EuroSpec

Seat Comfort

SNCF Rail Delivery Group DB ÖBB SBB CFF FFS

EuroSpec

Seat Comfort

1st edition

Original language: English

Paris, London, Munich (München), Utrecht, Vienna (Wien), Bern

September 2020

Table of Contents

Issue Record

Issue	Date	Comments	Source
1	September 2020	First Issue	

Revision History

Version	Date	Change

1 FOREWORD

EuroSpec is a group of European train operating companies providing harmonised product specifications for use in train procurement and refurbishment.

The main target is to align train operator's needs in order to reduce the whole life cycle cost of the train, shorten the delivery time and speed up the innovation cycle and the deployment of innovations.

The benefits of EuroSpec:

- Increase of reliability by sharing good practice and experience;
- Simplification of the tender process in time and cost as a result of fewer variations in requirements between tenders;
- Standardised products and cost reduction due to harmonisation of train operators' requirements;
- Reduction of diversity in request to the industry for more competitive and mature products;
- To provide to the industry free "Customer needs" for their future R&D program, through requirements that are not yet fulfilled by existing product nor solution.
- To promote through our common requirements to the industry the availability of information required for improving operation performance and ensuring long term sustainability of our assets, supporting open interfaces.

The EuroSpec specifications comprise merged functional and product basic requirements. All EuroSpec specifications focus on technical aspects based on lessons learned and on foreseen developments.

A EuroSpec specification is a voluntary specification designed to be used within the European region. The primary field of application is the European rolling stock domain and all associated interfaces.

Regarding the hierarchy this common specification can be positioned as follows, in order of prevalence:

- EN standards
- UIC Codes (leaflets)
- EuroSpec Specifications

- Company Specifications

2 INTRODUCTION

This document is a voluntary specification, produced by SNCF-VOYAGEURS, Rail Delivery Group (RDG), Deutsche Bahn (DB), Nederlandse Spoorwegen (NS), Österreichische Bundesbahnen (ÖBB) and Schweizerische Bundesbahnen (SBB).

Individual companies may choose to mandate it through internal instructions/procedures or contract conditions.

Purpose of this document

This document provides a voluntary specification for Seat Comfort for use by companies in the rail sector if they so choose.

The purpose of this document is to provide a common specification for Seat Comfort in rolling stock between train operators. This document is to replace individual company specific functional requirements and constitutes a common reference being used for tendering and verification.

This EuroSpec Seat Comfort specification makes references to academic research, see Chapter 11. Persons applying this EuroSpec should read the referenced academic research in order to understand the complex interactions between individual requirements. Full details are in the References section.

The EuroSpec Seat Comfort Working Group adopted the concept that the specification should be true for any population. Comfort cannot be described by specifying any one fixed measurement valid for all Europeans since all Europeans are not identical. Europeans can however be subdivided into populations. Identification of the intended population and corresponding anisotropic dataset, including weight, is required by this specification. Identification of the desired passenger activities and intended travel time is also required.

Design evaluation and optimization by pressure mapping of the seat pan contour has been added to the specification. Here optimal pressure distribution, gradient, maxima and prevention of hotspots are specified. Combined with the requirements for body contour, limitation of shear forces, choice of the correct seat angles, the shape of lumbar support and head support further optimization of comfort can be achieved, including whilst reclining. Starting from scratch or based on previous knowledge any 3D contour geometry can be the basis for further development. Optimal pressure distribution can be achieved by iteration of evaluation and contour optimization.

It should be understood that a sports car seat pan and seat back will not meet the postures requirements for railway seats. Multiple techniques are available to the suppliers to optimise pressure distribution. Combined with the questionnaires in the requirements, set the improvements in comfort, after each iteration, can be made insightful. The travel times intended by the customers, selected population and intended postures can be used as input for the evaluations.

This document is supported by supplementary documents which contains the questionnaires mentioned within.

Application of this document

- This specification is voluntary. Individual companies may however elect to mandate all or part of its use through company procedures or contract conditions. Where this is the case, the company concerned must specify the nature and extent of application.

- Specific compliance requirements and dates of application have therefore not been identified since these will be the subject of the internal procedures or contract conditions of those companies that choose to adopt this standard.

Safety responsibilities

- Users of documents published by SNCF-VOYAGEURS, Rail Delivery Group (RDG), Deutsche Bahn (DB), Nederlandse Spoorwegen (NS), Österreichische Bundesbahnen (ÖBB) and Schweizerische Bundesbahnen (SBB) are reminded of the need to consider their own responsibilities under the relevant European or national safety legislation.
- SNCF-VOYAGEURS, Rail Delivery Group (RDG), Deutsche Bahn (DB), Nederlandse Spoorwegen (NS), Österreichische Bundesbahnen (ÖBB) and Schweizerische Bundesbahnen (SBB) make no warranty that application of all or any part of documents published by SNCF-VOYAGEURS, Rail Delivery Group (RDG), Deutsche Bahn (DB), Nederlandse Spoorwegen (NS), Österreichische Bundesbahnen (ÖBB) and Schweizerische Bundesbahnen (SBB) is sufficient in itself to ensure safe systems of work or operation or to satisfy such responsibilities or duty of care.

Copyright

Approval and authorisation of this document

- The content of this document was approved for publication by the technical bodies of SNCF-VOYAGEURS, Rail Delivery Group (RDG), Deutsche Bahn (DB), Nederlandse Spoorwegen (NS), Österreichische Bundesbahnen (ÖBB) and Schweizerische Bundesbahnen (SBB).

3 SCOPE

This specification is applicable to rolling stock that is equipped with Passenger Seats.

This specification is an add-on to the Technical Specifications of Interoperability (TSI). The specification contains requirements at system level of Seat Comfort and its interfaces, and unifies the requested performances of the different operators.

This EuroSpec cannot be used directly, i.e, do not copy and paste into a specification; some thought as to which requirements are relevant to the type of service and journey time will be needed.

When used in a tender procedure, which will be the main utilization of this EuroSpec, it has to be clear that several additional operator specific requirements have to be defined. It has to be clear that the sole use of this EuroSpec will not be sufficient for a tender procedure since it only covers comfort relevant requirements.

Any other technical or operator specific requirements have to be chosen by the user. Also it might not be necessary to use this EuroSpec entirely for every tender procedure. Any user of this EuroSpec should feel free to use the parts of that are relevant for their specific tender procedure.

If an optional requirement (a Design Recommendation) is required the wording of the requirement may need to be reformatted to suit or if a requirement is not needed it can be ignored or deleted. See EuroSpec Requirements Management document.

This specification is not intended to block innovation or to prevent improvement. For this purpose, each requirement is followed by a rationale.

If applicable, the requirements are referenced to the EN 15380 structure. It is foreseen that more requirement sets and European standards will make use of this common reference structure.

4. NORMATIVE REFERENCES

The following referenced documents are indispensable for the application of this document. ENs are developed by CEN[1] or CENELEC[2] , UIC leaflets are developed by UIC[3] and are made available from their members.

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

GMRT2100 issue 4	Requirements for Rail Vehicle Structures
TEC REC 100-006	Interior Passive Safety in Railway Vehicles
UNIFE REF 001	Interior Passive Safety in Railway Vehicles
UIC Code 566	Loadings of coach bodies and their components
UIC Code 567	General provisions for coaches
ISO 13299	Sensory analysis — Methodology — General guidance for establishing a sensory profile
ISO 11035	Sensory analysis — Identification and selection of descriptors for establishing a sensory profile by a multidimensional approach
ISO 11136	Sensory analysis — Methodology — General guidance for conducting hedonic tests with consumers in a controlled area
ISO 4121:2003	Sensory analysis -- Guidelines for the use of quantitative response scales
ISO 8589:2007 including ISO 8589:2007 / Amd 1:2014	Sensory analysis -- General guidance for the design of test rooms
Technical specification for interoperability for persons with reduced mobility	Technical specification for interoperability relating to accessibility of the Union's rail system for persons with disabilities and persons with reduced mobility COMMISSION REGULATION (EU) No 1300 / 2014 of 18 November 2014
ISO 8587: 2003	Sensory analysis -- Methodology -- Ranking

[1] Comité Européen de Normalisation / European Committee for Standardization - www.cen.eu

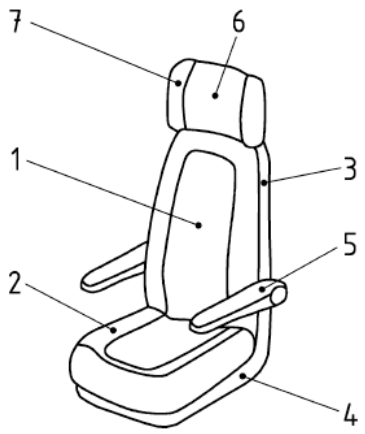
[2] Comité Européen de Normalisation Électrotechnique / European Committee for ElectrotechnicalStandardization - www.cenelec.eu

[3] Union internationale des chemins de fer / International Union of Railways - www.uic.org

5. TERMS, DEFINITIONS AND ABBREVIATIONS

TSI	Technical specification for interoperability
EN	EuroNorm
FAI	First Article Inspection
FII	First Installation Inspection
m	male
f	female
P5	5th percentile
P50	50th percentile
P95	95th percentile
WG	Working Group
SRP	Seat Reference Point
ISO	International Standards Organisation
SMART	Specific, Measurable, Attainable, Realistic, Timely

Seat components and symbols used in this document



Key:

1. seat back (back rest / cushion)
2. seat pan (squab) (base)
3. seat shell (back)
4. seat shell (base)
5. armrest
6. head support / headrest / anti-macassar or pillow
7. “ears” or head support / headrest

Figure 1: Seat components

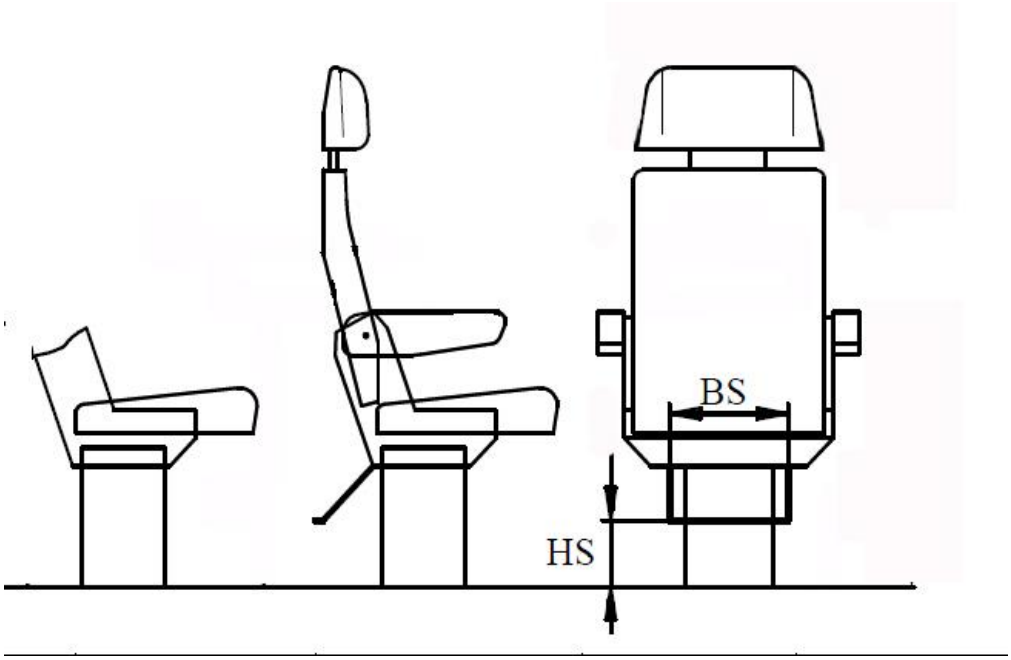


Figure 2: Symbols for footrests

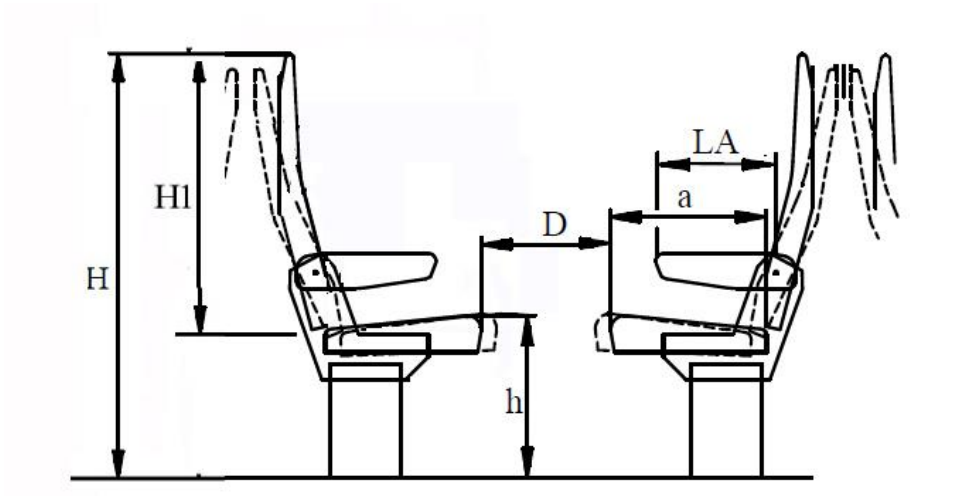


Figure 3: Symbols for viz-à-viz (facing) seats

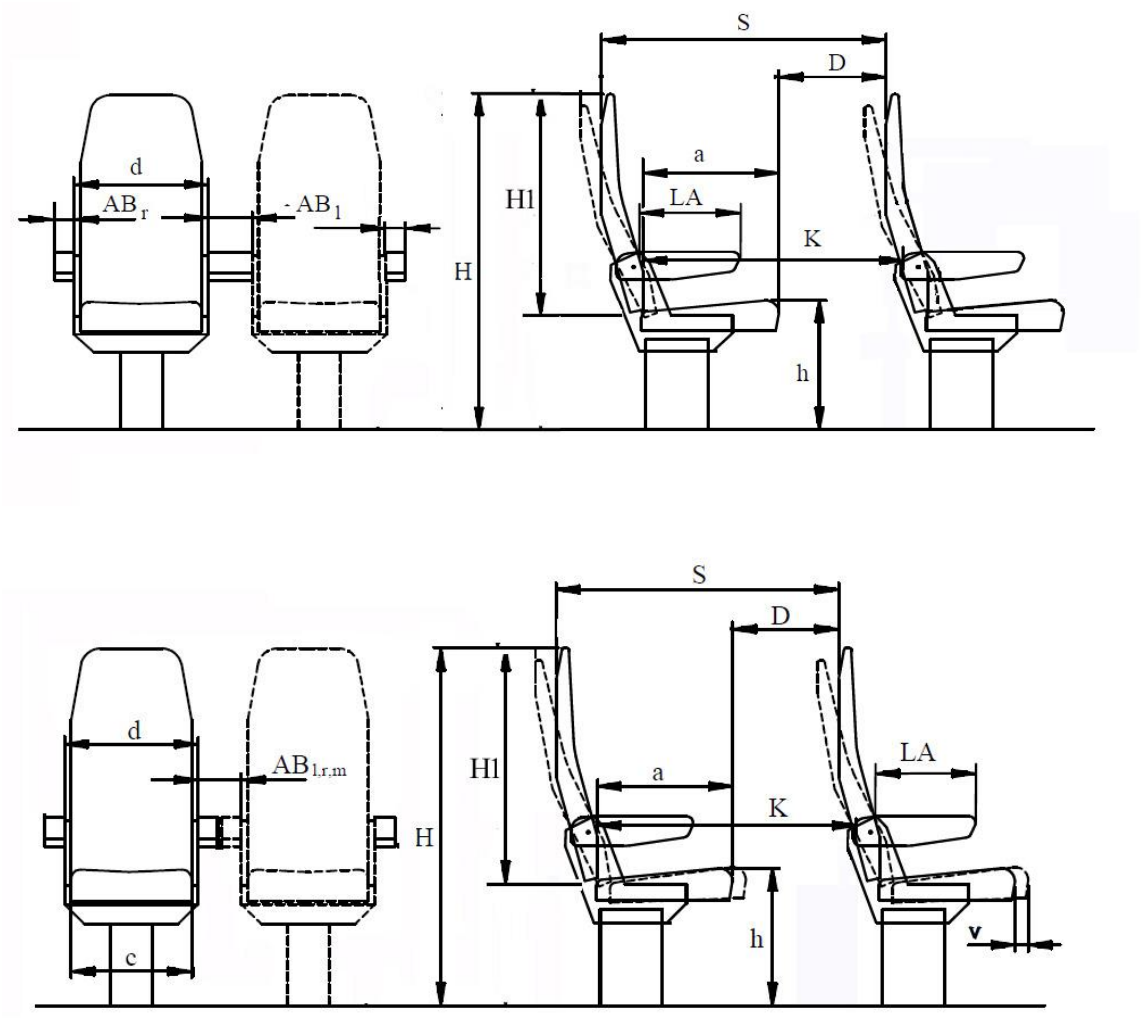


Figure 4: Symbols for seats in a row (airline) seats

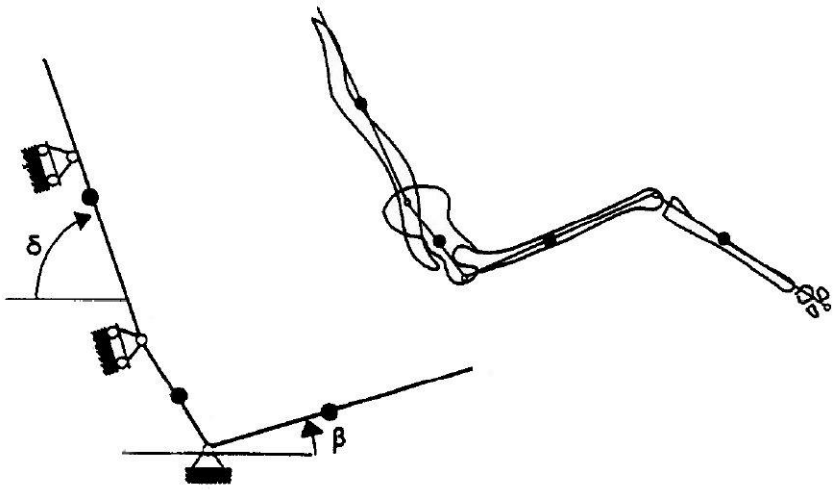


Figure 5: Symbols for seat angles (Goossens, 1995)

Key to symbols in figures above and in Appendix

Name	Symbol	Description
Seat base (squab) depth	a	measured from the seat base leading edge to a vertical line which touches the seat back cushion (unloaded)
Width of seat base (squab)	c	maximum measurement between the edges of the seat base
Distance between armrests / seat back width	d	minimum distance between the two armrests
Seat base (squab) height	h	measured between the floor covering and the upper level of the middle of the seat cushion (unloaded).
Possible movement of seat base (squab)	v	horizontally measured way of the seat base when inclined
Width of passage *(cushion to cushion or cushion to seat-back)*	D	distance between two opposing front edges of the seat bases / cushions, or between the front edge of the seat base and the backrest of the seat in front.
Seat height	H	overall height of the seat, measured between the floor covering and the upper edge of the backrest / headrest.
Seat squab to seat back height	H1	height of the seat back, measured between the squab and the upper edge of the backrest / headrest.
Knee / leg space for seats in a row.	K	distance on the centre longitudinal axis between the backrest front and backrest rear of the seat in front, measured 550 mm above the floor covering.
Seat pitch for seats in line	S	distance between two seats backs, measured within the upright position.
Armrest width	AB	maximum width of one or two armrests side by side of one or two seats
Width of footrest	BS	measurement of the usable surface of the footrest
Height of footrest	HS	measured between upper edge of the footrest and floor covering.
Armrest length	LA	useful length of the armrest measured from the backrest contour to the front of the armrest
Seat inclination angle	β	angle of inclination of the seat cushion to the horizontal.
Backrest tilt angle	δ	angle of inclination of the backrest cushion to the horizontal.

6. BACKGROUND

a. Guidance on approach taken

This section is to give guidance about the approach to achieve maximum seat comfort.

The measurable requirements in the EuroSpec offer the first set of requirements. The second set of requirements from questionnaires is to evaluate the perception of comfort. See figure 6.

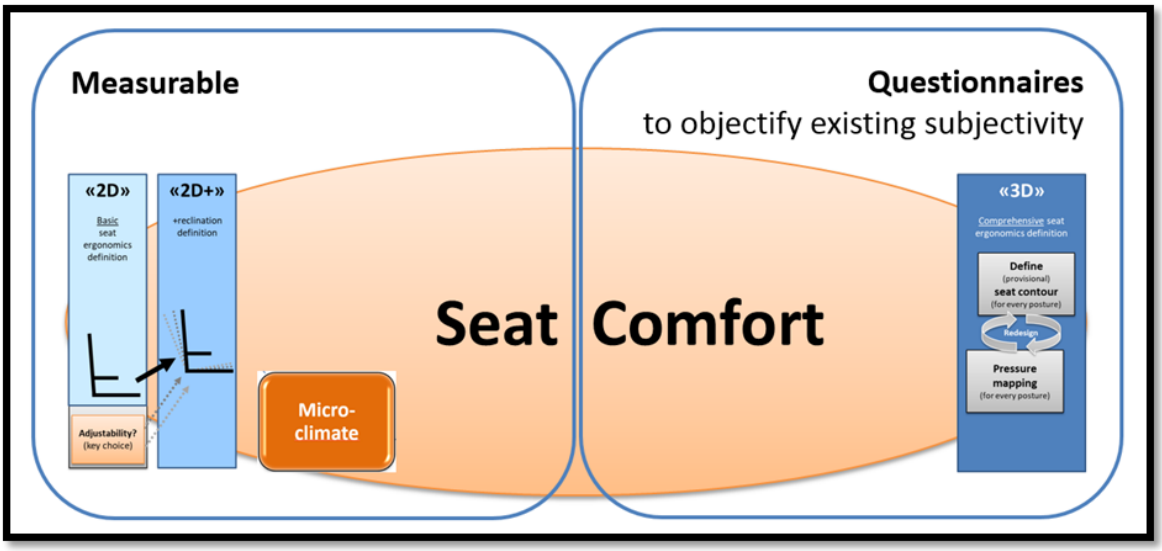


Figure 6. Basic principles of a seat ergonomics development process.

To objectify the subjective comfort perception the evaluation is procedurally standardized in the EuroSpec specification. Statistical analysis should be applied to quantify the evaluation. The evaluation can be used to optimize the comfort by redesign. Questionnaires in the supporting document are identified as widely applied in academic works. These were added, unchanged, to the specifications in an attempt to procedurally harmonize comfort evaluation. Depending on the project phase these questionnaires will allow seat manufacturers and operators to evaluate the seats and possibly identify points of improvements.

Application of ISO standards for Sensory Analysis have been identified as applicable to the procedures used for the sensory analysis of seat comfort. Since sensory perception of the skin / muscle / body is processed basically the same as the sensory perception of olfactory information created by the nose and mouth, the ISO standard for foodstuffs could also be made applicable to sensory evaluation of the skin / muscles / body. Specific ISO standards used in the food and beverages industry have detailed descriptions of how to prevent observational bias. Other ISO standards detail the environment in which an unbiased evaluation of, in this case, seat comfort can be best achieved. Further ISO standard detail statistical analysis methodologies should be applied in combination with the aforementioned Questionnaires to draw better conclusions. See https://www.iso.org/ics/67.240/x/ for an overview of Sensory Analysis standards.

These requirements should allow seat manufacturers to optimize the seat components in an iterative way. Once experience has been gained with application of these requirements the optimization process cost should be reduced.

The 2D parameters of a seat, see Figure 8, describe the basic dimensions of a seat, for example, width, height and depth. For the measurements between armrests and the seat pan width the external P95 female dimension is used. All technical requirements are written to not mention one

SMART fixed measurement, but to reference either the P5 female, P50 male, P50 female or P95 male. P5 female was applied to all “internal” measurements like “Seat Pan Height, Sitting”. P95 male was applied to all “external” measurements like “Seat Back Height, Sitting” but also for requiring i.e. the minimal pitch or table height. P50 male / female is only used in the EuroSpec Seat Comfort where satisfying a greater spread of the population is required. The “mean” of the population is ignored based on the idea that 95% of the population is “comfortable” when using the P5 and P95 percentiles. The external body measurements also prescribe the available space needed behind and below front facing seats. Here the P95 male is expected to be able to stretch his legs and extend them below a seat in front. By extending the legs the P95 male can achieve an optimum in the pressure distribution on the seat pan. Adjustability of the seat pan height would increase the potential of a seat to be comfortable for P5 and up passengers.

b. Seat comfort and seat ergonomics

The topic “Seat Comfort” covers a wide range of aspects. According to the Munich University of Technology (TU München)[4], seven parameters are most important for rail seat applications, see figure 7:

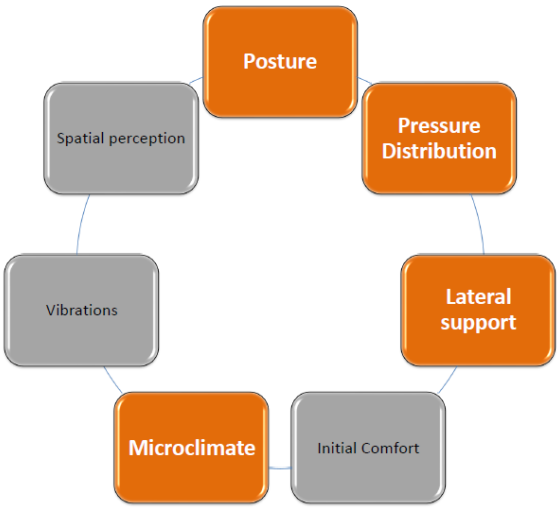


Figure 7. Seven parameters of seat comfort (Ulherr, A., *TU München*)

As a first contribution towards a potentially wider range of EuroSpec seat comfort specifications, this edition covers the areas “posture”, “pressure distribution”, “microclimate” and “lateral support” to describe the ergonomics of passenger seats on trains. It focuses on “conventional” seats for day trains, i.e. not sleeping, business class, tip-up seats or similar.

Identification of postures is based on the intended activities. The postures result in the necessary seat back and seat pan angles. When postures result in multiple seat back and seat pan angles, adjustability of the seat back and seat pan is a necessity. The relationship between the seat back angle and the preliminary seat pan angle is given by minimizing the shear forces acting on the body. This is also true for a reclined seat, therefore selection of the most favourable rotation/translation “point” during reclining is necessary. The friction coefficient of the upholstery should provide enough friction to prevent involuntary sliding of the passenger in the seat while travelling, accelerations and going through switches.

To compensate for the difference in body measurements, adjustments need to be able to be made by the passenger. Adjustment of seat pan height, head rest height, headrest angle, seat pan

[4] Ulherr, A. et. al., Presentation to EuroSpec Working Group on 11-Oct-2017

depth, etc. are recommended in the requirements set, but not required. Here available budget and intended comfort levels can affect the choices made for the necessary adjustability. Further optimization of the seat can be achieved by providing adjustability to the tables and armrest orientation and contour. These adjustments are specified as optional since the costs of implementation can be significant.

Requirements for adjustability were added to the specification as “design recommendations” or “options”. When applied, the adjustability of seat features allows passengers to adjust the seat to their personal needs between the P5 to P95 (5th percentile to 95th percentile) range. Giving passengers something to adjust not only provides comfort to the body, but also to the brain. A sense of control over one’s environment increases the perception of comfort.

Generally accepted Railway Standards were scanned to identify applicable requirements. The section for microclimate as described in the UIC 567:2004 is referenced to by the specification. These requirements ensure temperature and humidity control behind the back and below the buttocks. The section for upper limits to hand operating forces was identified in UIC 566:1990. This will limit the forced needed to operate the adjustable features of the seat.

c. One seat ergonomics algorithm for custom-made seats

Based on the academic findings this specification’s approach to defining seat ergonomics is applicable to at least all European countries. The basic idea is that the body shapes of the “population” using the train define the ideal shape of a train seat. This can be the residents of a region or more as well as a whole country or even several nations. For train services with a substantial share of tourists, the “population” target audience may even differ from the actual residents around the stations served.

While the “population” and its body shapes vary from one region or country to another, the seat development algorithm remains the same. The results are therefore “custom-made” seats for the target group.

d. Basic principles of seat development

The following figure 8 describes the approach taken in this EuroSpec as the development process of seats.

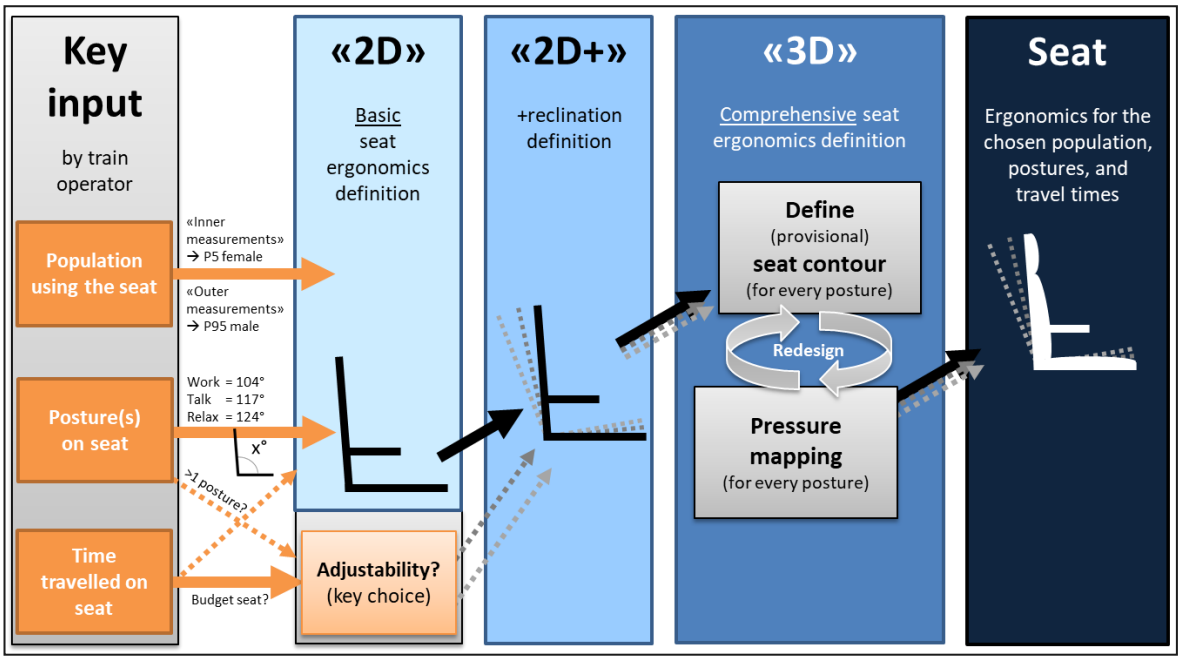


Figure 8: Basic principles of seat ergonomics development process.

Key inputs (by train operator)

Key inputs are described in lines identified by the Type Key “Key Input” of the specification in clause 8

1. Population using the seat

   The group of persons expected to use the train is to be defined. The term strictly describes the people “populating” the train, which will often but not always coincide with the catchment area’s population of the train services where the seat shall be used.

2. Posture(s) on seat

   The postures, for which the seat is expected to be used, is defined. This could be for working, talking, relaxing, etc. It is advisable to request that a single posture arrangement is “included in the seat price”. For more than one posture, see “Adjustability?” below.

3. Time travelled on seat

   This topic is closely related to “posture(s) on seat” and may have an impact on the posture(s) chosen. Usually, the longer the travel time or the more premium the service, the more likely is the offer of adjustable seats. However, this is a key business decision.

4. Adjustability?

   If more than one posture is to be offered, the postures have to be chosen. The expected cost impact will be more expensive and heavier seats, but also more space needed per adjustable seat. Adjustability can usually be freely chosen between the extreme angles.

This information can be collected using a Management-type Questionnaire, see Requirement SECO.6, 14 to 17 for example and supplementary document.

«2D»

The decisions made in “Key inputs” leads to several basic measurements, which can be extracted from different sources.[5] The key measurements are described in lines identified by the Type Key <<2d>> of clause 8.

«2D+»

If adjustability is chosen, up to three reference measurement sets are defined. It is described in lines identified by the Type Key <<2d+>> of clause 8.

«3D»

This process step aims to define the three-dimensional surface of the seat. Up to three initial seat contours are to be assessed for comfort. This is done by pressure mapping. It can be expected that a number of re-designs are necessary to meet the requirements. The outcome is to comply with the pressure distribution requirements set out in the specification. It is described in lines identified by the Type Key <<3d>> clause 8.

[5] Examples for sources: Schmidtke, Handbuch der Ergonomie, 1989. TU Delft database on http://dined.io.tudelft.nl/en/database/introduction.

Seat

Once the outcome complies with the requirements, the 3D surface shape of the ideal seat for the chosen population, postures, and quality (adjustability) is achieved.

Please be aware that this specification basically covers a bare seat. You may want to imagine a wooden chair that is perfectly shaped for the purpose – but no definition of foams or textile is included yet. This may be part of another EuroSpec at a later point.

7. GUIDANCE INFORMATION

The following sections are to give guidance on typical journey times and a weighting should some compromises on deciding on the importance of certain dimensions has to be made.

Journey time for seat usage

It is important to establish criteria for the design of seats that take account of intended usage; in particular, typical anticipated periods of seat occupancy. The following are some examples of how to split the "comfort" levels into journey types (linked to typical journey time) and seat type, as follows:

Journey type	Journey time	Seat class type
Inner suburban / metro	20 – 30 minutes	Standard
Inter-urban	60 – 90 minutes	Standard and First
Inter-city	>180 minutes	Standard and First

Compromise criteria

Some of the dimensions of a seat are less critical to comfort than others. The following table indicates some examples of those which should be altered last, indicated by a '3' and those that can be changed first, indicated by a '1'. They can also be used to weight the dimension if a "comfort number" is to be created for comparison purposes.

Dimension	Symbol	Weighting
Seat depth	a	3
Seat base width	c	3
Seat base height	h	3
Seat base inclination	β	2
Seat back height	H	3
Distance between armrests / seat back width	d	3
Seat back angle	δ	2
Armrest length	LA	1
Armrest height		2

Armrest width	AB	1
Table available		1
Foot rest width	BS	1
Upholstery		3

8. SPECIFICATIONS

This chapter describes the requirements and their objectives. For several requirements verifications are included. Verification describes how compliance to the requirement will be verified.

The columns of the specification are subsequent defined:

ID

Unique Identification of the requirement

Requirement classification

Importance and legal status of the requirement to the project To differentiate between the requirements with regard to relevance and legal status like Requirement (RE - mandatory), Design Recommendation (DR), Optional Requirement (OR) or Information (INFO).

Type Key

Key inputs are described in lines identified by the Type Key “Key Input”

Requirement-text

Description of the requirement

Rationale

Reason to state the requirement

Product element EN 15380-2

Link between requirement and the product element of the EN 15380-2

Change since last release

Description of the modifications that have been made to one or more attributes of this requirement since the last release

Verification

Verification type and point of time

Further information can be found in the document “EuroSpec Requirements Management” at www.eurospec.eu

ID	Requirement classification	Type Key	Requirement title	Requirement-text	Rationale	Comment for the reader: Description of value to be specified	Product element EN 15380-2	Change since last release	Verification				
									Offer of Tenderer(s)	Design Review	FAI[6]	FII[7]	Take-over
SECO.1			**Section: standards, general remarks**						-	-	-	-	-
SECO.2	INFO	--	Fulfilment of standards	All applicable standards for passenger interior equipment also need to be applied for the design and building of railway vehicles	Disclaimer		D-C		-	-	-	-	-
SECO.3	INFO	--	TSI PRM interface	The Persons with reduced mobililty TSI requirements takes presidence over this EuroSpec requirement set.			D-C		-	-	-	-	-
SECO.4	INFO	--	Seat dimensions for passive safety	See GMRT2100 and/or TEC REC 100-006 for passive safety based seat dimensions or similar. When they are applied the dimensions given in this Eurospec are subsidiary.	GMRT2100, TEC REC 100-006 or similar provide information regarding seat dimensions to ensure safety during dynamic impacts. When applied the dimensions in these requirements are subsidiary.		D-C		-	-	-	-	-
SECO.5			**Section: passenger seats**						-	-	-	-	-
SECO.6	INFO	Key Input	Gather information about intended use	The intended use of the seats can be defined by the train or seat purchaser by completing a' Management Questionnaire'. This will include the positions for which the seat will be used. See supporting documents EuroSpec Seat Comfort Appendices EuroSpec Seat Comfort Management Questionnaire, and EuroSpec Seat Comfort Fleet Manager VKM Questionnaire.	In order for seats to be developed according to this EUROSPEC, the manager needs to inform the developing parties of the intended uses of the seats. Without this information no educated development of a seat can be done. Asset Managers, Fleet Managers, etc are the intended managers in this requirement. i.e. the Manager of the organisation financing the seats.		D-C		Statement of compliance	System Description	Demonstration	Demonstration	Statement of comformity
SECO.7	RE	Key Input	Anthropometrics - use of a dataset	An anthropometric database shall be used to define measurement.	In Europe many databases are used such as DINED, SizeGERMANY, DIN 33402-2, RAMSIS, etc. Depending on the nation a choice should be made which to use. The EuroSpec Seat Comfort Management Questionnaire can be used to gather this information.		D-C		Statement of compliance	Analysis	-	-	Statement of comformity
SECO.8	INFO	Key Input	Anthropometrics - measurements of the population	The measurements of the population shall be equal to the measurements of the intended customer population.	In order to know which populations is to be used during comfort evaluation. The EuroSpec Seat Comfort Management Questionnaire can be used to gather this information.		D-C		-	-	-	-	-
SECO.9	INFO	Key Input	Anthropometrics - weight of the population	The weight of the population shall be equal to the weights of the intended customer population.	In order to know which weights are to be used during comfort evaluation. The EuroSpec Seat Comfort Management Questionnaire can be used to gather this information.		D-C		-	-	-	-	-
SECO.10	RE	Key Input	Intended customer population	The seats shall be designed for $$ Adults using a standard to suit the population.**Change red text to suitfor example**The seats shall be designed for **Dutch** Adults **using DINED 2004.20-60 mixed (m+f).** See **http://dined.io.tudelft.nl/****	To provide input to the supplier, to be used during design and development of the product. The EuroSpec Seat Comfort Management Questionnaire can be used to gather this information.	$$ = Population database to usefor example for DUTCH DINED 2004, 20-60, mixed (m+f). See http://dined.io.tudelft.nl/**	D-C		Statement of compliance	System Description	-	-	Statement of comformity
SECO.11	INFO	--	Anthropometrics - inner measurements	As a general principle in this specification P5 female measurements are used for "inner" dimensions.	An example of an inner dimension is "Buttock-popliteal depth".		D-C		-	-	-	-	-
SECO.12	INFO	--	Anthropometrics - outer measurements	As a general principle in this specification P95 male measurements are used for "outer" dimensions.	An example of an outer dimension is "Sitting height".		D-C		-	-	-	-	-
SECO.13	INFO	--	Anthropometrics - adjustable measurements	As a general principle in this specification P5 female to P95 male measures are used for adjustable dimensions.	To give a resonable range.		D-C		-	-	-	-	-
SECO.14	INFO	Key Input	Intended customer use duration time	A short journey lasts **$$ minutes/hours.**** ****Change red text to suit**	To provide input to the supplier, to be used during design and development of the product. $$ represents the time 2 Sigma below the mean. The EuroSpec Seat Comfort Management Questionnaire can be used to gather this information.	$$ in minutes or hours	D-C		-	-	-	-	-
SECO.15	INFO	Key Input	Intended customer use duration time	A mean journey lasts **$$ minutes/hours.**** ****Change red text to suit**	To provide input to the supplier, to be used during design and development of the product. $$ represents the mean time of a journey. The EuroSpec Seat Comfort Management Questionnaire can be used to gather this information.	$$ in minutes or hours	D-C		-	-	-	-	-

[6] First Article Inspection
[7] First Integration Inspection

ID	Requirement classification	Type Key	Requirement title	Requirement-text	Rationale	Comment for the reader: Description of value to be specified	Product element EN 15380-2	Change since last release	Verification				
									Offer of Tenderer(s)	Design Review	FAI[6]	FII[7]	Take-over
SECO.16	INFO	Key Input	Intended customer use duration time	A long journey lasts **$$ minutes/hours.**** ****Change red text to suit**	To provide input to the supplier, to be used during design and development of the product. $$ represents the time 2 Sigma above the mean. The EuroSpec Seat Comfort Management Questionnaire can be used to gather this information.	$$ in minutes or hours	D-C		-	-	-	-	-
SECO.17	INFO	Key Input	Intended customer use duration	The maximum journey lasts **$$ minutes/hours**.** ****Change red text to suit**	To provide input to the supplier, to be used during design and development of the product. The maximum travel time determines the extreme use situation. The EuroSpec Seat Comfort Management Questionnaire can be used to gather this information.	$$ in minutes or hours	D-C		-	-	-	-	-
SECO.18	INFO	<<3D>>	Passenger seats general	The shape of the seat is to meet the requirements of anthropometric methods and experience and offer optimal seat comfort by a body shaped design. An analysis of the seat pressure distribution is to be performed and the seat is to be optimised with regard to this analysis.	To ensure ergonomic seat comfort for the desired target group.		D-C		Statement of compliance	Analysis	Analysis	-	Statement of comformity
SECO.19	RE	Key Input	Posture - activity - task	The seat shall provide the possibility to adopt different body postures during a journey.The intended postures are:**- Reading- Relaxing (incl. staring / sleeping)- Working (i.e on laptop)- Talking****(Please strike the unwanted postures but keep the text)	The ability to change positions, particularly on long journeys slows the feelings of discomfort.Depending on the intended use a list of intended postures can be listed. TheEuroSpec Seat Comfort Management Questionnaire can be used to gather this information. See:Comfortable passenger seats Recommendations for design and researchSuzanne Hiemstra-van Mastrigt, ISBN: 978-94-6259-736-5See table 6.1, Postures A - K and Table 6.13 Groenesteijn, L., Hiemstra-van Mastrigt, S., Gallais, C., Blok, M., Kuijt-Evers, L., Vink, P., 2014.Activities, postures and comfort perception of train passengers as input for train seat design. Ergonomics 57(8): 1165–1165.	**(Please strike the unwanted postures but keep the text)	D-C		Statement of compliance	Analysis	-	-	Statement of comformity
SECO.20	RE	Key Input	Posture - activity - task	The chosen postures result enable seat back angles to be defined.	See SECO.53 to SECO.57.								
SECO.21	RE	<<3D>>	Pressure mapping	The body of the passenger when seated in the seat shall be prevented from having shear forces acting on it.	The forces acting on the skin are lowest when the angles of the seat back and seat pan are chosen correcty. The information provided by Goossens gives a diagram that can be used to give values to the angles. The angles should be based on the posture of the person. The posture is based on the activity of the person. See: Comfortable passenger seats Recommendations for design and research Suzanne Hiemstra-van Mastrigt, ISBN: 978-94-6259-736-5 Goossens, R.H.M., Snijders, C.J., 1995. Design criteria for the reduction of shear forces in beds and seats. Journal of Biomechanics 28(2); 225–230.		D-C		Statement of compliance	Analysis	Type test	-	Statement of comformity
SECO.22	RE	<<3D>>	Pressure mapping - duration of evaluation	The evaluation of discomfort of the seat using CP50 shall be done for a maximum duration of 15 minutes.	Hartung 2006 used 15 minutes as maximum during CP 50 discomfort evaluation. Reverence to Estermann 1999. Hartung showed that testing at longer time interfals did not result in significant discomfort changes releated to the shape of the seat pan. See: Hartung, J., 2006. Objektivierung des statischen Sitzkomforts auf Fahrzeugsitzen durch die Kontaktkräfte zwischen Mensch und Sitz. Dissertation am Lehrstuhl für Ergonomie, Technische Universität München, München.		D-C		-	-	-	-	-

ID	Requirement classification	Type Key	Requirement title	Requirement-text	Rationale	Comment for the reader: Description of value to be specified	Product element EN 15380-2	Change since last release	Verification				
									Offer of Tenderer(s)	Design Review	FAI[6]	FII[7]	Take-over
SECO.23	RE	<<3D>>	Pressure mapping - maximum allowable discomfort	The evaluation of discomfort of the seat using CP50 shall not exceed 20 (very slight discomfort)	Hartung 2006 used as maximum 20 during CP 50 discomfort evaluation. See: Hartung, J., 2006. Objektivierung des statischen Sitzkomforts auf Fahrzeugsitzen durch die Kontaktkräfte zwischen Mensch und Sitz. Dissertation am Lehrstuhl für Ergonomie, Technische Universität München, München.		D-C		Statement of compliance	Analysis	Type test	-	Statement of comformity
SECO.24	RE	<<3D>>	Pressure mapping - population	The pressure mapping process shall use the P50 (±P5) male for the evaluation.	Hartung 2006 used the P50 male population for creating the optimal pressure distribution. Harting 2006 used the P50 length and weight as a selection criteria only.		D-C		Statement of compliance	Prosess map evaluation report	Prosess map evaluation report	-	-
SECO.25	INFO	<<3D>>	Pressure mapping - procedure	A recommended procedure for evaluating pressure mapping can be found in Kilincsoy et al, 2016.	Currently no procedure for pressure evaluation is known to this working group. Based on evaluated studies this study represents the best insight into a procedure. Note to users: please share any procedures you are currently working with so the WG can try and establish a procedure.See:Application of ideal pressure distributionin development process of automobile seatsU. Kilincsoy, A. Wagnera, P. Vinkb and H. BubbcaBMW AG Forschungs- und Innovationszentrum, M¨unchen, GermanybFaculty of Industrial Design Engineering, Delft University of Technology, Delft, The NetherlandscTechnische Universit¨at M¨unchen, Lehrstuhl f¨ur Ergonomie, Garching, GermanyReceived 18 February 2015Accepted 24 June 2015		D-C		-	-	-	-	-
SECO.26	RE	<<3D>>	Pressure mapping - percentage of load	While a P50 (±P5) male passenger sits in an upright seated position on the seat, the pressure distribution, in terms of % of weight, pressing on the legs and buttocks shall be as shown in the diagram figure A001.	To ensure support without discomfort and unobstructed blood flow in the legs. See Zenk et al. 2012, Mergl 2006, Hartung 2006, Zenk 2008 The pressure distribution is percentile-dependent and population-dependent. The distribution of pressure is also dependent on the seat inclination angles, the postures (activities) and the contour shapes of the passengers. Therefore the P50 male in an upright sitting position is the starting point for seat contour development.		D-C		Statement of compliance	Analysis	Type test	-	Statement of comformity
SECO.27	RE	<<3D>>	Pressure mapping - gradient of load	While a P50 (±P5) male passenger sits in an upright seated position on the seat, the pressure distribution gradient, in terms of % of weight, pressing on the legs and buttocks shall be as shown in the diagram figure A002.	To ensure support without discomfort and unobstructed blood flow in the legs. See Zenk et al. 2012, Mergl 2006, Hartung 2006, Zenk 2008 The pressure distribution is percentile-dependent and population-dependent. The distribution of pressure is also dependent on the seat inclination angles, the postures (activities) and the contour shapes of the passengers. Therefore the P50 male in an upright sitting position is the starting point for seat contour development.		D-C		Statement of compliance	Analysis	Type test	-	Statement of comformity
SECO.28	RE	<<3D>>	Pressure mapping - maximum allowable pressures	While a P50 (±P5) male passenger sits in an upright seated position on the seat, the maximum pressure, in terms of % of N/cm^2 pressing on the legs and buttocks shall be as shown in the diagram figure A002.	To ensure support without discomfort and unobstructed blood flow in the legs. See Zenk et al. 2012, Mergl 2006, Hartung 2006, Zenk 2008The pressure distribution is percentile-dependent and population-dependent. The distribution of pressure is also dependent on the seat inclination angles, the postures (activities) and the contour shapes of the passengers. Therefore the P50 male in an upright sitting position is the starting point for seat contour development.		D-C		Statement of compliance	Analysis	Type test	-	Statement of comformity

ID	Requirement classification	Type Key	Requirement title	Requirement-text	Rationale	Comment for the reader: Description of value to be specified	Product element EN 15380-2	Change since last release	Verification				
									Offer of Tenderer(s)	Design Review	FAI[6]	FII[7]	Take-over
SECO.29	RE	--	Pressure mapping, hotspots	While a P50 (±P5) male / female passenger sits in any seated position on the seat, the pressure distribution gradient, in terms of % of weight, pressing on the legs and buttocks shall not show sensitive edges / spots.	To ensure support without discomfort and unobstructed blood flow in the legs. See Zenk et al. 2012, Mergl 2006, Hartung 2006, Zenk 2008 The pressure distribution is percentile-dependent and population-dependent. The distribution of pressure is also dependent on the seat inclination angles, the postures (activities) and the contour shapes of the passengers. Therefore the P50 male / female in an upright sitting position is the starting point for seat contour development. Choices regarding: - the positioning of construction elements in the seat pan, - the positioning of stitching, - etc, will cause pressure gradient peaks / hotspots which could cause discomfort to the buttocks, upper legs. Positioning of any features in / below the seat pan can have a negative effect on pressure distribution.		D-C		Statement of compliance	Analysis	Type test	-	Statement of comformity
SECO.30	RE	<<3D>>	Pressure mapping	The seat pan and cushion contour of the seat shall be optimised to provide support to the seated passenger's body.	Different body types need different support in order to optimise the pressure distribution. Contour information is provided in the studies done. See referenced studies below.Depending on the postures the shape of the seat pan and seat back should be shaped to accommodate the maximum amounts of postures with the best overall pressure distribution. see:Comfortable passenger seats Recommendations for design and researchSuzanne Hiemstra-van Mastrigt, ISBN: 978-94-6259-736-5Franz, M., Kamp, I., Durt, A., Kilincsoy, Ü., Bubb, H., Vink, P., 2011. A light weight car-seat shaped by human body contour, International Journal of Human Factors Modelling and Simulation, Vol. 2 (4), 314–326 An estimation of the human head, neck and back contour in an aircraft seat N.Nijholt, T.Tuinhof, J.M.A.Bouwens, U.Schultheis and P.Vink Faculty of Industrial Design Engineering, Delft University of Technology, Delft, The NetherlandsN. Nijholt,∗, T. Tuinhof, J.M.A. Bouwens, U. Schultheis and P. Vink, An estimation of the human head, neck and back contour in an aircraft seat,		D-C		Statement of compliance	Analysis	-	-	Statement of comformity
SECO.31	**Seat pan**		**Section: seat pan**						-	-	-	-	-

ID	Requirement classification	Type Key	Requirement title	Requirement-text	Rationale	Comment for the reader: Description of value to be specified	Product element EN 15380-2	Change since last release	Verification				
									Offer of Tenderer(s)	Design Review	FAI[6]	FII[7]	Take-over
SECO.32	RE	<<2D>>	Seat pan width	The seat pan width (c) shall be dimensioned on the hip breadth, sitting [24] of the P95 female. See figure 4 and figure A003,	The hip breadth is an "outer" dimension and should be based on the widest person in the population. Pregnant women are not the basis for this requirement, but women in general. The width, height and depth of the seat pan enable correct dimensioning of the seat pan, thus enabliing correct pressure distiribution. Correct pressure distribution will enable correct circulation of bloodflow in the legs.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.33	RE	<<2D>>	Seat pan height	Where the seat pan height is adjustable according to SECO.35 THEN the seat pan height (h) shall be dimensioned on the popletial height (sitting) [14] of the P5 female See figure 4 and figure A004.	The popliteal height is an "inner" dimension and should be based on the smallest person in the population. The height and depth of the seat pan enable correct dimensioning of the seat pan, thus enabling correct pressure distribution. Correct pressure distribution will enable correct circulation of blood flow in the legs. When a seat is not equipped with adjustability of the seat pan height, the p5 female measure may result in an unwanted decrease in comfort for the P50 male and up. If this is the case the P50 female measure is suggested as the measure to use. It is allowable to choose any other P value between p5 female and p50 female for this measure.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.34				Where the seat pan height (h) shall be dimensioned on the popletial height (sitting) [14] of the P50 female. See figure 4 and figure A004.									
SECO.35	DR	<<2D+>>	Seat pan height - adjustability	The seat pan height (h) shall be adjustable to suit the P95 male. See figure 4 and figure A004.	The buttock-popletial depth is an "inner" dimension and in order to support the legs of the P95 male correctly the seat should be made adjustable. (Design Recommentation)		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.36	RE	<<2D>>	Seat pan length	The buttock-popletial depth [32] of the P5 female shall be used for the seat pan length (a) dimension. See figures 3 & 4 and figure A005.	The buttock-popletial depth is an "inner" dimension and should be based on the smallest person in the population.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.37	DR	--	Seat pan length	The seat pan length (a) shall be made adjustable to support the P95 male. See figures 3 & 4.	The buttock-popletial depth is an "inner" dimension and in order to support the legs of the P95 male correctly the seat should be made adjustable. (Design Recommentation)		D-C		Statement of compliance	System Description	Demonstration	-	Statement of comformity
SECO.38	DR	<<3D>>	Seat pan contour	The contour of the seat pan shall follow the contour of the body, taking into account the postures / activities (SECO.19) of the passengers. See Hiemsta van Mastrigt, 2015, Chapter 7, Table 7.3, figure D.	Franz et al. (2011) and Hiemstra-van Mastrigt (2015) determined and combined 3D body contour measurements. These contours should be used to shape the seat base and seat back. Contour information should be used (or developed) for the chosen population. Depending on the intended postures / activities the contour of the seat should be adapted. The shape of a sports car seat should not be seen as a correct basis for the shape of a railway seat. The activity and posture in a sports car has no correlation to postures in a train.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.39	**Seat back**		**Section: seat back**						-	-	-	-	-
SECO.40	RE	<<2D>>	Seat back height	The sitting height [17] of the P95 male shall be used to dimension the seat back height (H1). See figures 3 & 4 and figure A006.	The sitting height is an "outer" dimension and should be based on the largest person in the population. This measure ensures that tall people will have backwards head support.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity

ID	Requirement classification	Type Key	Requirement title	Requirement-text	Rationale	Comment for the reader: Description of value to be specified	Product element EN 15380-2	Change since last release	Verification				
									Offer of Tenderer(s)	Design Review	FAI[6]	FII[7]	Take-over
SECO.41	RE	<<2D>>	Seat back width	While measured at the shoulder height, sitting [15] of the P95 male and the P95 female, the seat back width (d) shall be dimensioned on the shoulder breadth (bi deltoid) [22] of the P95 male. See figure 4 and figures A003 & A007.	The shoulder breath is an "outer" dimension and should be based on the largest person in the population. This measure ensures that widest people will have backwards back support. Both the female and male shoulder heights are used to ensure the contour of the back of the seat is wide enough to support both male and female P95.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.42	DR	<<3D>>	Seat back contour	The contour of the seat back shall follow the contour of the body, taking into account the postures / activities (SECO.19) of the passengers.	Franz et al. (2011) and Hiemstra-van Mastrigt (2015) determined and combined 3D body contour measurements. These contours should be used to shape the seat pan and seat back. Contour information should be used (or developed) for the chosen population. Depending on the intended postures / activities the contour of the seat should be adapted. The shape of a sports car seat should not be seen as a correct basis for the shape of a railway seat. The activity and posture in a sports car has no correlation to postures in a train.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.43	RE	<<2D>>	Seat back contour	The lumbar support shall have a maximum of 30 mm protrusion.	Carcone, S.M., Keir, J.K., 2007. Effects of backrest design on biomechanics and comfort during seated work. Applied Ergonomics 38: 755–764.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.44	RE	<<2D>>	Seat back contour	The position of the lumbar support above the seat pan shall be at the mean of the population (P50 male / female).	Korte, J., 2013. South African anthropometric dimensions for the design of an ergonomic office chair. Master thesis, Rhodes University, Grahamstown, South Africa, 2013.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.45	DR	<<3D>>	Seat back contour	Features such as stitching, embossing, etc, on the seat pan and back in areas of the body with more sensitivity shall be avoided.	Peter Vink, Daan Lips Sensitivity of the human back and buttocks: The missing link in comfort seat design, Delft University of Technology, Faculty of Industrial Design Engineering, The Netherlands		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.46	RE	<<2D>>	Seat back head support	The middle of the head support shall be dimensioned on the eye height, sitting, [16] of the P50 male / female. See figure A009.	For any seat back head support the support, be it sideways (ears) or only on the back of the head (small cushion), the support should be given at around the position of the temporalis muscles or near the occipitalis muscles. Since these locations are not measured in databases the measure of the eye height is chosen in this specification.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.47	DR	<<2D+>>	Seat back head support - adjustability	The middle of the head support shall be made adjustable to the eye height, sitting, [16] from the P5 female to the P95 male. See figure A009.	For any seat back head support the support, be it sideways (ears) or only on the back of the head (small cusion), should be given at around the position of the temporalis mucles or near the occipitalis muscles. Since these locations are not measured in databases the measure of the eye height is chosen in this specification. Making a headrest adjustable provides a feeling of control to the passengers.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.48	RE	<<2D>>	Seat back head support	Where the head support of the seats is shaped like "ears", the head support height shall be dimensioned on the shoulder height, [15], of the sitting P95 male. See figure A007.	Forward protruding parts are not to intersect with the shoulders of P95 males. Note:The shoulder height for the P95 male might be higher than the P5 female eye height. When this is true, choices need to be made with which measurements and adjustability is needed.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.49	DR	<<2D+>>	Seat back head support - adjustability	Where the head support of the seat is shaped like "ears", the head support height should be made adjustable to suit the shoulder height, when sitting [15], of the P5 female. See figure A007	Depending on the size and location of a head support the interaction with shoulders should be prevented. The P95 male is used to make sure the largest population will be able to fit. Making a headrest adjustable provides a feeling of control to the passengers.		D-C		Statement of compliance	System Description	Demonstration	-	Statement of comformity
SECO.50	RE	<<2D>>	Seat back head support	Where the head support of the seat is shaped like "ears", the width between the head support shall, as a minimum, be dimensioned on the head circumference [35] of the P95 male. See figure A008.	To prevent the seat back from becoming so narrow / slim that a person's head (outer dimension) will not fit the breadth needed, the head circumference is used as the minimum distance between the "seat-ears" . It is not intended to be the goal to dimension the head support to this dimension. People generally feel more comfortable when their heads are not enclosed.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.51	RE	<<2D>>	Seat back head support	Where the head support of the seats is shaped like "ears", the width between the head support shall accommodate adaptation of the listed postures.	Depending on the postures the passengers are intended to be able to take the shape of the back of the seat is different. This is also valid for the location of the head support.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity

ID	Requirement classification	Type Key	Requirement title	Requirement-text	Rationale	Comment for the reader: Description of value to be specified	Product element EN 15380-2	Change since last release	Verification				
									Offer of Tenderer(s)	Design Review	FAI[6]	FII[7]	Take-over
SECO.52	RE	<<2D>>	Seat back head support	Where the head support of the seats is shaped like "ears", the headrest shall provide a lateral shape and structure to support the head on both sides of the headrest.	To support the head.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.53	INFO	--	Seat height	The seat height (H) shall be dimensioned on the sitting height of the P95 male plus the popletial height (sitting) of the P5 female. See figures 3 & 4.	This is mentioned here as a reminder that the seat height is determined by other measurements and to prevent overspecifying.		D-C		-	-	-	-	-
SECO.54	**Reclining function**		**Section: reclining function**						-	-	-	-	-
SECO.55	RE	<<2D+>>	Reclining system	While seated in a "reading" posture the seat back angle [δ] shall be 76° to the horizontal.See figure A010a,	Hiemstra van Mastrigt (2015) showed that comfort evaluation is highest when people in a posture adjust the seat back angle to a given value.		D-C		Statement of compliance	System Description	Demonstration	-	Statement of comformity
SECO.56	RE	<<2D+>>	Reclining system	While seated in a "talking" posture the seat back angle [δ] shall be 68° to the horizontal. See figure A010a,	Hiemstra van Mastrigt (2015) showed that comfort evaluation is highest when people in a posture adjust the seat back angle to a given value.		D-C		Statement of compliance	System Description	Demonstration	-	Statement of comformity
SECO.57	DR	<<2D+>>	Reclining system	While seated in a "working" posture the seat back angle [δ] shall be 68° to the horizontal. See figure A010a,	Hiemstra van Mastrigt (2015) showed that comfort evaluation is highest when people in a posture adjust the seat back angle to a given value.		D-C		Statement of compliance	System Description	Demonstration	-	Statement of comformity
SECO.58	DR	<<2D+>>	Reclining system	While seated in a "relaxing" posture the seat back angle [δ] shall be 56° to the horizontal. See figure A010a,	Hiemstra van Mastrigt (2015) showed that comfort evaluation is highest when people in a posture adjust the seat back angle to a given value.		D-C		Statement of compliance	System Description	Demonstration	-	Statement of comformity
SECO.59	RE	<<2D+>>	Reclining system	Where multiple seat pan angles of the seat are the result of the listed postures, the seat shall offer the passenger the possibility of reclining the seat to the angles according to SECO 55, 56, 57, 58.	Depending on the postures the passengers are intended to be able to take, the seat pan angles are the resulting dimension of the seat back. When more than one angle is needed to support the person in a comfortable way the inclusion of a reclining function is the logical result.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.60	RE	<<2D+>>	Reclining system	When the seat back angle [δ] is changed, the seat pan angle [β] shall change proportionally, to avoid shear forces, see figure A010a, See requirement SECO.61 for the proportionality requirement.	In order to have no shear force acting on the body of the passenger the angles found in the study by Goossens & Snijder should be the basis for the relationship between seat base and seat back angles. Depending on the activity and resulting optimal posture, a set of optimal angle can be found for each posture. Goossens & Snijder, 1995, TU Delft		D-C		Statement of compliance	System Description	Demonstration	-	Statement of comformity
SECO.61	RE	<<2D+>>	Reclining system	The relationship between seat pan angle [β] and seat back angle [δ] shall be based on figure A010b.	In order to have no shear force acting on the body of the passenger the angles found in the study by Goossens & Snijder should be the basis for the relationship between seat base and seat back angles. Depending on the activity and resulting optimal posture, a set of optimal angle can be found for each posture. Goossens & Snijder, 1995, TU Delft		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.62	RE	<<3D>>	Reclining system - movement	While reclining from the smallest to the largest seat back angle, the pressure, in terms of N/cm^2, pressing on the legs and buttocks shall not exceed the maximum as shown in the diagram. See figure A002.	To prevent unwanted pressure distribution changes. While measuring the pressure distribution, while reclining, the movement of the reclining seat shall be such that the maximum allowable pressures are not exceeded. The combined rotation and / or translation of the reclining seat shall be in such a way that the maximum allowable pressures are not exceeded. Please note: this is not the SRP (seat reference point) used in some seat designs.		D-C		Statement of compliance	System Description	Type test	-	Statement of comformity
SECO.63	**Armrests**		**Section: armrests**						-	-	-	-	-
SECO.64	RE	<<2D>>	Armrest	Each seat shall have one left and one right armrest.	To ensure sufficient support of the forearm and relaxation of the shoulders		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.65	DR	<<2D>>	Armrest	Each seat shall have one individual left and one individual right armrest.	Individual armrests are more comfortable than shared armrests. This is true for double-, triple-, … sitting positions.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity

ID	Requirement classification	Type Key	Requirement title	Requirement-text	Rationale	Comment for the reader: Description of value to be specified	Product element EN 15380-2	Change since last release	Verification				
									Offer of Tenderer(s)	Design Review	FAI[6]	FII[7]	Take-over
SECO.66	DR	<<2D>>	Armrest clearance	The hip breadth, sitting [24] of the P95 female shall be used to dimension the distance between the armrests (d). See figure A013.	The hip breadth, sitting, is an "outer" dimension and should be based on the widest person in the population. The hip breadth is the limiting factor for persons moving out of a chair with folded down armrests. This WG assumed that belly circumference is not the limiting factor for this measurement.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.67	DR	<<2D>>	Armrest length	While the elbow is bent to a 90° angle, the armrest length (LA) shall be dimensioned on the Elbow-finger tip length (29) reduced by the hand length (43) of the P50 male / female. See figures A011 and A012.	The armrest should be long enough to support the maximum amount of persons, thereby lowering the pressure on the skin to a minimum. Freedom of movement in the wrist is preferable over restricting the wrist joint. To prevent this for the P5 female the Elbow finger tip length is reduced by the hand length as the basis for the length of the armrest. The choice of the P50 male / female is made to give more people support on the skin.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.68	RE	<<2D>>	Armrest width	The breadth over the elbow of the P95 male / female shall be used to dimension the minimum armrest width.	To minimise surface contact pressure between the elbow and the armrest top / supporting face.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.69	RE	<<2D>>	Armrest height	Where the seat has a seat back or stowable table, with the table deployed and the arm rest folded down, the top face of the armrest shall be parallel to the table top surface + mobile device keyboard thickness offset. Note: if no mobilie device use is foreseen then the offset is zero.	The table top and armrest are best when coplanar. The table is positioned with Z coordinates based on the Thigh Thickness, sitting (9) and the Knee height sitting (88) of the P95 male. Together with the thicknes of the table the top face of the table is defined. The armrest height should follow this height in order to ensure a comfortable height for working on the table. This means the armrest height is the result of the tabletop height and not related to Elbow Height when Sitting (13) .		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.70	DR	<<3D>>	Armrest contour	The armrest lower cross section should follow the upper leg contour, with an offset, that provides an increase in the free space. See figure A014.	To create maximum space freedom of movement around the legs the armrest section view should follow the contour of the upper legs. Use P5 persons for minimal contour radii.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.71	RE	<<3D>>	Armrest cushioning	The armrest shall be covered with a soft cushioned material where the passenger's arm comes into contact with it.	To ensure sufficient support of the forearm and relaxation of the shoulders		D-C		Statement of compliance	System Description	Type test	-	Statement of comformity
SECO.72	RE	<<3D>>	Armrest cushioning	Cushioning of the armrests shall be added to prevent discomfort on the elbows.	To prevent elbow and lower arm discomfort, irritation and / or pain caused by a hard surface.		D-C		Statement of compliance	System Description	Type test	-	Statement of comformity
SECO.73	DR	<<2D+>>	Armrest orientation - adjustability	While adopting the listed postures, the armrest shall be adjustable (rotation around the y-axis) to support the elbow joint.	Depending on the posture, the angles of the joints of the wrists, shoulders, upper torso, neck and elbows differ. The location of the elbow joint is a result of all these angles and all length measurements of these body parts. Adjustment of the location where the lower arm and / or elbow is supported by the armrest increases the feeling of control and allows for optimal joint angles.		D-C		Statement of compliance	System Description	Demonstration	-	Statement of comformity
SECO.74	DR	<<2D+>>	Armrest orientation - adjustability	While adopting the listed postures, the armrest shall be adjustable (rotation around the z-axis) to support the elbow joint.	Depending on the posture the angles of the joints of the wrists, shoulders, upper torso, neck and elbows differ. The location of the elbow joint is a result of all these angles and all length measurements of these body parts. Adjustment of the location where the lower arm and / or elbow is supported by the armrest increases the feeling of control and allows for optimal joint angles.		D-C		Statement of compliance	System Description	Demonstration	-	Statement of comformity
SECO.75	**Legroom**		**Section: legroom / width of passage**						-	-	-	-	-
SECO.76	RE	<<2D>>	Legroom / accessibility	The seat in front shall not protrude into the Buttock-Knee Depth Sitting (33) space of the P95 male. See figure A015.	Minimum measured distance in the centre longitudinal axis of the seat between two opposing backrests		D-C		Statement of compliance	System Description	Statement of comformity	Demonstration	Statement of comformity
SECO.77	RE	<<2D>>	Legroom / accessibility	The seat in front shall not protrude into the Knee height sitting (88) space of the P95 male. See figure A016.	Minimum measured distance in the centre longitudinal axis of the seat between two opposing backrests		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity

ID	Requirement classification	Type Key	Requirement title	Requirement-text	Rationale	Comment for the reader: Description of value to be specified	Product element EN 15380-2	Change since last release	Verification				
									Offer of Tenderer(s)	Design Review	FAI[6]	FII[7]	Take-over
SECO.78	RE	<<2D>>	Legroom / accessibility	The P95 male whilst in a seated position shall be able to extend his feet forward towards the seat in front in order to achieve optimal pressure distribution.	Since the seat pan height is dimensioned on the P5 female, the P95 male needs to be able to extend their feet forward in order to create the ideal pressure distribution. The space between seats should allow the extension of the legs and enable the ideal pressure.		D-C		Statement of compliance	System Description	Statement of comformity	Demonstration	Statement of comformity
SECO.79	RE	<<2D>>	Legroom / accessibility	The Chest depth (27) of the P95 male shall be used to dimension the minimum width of passage (D). See figure A017.	The width of passage (D) is an "outer" dimension and should be based on the widest person in the population. Pregnant women are the basis for this requirement. This is also true for reclined seats.		D-C		Statement of compliance	System Description	Statement of comformity	Demonstration	Statement of comformity
SECO.80	**Tables**		**Section: tables**						-	-	-	-	-
SECO.81	RE	<<2D>>	Table - folding	The seat shall be equipped with a table, be it stowable or drop-down.	To ensure a relaxed working height with support of the forearm on the armrest. A table can be stowed in / on the back of the seat in front or in another location in the seat structure. Each sitting position needs to have the individual use of a table which is stowable somewhere in / on the seat.		D-C		Statement of compliance	System Description	Demonstration	-	Statement of comformity
SECO.82	RE	<<2D>>	Table - folding	The drop-down or stowable table shall be dimensioned according to the listed postures.	Depending on the posture (e.g. eating, use of laptop, reading a book,…) the dimensions of the table are a result of the functional use.		D-C		Statement of compliance	System Description	Statement of comformity	Demonstration	Statement of comformity
SECO.83	RE	<<2D>>	Table - height	While the table is used (i.e. not stowed), the bottom side of the table shall not protrude into the Thigh Thickness, sitting (9) space and the Knee height sitting (88) space of the P95 male. See figure A012 and A016.	To prevent interaction between the knee / thigh and the lower parts of the table a clearance is needed. The P95 male / female is used for this measurement to ensure that larger persons fit. Depending on the population the Thigh clearance, sitting [9] or the Knee height sitting (88) may be the limiting measure.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.84	RE	<<2D>>	Table - dimensions	When the table is folded down, while seated in the most upright posture, the table shall not protrude into the abdominal depth (30) of the P95 male. See figure A012.	To prevent interaction between the body and the parts of the table a clearance is needed. The P95 male is used for this measurement to ensure that larger persons fit.		D-C		Statement of compliance	System Description	Statement of comformity	Demonstration	Statement of comformity
SECO.85	RE	<<2D+>>	Table - dimensions - adjustability	When the table is folded down, while seated in the most upright posture, while the upper arm is pointing down 90 degrees to the table, the edge of the table shall be adjustable between the P5 female to P95 male elbow fingertip length (29) minus half the hand length (43). See figures A011 & A012	The combination of body measurements result in a complex interaction. To ensure that most people will be able to use the table while adopting a comfortable posture, an adjustable table is required. Adjustment of the table will both ensure correct ergonomics and comfort (feeling of control of one's environment)		D-C		Statement of compliance	System Description	Statement of comformity	Demonstration	Statement of comformity
SECO.86				The adjustability shall be limited so to not protrude into the abdominal depth (30). See figure A012.									
SECO.87	**Footrest**		**Section: footrest**						-	-	-	-	-
SECO.88	INFO	--	Footrest	The use of a footrest is no longer needed to provide comfort since the seat base height is based on the P5 female.	Seat base height, in the past, used to be based on P50 person. This meant a footrest was provided for the smaller population. This is no longer needed..		D-C		-	-	-	-	-
SECO.89	OR	<<2D+>>	Footrest - adjustability	The footrest (HS), where provided, shall be adjustable in a minimum of two steps in addition to the end positions.	A footrest which is only used in one position does not facilitate adjustment and the feeling of control. Therefore a minimum amount of adjustment increments has been formulated.		D-C		Statement of compliance	System Description	Demonstration	-	Statement of comformity
SECO.90	OR	<<2D>>	Footrest - width	A footrest (BS), if provided, shall be dimensioned on the P95 (male / female) Foot Breadth (42) and Hip Breadth (24) See figure A013 & A018.	A footrest that allows a P95 foot (without shoe) will ensure large amounts of people can put their feet on it. It is the choice of the WG that it is not needed to adjust for shoe dimensions.		D-C		Statement of compliance	System Description	Statement of comformity	-	Statement of comformity
SECO.91	**Comfort Features**		**Section: comfort features**						-	-	-	-	-
SECO.92	RE	<<2D>>	Physiological properties of seat cushions (microclimate)	The composition of seat pan- and seat back cushions shall be designed for permeability and derivation of humidity and heat to maintain a physiological comfortable microclimate in the contact areas between the seat and the passenger. This microclimate has to stay comfortable for long term use (the temperature has to increase to max. 35°C and the relative humidity has to increase to max. 70% in the contact area after 2 hours of seating). The testing scenario for this requirements has	To prevent unwanted build up of temperature and sweat on the body. From UIC 567:2004, paragraph D.4.3		D-C		Statement of compliance	System Description	Type test	-	Statement of comformity

ID	Requirement classification	Type Key	Requirement title	Requirement-text	Rationale	Comment for the reader: Description of value to be specified	Product element EN 15380-2	Change since last release	Verification				
									Offer of Tenderer(s)	Design Review	FAI[6]	FII[7]	Take-over
				to be performed as defined in UIC 567 - D.4.3. See figures A019a and A019b.									
SECO.93	RE	<<2D>>	Seat feature operation	While operating seat functions, the necessary maximum hand and finger forces needed by the passenger shall be according to UIC 566:1990, appendix 5	To ensure the seat functions can be operated by Persons with reduced mobility at acceptable levels of operating forces.		D-C		Statement of compliance	System Description	Type test	-	Statement of comformity
SECO.94	INFO	<<2D+>>	Adjustability / Control	Adjustability by the passenger of features on the seat is recommended.	The feeling of comfort increases when passengers can influence their environment.		D-C		Statement of compliance	System Description	Demonstration	-	Statement of comformity
SECO.95	**Sensory Analysis**		**Section: sensory analysis**						-	-	-	-	-
SECO.96	INFO	<<3D>>	Sensory analysis	The ISO standards used for Sensory analysis (ISO/TC 34/SC12) may be used as a basis for testing seat comfort.	Make use of ISO standard for sensory analysis in order to prevent bias in the test methodology for seat comfort. The ISO standards for testing "foodstuffs" describe the methodology to prevent unbiased sensory analysis. These standards can also be used to analyse the comfort of seats, since the sensory perceptions of the body also are a sensory body sense.		D-C		-	-	-	-	-
SECO.97	RE	<<3D>>	Sensory analysis - Test Seats	The test seats shall represent the actual design status of the seats, except for the upholstery which shall be a featureless neutral grey version of the actual upholstery. See figure A020.	To prevent visual bias by the assessors testing the seats the upholstery should be of neutral design. To evaluate the other properties of the upholstery, like friction and touch, the upholstery should be the same for all properties except colour, (e.g. gloss etc and finish should be the same).		D-C		Statement of compliance	Statement of compliance	Statement of compliance	Statement of compliance	Statement of comformity
SECO.98	RE	<<3D>>	Sensory analysis - Test persons	The test persons shall be chosen from actual population that will use the seat.	Match the test persons with the intended population.		D-C		Statement of compliance	Statement of compliance	Statement of compliance	Statement of compliance	Statement of comformity
SECO.99	DR	<<3D>>	Sensory analysis - Methodology - Testing	The methodology desctibed in the following standards should be used in order to test the sensory analysis: ISO 13299, Sensory analysis — Methodology — General guidance for establishing a sensory profile ISO 11035, Sensory analysis — Identification and selection of descriptors for establishing a sensory profile by a multidimensional approach ISO 11136, Sensory analysis — Methodology — General guidance for conducting hedonic tests with consumers in a controlled area	The standards in this requirement are used in sensory analysis. The methodology can be adopted when sensory analysis is performed on seats. The premise is that discomfort (pain) and the sense of smell and taste are processed in the same areas of the brain.		D-C		Statement of compliance	Statement of compliance	Statement of compliance	Statement of compliance	Statement of comformity
SECO.100	DR	<<3D>>	Sensory analysis - Methodology - Ranking	The methodology described in ISO 8587:2006 should be used in order to rank sensory analysis.	The standards in this requirement are used in sensory analysis. The methodology can be adopted when sensory analysis is performed on seats.		D-C		Statement of compliance	Statement of compliance	Statement of compliance	Statement of compliance	Statement of comformity
SECO.101	DR	<<3D>>	Sensory analysis - Methodology - Classification	The methodology described in ISO 4121:2003 should be used in making a response scale.	The ISO 4121:2003 details different kinds of response scales for the sensory analysis of Foodstuffs. This same methodology can be used to make sensory anaylsis questionnaires, with response scales, for the evaluation of "Comfort". Since comfort is also a sensory perception this ISO standard can be used for assessing comfort.		D-C		Statement of compliance	Statement of compliance	Statement of compliance	Statement of compliance	Statement of comformity
SECO.102	DR	<<3D>>	Sensory analysis - Methodology - Test room	The environment in which the comfort of the seat is tested should be based on ISO 8589:2007 including ISO 8589:2007/Amd 1:2014	The neutral environment of a test room should prevent bias of the test person.		D-C		Statement of compliance	Statement of compliance	Statement of compliance	Statement of compliance	Statement of comformity
SECO.103	INFO	<<3D>>	Sensory analysis - Methodology - Questionnaires	The comfort level can be investigated using the questionnaires in supporting document "Seat Comfort - Questionnaires"	During the project startup the seat supplier will question the train operator about the intended comfort level. During the PCR the seat supplier will question the operator about the intended comfort level. During the CCR the seat supplier will question the train operator about the intended comfort level. During the FAI the seat supplier will question a panel about the realised comfort level. During the first integration in the vehicle the seat supplier will question a panel about the realised comfort level. During the operation the seat supplier will question the train operator about the		D-C		-	-	-	-	-

ID	Requirement classification	Type Key	Requirement title	Requirement-text	Rationale	Comment for the reader: Description of value to be specified	Product element EN 15380-2	Change since last release	Verification				
									Offer of Tenderer(s)	Design Review	FAI[6]	FII[7]	Take-over
					realised comfort level. The questionnaires in document "EuroSpec Seat Comfort Appendices" can be used for these evaluations.								

9. APPENDIX

The Excel document <Write the name here> with all attributes is available on request (see contact on website).

The following figures are used in the Appendix.

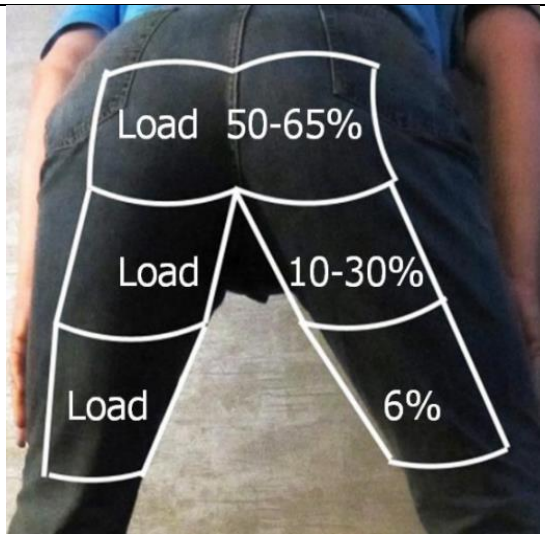


Figure A001 Pressure Distribution

SECO.26

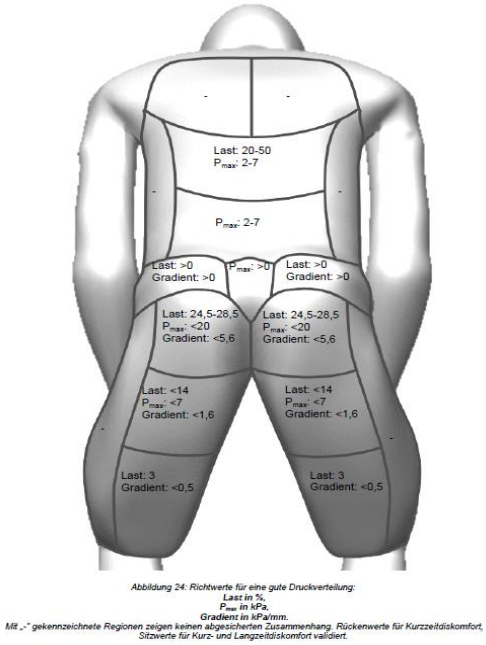


Figure A002 Pressure Distribution Gradient

SECO.27, SECO.28, SECO.62

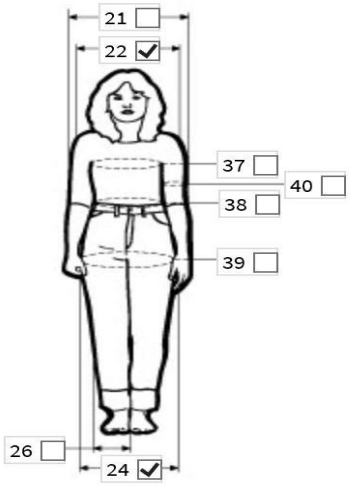


Figure A003

SECO.32 Hip Width (24)

SECO.41 Shoulder breadth (22)

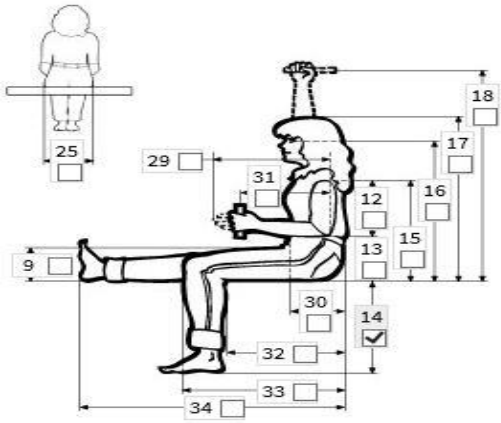


Figure A004 popletial height (14)

SECO.33, SECO.34, SECO.35

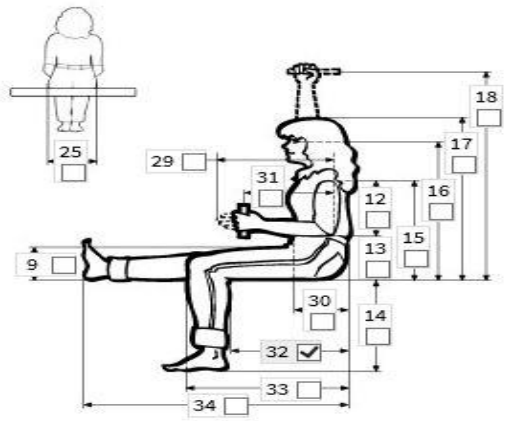


Figure A005 buttock-popletial depth [32]

SECO.36

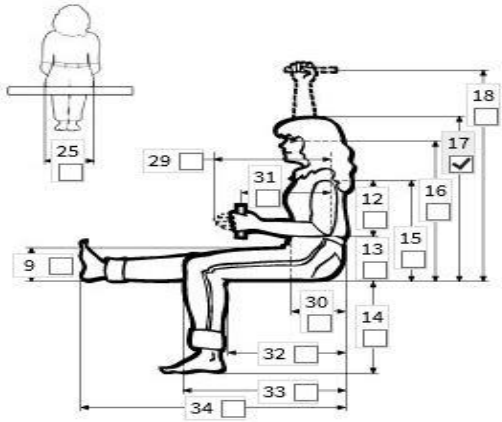


Figure A006 sitting height (17)

SECO.40

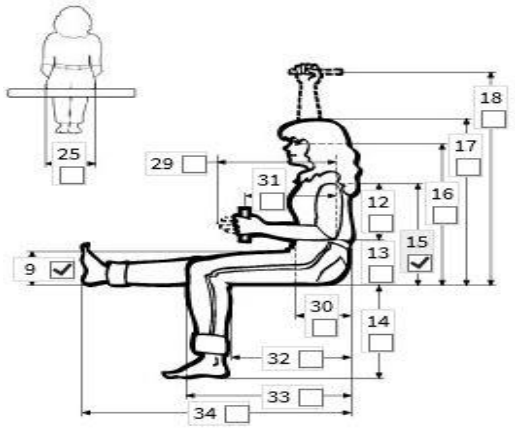


Figure A007 shoulder height 15

SECO.41, SECO.48, SECO.49

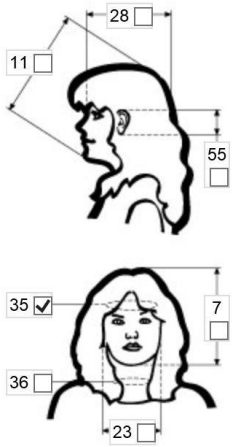


Figure A008 head circumference (35)

SECO.50

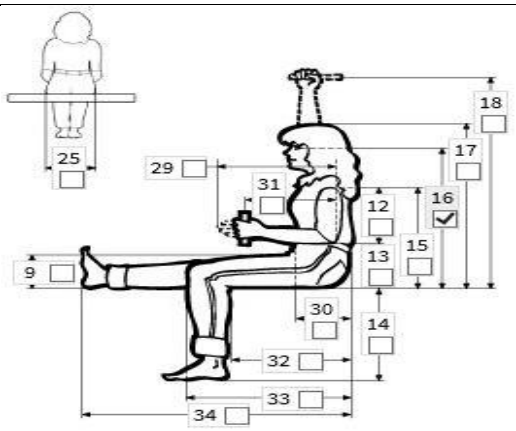


Figure A009 eye height (16)

SECO.46, SECO.47

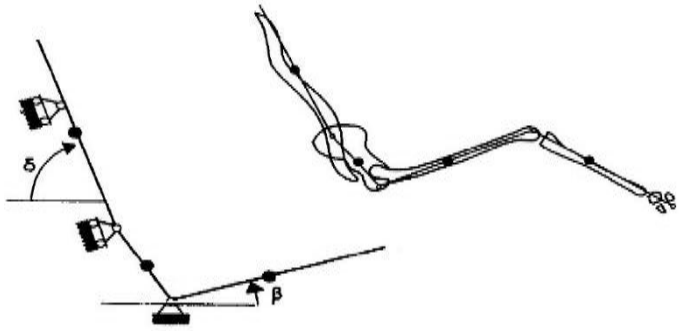


Figure A010a Seat pan angle

SECO.55 to 58 and SECO.60

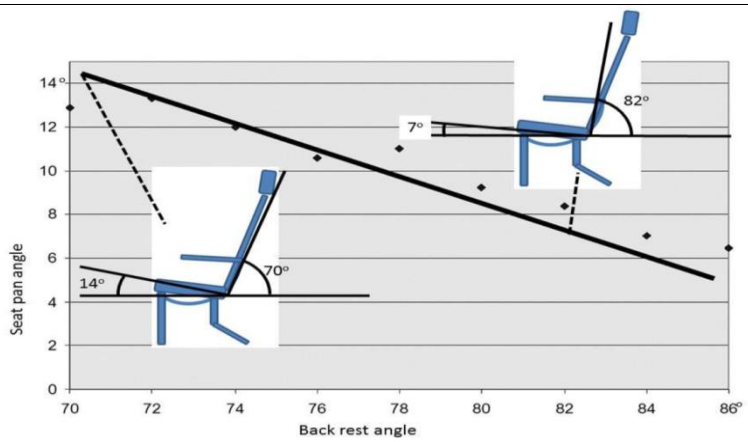


Figure A010b Seat pan angle and seat back relationship

SECO.61

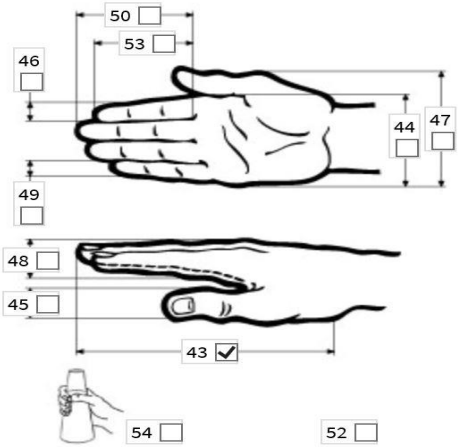


Figure A011 hand length (43)

SECO.67, SECO.85

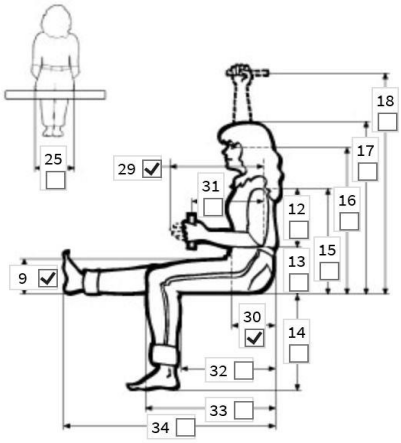


Figure A012

SECO.67, SECO.83, SECO.85 Elbow- finger tip length (29) and Thigh Thickness, sitting (9)

SECO.84, SECO.86 abdominal depth (30)

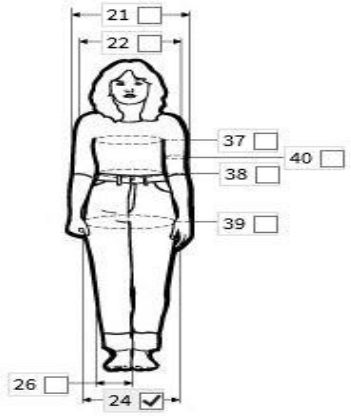


Figure A013 hip breadth (24)

SECO.66, SECO.90

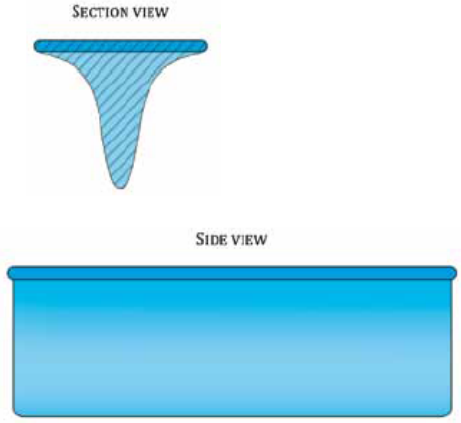


Figure 014 Armrest contour

SECO.70

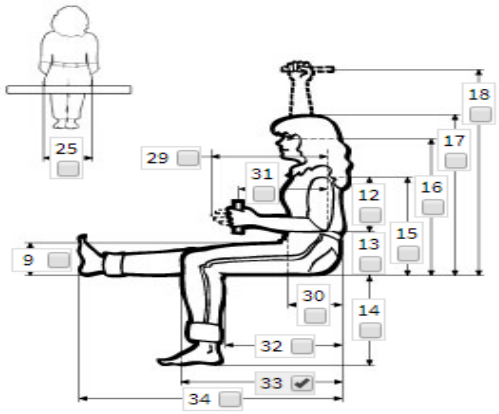


Figure A015 Buttock-Knee Depth Sitting (33)

SECO.76

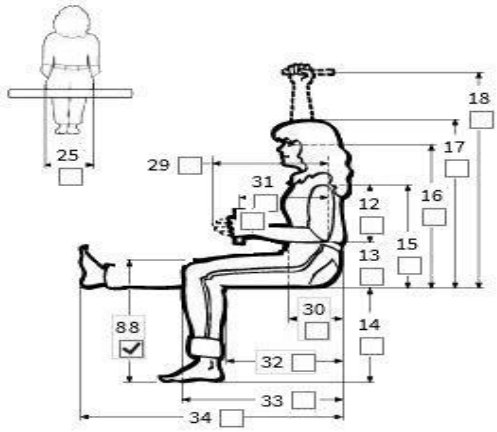


Figure A016 Knee height sitting (88)

SECO.77, SECO.83

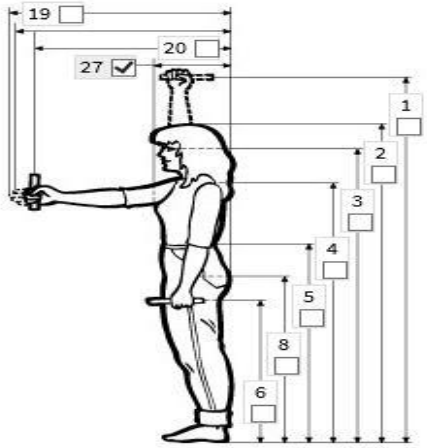


Figure A017 Chest depth (27)

SECO.77

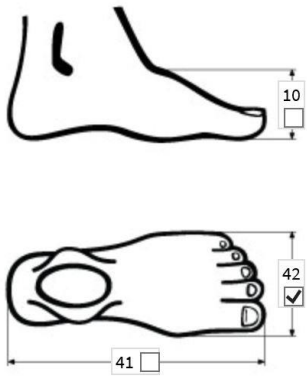


Figure A018 Foot Breadth (42)

SECO.87

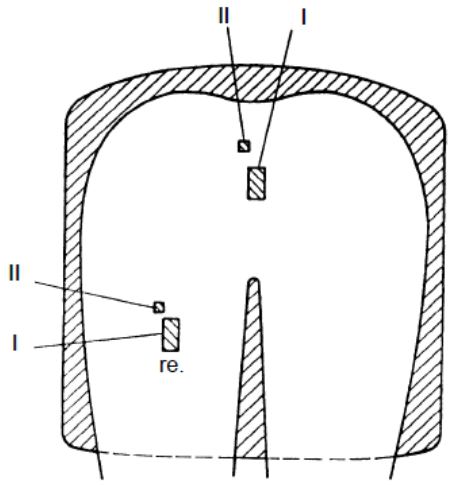


Figure A019a Micro climate

SECO.92

Note I and II are probes for measuring temperature and relative humidity of the skin and contact area. See UIC 567 for more information.

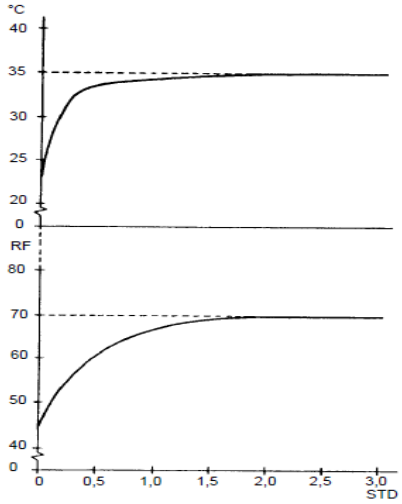


Figure A019b Micro climate limiting values, temperature in °C top and relative humidity in % bottom.

SECO.92

Figure A020 Upholstery samples

SECO.97

10. BIBLIOGRAPHY

DIN 51131	Testing of floor coverings - Determination of the anti-slip property - Method for measurement of the sliding friction coefficient
EN 15380 series	Railway applications. Designation system for railway vehicles. General principles
EN 16989	Railway applications – Fire protection on railway vehicles – Fire behaviour test for a complete sea
EN 45545-2 and successor	Railway applications - Fire protection on railway vehicles - Part 2: Requirements for fire behaviour of materials and components
UIC Code 513	Guidelines for evaluating passenger comfort in relation to vibration in railway vehicles
UIC Code 562	Space For Baggage Racks, Coat-hooks And Lockers
Extract from TMST technical specification relating to seats	
EUKL SK 271 issue B	Specification of Comfort Criteria for Eurostar Train Passenger Seats
A guide to the design and comfort of seats in rail vehicles	University of Southampton, Draft, 24th March 2010
Measuring, evaluating and assessing the transmission of vibration through the seats of railway vehicles	December 2015 – University of Southampton
SNCF Rolling Stock Specification ST-M 117 G	Seats, couchettes and beds for use in passenger vehicles
Norme Francais NF F 31-119 (December 1995)	Railway rolling stock – Behaviour of rolling stock's seats at statics stress, fatigue stress, vibrations stress and shocks stress
Eurostar seat softness testing process	July 2009
Draft BS ISO 7173	Furniture - Seating - Test methods for the determination of strength and durability
Draft BS ISO 16840-2	Wheelchair seating Part 2: Determination of physical and mechanical characteristics of devices intended to manage tissue integrity - Seat cushions

Draft BS EN 4730	Aerospace series - Anthropometric dimensioning of aircraft seats
Various articles and extracts	From Modern Railways and Professional Engineer Rail Magazine (April 15th – April 28th 2015), relating to Class 319 seat comfort Feedback from Hitachi regarding seat specifications used for Japanese railways
RSSB S024	Knowledge Search on seat comfort
Presentation to EuroSpec Working Group on 11-Oct-2017	Ulherr, A. et. al.,
Various academic papers including:	
Ergonomische Beurteilung Passagiersitz für FV-Dosto im Auftrag der Schweizerischen Bundesbahnen SBB	31.10.2011, Dr. Barbara Bönisch, Prof. Dr. Jürgen Held, p. 12
Comfortable passenger seats Recommendations for design and research	Suzanne Hiemstra-van Mastrigt, ISBN: 978-94-6259-736-5 See table 6.1, Postures A - K
Activities, postures and comfort perception of train passengers as input for train seat design	Groenesteijn, L., Hiemstra-van Mastrigt, S., Gallais, C., Blok, M., Kuijt-Evers, L., Vink, P., 2014. . Ergonomics 57(8): 1165–1165.
Objektivierung des statischen Sitzkomforts auf Fahrzeugsitzen durch die Kontaktkräfte zwischen Mensch und Sitz	Hartung, J., 2006. Dissertation am Lehrstuhl für Ergonomie, Technische Universität München, München.
Application of ideal pressure distribution in development process of automobile seats	U. Kilincsoya,∗, A. Wagnera, P. Vinkb and H. Bubbc a) BMW AG Forschungs- und Innovationszentrum, München, Germany b) Faculty of Industrial Design Engineering, Delft University of Technology, Delft, The Netherlands c) Technische Universit¨at M¨unchen, Lehrstuhl f¨ur Ergonomie, Garching, Germany Received 18 February 2015 Accepted 24 June 2015
A light weight car-seat shaped by human body contour,	Franz, M., Kamp, I., Durt, A., Kilincsoy, Ü., Bubb, H., Vink, P., 2011. International Journal of Human Factors Modelling and Simulation, Vol. 2 (4), 314–326
An estimation of the human head, neck and back contour in an aircraft seat	N.Nijholt, T.Tuinhof, J.M.A.Bouwens, U.Schultheis and P.Vink Faculty of Industrial Design Engineering, Delft University of Technology, Delft, The Netherlands

South African anthropometric dimensions for the design of an ergonomic office chair	Korte, J., 2013 Master thesis, Rhodes University, Grahamstown, South Africa, 2013
Sensitivity of the human back and buttocks: The missing link in comfort seat design	Peter Vink, Daan Lips Delft University of Technology, Faculty of Industrial Design Engineering, The Netherlands
Handbuch der Ergonomie, 1989. TU Delft database on http://dined.io.tudelft.nl/en/database/introduction	Schmidtke

11. REFERENCES

Carcone, S., & Keir, P. (2007). Effects of backrest design on biomechanics and comfort during seated work. *Applied Ergonomics, Vol. 38, Issue 6*, 755-764.

Franz, M., Kamp, I., Durt, A., Kilincsoy, U., Bubb, H., & Vink, P. (2011). A light weight car seat shaped by human body contour. *Int. J. of Human Factors Modelling and Simulation, Vol. 2, No. 4*, 314-326.

Goossen, R., & Snijders, C. (1995). Design criteria for the reduction of shear forces in beds and seats. *Journal Biomechanics, Vol. 28, No. 2*, 225-230.

Groenesteijn, L., Hiemstra-van Mastrigt, S., Gallais, C., Blok, M., Kuijt-Evers, L., & Vink, P. (2014). Activities, postures and comfort perception of train passengers as input for train seat design. *Ergonomics, 57:8*, 1154-1165.

Hartung, J. (2006). *Objektivierung des statischen Sitzkomforts auf Fahrzeugsitzen durch die Kontaktkräfte zwischen Mensch und Sitz. PhD thesis.* Technische Universität München.

Kamp, I., Kilincsoy, U., & Vink, P. (2011). Chosen postures during specific sitting activities. *Journal of Ergonomics, 54:11*, 1029-1042.

Kilincsoy, U., Wagner, A., Vink, P., & Bubb, H. (2016). Application of ideal pressure distribution in development process of automobile seats. *Journal Work, vol. 54, no. 4*, 895–904.

Korte, J. (2013). *South African anthropometric dimensions for the design of an ergonomic office chair. Master thesis.* Rhodes University, Grahamstown, South Africa.

Mastrigt, S. H.-v. (2015). *Comfortable passenger seats. Recommendations for design and research. PhD thesis.* TU Delft.

Mergl, C. (2006). *Entwicklung eines Verfahrens zur Optimierung des Sitzkomforts auf Automobilsitzen, PhD thesis.* Technische Universität München.

Molenbroek, J. (2019). *DINED / Anthropometry in design*. https://dined.io.tudelft.nl/en

Naddeo, A. (2017). *Towards predicting the (dis)comfort performance by modelling: methods and findings, PhD thesis.* TU Delft.

Nijholt, N., Tuinhof, T., Bouwens, J., Schultheis, U., & Vink, P. (2016). An estimation of the human head, neck and back contour in an aircraft seat. *Journal Work, Vol. 54*, 913-923.

Ulherr, A. et. al., Presentation to EuroSpec Working Group on 11-Oct-2017

Vink, P., & Lips, D. (2017). Sensitivity of the human back and buttocks: The missing link in comfort seat design. *Applied Ergonomics, 58*, 287-292.

Zenk, R. (2008). *Objektivierung des Sitzkomforts und seine automatische Anpassung. PhD thesis.* Technische Universität München.

Zenk, R., Franz, M., Bubb, H., & Vink, P. (2012). Technical note: Spine loading in automotive seating. *Applied Ergonomics 43*, 290-295.

12. THANKS.

The Working Group would like to thank the following people specifically and many others, for their input with information, training, suggestions, comments and contributions for the creation of this EuroSpec:

Dipl.-Ing. Annika Ulherr – TU München

Dr. Barbara Held – seat ergonomics expertise, free-lancer (for SBB)

Prof. Dr Peter Vink - TU Delft

Dr. Suzanne Hiemstra van Mastrigt - TU Delft

Dr Michael Wichtl - Vienna

From SBB: Antoine Varone and Rahel Stähli

From DSB: Jens Ring Bursche

13. ACKNOWLEDGEMENTS.

For figures

Figure 1 – CEN

Figures 2 – 4 – UIC but modified

Figure 5 – Goossens 1995

Figures 6 – 8 - EuroSpec

A001: Zenk, 2016

A002: Mergl, 2006

All Dined Images: Molenbroek, 2019

A010A: Goossens, 1995

A010B: Image by Vink, 2017 based on Goossens & Snijder, 1995

A014: Hiemstra-van Mastrigt, 2015

A019a and A019b: Credit UIC

A020: EuroSpec

EuroSpec

“EuroSpec” stands for European Specifications for railway rolling stock. The activity is an initiative of several European train operating companies (TOC). The main focus is on trains consisting of self-propelled carriages, using electricity as the motive power (EMU).

Paris, London, Munich (München), Utrecht, Vienna (Wien), Bern

September 2020