.

4. Measures

It is important to gather structured and repeatable subjective feedback using questionnaires, for example, to allow comparison between different seats for the same measure. This structured feedback may be augmented by more qualitative methods such as focus groups, the advantage of which is that they can provide a valuable source of unprompted and detailed feedback, however it is recommended this process is not used in isolation.
Example questionnaires for users can be found in *EuroSpec Seat Comfort Questionnaire* (2020) report. These broadly fall into two categories:

- General comfort questionnaires (further interpretation required by an SME):
  - Body part discomfort scale
  - Method CP50
  - Method localised postural discomfort
  - Red discomfort/green comfort body map
- Task/seat design aspect specific (targeted questions)
  - Task Specific Comfort Questionnaire

It is recommended to use at least one general comfort questionnaire method combined with a task specific comfort questionnaire. This permits a degree of triangulation, which should isolate any problems areas with the seat that can be addressed through redesign.

8.5.2 Utilization of off-the-shelf solutions

To adopt off-the-shelf seating based on acceptable use in a comparable context, justification of the following shall be provided:

(a) The target population is comparable in terms of the applicable physical dimensions to the population in which the off-the-shelf seating is used.

Commentary *C8.5.2*

Anthropometric data can be considered comparable when the 5th to 95th percentile adult male and adult female dimensions for the following measurements are closely comparable (i.e., less than or equal to 30 mm for length dimensions or 5 kg for weight deviation from the Australian adult data):

- seated hip breadth;
- bideltoid shoulder breadth;
- knee height (vertical distance from standing surface to knee crease);
- buttock to front of knee (sitting) length; and
- mass.

(b) The duration of travel is comparable (i.e., the typical journey length and maximum journey length are similar to those in which the off the shelf seating is used).

(c) The user demographics are comparable in terms of age profile, physical ability, general purpose of travel (e.g., comparable proportions of passengers commuting to/from work vs. holiday travel) and group size (e.g., comparable proportions of passengers travelling individually versus family groups)

(d) The activities intended to be undertaken (e.g., laptop use, sleeping, consuming meals) in the seats are comparable.

(e) Ride conditions are comparable (e.g., ride index specified in the comparable context/project and local project are in the same band/range).

(f) Suitable evidence of user satisfaction and comfort from where the off-the-shelf seating is currently used. Note that all aspects of the seating including distance to seats in front need to be identical for this to be a valid measure. Suitable evidence shall consist of:

(i) provision of the user trialling data from the original installation that demonstrates the acceptability and comfort of the seating through initial user testing. This testing shall have been undertaken in accordance with the requirements of Section 8.4.1, or other equivalent methods that are determined by a qualified human factors specialist to be suitably robust; or

(ii) conduct of user trialling meeting the requirements specified in Section 8.4.1 in situ in a train on which the seating has been installed; or

(iii) evidence of qualitative user feedback gained from customer satisfaction surveys or similar indicating the suitability and comfort of seating, supplemented by evidence that injuries/complaints/issues/concerns raised in relation to the seating are minimal and do not indicate any significant problems.

Section 9 Accelerated life cycle testing

For each passenger seat and/or appointment, the expected loads and number of cycles applied to each seat assembly, seat component or appointment over the life of the asset shall be determined by measurement and/or calculation.

Limiting criteria for component deformation shall be determined prior to commencement of testing and agreed with the end user RTO.

Commentary *C9-1*

Limiting criteria should be defined as two different sets of values:

1. The settling or scragging deformation the assembly will encounter the first time the maximum load is applied (NOTE: this can be several mm and typically for aesthetics to limit misalignment between components on adjacent assemblies); and

2. The deformation encountered on subsequent loadings (NOTE: this should be zero or as close to zero as practically measured. If not zero, then the component can be going into plastic deformation and with potential effect on fatigue life).

Accelerated life cycle testing shall be undertaken to type test the seats and/or appointments by applying these loads over the estimated number of loading cycles for the train asset life or between scheduled maintenance replacement/overhaul as applicable.

Accelerated life cycle testing shall also include testing of the mounting of the passenger seat and/or appointment to the vehicle carbody or other equipment over the asset life.

Commentary *C9-2*

Cantilevered seat arrangements are particularly prone to failure either on the seat itself, the fasteners, brackets and/or structural attachment of the vehicle carbody. This is typically a result of passenger body masses used in fatigue and load calculations not representing the actual passenger masses encountered in service.

Centre mounted pedestal seats (with reversible functionality) without a wall fixing are particularly prone to vibration issues (with or without passengers seated).

Accelerated life cycle testing shall include but not be limited to:

(a) flip-up (including wheelchair position) seat mechanisms;
(b) footrests;
(c) armrests;
(d) headrest mechanisms;
(e) reclining mechanisms;
(f) reversible seat mechanisms;
(g) seat back tables; and
(h) tip-over mechanisms.

Where the seat assembly, seat component and/or appointment is designed to be replaced and/or overhauled during the overall train asset life (e.g., seat cushion and/or cover replacement), the expected loads and number of cycles between such maintenance events shall be used for the accelerated life cycle testing.

Commentary *C9-3*

There is a clear distinction between fatigue testing and durability testing:

1. Fatigue testing is for the components expected to last the full life of the seat / train. The number of cycles is expected to be in millions and there should be a clear definition on what loads are to be applied and how on the S-N curve is calculated or tested to.

2. Durability testing is for the complete assembly but focusing on the exchangeable parts for function and aesthetics.

If any component failure or deformation exceeding set limiting values are encountered during accelerated life cycle testing, the failed or deformed component/s shall be re-designed and subject to an accelerated life cycle series of tests again until the accelerated life cycle testing meets the requirements.

The anthropometric data to be used for measurement and/or calculation shall be the iMOVE 6-002 / Australian Size Variation for Design / M004: Detailed anthropometry dataset / V2.0 – 30/06/2023 / NHS detailed anthropometry - adults 18-64 years old / 95th percentile male mass data.

Section 10 Passenger seating appointments

10.1 General

The inclusion and design of passenger seating appointments shall be based upon factors such as:

(a) duration of travel;
(b) class of travel;
(c) ergonomics;
(d) human factors;
(e) customer expectations;
(f) RTO expectations;
(g) safety; and
(h) dimensional and structural limitations.

The inclusion of appointments should be defined early in the concept design phase and should be incorporated into mock-ups and subject to user testing.

Commentary *C10.1*

Dimensional and structural limitations are the physical space allocation available for the passenger seating appointments and any structural limitations of the carbody or other attachment point.

Appointments for passenger seats relate to the user experience aspect of comfort.

The selection of appointments has the potential to enhance passenger perception of seat comfort on longer journeys but is less likely to benefit shorter journeys, and possibly impede passenger movement and train capacity.

10.2 Brackets, connection to vehicle body and fasteners

Seating and associated brackets, fasteners and body mountings, shall be in accordance with and dynamically tested to the requirements of GMRT 2100. The acceleration pulse(s) from the design collision scenarios specified in EN 15227 shall be applied in the dynamic testing.

10.3 Armrests

Armrests (if fitted) including design loads, passenger containment measures and injury minimization shall be in accordance with GMRT 2100.

10.4 Headrests

Headrests (if fitted) shall be in accordance with GMRT 2100.

10.5 Footrests

Footrests (if fitted) including design loads and injury minimization shall be in accordance with GMRT 2100.

10.6 Grab handles

Grab handles (if fitted) including design loads shall be in accordance with DSAPT, AS 7470 and GMRT 2100.

10.7 Grab poles

Grab poles (if fitted) including design loads shall be in accordance with DSAPT, AS 7470 and GMRT 2100.

10.8 Seat mechanisms

Seat mechanisms shall be in accordance with AS 7470.

Seat mechanisms (excluding tip-over seat mechanisms) shall be in accordance with GMRT 2100.

10.9 Tables

Tables (if fitted) including design loads and injury minimization shall be in accordance with GMRT 2100.

Seat back fitted drop down tables should:

(a) have orientation and sufficient dimension to allow for placement of a portable electronic device (e.g., laptop computer, tablet, etc);

(b) maintain the table stowed in an upright position unless deployed;

(c) include a raised edge to minimize the potential for a food or drink accidental spillage during normally experienced train forces;

(d) include a recessed circular region for locating cups or drinks.

10.10 Coat hooks

Coat hooks (if fitted) including design loads and injury minimization shall be in accordance with GMRT 2100.

10.11 Seat power outlets and infotainment systems

Seat power outlets and infotainment systems (if fitted) shall be in accordance with AS 7530.

Section 11 Safety in design

Interior passive safety for passenger seats and internal appointments shall be in accordance with GMRT 2100.

Passenger personal safety including normal access and emergency egress shall not be inhibited or decreased from the design and installation of the passenger seats and appointments.

The passenger seating areas shall exclude slip, trip and fall hazards.

Passenger seats and appointments shall be designed to eliminate potential personal injury points to all passengers including children, toddlers and babies such as but not limited to:

(a) sharp edges;

(b) pinch points;

(c) trapping of fingers or other body parts;

(d) strain injury from normal operation; and

(e) electric shock from any seat mounted power equipment.

Passenger seats and appointments shall be designed to minimize potential personal injury points to crew, cleaning and maintenance staff including but not limited to strain injury from seat adjustments and seat orientation/direction changes.

The design of passenger seats and appointments shall minimize the risk of retention of objects (e.g., needles and other sharps) causing injury to passengers, cleaning staff or maintenance staff.

The space underneath the passenger seats shall be clearly visible or fully enclosed.

Section 12 Vandalism resistance and cleaning

Passenger seats and appointments including the materials and finishes shall be resistant to vandalism but not limited to:

(a) cutting and tearing of seat covers and cushions;

(b) partial or complete removal of components;

(c) malicious tampering of components and other moveable components;

(d) vandalism resulting in a potential safety hazard;

(e) scratching and scribing damage and/or graffiti using a knife or similar sharp item;

(f) permanent marker graffiti;

(g) painted graffiti;

(h) chemical graffiti;

(i) liquids;

(j) human waste; and

(k) fire and other heat sources.

For potential failure modes that can be subject to malicious loadings (e.g., tables, seat backs, tip-over/tip-up mechanisms), the design should minimize the potential for failure in an un-safe condition.

The passenger seats and appointments manufacturer shall advise a list of suitable graffiti removal chemicals, cleaning chemicals and techniques and provide a declaration of chemical compatibility with test results against the actual material for verification. Chemicals currently used by the RTO/maintainer for these purposes should be compatible for use on the passenger seats and appointments unless specifically excluded as being incompatible.

The passenger seats and appointments shall not be affected by the repeated application of graffiti removal chemicals and techniques, other standard non-hazardous cleaning chemicals and techniques, or combinations of these cleaning agents and techniques.

Graffiti removal and cleaning chemicals and agents shall not decrease the fire resistance or other fire properties of the materials.

The passenger seats and appointments shall minimize visible screws or gaps and prevent vandals from removing equipment or accessing areas behind panelling or covers. Where fasteners are accessible by the public, fasteners shall be tamper-proof, security fastener type.

Anti-graffiti coatings should be applied to surfaces to make it easier to remove graffiti or other markings by creating a protective barrier that prevents paint and other substances from adhering to the surface.

The passenger seats and appointments shall be designed and installed to facilitate the rapid remediation, repair and restoration and in-service maintenance of any passenger accidental occurrences (e.g., liquid spills, human waste, etc), vandalism and/or graffiti incidents.

Commentary *C12*

A Standard that can be referenced is NF F31-112, *Railway rolling stock - Protection in relation to graffiti - Tests procedures and methods of valuation, behaviour of materials and products of expulsion*.

Section 13 Maintenance

Human factors requirements for seat maintenance, repair, installation and replacement shall be evaluated and included in the HFIP.

Removal and replacement of seat and appointment assemblies shall be via the existing train internal and external doorways. The removal of windows or other items shall not be required to replace seats or appointments.

Spare parts across different seat type configurations on the same fleet should be designed for compatibility to minimize the RTOs spare parts inventory.

The passenger seat and appointments manufacturer/supplier shall develop and provide to the RTO/maintainer:

(a) a technical maintenance plan;

(b) individual comprehensive instructions detailing all maintenance and repair/replacement tasks;

(c) component/assembly masses and safety requirements for material handling;

(d) comprehensive spare parts manual;

(e) maintenance training package;

(f) recommended spare part types and quantities to be held by the RTO/maintainer;

(g) list of suppliers, contact details and address for all components;

(h) a list of special tools; and

(i) recommended cleaning (including for vandalism) and repair procedures and chemicals.

The technical maintenance plan schedules shall align with the overall technical maintenance plan schedules for the rolling stock.

The seats and appointments shall allow for in train replacement of items such as:

(j) seat fabric/covers;

(k) seat cushions and squabs;

(l) reclining mechanisms;

(m) tables;

(n) tip-up and tip-over mechanisms;

(o) footrests;

(p) headrests;

(q) armrests;

(r) grab handles; and

(s) grab poles.

Section 14 Environmental management systems and sustainability

Environmental management systems (EMS) for the design, manufacture, maintenance, disposal and end of asset life recycling capability should comply with the relevant requirements of the organisation procuring the passenger seats and appointments (which may be part of a whole of train procurement).

The EMS should evaluate and minimize environmental impact over the whole lifecycle of the asset for:

(a) energy use and greenhouse gas emissions in manufacture;

(b) energy use and greenhouse gas emissions in transportation;

(c) materials and waste;

(d) pollution control; and

(e) end of asset life disposal and recycling.

Local (in-country) manufacturing and/or assembly should also be assessed as part of the EMS.

Commentary *C14*

EMS elements can include management plans, procedures and protocols, checklists, training and awareness programs. The EMS should be appropriate to the scale, nature and impacts of the project activities. Any documents incorporated into the EMS need to be concise and practical for the intended user (contractors, subcontractors and workforce).

Depending on the environmental issues, risks and client (user) requirements, the EMS can be certified as consistent with standard AS/NZS ISO 14001. The EMS may also form part of a broader integrated management system, which can cover other aspects including safety and quality. Ensuring the head contractor's EMS is certified is considered good practice. This facilitates setting and achieving of objectives and targets and allows risk and opportunities assessments of key elements of an EMS.

A full description of the requirements of an EMS is described in AS/NZS ISO 14001.

For further guidance on EMS and sustainability, refer to:

- RISSB Requirements for the Procurement of Rolling Stock Guideline; and
- Australasian Railway Association - Sustainability Guide

Appendix A Passenger comfort options (Informative)

The tables in this appendix provide guidance for the seat designs to incorporate enhanced passenger comfort.

Appendix Table A-1 Comfort

Transit distance	Short	Medium	Long
Train type	Metro/suburban	Outer suburban/regional	Regional/intercity
Seat width between armrests (Transverse)	460 ~ 503 mm	503 ~ 524 mm	525 mm
Seat width (Longitudinal)	556 ~ 560 mm	561 ~ 565 mm	566 mm
Seat height	440 mm	440 mm	440 mm
Seat depth	435 mm	435 mm	435 mm
Armrest height	240 mm (Fixed)	230 ~ 240 mm (Adjustable)	185 ~ 285 mm (Adjustable)
Backrest width	533 ~ 540 mm	541 ~ 548 mm	>549 mm
Underside headrest to seat	670 mm	570 ~ 670 mm (Adjustable)	540 ~ 670 mm (Adjustable)
Point of contact - Nape of neck	590 ~ 756 mm (Fixed)	590 ~ 756 mm (Adjustable)	590 ~ 756 mm (Adjustable)
Angle of seat	(-12) ~ (-15) deg	(-6) ~ (-15) deg	(-6) ~ (-20) deg
Angle between seat and back	100 ~ 105 deg	95 ~ 105 deg	95 ~ 120 deg
Legroom - Normal arrangement (Transverse)	731 ~ 765 mm	766 ~ 800 mm	>800 mm
Legroom - Bay seating arrangement (Transverse)	1,461 ~ 1,530 mm	1,531 ~ 1,600 mm	>1,600 mm
Clearance under table	N/A	650 mm	650 mm

Appendix Table A-2 Features

Transit distance	Short	Short	Medium	Long
Train type	Metro	Suburban	Outer Suburban/regional	Regional/intercity
Seat configuration	Longitudinal/transverse	Longitudinal/transverse	Transverse	Transverse
Seat type	Low back	Low back	Medium or high back	High back
Seat spacing or pitch	Minimum	Minimum	Medium	Medium to wide
Armrest	Optional	Optional	Recommended	Recommended
Headrest	Not recommended	Optional	Recommended	Recommended
Footrest	Not recommended	Not recommended	Recommended	Recommended
Flip down table	Not recommended	Not recommended	Recommended	Recommended
Rear seat storage pocket	Not recommended	Not recommended	Optional	Recommended
Cup holder	Not recommended	Not recommended	Optional	Recommended
Integrated power sockets	Not recommended	Not recommended	Optional	Recommended
Coat hook	Not recommended	Optional	Recommended	Recommended

Appendix B Passenger seat and appointment type examples (Informative)

The images in this appendix show example passenger seat and appointment types typically used in the Australian and New Zealand rail industry.

Appendix Figure B-1 Example longitudinal seating – metro

Appendix Figure B-2 Example longitudinal seating vestibule – heavy rail

Appendix Figure B-3 Example wheelchair flip-up longitudinal seating – heavy rail

Appendix Figure B-4 Example wheelchair flip-up longitudinal seating – heavy rail

Appendix Figure B-5 Example wheelchair flip-up longitudinal seating – light rail

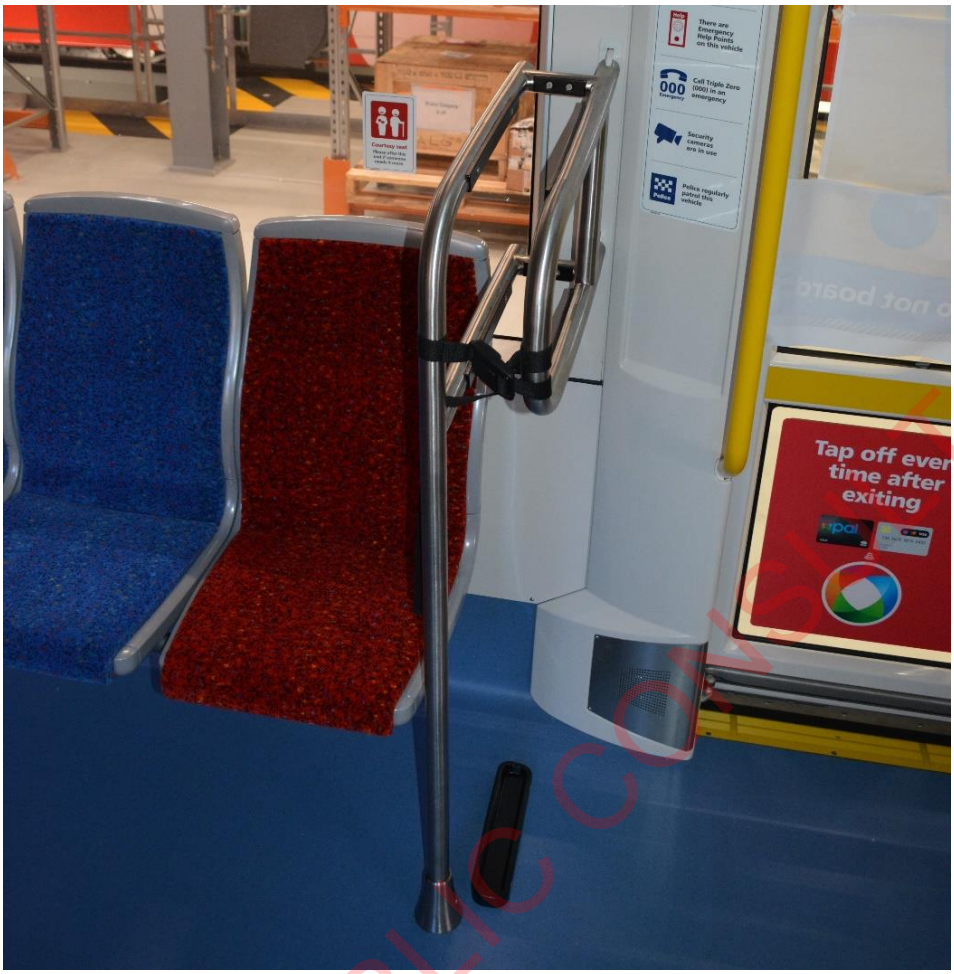
Appendix Figure B-6 Example tip-over transverse seating – short distance train

Appendix Figure B-7 Example single tip-over transverse seating – short distance train

Appendix Figure B-8 Example tip-over transverse seating – medium distance train

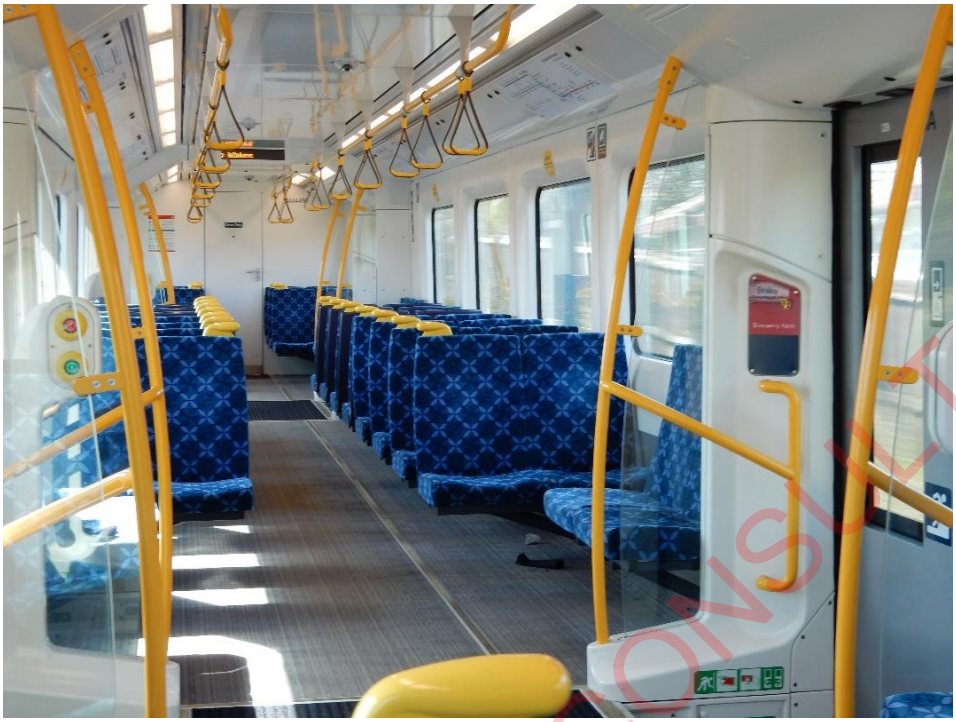
Appendix Figure B-9 Example single transverse seat – light rail

Appendix Figure B-10 Example priority seat – heavy rail

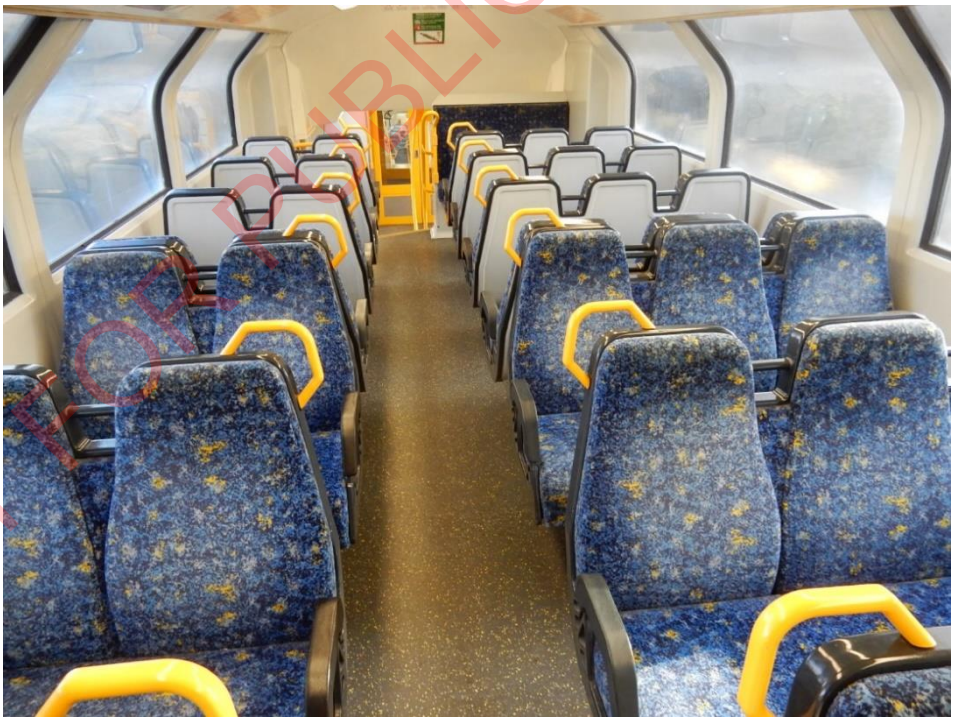


Appendix Figure B-11 Example priority seat – light rail

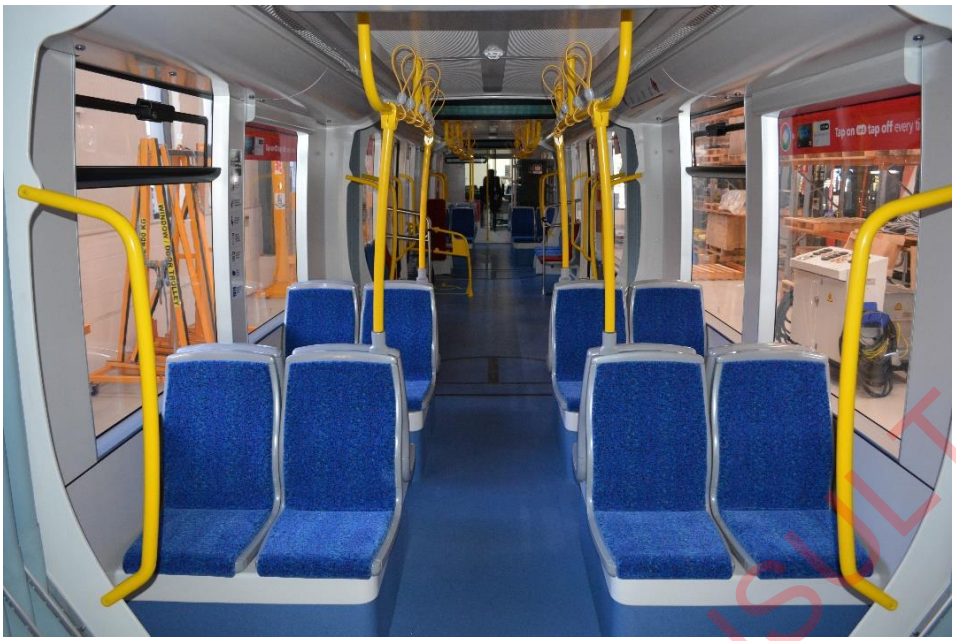
Appendix Figure B-12 Long distance train seating



Appendix Figure B-13 Example fixed transverse seating – heavy rail



Appendix Figure B-14 Example fixed transverse seating – heavy rail



Appendix Figure B-15 Example fixed transverse seating – light rail

Appendix Figure B-16 Example headrest – medium distance train

Appendix Figure B-17 Example headrest – long distance train

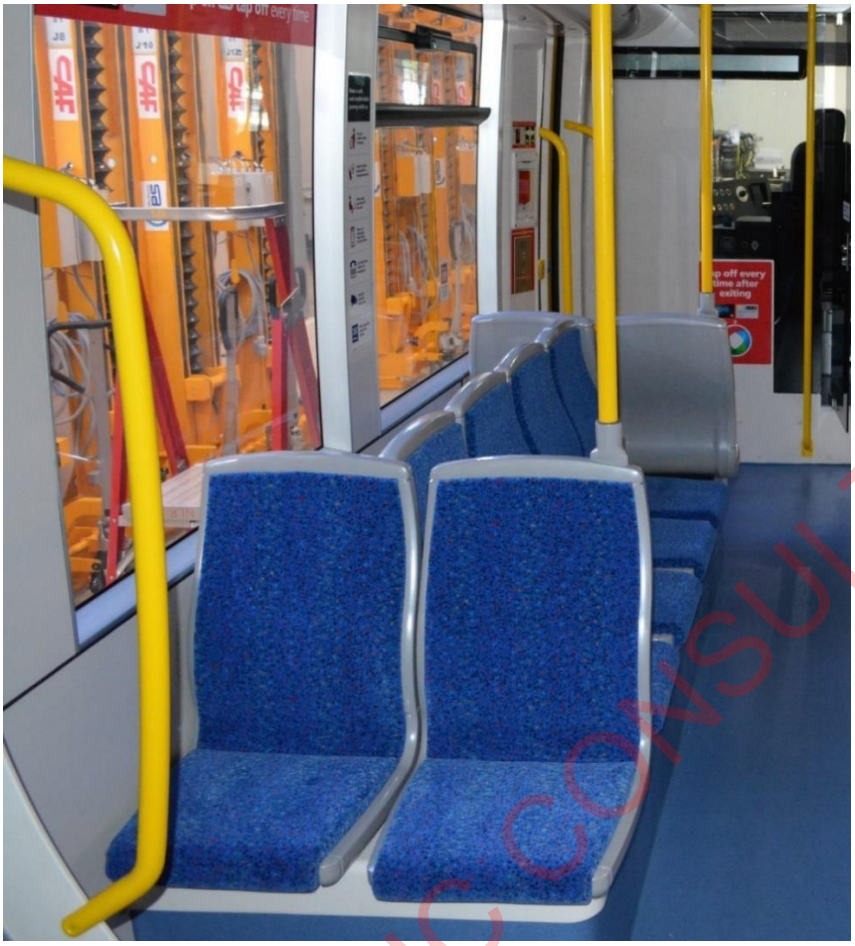
Appendix Figure B-18 Example footrest – medium distance train

Appendix Figure B-19 Example armrest 1

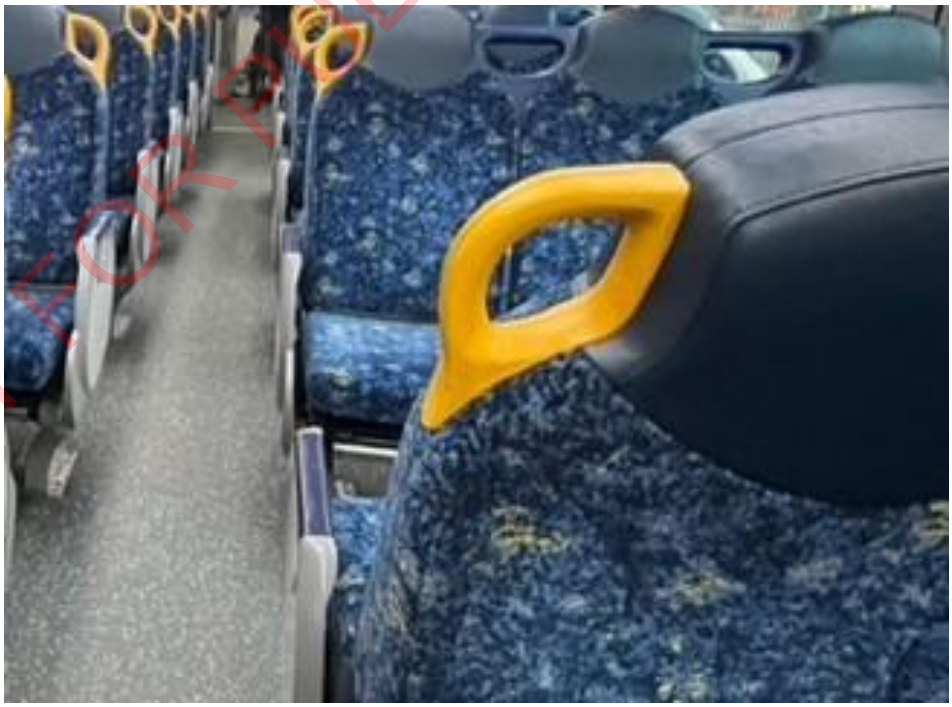
Appendix Figure B-20 Example armrest 2

Appendix Figure B-21 Example armrest 3

Appendix Figure B-22 Example armrest – long distance train

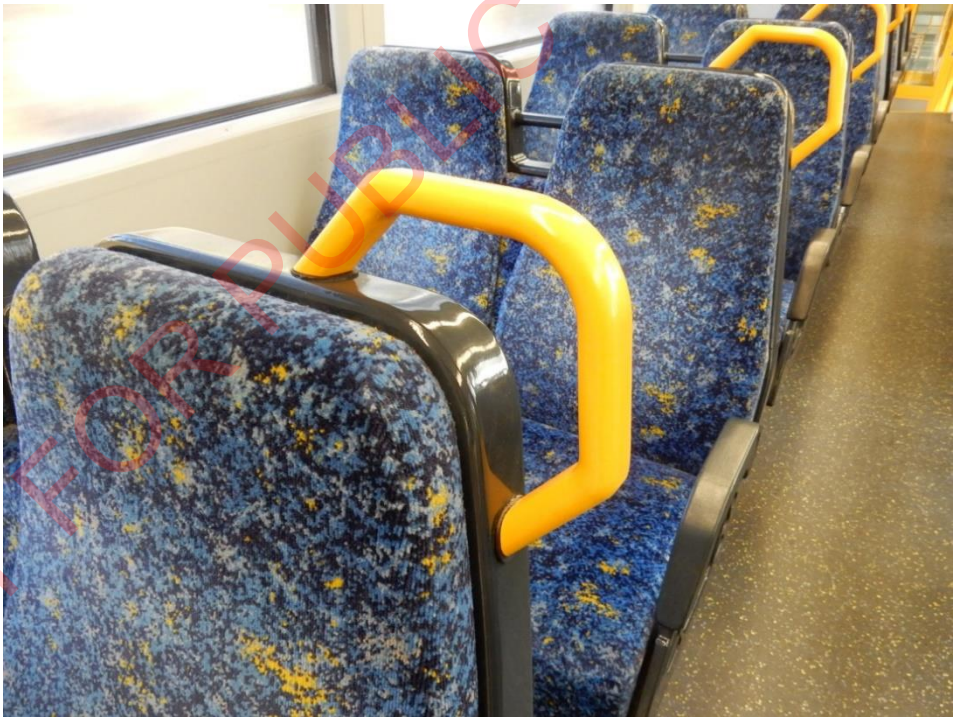


Appendix Figure B-23 Example grab pole



Appendix Figure B-24 Example seat back grab handle

Appendix Figure B-25 Example seat back grab handle



Appendix Figure B-26 Example seat back grab handle

Appendix Figure B-27 Example seat recliner actuator

Appendix Figure B-28 Example reversible seat mechanism

Appendix C Hazard register (Informative)

Hazard Number	Hazard
5.44.1.1	Impact with interior surfaces (Impact caused by excessive accelerations)
5.44.1.28	Body parts being hit on protruding interior features (Person inside train - Impact with part of train)
7.2.1.10	Harm to Persons - Human Factors - Vandalism
7.2.1.13	Harm to Persons - Human Factors - Poor ergonomic design
5.3.1.3	Harm to persons - Derailment or Collision, Human Error, Track Failure, Design Failure, Health, Organisational SMS Failure, Security Breaches, Loads not Secure and or Vandalism - Bodily impact
5.3.1.4	Harm to persons - Derailment or Collision, Human Error, Track Failure, Design Failure, Health, Organisational SMS Failure, Security Breaches, Loads not Secure and or Vandalism - Trips and falls
5.3.1.15	Harm to persons - Derailment or Collision, Human Error, Track Failure, Design Failure, Health, Organisational SMS Failure, Security Breaches, Loads not Secure and or Vandalism - Sharp edges, burrs or cuts
5.3.1.16	Harm to persons - Derailment or Collision, Human Error, Track Failure, Design Failure, Health, Organisational SMS Failure, Security Breaches, Loads not Secure and or Vandalism - Rotating or moving parts or cuts
5.3.1.44	Harm to persons - Derailment or Collision, Human Error, Track Failure, Design Failure, Health, Organisational SMS Failure, Security Breaches, Loads not Secure and or Vandalism - Back pain / musculoskeletal injury due to inadequate seating

Appendix D Bibliography (informative)

The following referenced documents are used by this Standard for information only:

- AS 7520.3, *Australian Railway Rolling Stock - Body Structural Requirements, Part 3: Passenger Rolling Stock*
- ISO 14001, *Environmental Management Systems*
- NF F31-112, *Railway rolling stock - Protection in relation to graffiti - Tests procedures and methods of valuation, behaviour of materials and products of expulsion*
- Australasian Railway Association – *On Track to a Sustainable Future*
- *EuroSpec Seat Comfort Questionnaire*, 2020
- RISSB Guideline – *Integration of Human Factors Across the Project Lifecycle*
- RISSB Guideline – *Integration of Human Factors in Engineering Design*
- RISSB Guideline – Requirements for the Procurement of Rolling Stock