Rail Industry Guidance Note
GMGN2696
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Assessment of Passenger Seat Comfort

Synopsis

This document gives guidance on the assessment of static comfort for passenger seats on rolling stock. It includes criteria to measure aspects of a passenger seat including dimensions, pad thickness and compressibility to enable quantification of comfort. This document also includes information on the seats' durability, appearance, accessories, pressure map, hardness, and contour.

Published by RSSB

Issue record

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One	June 2023 [proposed]	Original document.

Superseded documents

This standard does not supersede any other Railway Group documents.

Supply

The authoritative version of this document is available at www.rssb.co.uk/standards-catalogue. Enquiries on this document can be submitted through the RSSB Customer Self-Service Portal https://customer-portal.rssb.co.uk/

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Part 1 Purpose and introduction

1.1 Purpose

1.1.1 This document gives guidance on the assessment of static seat comfort for passengers on railway vehicles. This document does not set out requirements.

1.2 Background

1.2.1 RSSB Research Project T1140 (2019) was delivered by the Furniture Industry Research Association (FIRA) and Arup. The project contained information for measuring and scoring dimensions for features on passenger seats to quantify a measure of static comfort to enable comparison and inform decision-making on seat procurement.

1.2.2 Commitment 41 in the the Williams-Shapps Plan for Rail, published in May 2021, is as follows:

> 41. Trains will be made more pleasant to travel on and easier to work aboard. Because the emphasis was on carrying more passengers, recent designs of new trains have compromised on passenger comfort, with hard seats in close configuration and features such as tables no longer commonplace. In this new era, where more travel is likely to be discretionary, the railways will have to do more to satisfy their passengers. Great British Railways will introduce new design and ride standards that will make sure all new trains are more comfortable than their predecessors. Subject to negotiations with suppliers and business case approval, Great British Railways will bring forward the normal replacement cycles on existing trains equipped with "ironing-board"-like seats, beginning with long-distance trains, in order to make the seats significantly more comfortable, or to replace and eventually remove them altogether.

1.2.3 This guidance note gives information that is intended to support Railway Undertakings and train manufacturers in assessing the static comfort for passenger seats as part of a new build or refurbishment of passenger railway vehicles.

1.2.4 Requirements for passenger seat design are set out the following National Technical Specification Notices (NTSNs):

a) Locomotive and Passenger (LOC&PAS NTSN)
b) Persons of Reduced Mobility (PRM NTSN) .

1.2.5 Requirements related to vehicle fire safety which includes design are set out in:

a) GMRT2130
b) RIS-2730-RST
c) BS EN 45545 (There are five parts in the BS EN 45545 series of Euronorms. BS EN 45545-2 sets out requirements that are relevant for seats.)
d) BS EN 16989:2018.

1.2.6 Requirements related to the structural performance of seats are set out in GMRT2100 Rail Vehicle Structures and Passive Safety. An ISO document containing requirements for the structural performance of seats is being developed by ISO/TC 269/SC 3/WG 6.

1.2.7 Additional information relating to railway passenger seats can be found in the Key Train Requirements (KTR) document published by the Rail Delivery Group (RDG).

1.3 Health and safety responsibilities

1.3.1 Users of documents published by RSSB are reminded of the need to consider their own responsibilities to ensure health and safety at work and their own duties under health and safety legislation. RSSB does not warrant that compliance with all or any documents published by RSSB is sufficient in itself to ensure safe systems of work or operation or to satisfy such responsibilities or duties.

1.4 Structure of this document

1.4.1 Guidance is provided as a series of sequentially numbered clauses.

1.5 Approval and authorisation of this document

1.5.1 The content of this document will be approved by Rolling Stock Standards Committee on 9 March 2023 [proposed].

1.5.2 This document will be authorised by RSSB on 28 April 2023 [proposed].

Part 2 General guidance

2.1 Seat comfort score calculation

Guidance

G 2.1.1 The objective of scoring a seat design based on the sum of its features is to enable quantitative comparison between different seat designs. This was set out as a core principle in T1140.

G 2.1.2 Since the implementation of T1140, feedback has been received to enable changes to be made to the initial methodology.

G 2.1.3 Figure *1* shows the expected range of scores for comfort ratings based on the type of passenger rolling stock operation taken from T1140. Note that the values set out are not absolute and they can be adjusted to suit the operation and purpose of the rolling stock and procurer's specifications.

G 2.1.4 T1140 concluded that reduced seat comfort would be acceptable for short range journeys such as metro systems while passengers will expect higher levels of seat comfort for first class and high speed inter-city services.

Figure 1: Expected range of scores for seats from T1140

G 2.1.5 The comfort levels for the static assessment of passenger seats can be compared using the method set out in this Guidance Note as shown in Table *1*.

Category	Score	Reference
Seat dimensional features	X	*Part 3*
Seat pad and backrest pad thickness	Y	*Part 4*
Seat compression	Z	*Part 5*
Total score	X +Y + Z	-

Table 1: Seat comfort score calculation

G 2.1.6 The methods to determine the scores for the seat dimensional features, seat pad and backrest pad thickness, and seat compression are set out in each respective part of this Guidance Note.

G 2.1.7 Other criteria such as seat durability, appearance, and accessories do not form part of the overall seat comfort score so they are contained in Appendix *A*, Appendix *B*, and Appendix *C*, respectively.

G 2.1.8 *Part 3* sets out the following criteria for assessing comfort based on the seat's dimensional features:

a) Seat height*
b) Seat depth*
c) Seat width and gap between armrests
d) Backrest
e) Armrest height
f) Underside of headrest to seat
g) Angle of seat
h) Angle between seat and back
i) Legroom
j) Bay seating arrangement
k) Clearance under tablet*
l) Tablet depth

Note: *Numerical values for seat criteria are provided for the purposes of scoring seat comfort. Seat height, seat depth, and clearance under tablet are not scored, see Table *2*.

G 2.1.9 Seats that do not meet the dimensional criteria for seat height and / or depth are deemed to not be comfortable. If this were to occur, comfort scores based on other criteria can still be undertaken for informative purposes only.

G 2.1.10 *Part 4* gives criteria for the measurement and scoring of the thickness of the seat pad and back pad, respectively.

G 2.1.11 *Part 5* gives criteria for the measurement and scoring for the compressibility for the seat pad and back pad, respectively.

G 2.1.12 The maximum possible score from each seat dimension assessment is shown in Table *2*.

Dimension	Score
Seat height	-
Seat depth	-
Seat width and gap between armrests	9
Backrest	10
Armrest height	8
Underside of headrest to seat	4
Angle of seat	8
Angle between seat and back	12
Legroom	8
Bay seating arrangement	6
Clearance under tablet	-
Tablet depth	5
Total	**70**

Table 2: Maximum possible scores for seat dimensions

G 2.1.13 The maximum possible score from the seat thickness tests are shown in Table *3*.

Thickness	Score
Seat pad	5
Seat back	5
Total	**10**

Table 3: maximum possible scores for seat thickness

G 2.1.14 The maximum possible score from the seat thickness tests are shown in Table *4*.

Compressibility	Score
500 N	10
1100 N	10
Total	**20**

Table 4: Maximum possible scores for seat compressibility

G 2.1.15 The sum of scores from all three tables gives a maximum score of 100.

G 2.1.16 The overall scores can be revised in the seat specification to take account of features that have been omitted from the seat.

G 2.1.17 For example, if seats do not come equipped with tablets, then the overall maximum score is 95.

G 2.1.18 A percentage-based scoring system can be used.

2.2 Chair measurement device

Guidance

G 2.2.1 To accurately measure the seats under load, a weighted chair measurement device (CMD) is used, in accordance with ISO TR 24496:2017.

G 2.2.2 The CMD has been used to measure chair dimensions for office seating and provides a robust and accurate method of measuring seats because it replicates the weight distribution of a human being and provides adjustable seat and back panels with integrated measurement rules to provide accurate measurements.

G 2.2.3 A CMD can be used to verify the seat dimensions as part of the verification process for the overall seat comfort score.

G 2.2.4 An example of a CMD is shown in Figure *2*.

Figure 2: Example of a CMD used by FIRA

2.3 Comfort categories

Guidance

G 2.3.1 The seat and its immediate surroundings are the parts of the rail vehicle with which the passenger is in physical contact for a large percentage of the journey time. Therefore, the comfort provided by the seat contributes a significant part of the passenger's perception of the journey's quality. In this context it is convenient to define seat 'comfort' in the following categories and using appropriately derived measures as shown in Table *5*.

Comfort Category	Description
Postural	This is characterised by a set of data including the contours, dimension, angles, adjustments, deflections and seat features (armrests etc). It also permits the passenger to relax the muscles in parts of their body such as legs, arms, neck and spine during the journey.
Sensory	When the human body is sitting, a range of sensory receptors allows it to distinguish various types of mechanical forces measured by the response to pressure. The pressure between the occupant and the seat and the corresponding local hardness of the seat, or feature of the seat, are important measures in the occupant's perception of comfort.
Ride	This is characterised by measures that isolate the passenger from shocks and movements generated by the vehicle's motion. (This guide only currently considers static comfort, other measures may be incorporated at a later date).
Visual	It has long been recognised that 'design influences emotion' and in this regard the design of the seat and its surroundings will significantly influence a passenger's perception of the quality of the journey.

Table 5: Categories of comfort

G 2.3.2 For this guidance note, the criteria set out in *Part 3* relate to postural comfort as the seat design affects how the passenger is positioned within the seat.

G 2.3.3 Aspects of sensory comfort are covered in *Part 4* and *Part 5* as these affect how the passenger's load is transferred to the seat pad and seat back.

G 2.3.4 Factors relating to dynamic ride comfort such as vibration dosage and accelerations are not set out in this document. Additional research outputs may be included in this document as part of a future revision.

G 2.3.5 Aspects of visual comfort are covered in Appendix *B* which set out guidance on how passengers' visual perception of seat comfort can be quantified.

G 2.3.6 Additional information on other factors that can affect passenger seat comfort are set out in Appendix *D*. The appendix includes information on:

a) Seat pressure mapping
b) Seat hardness and measurement
c) Seat contour.

Part 3 Seat comfort assessment - dimensions

3.1 Seat height (loaded)

Guidance

G 3.1.1 Figure *3* shows dimension A which is the measurement of the vertical distance from the vehicle floor to the top of the seat surface with a simulated seated passenger.

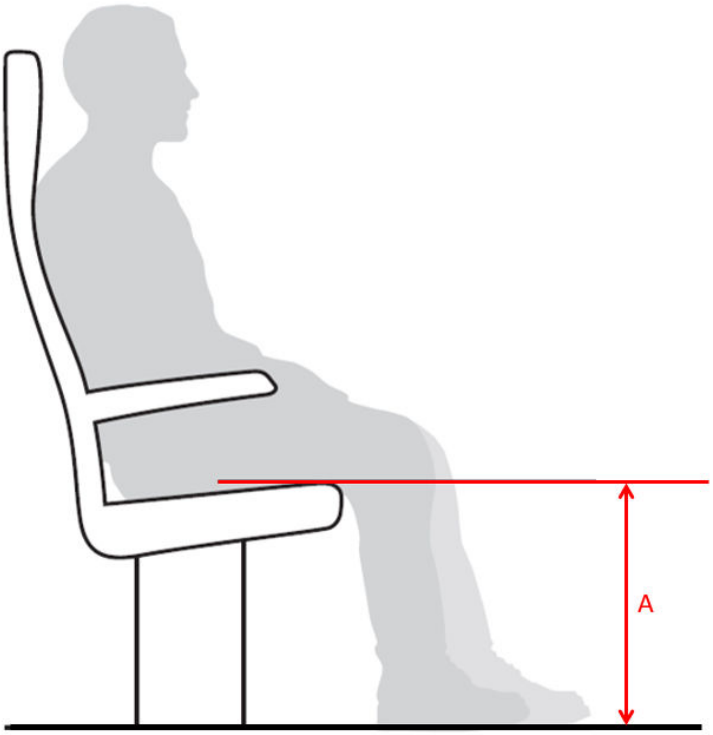

Figure 3: Dimension A - Seat height (loaded)

G 3.1.2 A target value of the the loaded seat height is 440 mm ±10 mm above the floor level of the rail vehicle is set.

G 3.1.3 The dimension measures the vertical distance from the footrest surface to the lower surface of the thigh immediately behind the knee, bent at right angles.

G 3.1.4 The PRM NTSN gives a range of values for priority seats to have a height of 430 - 500 mm above vehicle floor level.

G 3.1.5 A value that is too high will reduce the blood flow to the feet causing pins and needles or numbness if the passenger remains seated for extended periods of time.

G 3.1.6 Stretching of legs to 30˚ can enable tall users to sit comfortably.

G 3.1.7 Using 5th percentile female dimension results in seats that are too low for all men and 95 % of women.

G 3.1.8 The dimension for comfort is based on the dimensions of the 50th percentile female.

G 3.1.9 The measurement undertaken includes the vertical distance, measured at the front of the seat, from the loaded seat to the floor.

G 3.1.10 The directions are: Measure the seat height as the vertical distance from the loaded seat to the floor, as shown in Figure 4. The measuring scale is placed through the seat height slot of the CMD at the front of the seat.

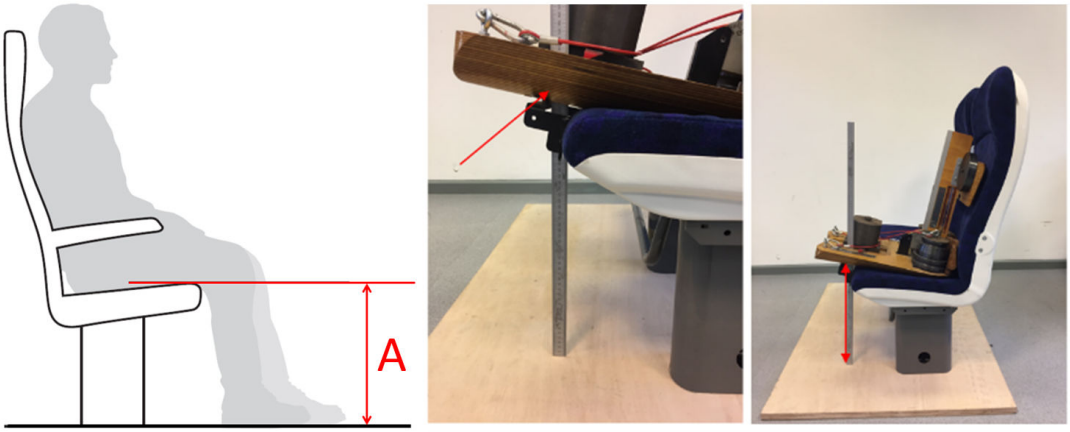

Figure 4: Seat height (loaded) - Measurement method

3.2 Seat depth

Guidance

G 3.2.1 Dimension B in Figure *5* shows the dimension for the buttock - popliteal length as set out in BS EN ISO 7250-1:2017, clause 6.4.7.

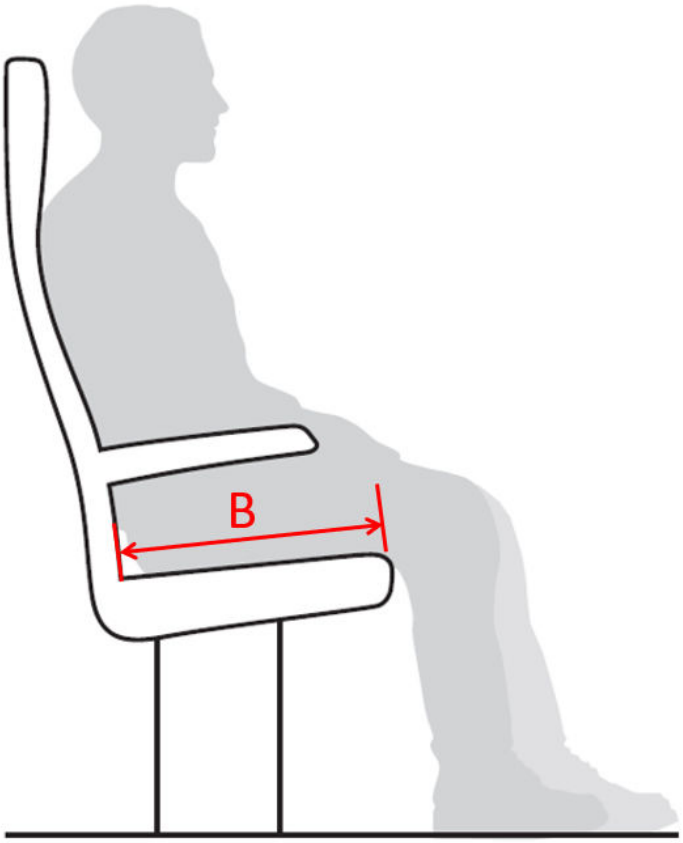

Figure 5: Seat depth - Dimension B

G 3.2.2 The seat depth measures the horizontal distance from the hollow of the knee to the rearmost point of the buttock.

G 3.2.3 It is good practice for the seat depth value to be 435 mm ±10 mm.

G 3.2.4 Seats with a seat depth value outside of this range are deemed to be uncomfortable.

G 3.2.5 If the seat is too deep, people with smaller statures will not be able use the backrest; this can cause slouching which can lead to backache.

G 3.2.6 This dimension is based on German Anthropometric data PD CEN/ISO TR 7250-2:2011+A1:2013 for a 5th percentile female.

G 3.2.7 To measure the seat depth using a CMD, read the scale for the distance from the backrest line measured parallel to the CMD buttocks pad to the front of the seat indicated by the red lines as shown in Figure *6*.

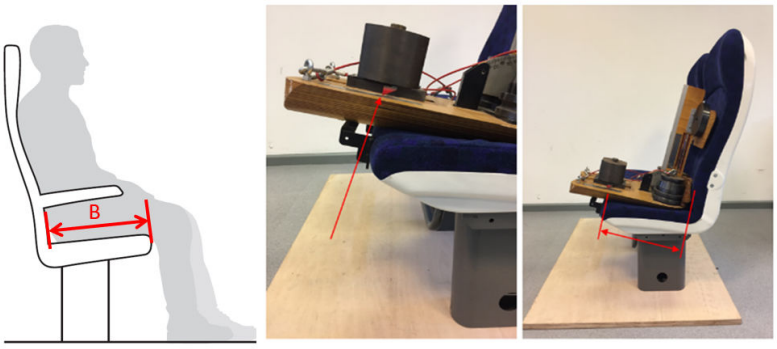

Figure 6: Seat depth - Measurement

3.3 Seat width and gap between armrests

3.3.1 Seats with armrests

Guidance

G 3.3.1.1 Figure *7* shows the dimension C1 for the gap between armrests for seats while dimension C2 shows the dimension for the seat width.

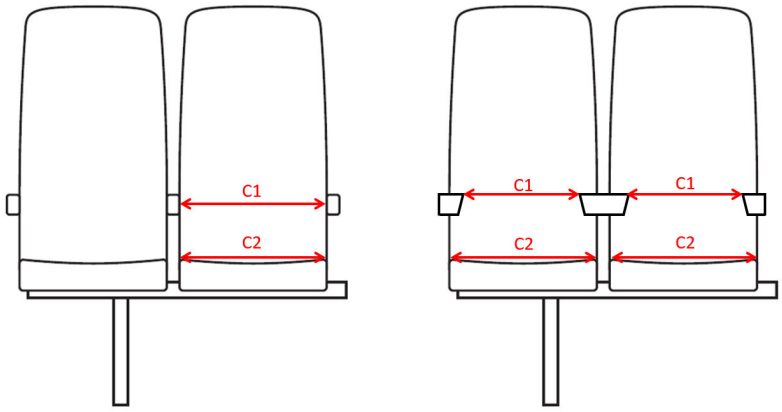

Figure 7: Gap between armrests - Dimension C

G 3.3.1.2 For seat designs where the inside edge of the armrests are aligned with the edge of the seat pad, then dimensions C1 and C2 will have the same value.

G 3.3.1.3 The gap between armrests is defined as the hip breadth when seated, as set out in BS EN ISO 7250-1, clause 6.2.10.

G 3.3.1.4 This dimension is measured across the widest portion of the hips and it is good practice for it to be large enough to allow persons with wide hips to move across the arm rests.

G 3.3.1.5 The scores for the gap between armrests for seats are shown in Table *6*.

Dimension (mm)	<440	440 - 459	460 - 503	504 - 524	>525
Score	0	2	9	8	7

Table 6: Scores for the gap between armrests

G 3.3.1.6 In general, female hip dimensions are wider than for the equivalent sizes male; the dimensions in Table *6* are therefore based on female measurements.

G 3.3.1.7 The gap between armrests is the minimum horizontal distance between armrest assembly from the rear of the seat surface width zone forward to the front edge of the armrest or armrest assembly as measured above the top of the seat surface.

G 3.3.1.8 Using callipers, measure the smallest horizontal distance between the armrests as shown in Figure *8*. This can be used for all seats with arms including linear seats.

Figure 8: Seat width measurement

3.3.2 Seats without armrests

3.3.2.1 Seats with spacers in between

Guidance

G 3.3.2.1.1 Figure *9* shows dimension D1 as the seat width for seat assemblies without armrests, but with spacers in between.

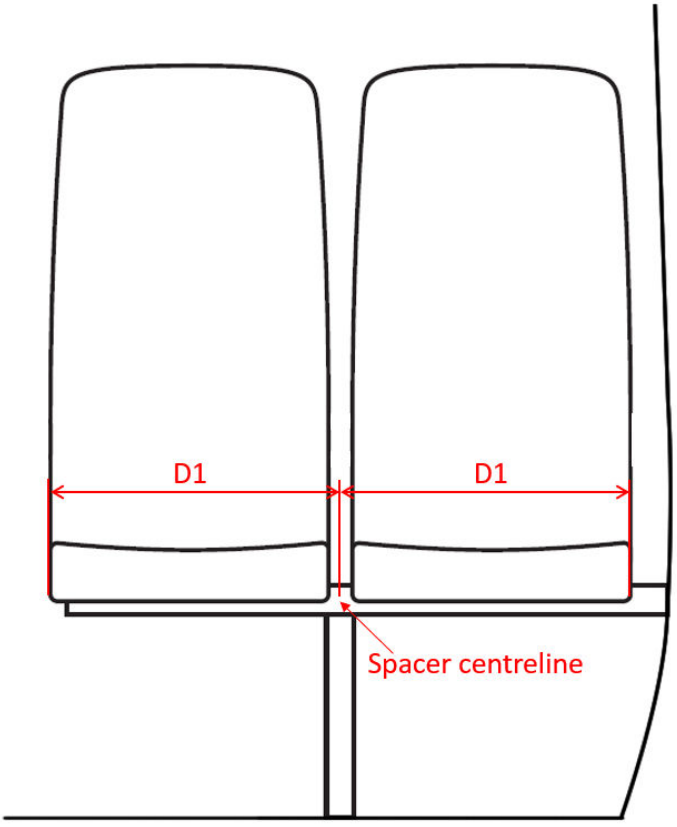

Figure 9: Seat width - with spacers - Dimension D1

G 3.3.2.1.2 Figure *9* includes the illustration of the vehicle wall to show that passengers sitting next to the vehicle wall do not have usable space on that side of the seat hence the justifying the measurement of dimension D1 up to the edge of the seat pad only.

G 3.3.2.1.3 The scores for seats without armrests are set out in Table *7*.

Dimension (mm)	<440	440 - 459	460 - 503	504 - 524	>525
Score	0	1	4.5	4	3.5

Table 7: Scores for the gap between armrests

G 3.3.2.1.4 Seats without armrests are less comfortable compared to seats with armrests so the scores are halved.

G 3.3.2.1.5 The measurement is undertaken from the centreline of the central spacer on side of the seat, to the edge of the seat pad.

3.3.2.2 Seats without spacers in between

Guidance

G 3.3.2.2.1 Figure *10* shows dimension D2 as the seat width for seat assemblies without spacers in between.

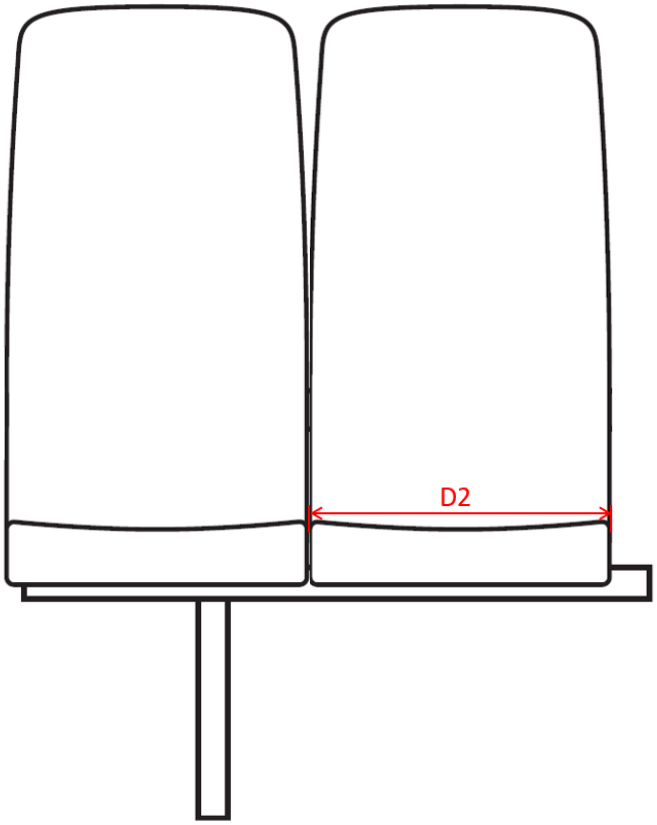

Figure 10: Seat width - without spacers - Dimension D2

G 3.3.2.2.2 The scores for seats without armrests and spacers are set out in Table *7*.

G 3.3.2.2.3 The measurement is undertaken from the edge of one seat to its other edge.

3.4 Backrest

Guidance

G 3.4.1 The dimension for the seat's backrest is shown in Figure *11* as Dimension E.

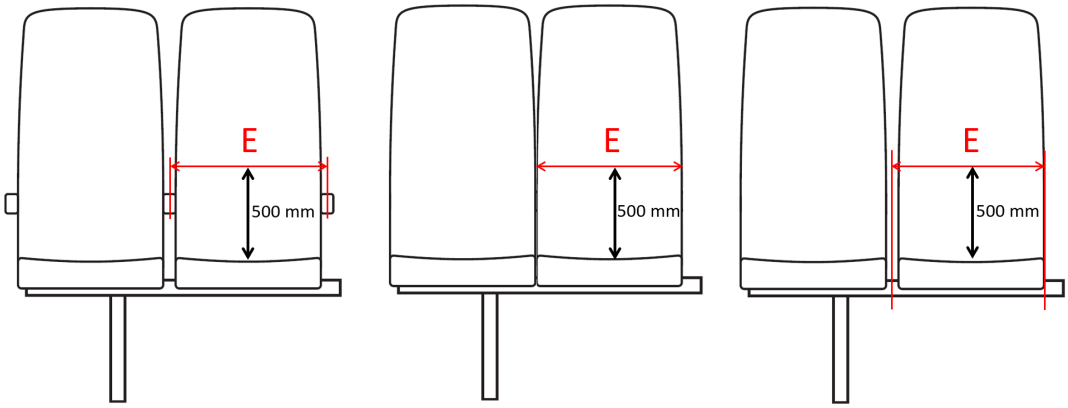

Figure 11: Backrest - Dimension E

G 3.4.2 It is good practice for the backrest's minimum value to be 525 mm.

G 3.4.3 The range of scores for the seat's backrest is shown in Table *8*.

Dimension (mm)	<500	500 - 524	525 - 532	533 - 540	541 - 548	>549
Score	0	1	2.5	5	7.5	10

Table 8: Scores for the backrest

G 3.4.4 The dimension for the backrest is driven by the shoulder (bideltoid) breadth, as set out in ISO 7250-1:2017, clause 6.2.8.

G 3.4.5 This dimension measures the distance across the maximum lateral protrusions of the right and left deltoid muscles and is driven by the size for a 95th percentile male.

G 3.4.6 Measure the horizontal distance across the backrest at a height of 500 mm above the unloaded seat surface.

G 3.4.7 If a spacer is present, then half the spacer's width can be included as part of the backrest width.

G 3.4.8 For seats without spacers in between, using calipers, measure the backrest width from the outer edge of the seat to the closest edge of the adjacent seat as shown in Figure *12*.

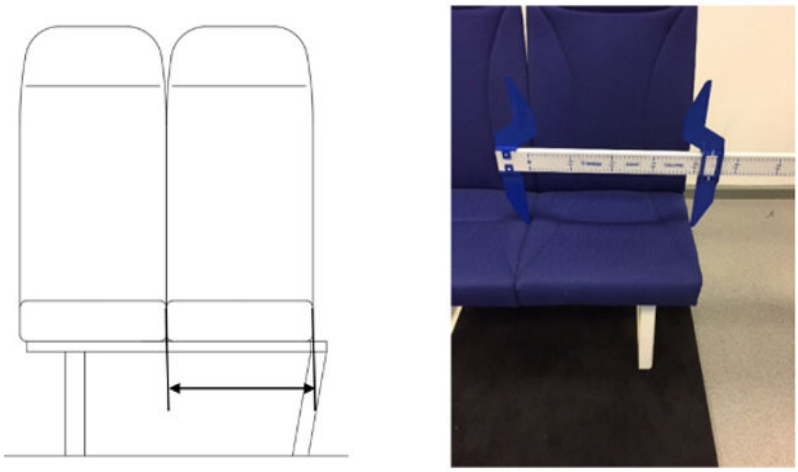

Figure 12: Backrest measurement

3.5 Armrest height

Guidance

G 3.5.1 The dimension for the armrest height is shown in Figure *13* as Dimension F.

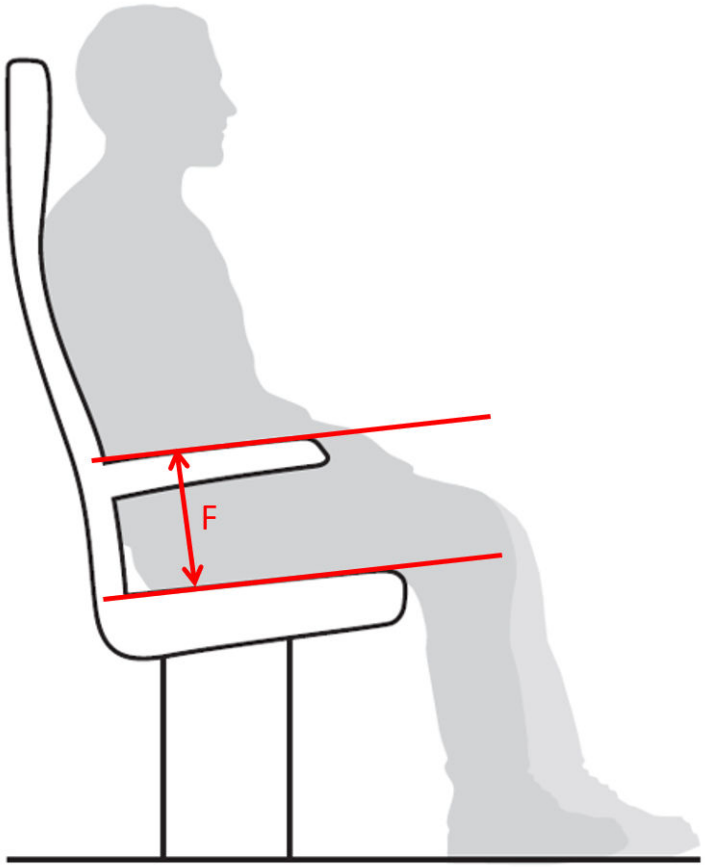

Figure 13: Armrest Height - Dimension F

G 3.5.2 The armrest height is the distance from the top surface of the armrest to the bottom of the loaded CMD buttocks pad parallel to the backrest line at a distance of 214 mm from the backrest line.

G 3.5.3 This is defined in BS EN ISO 7250-1:2017, clause 6.2.5 as 'elbow height, sitting'.

G 3.5.4 The dimension is based on German Anthropometric data PD CEN/ ISO TR 7250-2:2011+A1:2013 for a 50th percentile male.

G 3.5.5 The scores for the armrest height are shown in Table *9*.

Dimension (mm)	<185	185 - 229	230 - 250	251 - 285	>285	185 - 285 (adjustable)
Score	0	2	6	2	0	8

Table 9: Scores for armrest height

G 3.5.6 It is good practice for the armrest to have a minimum width of 40 mm.

G 3.5.7 The armrest height is the distance from the top surface of the armrest to the bottom of the loaded CMD buttocks pad parallel to the backrest line at a distance of 214 mm from the backrest line.

G 3.5.8 To measure the armrest height, measure a straight line between the top of the armrests where it crosses the scale on the front of the vertical member of the CMD as shown in Figure *14*.

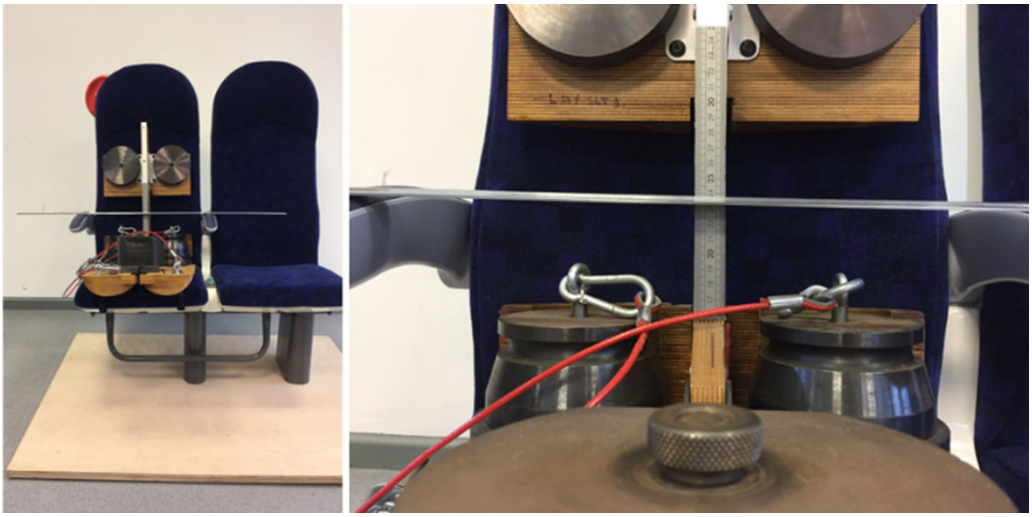

Figure 14: Armrest measurement

G 3.5.9 It is good practice to avoid the use of armrests that are hard as they are uncomfortable. The use of cushion material on the surface of armrests can result in increased comfort but may be more susceptible to vandalism.

3.6 Underside of headrest to seat

Guidance

G 3.6.1 The dimension for the underside of the headrest to seat is shown as Dimension G in Figure *15*.

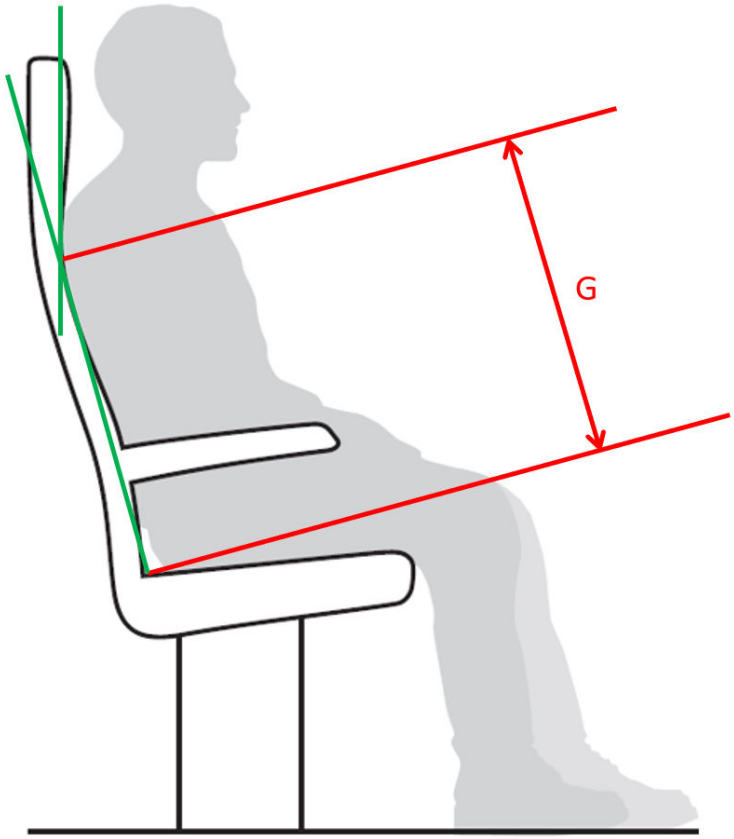

Figure 15: Underside of headrest to seat - Dimension G

G 3.6.2 The underside of headrest to seat dimension captures the body dimension for a passenger's shoulder height when seated, as defined in BS EN ISO 7250-1 clause 6.2.4.

G 3.6.3 It is the distance from the seat's sitting surface to the passenger's acromion.

G 3.6.4 The scores for Dimension G are shown in Table *10*.

Dimension (mm)	<540	540 - 659	660 - 680	>680
Score	0	2	4	0

Table 10: Scores for the underside of headrest to seat

G 3.6.5 Using a tape measure, measure from the back of the seat to the point on the backrest where the angle changes as shown in Figure *16*.

G 3.6.6 The measurement is undertaken when the tape measure is positioned in the median plane and flush to the seat back.

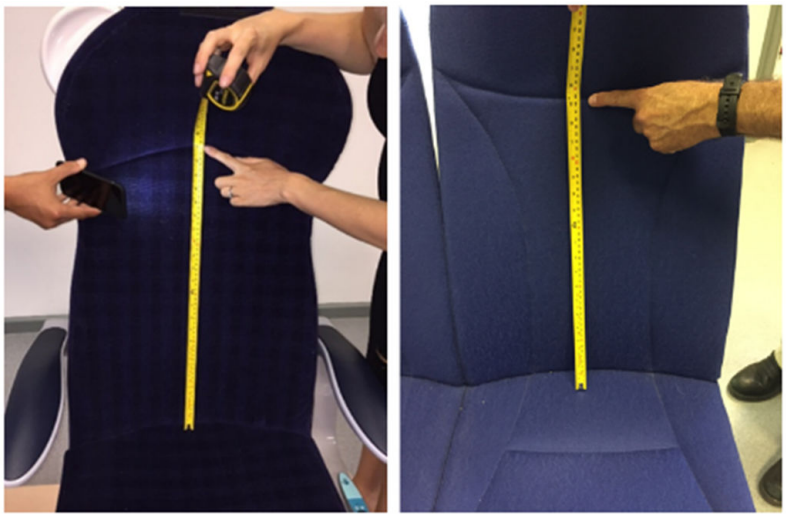

Figure 16: Underside of headrest to seat measurement

3.7 Angle of seat

Guidance

G 3.7.1 The angle of the seat is shown as Dimension H as shown in Figure *17*.

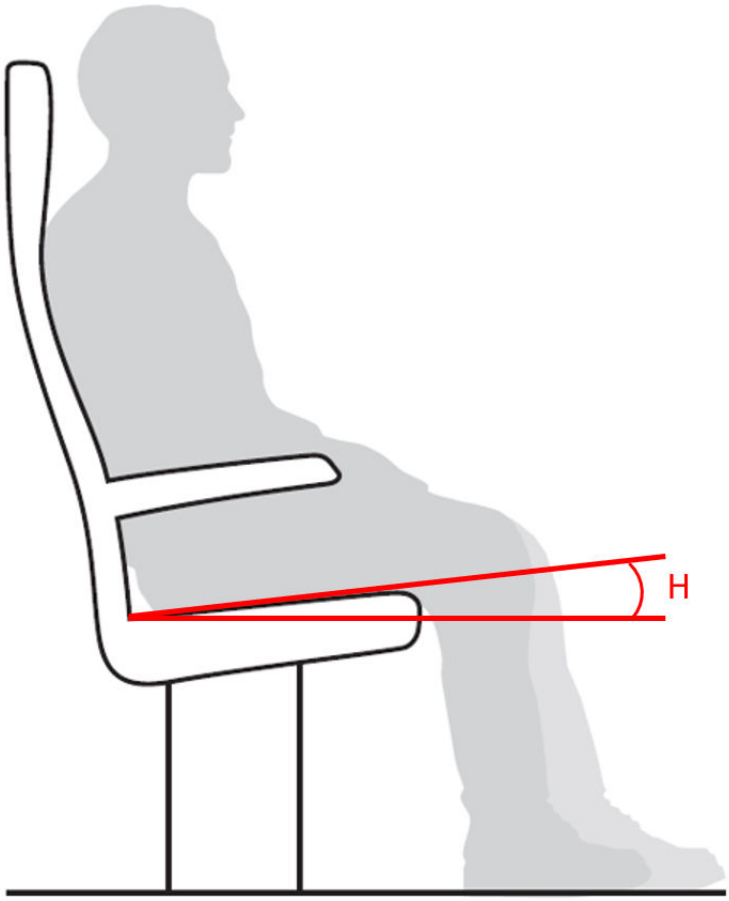

Figure 17: Angle of seat - Dimension H

G 3.7.2 This dimension is not directly related to anthropometric measurements.

G 3.7.3 It is based on comfortable angles for back support and activities for work chairs, and measured train seats.

G 3.7.4 The seat's angle is designed to prevent passengers from sliding off the seat.

G 3.7.5 The angle of the seat is based on dimensions set out in the office seating standard BS EN 1335-1:2020.

G 3.7.6 The scores are shown in Table *11*.

Note: Negative values of angles are given to show that the seats are rearwards inclined (i.e. not sloping forward).

Dimension (mm)	>-2˚	-2˚ to -5˚	-6˚ to -9˚	-10˚ to -12˚	<-12˚
Score	Uncomfortable	4	8	4	Uncomfortable

Table 11: Scores for the angle of the seat

G 3.7.7 The seat inclination is the angle between the loaded CMD buttocks and the horizontal plane.

G 3.7.8 To obtain the angle of the seat, place the CMD on seat and then read the angle from the protractor positioned on the buttocks pad of the CMD as shown in Figure *18*.

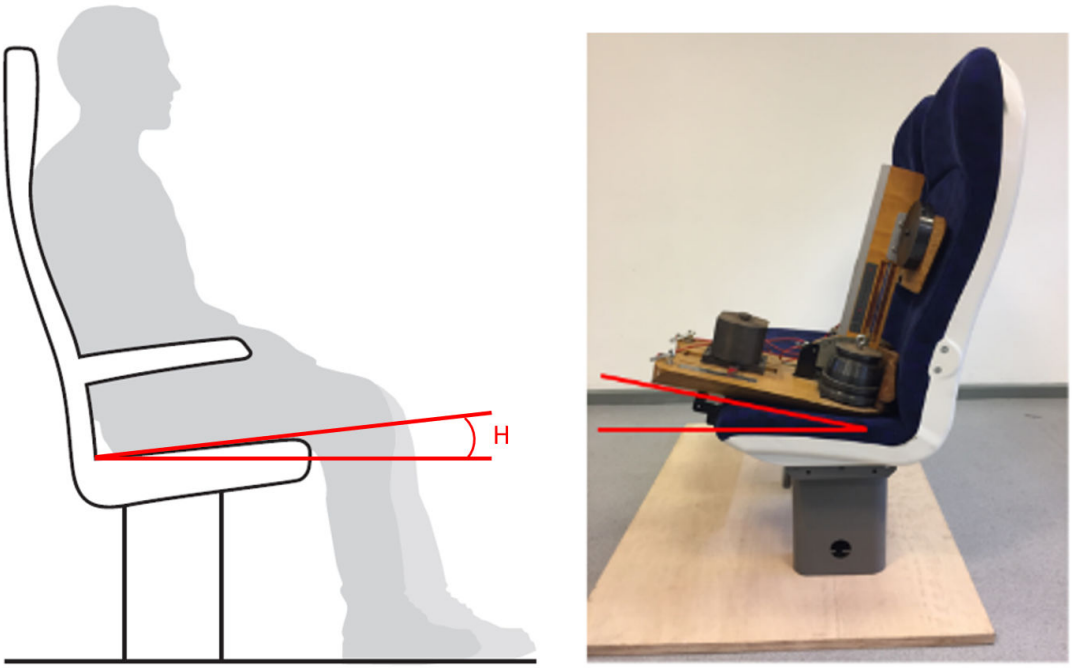

Figure 18: Angle of seat measurement

3.8 Angle between seat and back

Guidance

G 3.8.1 The angle between the seat and back is shown in Figure *19* as Dimension I.

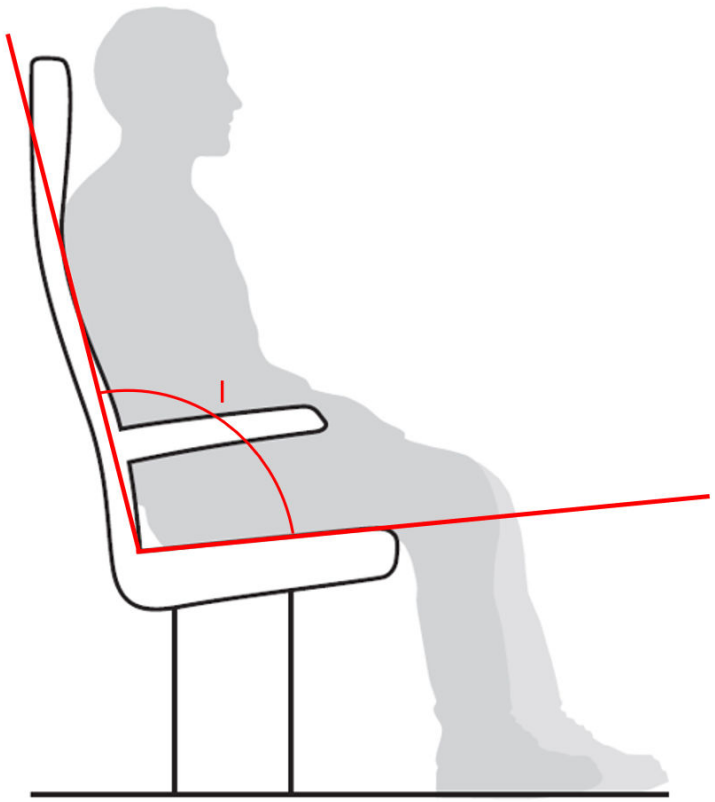

Figure 19: Angle between seat and back - Dimension I

G 3.8.2 This dimension is not directly related to anthropometric measurements and it is based on comfortable angles for back support and activities for work chairs and measured train seats.

G 3.8.3 The angle between the seat and back is based on dimensions set out in the office seating standard BS EN 1335-1:2020.

G 3.8.4 This dimension specifies the angle between the loaded backrest and the loaded seat.

G 3.8.5 The scores are shown in Table *12*.

Dimension (mm)	<95°	95° - 99°	100° - 105°	95° - 105° (adjustable)	95° - 120° (adjustable)
Score	Uncomfortable	2	4	7	12

Table 12: Scores for the angle between the seat and back

G 3.8.6 To measure the angle between the seat and the back, place a CMD on the seat and then read the angle directly using the angle indicator on the vertical member of the CMD shown in Figure *20*.

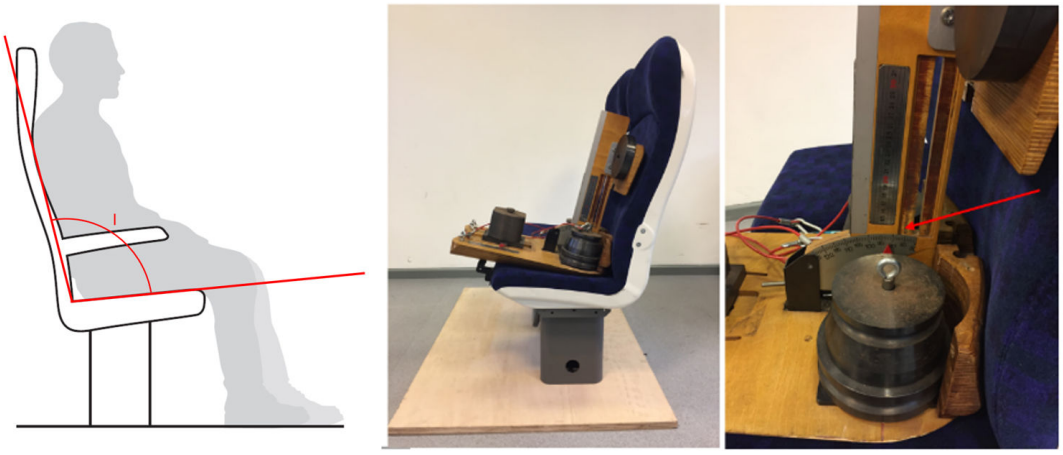

Figure 20: Measurement of angle between seat and back

3.9 Legroom

Guidance

G 3.9.1 The legroom is defined as Dimension J as shown in Figure *21*.

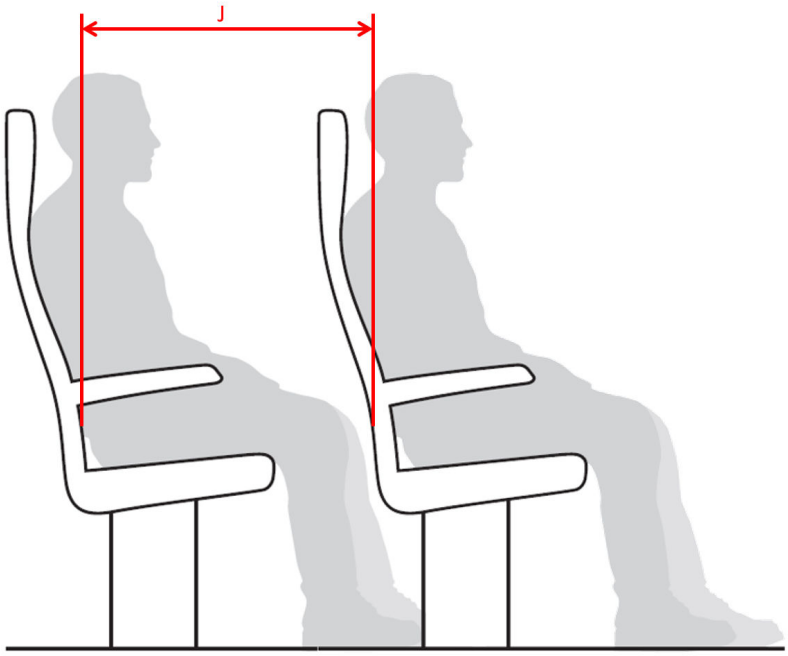

Figure 21: Legroom - Dimension J

G 3.9.2 This dimension measures the buttock to knee length as set out in BS EN ISO 7250-1, clause 6.2.12.

G 3.9.3 The scores for the legroom are set out in Table *13*.

Dimension (mm)	<695	695 - 730	731 - 765	>766
Score	0	2.5	5	8

Table 13: Scores for the legroom

G 3.9.4 The rationale for this dimension is that this measures the horizontal distance from the foremost point of the kneecap to the rearmost point of the buttock to provide adequate room between the knees and the back of the seat in front .

G 3.9.5 It is good practice for the seat support leg to not unduly restrict passenger legroom.

G 3.9.6 The measurement values are based on a German anthropometric data as set out in CEN ISO/TR 7250-2:2011/A1:2013 for a 95th percentile male with 10 mm clothing allowance and 30 mm clearance.

G 3.9.7 Distance J is measured as the horizontal distance between the back of the seat (at 120 mm offset to the median plane) and to the back of seat at a height of 620mm.

G 3.9.8 The height of 620mm is the vertical distance from the floor to the highest point of the superior border of the patella (kneecap) of 95th percentile male.

G 3.9.9 It is good practice to allow passengers to stretch their legs out under seats in front of them. The inclusion of equipment in this space will prohibit passengers to do so, thus reducing their comfort.

G 3.9.10 It is good practice for seat assemblies to adopt the use of a central support pedestal as it provides equity in terms of foot space and better under-seat storage.

3.10 Bay seating arrangement

Guidance

G 3.10.1 Distance K is measured as the horizontal distance between the backs of the two facing seats (offset 120 mm from the median plane) at a height of 620 mm as shown in Figure *22*.

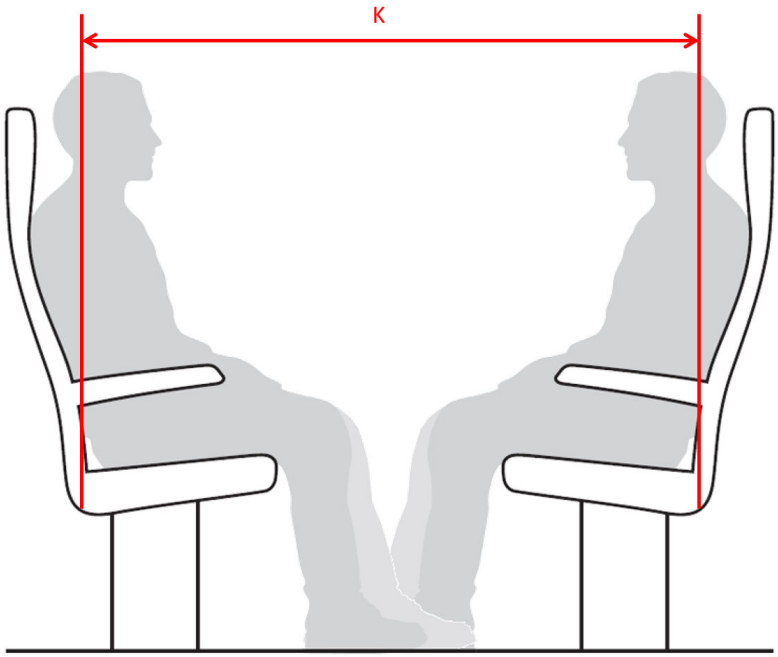

Figure 22: Bay seating arrangement measurement - Dimension K

G 3.10.2 The scores for the legroom of the bay seat arrangements are shown in Table *14*.

Dimension (mm)	< 1390	1390-1460	1461-1530	> 1531
Score	0	2	4	6

Table 14: Score for the legroom of bay seat arrangements

G 3.10.3 It is good practice for the the seat support leg to not unduly restrict passenger legroom.

G 3.10.4 This dimension is intended to maintain a comfortable clearance between knees of passengers sitting opposite each other in bay seating arrangements.

3.11 Clearance under tablet

Guidance

G 3.11.1 Distance L is measured as the vertical distance from the floor to the lowest point on the underside of the fold down tablet shown in Figure *23*.

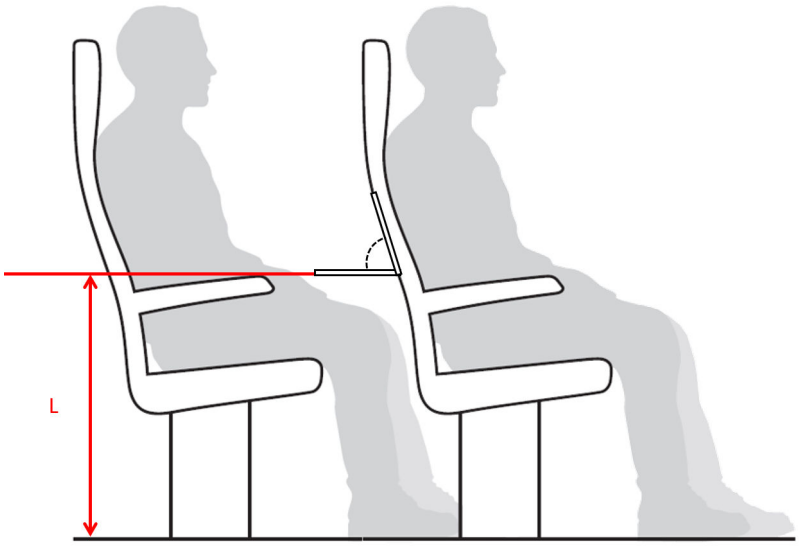

Figure 23: Clearance Under Tablet - Dimension L

G 3.11.2 Distance L is to allow thigh clearance for the 95th percentile male, set out in ISO 7250-1:2017 clause 4.2.13.

G 3.11.3 Values of dimension L within 650 mm ± 5mm are considered to be comfortable.

G 3.11.4 The dimension is intended to achieve a comfortable clearance of 40 mm between the top of the passenger's knee and the underside of the tablet.

3.12 Tablet depth

Guidance

G 3.12.1 The usable tablet depth is defined as Dimension M as shown in Figure *24*.

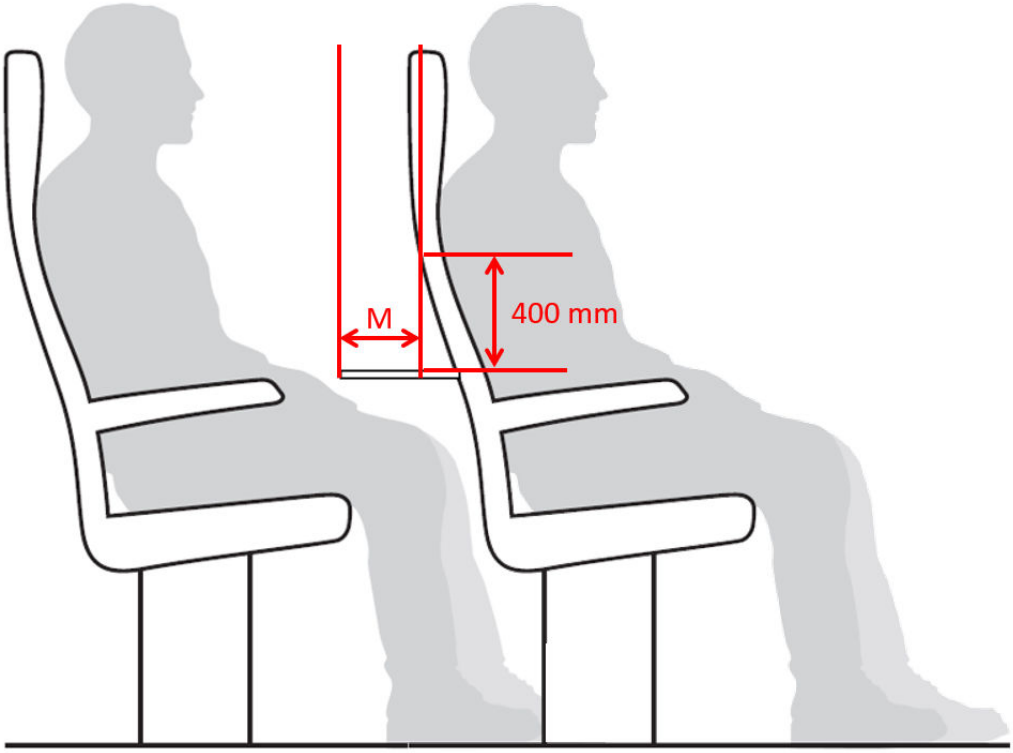

Figure 24: Tablet depth - Dimension M

G 3.12.2 The tablet 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 tablet surface.

G 3.12.3 This measurement is undertaken along the seat's centerline.

G 3.12.4 The scores for the tablet depth are set out in Table *15*.

Dimension (mm)	<120	120 - 150	151 - 200	>201
Score	0	1	2	0

Table 15: Scores for the tablet depth

G 3.12.5 Additional scores can be given for tablets that are capable of extending towards the passenger and are given in Table *16*.

Extension (mm)	0 - 50	51 - 100	>101
Score	1	2	3

Table 16: Scores for tablet extension

G 3.12.6 A tablet can provide a level surface for passengers to place refreshments, personal entertainment devices such as mobile phones, or portable work devices such as laptops.

G 3.12.7 The depth of the tablet determines the space available for passengers to place their items upon, or to which the extent a laptop's screen can be opened.

G 3.12.8 This dimension is affected by the seat pitch and angle where the tablet is installed.

G 3.12.9 It is good practice to consider the legroom as part of the design of the tablet. Tablets that are short can be difficult for passengers to reach and use if the legroom is too great. Conversely, if the legroom is too small, long tablets can obstruct the passenger and lead to more severe injuries in the event of a collision or derailment.

G 3.12.10 Tablets with an extendable design can allow for a shorter overall tablet length to be installed as it can be pulled towards the passenger to increase its effective depth.

G 3.12.11 For tablets that are extendable, it is good practice to consider the total length of the tablet when it is extended with respect to requirements relating to crashworthiness and interior passive safety relating to passenger injury in the event of a collision or derailment.

G 3.12.12 For passengers wanting to use laptop computers with a hinged screen, a tablet with a greater depth can enable the screen to be opened at to a larger angle to allow a better viewing angle.

G 3.12.13 Guidance on the design of tablets relating to interior passive safety are set out in Appendix A.13 of GMRT2100 Issue 6.1.

G 3.12.14 Figure *25* below defines the zone for which no parts of the passenger's body is to be in contact with in the event of a derailment or collision for purposes of reducing the risk of chest or abdominal contact.

G 3.12.15 It is good practice to adopt a tablet with a length to ensure that no parts of passengers enter the zone set out in *25*.

G 3.12.16 Additional information on this can be found in 'Unife Technical Report for Interior Passive Safety in Railway Vehicles' (December 2014).

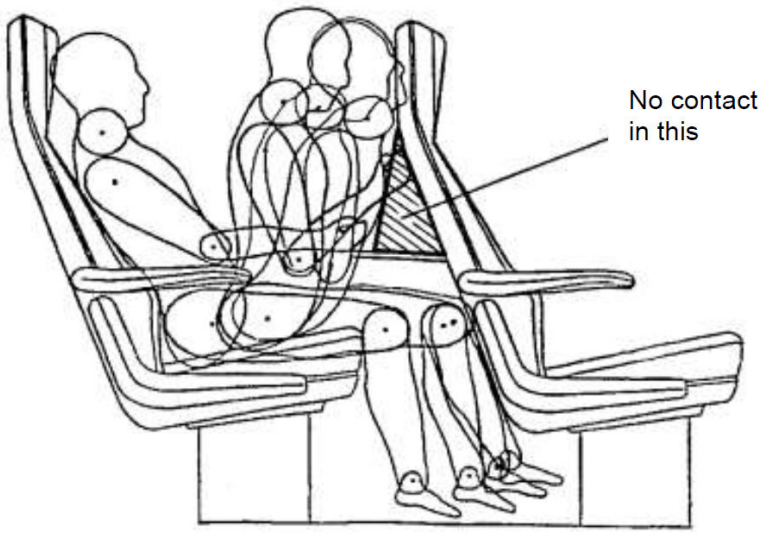

Figure 25: No contact zone (Unife TecRec, 2014)

Part 4 Seat Comfort Assessment - Pad Thickness

4.1 Seat Pad

Guidance

G 4.1.1 The seat pad includes any compressible seat cushion material and interlayers, including the outer fabric, fire barrier materials, foam, mesh, and compression springs.

G 4.1.2 It does not include the thickness of the rigid seat shell structure.

G 4.1.3 The scores and methods in this document are not intended to inhibit innovation in terms of seat design or materials. If new cushion technologies are introduced - that fulfill the criteria set out in the other parts of this document - the scores for thickness in this section can be fully awarded.

G 4.1.4 The seat pad is a component that is visible to passengers so in addition to its physical impact on comfort, it also has a psychological impact on the perceived level of comfort.

G 4.1.5 Generally, a thin seat pad may not appear to be comfortable.

G 4.1.6 A thin seat pad of approximately 20-40 mm thick requires a high compression hardness to prevent the pad bottoming out which results in a reduction in comfort.

G 4.1.7 'Bottoming out' means that the foam is compressed to such an extent that it comes in contact with the underside of the seat pan.

G 4.1.8 It is good practice for the minimum seat pad thickness to be 50 mm.

G 4.1.9 The scores for the seat pad thickness are set out in Table *17*.

Thickness (mm)	<30	30 - 49	50 - 60	>60
Score	0	3	4	5

Table 17: Seat pad thickness scoring

G 4.1.10 To obtain the dimension for the seat pad thickness, measure height of seat pad from top side of rigid seat base to top side of fabric cover.

G 4.1.11 If the seat pad thickness varies, measure the seat pad thickness 70 mm off seat centreline and 130 mm from back surface as shown in Figure *26*.

G 4.1.12 This dimension measures the point of contact of the ischial tuberosities when in the sitting position.

Figure 26: Seat Pad Thickness Measurement

4.2 Back Pad

Guidance

G 4.2.1 The back pad thickness consists of the compressible back cushion interlayers, including the outer fabric, fire barrier materials, foam, mesh, and any additional compression material.

G 4.2.2 It does not include the thickness of the rigid back shell structure.

G 4.2.3 The scores for the back pad thickness are shown in Table *18*.

Dimension (mm)	<25	25 - 30	31 - 35	>35
Score	0	3	4	5

Table 18: Back Pad Thickness Scores

G 4.2.4 To carry out the measurement, measure 280mm vertical distance from seat pad surface to back pad and mark a centre point as shown in Figure *27*.

G 4.2.5 Measure the back pad thickness of pad at the centre point using a horizontal rule and caliper depth measuring blade.

G 4.2.6 The back pad thickness is the the side pad thickness minus the centre pad depth.

G 4.2.7 The measurement height of 280 mm refers to the passenger's elbow height (sitting) + 40mm comfort, as set out in ISO 7250-1 clause 6.2.5.

Figure 27: Back pad thickness measurement

Part 5 Seat Comfort Assessment - Compressibility

5.1 General

Guidance

G 5.1.1 The purpose of the seat pad is to provide enough compression for a lighter 5th percentile female to feel comfortable and enough pad hardness to accommodate heavier 95th percentile male, without bottoming out and losing its compressibility.

G 5.1.2 There are two tests loads to determine the seat pad's compressibility:

a) 500 N
b) 1100 N.

G 5.1.3 These tests are described in *5.2* and *5.3*, respectively.

G 5.1.4 The position of the indenter where load is applied for both test loads, and illustration for measuring compression is shown in Figure *28*.

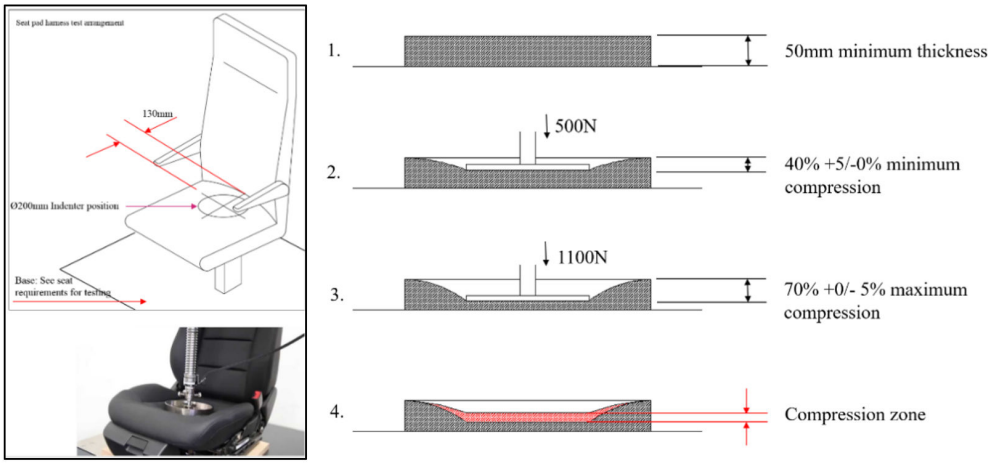

Figure 28: Indenter application and compression

G 5.1.5 Figure *29* below shows an example of seat scores based on a test case in T1140. It shows that there are diminishing values for the scores as the seat pad thickness increases.

PARAMETER	VALUE	REQUIREMENT	SCORING						SCORE
Seat pad thickness	77 mm	min 50	< 30	30-49	50-60	> 60			
		score	0	1.75	3.00	3.50			**3.50**
Back pad thickness	80	min 25	< 25	25-30	31-35	> 35			
		score	0	1.75	3.0	3.50			**3.50**
Seat pad hardness	57.8	min 40%40	< 40	40-43	44-47	43-51	52-55	56-59	
Compression percentage under 500N		score	0	3	6	9	12	9	**9**
Seat pad hardness	75.5	Max 70%	>70	70-64	63-60	57-59	51-56		
Compression percentage under 500N		score	0	3	6	9	12		**0**
			TOTAL SCORE for Seat and back pad characteristics						**16.00**

Figure 29: Example of seat pad thickness scoring from T1140

5.2 500 N Compression Test

Guidance

G 5.2.1 The purpose of this test is to determine the seat pad's performance in providing enough compression for a 5th percentile female (49.9 kg) passenger to feel comfortable.

G 5.2.2 To perform this test, a force of 500 N is applied to the seat using a Ø200mm indenter for 30 s.

G 5.2.3 The seat pad's target minimum compression is 40 % of the overall seat pad thickness.

G 5.2.4 The seat indentation hardness can be measured using an indentometer which compresses the seat to various levels and for various times to arrive at a value in Newtons (N).

G 5.2.5 The seat and back pad scores for compression values at a load of 500 N are shown in Table *19*.

Compression (%)	<40	40 - 43	44 - 47	48 - 50	51 - 52
Score	0	3	5	7	10

Table 19: Seat pad compressibility score - 500 N

5.3 1100 N Compression Test

Guidance

G 5.3.1 The purpose of this test is to determine the seat pad's performance in providing enough compression for a 95th percentile male (110 kg) passenger to sit without the seat pad bottoming out.

G 5.3.2 To perform this test, a force of 1100 N is applied to the seat using a Ø200 mm indenter for 30 s.

G 5.3.3 The maximum allowable compression is 70 % of the overall seat pad thickness.

G 5.3.4 The seat indentation hardness can be measured using an indentometer which compresses the seat to various levels and for various times to arrive at a value in Newtons (N).

G 5.3.5 The seat and back pad scores for compression values at a load of 1100 N are shown in Table *20*.

Compression (%)	51 - 56	57 - 59	60 - 63	64 - 70	>70
Score	10	7	5	3	0

Table 20: Seat pad compressibility score - 1100 N

Appendices

Appendix A Seat durability

A.1 Durability

Guidance

G A.1.1 The seat pad durability test ensures that the seat pad has the level of durability, compression recovery and hardness for its intended use.

G A.1.2 BS 6261:1982. Method for Evaluating the Application of and Interaction Between Components in Upholstered Furniture sets out requirements to test the long-term durability of the seat structure and long-term comfort performance of the seat pad.

G A.1.3 This test is undertaken on a seat assembly which include the seat cushion interlayers, including the outer fabric, fire barrier materials, foam, mesh, and other additional compression materials.

G A.1.4 This test is undertaken on a complete seat assembly which also includes the outer shell and leg support structure.

G A.1.5 A dynamic load compression test consisting of 200,000 cycles is recommended for heavy duty transport seats.

G A.1.6 The test is undertaken using an indenter that is a buttock shaped pad to replicate a person sitting, compressing and moving in the seat.

G A.1.7 The number of cycles is intended to replicate approximately 10 years of use based on the assumption that 54.8 people sit and move in the seat per day, for 365 days per year, for 10 years.

G A.1.8 The minimum target is 5 % or less of deformation after 50,000 cycles.

G A.1.9 The long-term seat durability performance levels and scores are shown in Table *21*.

Criteria	5 % or less deformation after 20,000 cycles	5 % or less deformation after 50,000 cycles	5 % or less deformation after 100,000 cycles	5 % or less deformation after 150,000 cycles	5 % or less deformation after 200,000 cycles
Score	0	1	3	5	7

Table 21: Long-term seat durability scores

G A.1.10 An example of a seat durability test is shown in Figure *30*.

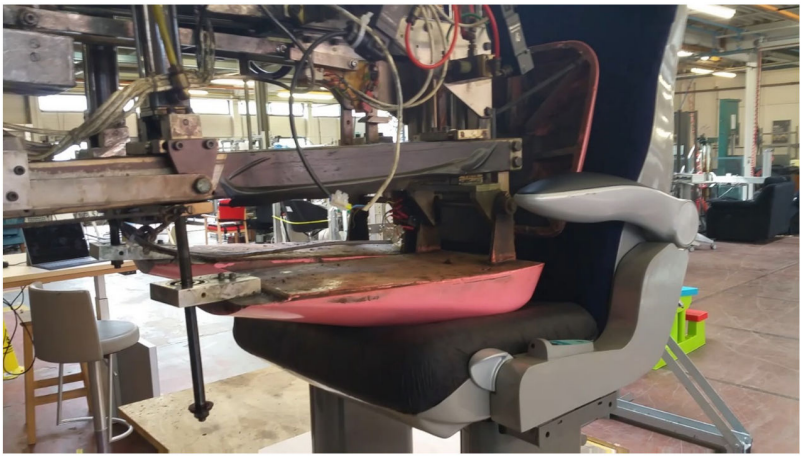

Figure 30: Example of a seat durability test

Appendix B Seat appearance

B.1 Seat appearance and attractiveness survey

Guidance

G B.1.1 A seat appearance and attractiveness survey can be used to

a) Present different seats that have achieved the minimum seat dimensions and compression requirements to passengers for user evaluation
b) Engage with passengers and promote customer feedback and choice
c) Gather data from passengers on which seats are the most attractive and comfortable.

G B.1.2 The results from the survey are likely to be subjective.

G B.1.3 Therefore, this survey is optional and it is not advisable to be used in isolation of the minimum seat dimensions and associated tests to rate, and select seats.

G B.1.4 The survey can be undertaken at stations, whilst passengers are waiting for their train departure.

G B.1.5 An example of a seat appearance and attractiveness survey including questions and rating scales follows.

Question 1: How comfortable does the seat look to sit on?

Considerations:

- Shape of the seat
- Size of seat, height, and width
- Appearance of softness (cushioning)
- Accessories (e.g. table, arm rest, cup holder, ability to recline, etc)

Response	Very uncomfortable	Uncomfortable	Neutral	Comfortable	Very comfortable
Score	0	1	2	3	4

Question 2: When approaching the seat, how attractive does it look?

Considerations:

- Shape of the seat
- Size of seat, height, and width
- Degree of integration of accessories
- Colour, pattern, and material (e.g. fabric or leather).

Dimension	Very unattractive	Unattractive	Neutral	Attractive	Very attractive
Score	0	1	2	3	4

Question 3: How comfortable is the seat to sit in?

Considerations:

- The seat and and back padding, and seated comfort
- The seat shape and size are comfortable
- The accessories support my journey activities and are intuitive and comfortable to use.

Dimension	Very uncomfortable	Uncomfortable	Neutral	Comfortable	Very comfortable
Score	0	1	2	3	4

G B.1.6 To assess a user's perceived attractiveness and comfort of the seat, the following can be utilised:

a) A survey location (ideally a mainline station, used by the Train Operating Company);
b) A briefing note and questionnaire;
c) Selection of seats for testing;
d) Passive screens to reduce impact from the surrounding environment;
e) Incentive for completing the test.

G B.1.7 It is advised that a suitable number of analysts carry out the survey using feedback from passengers for convenience and speed.

G B.1.8 Each seat set can be labelled A, B, and C etc as shown in Figure *31* as an example.

G B.1.9 It is good practice to record the model or make of each seat.

G B.1.10 It is proposed that partition screens have a minimum height of 1800 mm to allow participants to concentrate on and consider individual seats.

G B.1.11 Seats can be double or single configurations to match the proposed seating layout on trains.

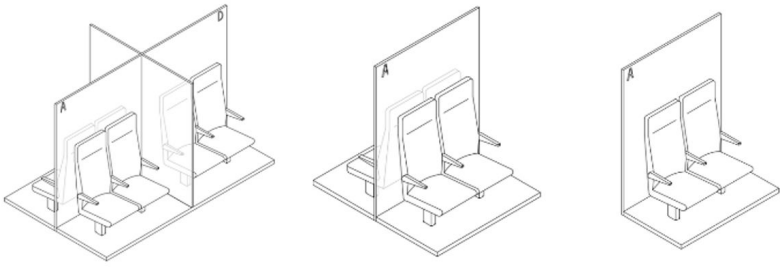

Figure 31: Seat survey layout example

G B.1.12 An example of a seat survey area with two options for displaying a briefing note (instructions) is shown in Figure *32*.

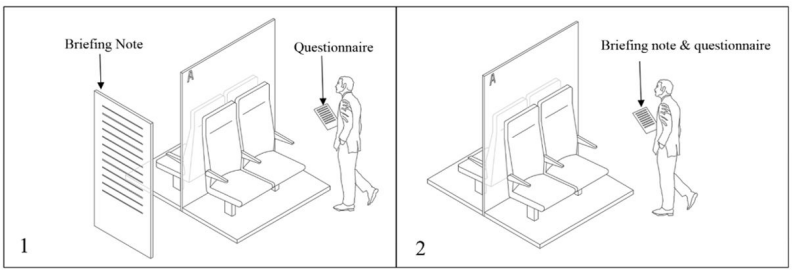

Figure 32: Seat survey area with briefing note

G B.1.13 A briefing note containing instructions and a questionnaire is provided to the person undertaking the survey.

G B.1.14 These two documents can contain:

a) Aim of the survey the user are about to participate in;
b) Statement stating the user's role in the questionnaire;
c) A clear description of the survey procedure, how long it will take, providing an insight into what it will explore and why;
d) Statement explaining that participation is voluntary and users can withdraw at any time;
e) Statement that data collected will be anonymous, containing no personal details, other than age and gender and will comply with requirements of GDPR.

G B.1.15 Table *22* shows an example of a briefing note.

G B.1.16

The following survey focuses on train seat comfort.

We would like to find out your opinion on the appearance and comfort of train seats.

- You are asked to look at train seats and provide a rating for your initial impression of the how comfortable they look and their attractiveness;
- After this, you will be asked to sit in the train seats and rate physical comfort.
- We will then ask you to make any comments (positive or negative) about the seats;
- It will last approximately 5* minutes;
- Please be open and honest with your answers.
- The survey will be used to inform our selection of train seats;
- If you have any questions please feel free to ask one of our helpers;
- The survey is anonymous, no personal data that can be traced to you is required;
- The survey is voluntary and you can withdraw at any time.

On behalf of ……. Rail, thank you for your participation.

* Seat survey times:

- 1 seat 5 minutes;
- 2 seats 8 minutes;
- 3 seats 11 minutes;
- 4 seats 14 minutes.

Table 22: Example of a seat survey briefing note

Tables *23* and *24* show an example of a questionnaire with two pages.

G B.1.17

Seat Comfort and Attractiveness Questionnaire

Gender: Male ☐ Female ☐

Age: 14-20 ☐ 20-30 ☐ 30-40 ☐ 40-50 ☐ 50-60 ☐ 60+ ☐

Reason for journey: Work ☐ Leisure ☐

SEAT A

4. Please provide feedback on why you find this seat attractive or unattractive.

5. When approaching the seat how attractive does it look?

0	1	2	3	4
Very Unattractive	**Unattractive**	**Neither Unattractive nor Attractive**	**Attractive**	**Very Attractive**

Please consider the following in regard to seat attractiveness:

- Shape of seat;
- Size of seat, width and height;
- The accessories are well integrated into the seat;
- Colour/Pattern and fabric.

Table 23: Example of a questionnaire (first page)

6. **How comfortable does the seat look to sit in?**

0	1	2	3	4
Very Uncomfortable	Uncomfortable	Neither Uncomfortable nor Comfortable	Comfortable	Very Comfortable

Please consider the following in regard to seat comfort

- Shape of seat
- Size of seat, such as height and width;
- Seat looks soft (Cushioning).

7. **Please provide feedback on why you find this seat comfortable or uncomfortable.**

8. **How comfortable is the seat to sit in?**

0	1	2	3	4
Very Uncomfortable	Uncomfortable	Neither Uncomfortable nor Comfortable	Comfortable	Very Comfortable

Table 24: Example of questionnaire (second page)

Appendix C Seat Accessories

C.1 Accessories

Guidance

G C.1.1 Accessories for passenger seats relate to the user experience aspect of comfort.

G C.1.2 The selection of accessories could enhance passenger perception of seat comfort on longer journeys but is less likely to benefit shorter journeys and could impede passenger movement.

G C.1.3 A non-exhaustive list of examples of seat accessories is shown in Figure *33*.

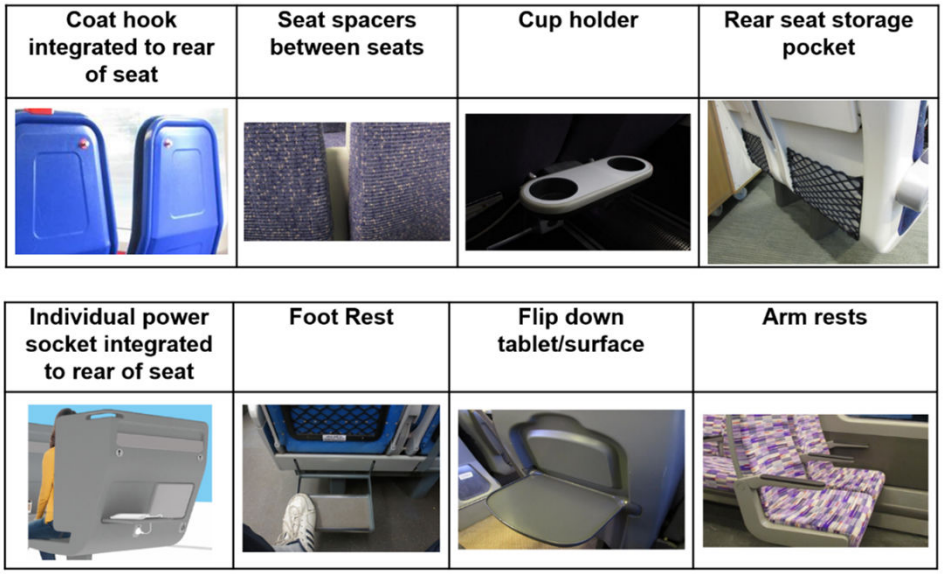

Figure 33: Examples of seat accessories

Appendix D Additional Information

D.1 Pressure map

Guidance

G D.1.1 Document EUKL SK 271 ISSUE A (5 May 2019) titled, "Specification of Comfort Criteria for Eurostar Train Passenger Seats" sets out information for passenger seat comfort and a process to determine the pressure map on passenger seats.

G D.1.2 Paragraph 4.2.3.16 Distribution of Pressure sets out the following maximum pressure values:

a) On the ischia: 60 g/cm^2
b) On the thighs: 15 g/cm^2.

G D.1.3 Figure *34* shows the image present in Appendix D of EUKL SK 271 ISSUE A on pressure distribution of the passenger - seat interface.

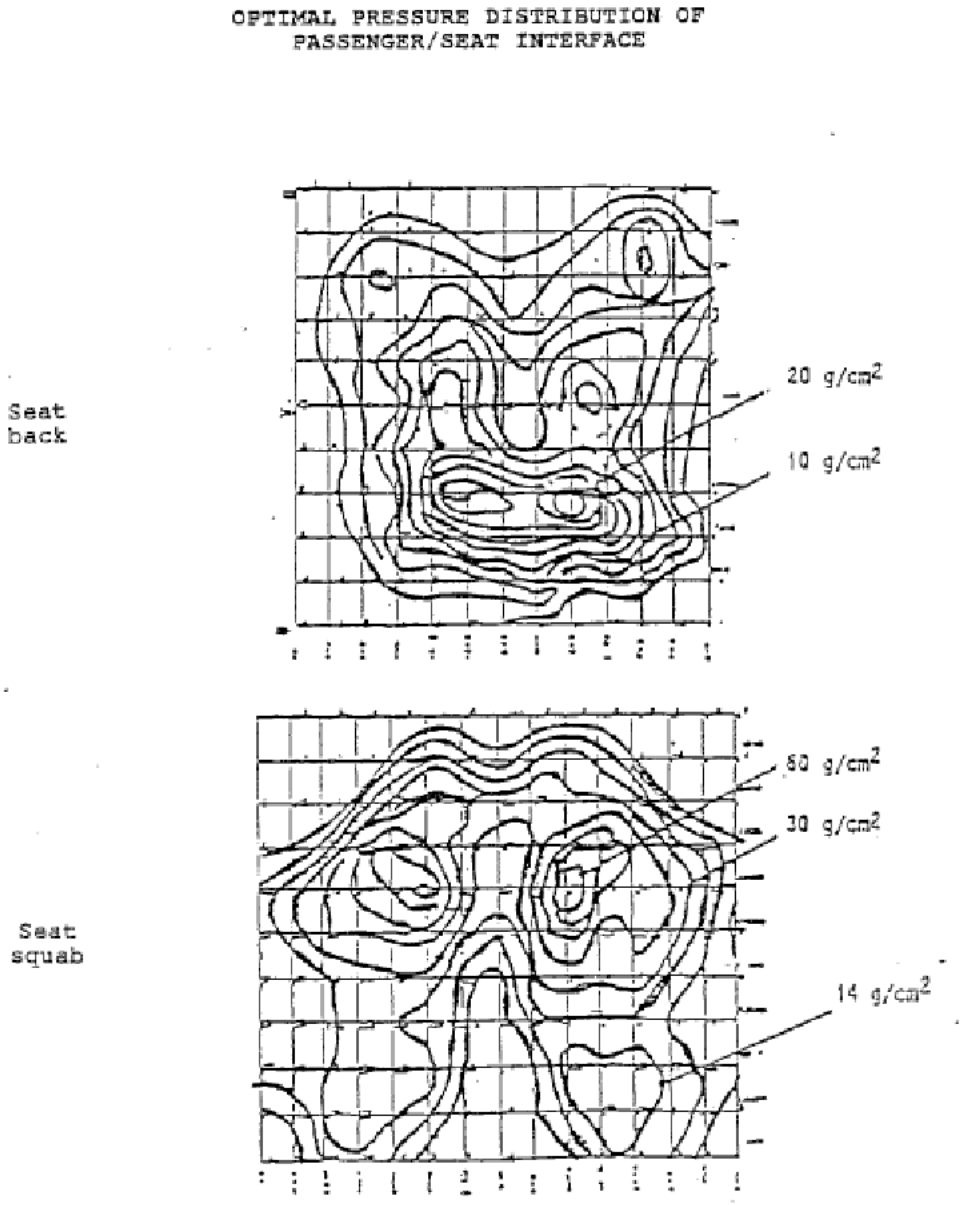

Figure 34: Optimal Pressure Distribution of Passenger - Seat Interface

D.2 Seat hardness

Guidance

G D.2.1 Document EUKL SK 271 (5 May 2019), sets out information for passenger seat comfort and a process to determine the hardness of passenger seats.

G D.2.2 Paragraph 4.2.314 Hardness of Cushions sets out a requirement that the vertical stiffness characteristics of all seat pads are to remain in the envelopes as set out in Appendix G of the document.

G D.2.3 The paragraph also states that the characteristics are to be determined using a test dolly as set out in Appendix G of the document.

G D.2.4 Figure *35* shows the test dolly that is applied vertically at each of the equally-spaced coordinates shown in Figure *36* using a suitable guidance apparatus above the seat cushion.

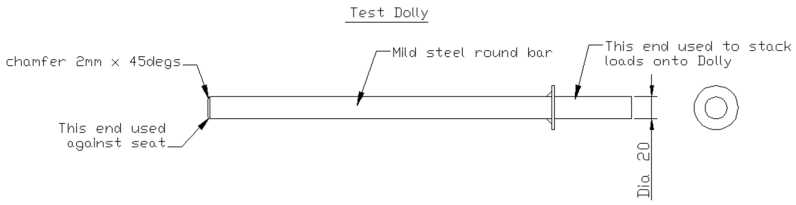

Figure 35: Test dolly

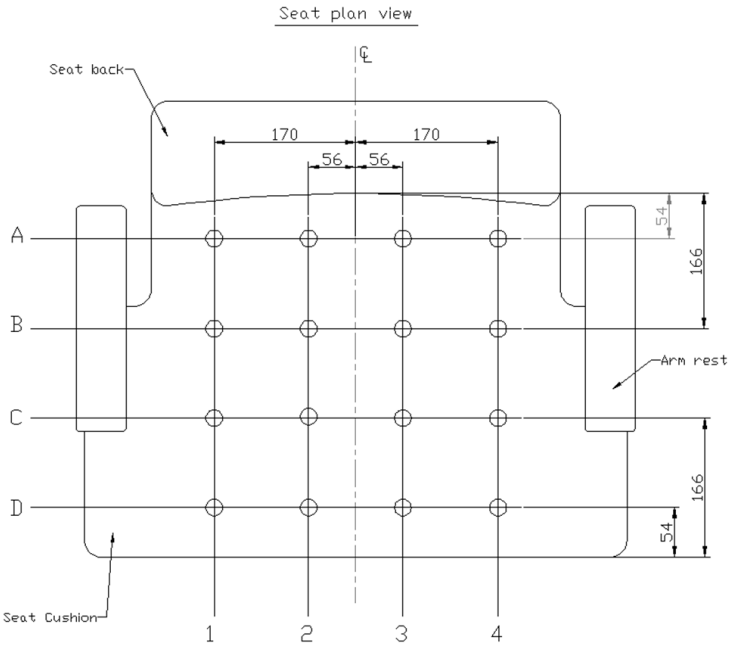

Figure 36: Seat plan view

G D.2.5 The load-deflection characteristic is determined at each of the 16 locations for progressively increasing loads up to the 11 kg weight.

G D.2.6 Characteristics for A1, A2, A3, and A4 are to remain within the upper and lower bounds shown in Figure *37*.

G D.2.7 Characteristics for B1, B2, B3, B4, C1, C2, C3, and C4 are to remain within the upper and lower bounds shown in Figure *38*.

G D.2.8 Characteristics for D1, D2, D3, and D4 are to remain within the upper and lower bounds shown in Figure *39*.

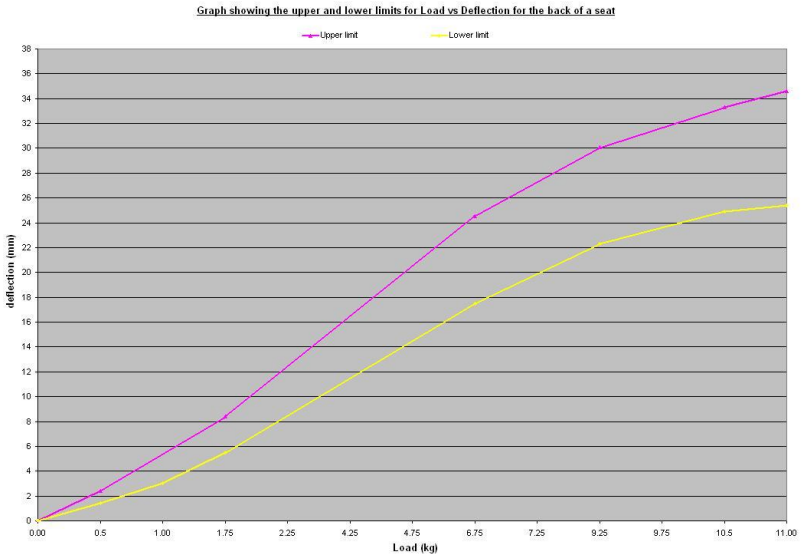

Figure 37: Load-deflection characteristic for the back of the seat

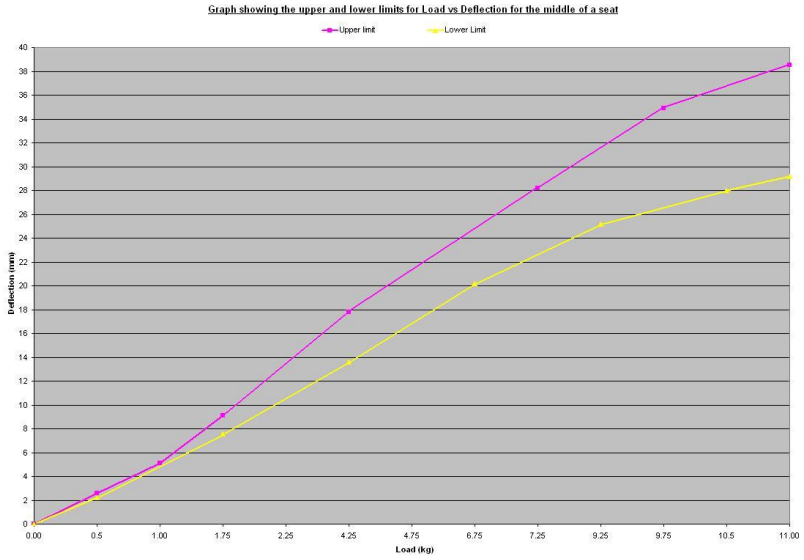

Figure 38: Load-deflection characteristic for the middle of the seat

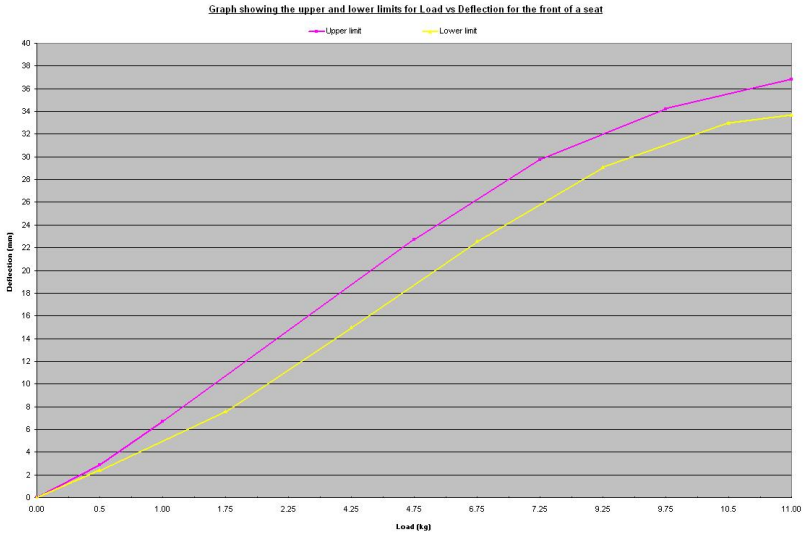

Figure 39: Load-deflection characteristic for the front of the seat

D.3 Seat contour

Guidance

G D.3.1 The use of backrest curvature in the horizontal plane is a form of seat contouring and it can bring several benefits:

- provides better support passengers and reduces side sway
- allows less foam to be used whilst maintaining comfort
- provides increased knee space in uni-directional configuration when the rear of the seat is profiled as an offset of the front.

G D.3.2 Concavity can be greater in the area around the waist compared to the thoracic region to mimic the natural contours of the body. Gentle convexity in the lumbar region in the vertical plane can be beneficial for passenger comfort

G D.3.3 Contouring in the headrest region is beneficial - particularly on regional and intercity seating - as it can provide head support when resting.

G D.3.4 Ideally the headrest 'ears' are angled to provide support for the natural tilt of the head when resting.

G D.3.5 The radius values shown in Figure *40* are approximate and are measured from an existing seat product. These are not intended to be prescriptive but rather to illustrate the curvature trend.

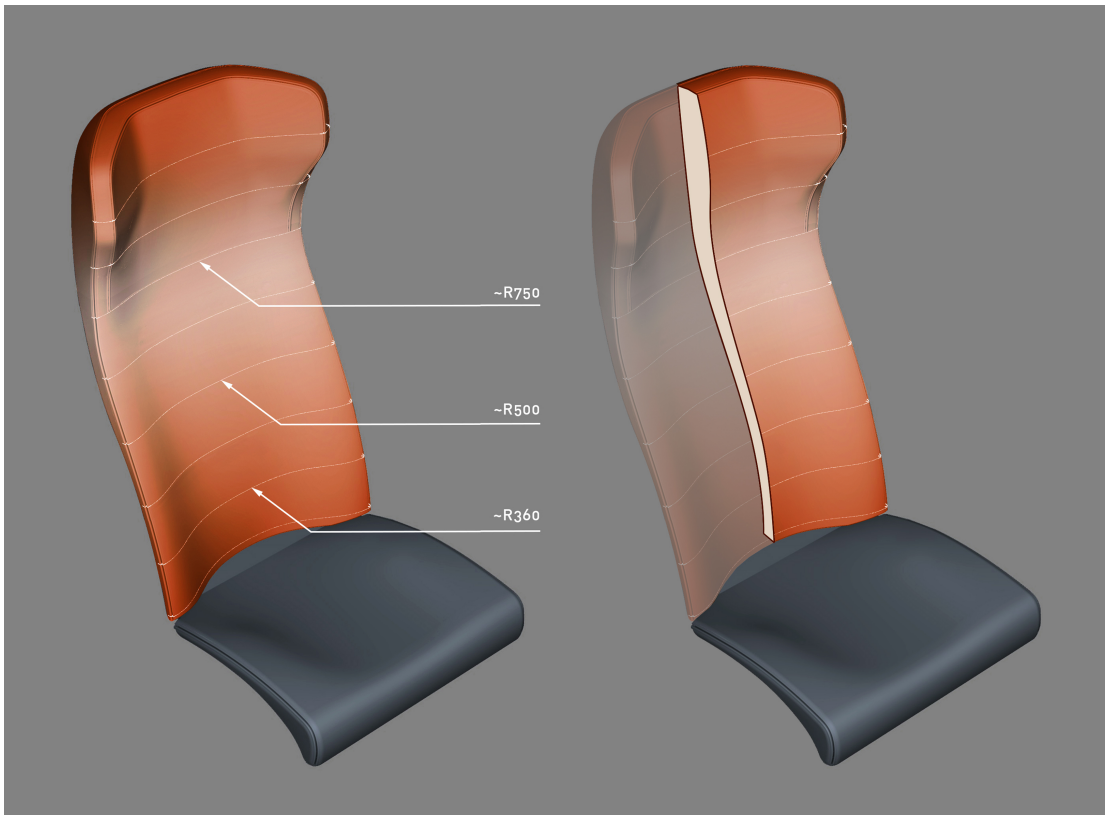

Figure 40: Example image of a seat with contouring

G D.3.6 It is not advisable for contouring to be excessive as it can cause passengers to feel overly constrained in the seat.

Definitions

acromion	The bony tip of the outer edge of the shoulder blade (scapula) that comes off the top of the back side of this bone
bideltoid	Maximum horizontal breadth across the shoulders, measured to the protrusions of the deltoid muscles
CMD	Chair Measurement Device
deltoid	The muscle forming the rounded contour of the human shoulder
ischial tuberosities	The V-shaped bone at the bottom of the pelvis that makes contact with a surface when a person is sitting down (i.e. sitting bones)
ischum (plural: ischia)	A paired bone of the pelvis that forms the lower and back part of the hip bone
ISO	International Organization for Standardization
popliteal length	The distance from the underside of the foot to the underside of the thigh at the knees
tablet	A surface installed to the back of the seat that can be folded out for use by passengers to place items
thoracic	related to the thorax (chest area)

References

The Standards catalogue gives the current issue number and status of documents published by RSSB: http://www.rssb.co.uk/standards-catalogue.

RGSC 01	Railway Group Standards Code
RGSC 02	Standards Manual

Documents referenced in the text

Railway Group Standards

GMRT2100	Rail Vehicle Structures and Passive Safety
GMRT2130	Vehicle Fire Safety

RSSB documents

RIS-2730-RST	Vehicle Fire Safety and Evacuation

Other references

BS 6261:1982	Method for evaluating the application of and interaction between components in upholstered furniture
BS EN 1335-1:2020	Office furniture. Office work chair Dimensions. Determination of dimensions
BS EN 16989	Fire protection on railway vehicles - Fire behaviour test for a complete seat
BS EN 45545	Fire protection on railway vehicles
BS EN ISO 7250-1	Basic human body measurements for technological design — Part 1: Body measurement definitions and landmarks
ISO TR 24496:2017	Office furniture - Office work chairs - Methods for the determination of dimensions'
Locomotives and Passenger Rolling Stock NTSN	Locomotive and Passenger National Technical Specification Notice, published by the Secretary of State on 1 January 2021 pursuant to regulation 3B of the Railways (Interoperability) Regulations 2011. This NTSN replaces and substantially reproduces the provisions of Commission Regulation (EU) 1302/2014 (the LOC & PAS TSI), and includes relevant amendments made by Commission Implementing Regulation (EU) 2019/776 which came into force in June 2019.
PD CEN/ISO TR 7250-2:2011+A1:2013	Basic human body measurements for technological design — Part 2: Statistical summaries of body measurements from national populations
Persons with Reduced Mobility NTSN(PRM NTSN)	Persons with Reduced Mobility National Technical Specification Notice, published by the Secretary of State on 1 January 2021

	pursuant to regulation 3B of the Railways (Interoperability) Regulations 2011. This NTSN replaces and substantially reproduces the provisions of Commission Regulation (EU) No 1300/2014 (the PRM TSI), and includes relevant amendments made by Commission Implementing Regulation (EU) 2019/776 which came into force in June 2019.

Other relevant documents

KTR	Key Train Requirements
Williams-Shapps Plan for Rail	
T1140	Defining the requirements of a seat comfort selection process
Unife TecRec - Interior Passive Safety	Unife Technical Report for Interior Passive Safety in Railway Vehicles (December 2014)