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Railway applications — Air conditioning for main line rolling stock — Comfort parameters and type tests

bsi.

National foreword

This British Standard is the UK implementation of EN 13129:2016. It supersedes BS EN 13129-1:2002 and BS EN 13129-2:2004 which are withdrawn.

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Bahnanwendungen - Luftbehandlung in Schienenfahrzeugen des Fernverkehrs - Behaglichkeitsparameter und Typprüfung

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European foreword

This document (EN 13129:2016) has been prepared by Technical Committee CEN/TC 256 “Railway applications”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2017, and conflicting national standards shall be withdrawn at the latest by February 2017.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 13129-1:2002 and EN 13129-2:2004.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive 2008/57/EC.

For relationship with EU Directive 2008/57/EC, see informative Annex ZA, which is an integral part of this document.

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1 Scope

This European Standard establishes comfort parameters of air conditioning for passenger compartments or saloons of railway vehicles (single level or double-decker). These comfort parameters apply in a similar way to the areas reserved for train staff.

The European Standard also specifies conditions, performance values and the comfort parameter measurement methods for compartments or saloons.

This European Standard is applicable to main line rail vehicles. It does not apply to suburban vehicles, metros, tramways and driver's cabs.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN ISO 7726:2001, *Ergonomics of the thermal environment - Instruments for measuring physical quantities (ISO 7726:1998)*

3 Terms and definitions

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

3.1
comfort
agreeable sensation perceived by a person concerning his or her climatic environment

3.2
air conditioning installation
equipment intended for ventilation and/or heating and/or cooling and/or filtration

3.3
forced air ventilation
air circulation generated by a mechanical action

3.4
natural ventilation
air circulation generated without mechanical action

3.5
preheating
process which enables the interior temperatures to be raised without the presence of passengers

3.6
precooling
process which enables the interior temperatures to be lowered without the presence of passengers

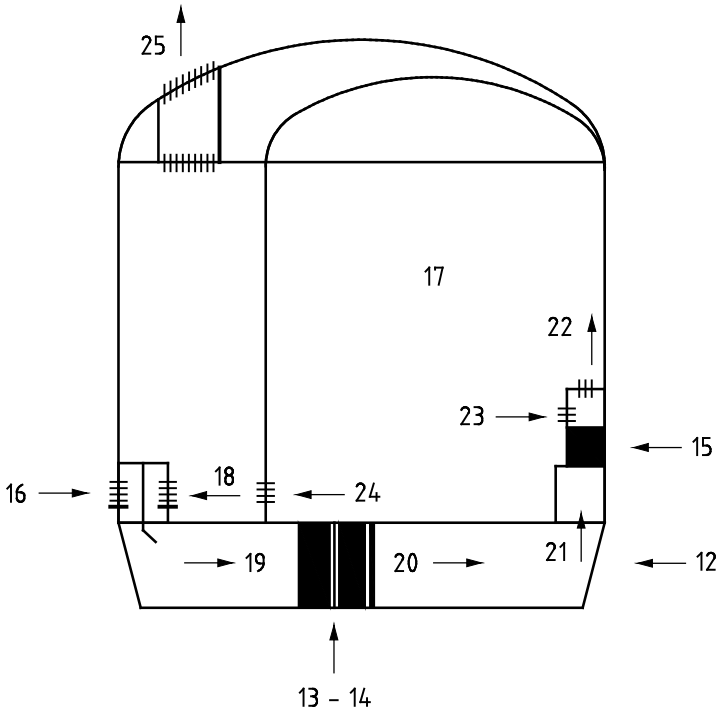
3.7
heating
process which enables the interior temperatures to be raised or maintained

3.8
cooling
process which enables the interior temperatures to be lowered or maintained

3.9
dehumidifcation
process which reduces the absolute humidity of the interior air

3.10
air conditioning device
device which includes ventilation, heating, cooling and/or dehumidification

3.11
heating and ventilation device
device which includes ventilation and heating



NOTE The numbers correspond to the following definitions.

Figure 1 — Diagram explaining certain railway terms

Note 1 to entry: This representation is only given as an example and does not prejudice the design of the installation.

3.12
air handling unit
group of components designed to move, filter and/or mix, heat and/or cool the air

Note 1 to entry: See Figure 1, No 12.

3.13
cooling unit
system that carries out the cooling function in a centralized and/or decentralized manner

Note 1 to entry: See Figure 1, No 13.

3.14
principal heating unit
system that carries out the heating function in a centralized and/or decentralized manner with the use of heating elements

Note 1 to entry: It is possible that the heating elements are either associated with forced air ventilation or not.

Note 2 to entry: See Figure 1, No 14.

3.15
auxiliary heating unit
de-centralized heating element(s) for adding heat locally

Note 1 to entry: See Figure 1, No 15.

3.16
fresh air
air taken from outside the vehicle

Note 1 to entry: See Figure 1, No 16.

3.17
room air
air contained in a specified space

Note 1 to entry: See Figure 1, No 17.

3.18
recirculated or return air
air taken from the interior of a specified space and re-used

Note 1 to entry: See Figure 1, No 18.

3.19
mixed air
combination of fresh air and recirculated air

Note 1 to entry: See Figure 1, No 19.

3.20
treated or conditioned air
air that has been filtered

Note 1 to entry: It is possible that the air can have had energy exchanged as it passed through the air handling unit.

Note 2 to entry: See Figure 1, No 20.

3.21
primary air
quantity of treated air entering the ducts

Note 1 to entry: See Figure 1, No 21.

3.22
supply air
treated air supplied to a specified space

Note 1 to entry: The treated can be combined with some induced air.

Note 2 to entry: See Figure 1, No 22.

3.23
induced air
room air that is taken and re-used locally without additional conditioning

Note 1 to entry: See Figure 1, No 23.

3.24
transfer air
air leaving a specified area

Note 1 to entry: See Figure 1, No 24.

3.25
exhaust air
air rejected outside the vehicle

Note 1 to entry: See Figure 1, No 25.

3.26
interior temperature setting
$\boldsymbol{T_{ic}}$
target temperature to be achieved by the room air

3.27
mean interior temperature
$\boldsymbol{T_{im}}$
arithmetic mean of the interior air temperatures measured 1,1 m above the floor unless specified differently

Note 1 to entry: Refer to normative Annex E.

3.28
mean exterior temperature
$\boldsymbol{T_{em}}$
arithmetic mean of the exterior air temperatures measured at minimum 0,1 m away from car body

Note 1 to entry: Refer to 17.2.

3.29
control settling time
$\boldsymbol{t_{cs}}$
maximum allowed time for achieving stabilized condition after a change of T_{ic}

3.30
system reaction time
$\boldsymbol{t_{rs}}$
maximum allowed time for achieving stabilized conditions after a parameter change

EXAMPLE T_{em}, wind speed, solar load, occupation.

3.31
comfort envelope
compartment or saloon areas normally occupied by passengers, including bar areas and aisles

3.32
comfort zone
subset of the comfort envelope such as compartments or other areas

3.33
horizontal range of the extreme interior air temperatures
absolute difference of the extreme interior air temperatures measured at 1,1 m from the floor

Note 1 to entry: Refer to normative Annex E.

3.34
vertical range of the extreme interior air temperatures
absolute difference of the extreme interior air temperatures in vertical direction at different heights

Note 1 to entry: Refer to normative Annex F and normative Annex G.

3.35
local annexe
place where passengers stay temporarily

EXAMPLE Side corridors, vestibules, wash rooms, WCs, nursery, gangways.

3.36
catering service area
space or compartment reserved for staff specializing in the preparation and/or sale of food

3.37
heat transfer coefficient
k
ratio between the density of the heat flow rate per unit of surface area and the prevailing difference in temperature T_{im} and T_{em} across the relevant walls of the vehicle

Note 1 to entry: The coefficient k takes account of the efficiency of the insulation of the exterior walls and the effect of the infiltration of air caused by the non-airtightness of the vehicle in motion (doors, windows, various openings) and is applicable to all or part of the vehicle.

Note 2 to entry: This value is expressed in $W/(m^2\ K)$.

3.38
total solar energy transmittance
solar factor
g
ratio between the overall energy flow transmitted to the interior of the vehicle through the window, and the incident solar radiation

3.39
equivalent solar load
total heat received by 1 m^2 surface perpendicular to the radiation emitted by a luminous source (solar equivalent)

Note 1 to entry: According to normative Annex D the simulation of solar exposure is performed with the luminous source inclined at an angle of 30° to the horizontal.

3.40
heat emission per person
heat emitted by a seated person normally dressed differentiated into latent (q_{lat}) and sensible heat emission (q_{sens})

Note 1 to entry: For values refer to normative Annex J.

3.41
stabilized operation
operation after t_{cs} or t_{rs}

Note 1 to entry: Refer to 9.3.2 and 9.3.3.

3.42
stabilized condition
stabilized condition is achieved when the difference between the maximum and the minimum values of T_{im} is less than or equal to the defined limits

Note 1 to entry: Refer to 9.3.4.

3.43
stand by operation
mode under which a predetermined interior temperature range is maintained during non-operational activity of the vehicle

3.44
maximum passenger load
passenger load corresponding to all seats occupied, including tip-up seats and wheelchair areas in the comfort areas

3.45
single result
$\boldsymbol{X_{ijk}}$
value measured in a single measuring point k or the value calculated over all single measuring points from a group k related to one specific T_{im}, in a single test i, for a single comfort parameter j, considered without regarding measuring tolerances

Note 1 to entry: Refer to Clause 15 for measuring tolerances.

3.46
quality limit
q1
target quality limit that if fulfilled results in 100% fulfilment

3.47
quality limit
q2
quality limit required to be fulfilled

3.48
weighting factor
$\boldsymbol{w_{ijk}}$
factor to assign importance to different measuring points and parameters

3.49
single conformity level
Y_{ijk}
conformity level for one comfort parameter j, in one specific test i, at one measuring point k or group of measuring points k, in relation to the corresponding quality limits q1 and q2

3.50
specific conformity level
$Y_{ij,s}$
weighted arithmetic mean of all single conformity levels Y_{ijk} in one zone s for one comfort parameter j, in one specific test i

3.51
conformity level CL_i of a single test
weighted arithmetic mean of all relevant specific conformity levels $Y_{ij,s}$ for one test i

3.52
conformity level CL_{SS}, CL_{int} and CL_{TDP}
arithmetic mean of all relevant conformity levels CL_i for the steady-state tests, intermediate tests and typical daily profiles

3.53
overall conformity level
CL
sum of the weighted conformity levels

Note 1 to entry: The overall conformity level (CL) calculation is defined in normative Annex B.

3.54
degraded mode
operation of the air conditioning installation with defined limitations in performance

3.55
technical specification
document, describing specific parameters and/or product requirements as an addition to the requirements of this standard

3.56
climatic zone
climatic conditions used to size the air conditioning installation

Note 1 to entry: Refer to Subclauses 7.1.1 and 7.1.2 for the definition of design and the extreme conditions.

4 Compliance with the standard

The measured parameters considered for the evaluation of the overall conformity level are those specified in 9.3 and 10.1.1 to 10.1.4. The calculation method is specified in normative Annex B.

The overall conformity level is determined as follows:

- Level A: 97 % ≤ CL ≤ 100 %;
- Level B: 93 % ≤ CL < 97 %;
- Level C: 85 % ≤ CL < 93 %;

- Below 85 % or if at minimum one parameter fails the q2 limit, the standard is not conformed to.

The minimum overall conformity level to be applied should be defined in the technical specification. In the absence of such a definition, level C shall be reached at least.

5 Comfort parameters

During normal passenger service, comfort is assessed:

a) on the basis of the following interior climate parameters:

   i) air temperature,

   ii) air speed,

   iii) relative humidity,

   iv) surface temperatures.

b) as a function of thermal exchange between the interior climate and a seated person dressed normally in accordance with Figure J.1.

c) as a function of the exterior climatic conditions which have an indirect effect.

The assessment shall be performed in accordance with normative Annex B and shall be based on the following 7 comfort parameters:

1) range of T_{im} with respect to T_{ic},

2) horizontal range of the extreme air interior temperatures,

3) vertical range of the extreme interior air temperatures for seated and standing passengers,

4) surface temperatures,

5) humidity,

6) air speed,

7) quality of regulation.

6 Quality limits

Each individual country shall be allocated to climatic zones for winter and summer.

NOTE 1 In case any information regarding the classification is requested in technical specification see informative Annex A.

The evaluation of the comfort parameters shall be done by quality limits q1 and q2.

The quality limits q1 and q2 of the extended range shall also be applied to all intermediate test conditions independently of exterior temperature.

NOTE 2 These quality limits are defined depending on exterior temperature in a normal and an extended range.

NOTE 3 The normal range represents the most commonly-occurring range of exterior temperature and therefore is highly important for the quality of comfort. The extended range is valid for extreme conditions, where a slight decrease of thermal comfort is acceptable.

The quality limits (normal or extended) shall be defined as a function of the mean exterior temperature (T_{em}) in accordance with Table 1 and Table 2.

Table 1 — Quality limits according the climatic zones - Winter

Zone (Winter)	Normal range of q1, q2 °C	Extended range of q1, q2 °C
I	$T_{em} \geq 0$	$-10 \leq T_{em} < 0$
II	$T_{em} \geq -10$	$-20 \leq T_{em} < -10$
III	$T_{em} \geq -20$	$-40 \leq T_{em} < -20$

Table 2 — Quality limits according the climatic zones - Summer

Zone (Summer)	Normal range of q1, q2 °C	Extended range of q1, q2 °C
I	$T_{em} \leq + 35$	$+ 35 < T_{em} \leq + 40$
II	$T_{em} \leq + 28$	$+ 28 < T_{em} \leq + 35$
III	$T_{em} \leq + 22$	$+ 22 < T_{em} \leq + 28$

7 Service conditions

7.1 Exterior conditions

7.1.1 Design conditions

The comfort conditions shall be satisfied between the limits of the exterior conditions for the relevant climatic zones given in Table 3 except where indicated otherwise in the technical specifications (tunnel operation for example). Each individual country shall be allocated to climatic zones for winter and summer.

NOTE In case any information regarding the classification is requested in technical specification see informative Annex A.

Table 3 — Definition of design conditions

Zone	Winter	Summer		
	Minimum exterior temperatures °C	Maximum exterior temperatures °C	Relative humidity [%]	Equivalent solar load (En) W/m²
I	−10	+ 40	40	800
II	−20	+ 35	50	700
III	−40	+ 28	45	600

7.1.2 Extreme conditions

The interior conditions as defined in 8.2, 8.4, and Clause 10 do not need to be conformed to for extreme conditions. The air conditioning installation shall be able to operate with full capacity under extreme temperatures in accordance with Table 4.

Each individual country shall be allocated to climatic zones for winter and summer.

NOTE 1 In case any information regarding the classification is requested in the technical specification see informative Annex A.

Table 4 — Definition of extreme conditions

Zone	Winter	Summer		
	Minimum exterior temperatures °C	Maximum exterior temperatures °C	Relative humidity %	Equivalent solar load (En) W/m²
I	−15	+ 45	30	800
II	−25	+ 40	40	700
III	−45	+ 33	30	600

The air conditioning installation shall also continue to operate in (reduced) cooling mode up to the temperatures as shown in Table 5. Each individual country is allocated to climatic zones for winter and summer.

NOTE 2 In case any information regarding the classification is requested in the technical specification see informative Annex A.

Table 5 — Definition of operational limiting conditions

Zone	Summer		
	Maximum exterior temperatures °C	Relative humidity %	Equivalent solar load (En) W/m²
I	+ 50	25	800
II	+ 45	30	700
III	+ 38	25	600

7.2 Interior conditions

The influence of the operation of any installed system on the thermal comfort shall be taken into account. These operating conditions shall be defined in the technical specifications. The thermal comfort shall be assessed on the basis of an even distribution of passengers (e.g. over the seats).

EXAMPLE Examples of installed systems are catering equipment and electrical cubicles.

8 Performance of the heating and cooling installations

8.1 Preheating

The preheating conditions and performance shall be defined in the technical specification.

NOTE 1 Preheating conditions and performance are: electrical power consumption and voltage, interior air temperature increase and time, etc.

NOTE 2 In the absence of any of the above specifications, the preheating time to reach $T_{im} \geq 18$ °C depends on the performance defined in 8.2.

8.2 Heating

The installed heating capacity shall ensure at least a mean interior temperature (T_{im}) in the comfort envelope of 21 °C, except if another value is defined in the technical specification:

— at the design conditions given in 7.1.1,

— at the maximum vehicle operational speed,

— without solar load,

— taking into account the most critical operational case for the design (e.g. occupation and the related minimum fresh air flow in accordance with Table 11 and Table 12.

8.3 Precooling

The precooling conditions and performance shall be defined in the technical specification.

NOTE 1 Precooling conditions and performance are: electrical power consumption and voltage, interior air temperature decrease and time, etc.

NOTE 2 In the absence of any of the above specifications, the precooling time depends on the performance defined in 8.4.

At the end of the precooling phase, the interior air temperature shall not be more than 2 K above T_{ic}.

8.4 Cooling

The installed cooling capacity shall ensure the possibility to reach a mean interior temperature (T_{im}) in the comfort envelope as specified in Table 6 below:

— at the design conditions given in 7.1.1,

— taking into account the maximum passenger load (see Figure J.1 for heat emitted by seated person) and the related minimum fresh air flow in accordance with Table 11,

— taking into account the additional internal loads and relevant external loads (e.g. heat emitted by components).

Table 6 — Maximum mean interior temperature at the design condition

Summer zone	Mean interior temperature °C
I	+ 27
II	+ 27
III	+ 25
NOTE For summer zones see informative Annex A if any condition is requested in the technical specification.	

8.5 Stand by operation

In absence of any indication regarding the stand by operation and performance in the technical specification, the system shall be able to maintain T_{im} above +3 °C in winter conditions and lower than +30 °C in summer conditions.

NOTE Performances are electrical power consumption and voltage, setting temperature and time to reach normal setting temperature.

8.6 Door opening sequence

During 3 sequences of door opening and closing, the mean interior temperature (T_{im}) shall be observed. Before starting the next sequence the range of T_{im} with respect to T_{ic} shall be within the q2 limit defined in 10.1.1. In the absence of detail in the technical specification, a sequence is defined as 20 min operation with 19 min doors closed, 1 min doors open.

8.7 Degraded mode operation

The degraded mode, the boundary conditions, the performances to be achieved and the tests of degraded mode should be defined in the technical specification.

9 Control

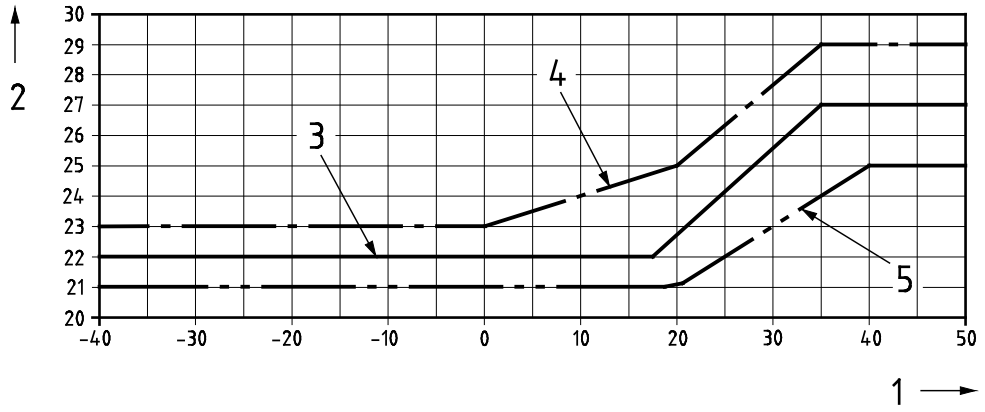
9.1 General

Each vehicle shall be fitted with a regulation system which shall enable the comfort parameters defined in this European Standard to be achieved.

9.2 Interior temperature setting

The technical specification should define a regulation curve for the interior temperature setting (T_{ic}) with the control device set in the mid position. The curve shall be within the limits given in Figure 2.

In the absence of such a definition, the curve proposed in Figure 2 shall be used:



Key

1 T_{em} mean exterior temperature [°C]
2 T_{ic} interior temperature setting [°C]
3 proposed curve
4 upper limit
5 lower limit

Figure 2 — Proposed regulation curve and limits for the interior air temperature

NOTE Formula of the proposed regulation curve:

$$T_{em} \leq 17{,}5\ °C: T_{ic} = 22\ °C \quad (1)$$

$$17{,}5 < T_{em} < 35\ °C: T_{ic} = 22 + 2/7\ (T_{em} - 17{,}5)\ °C \quad (2)$$

$$T_{em} \geq 35\ °C: T_{ic} = 27\ °C \quad (3)$$

Within the performance limits defined in 8.2 and 8.4, it shall be possible to vary the temperature setting in each comfort zone independently of the other areas by means of a control device that gives a minimum range of regulation of ± 2 K (+2 K and −4 K for couchette coaches and sleeping cars).

Outside these performance limits, temperature deviations are permitted.

The variation given by moving the control device from one position to the next shall not be greater than 1 K.

Each time the installation is put into service, or in stand-by operation, T_{ic} should be reset to the value of the mid position. During pre-conditioning the change of T_{ic} should be ignored.

For coaches with more than one comfort zone, at the time of a change of setting of one (or more) control devices, the mean interior temperature of the other comfort zones shall remain within the tolerance band (see 10.1.1). It is permissible in agreement with the operator to regard separate comfort zones as a unit from a regulating point of view.

9.3 Quality of regulation

9.3.1 General

The criteria in the following subclauses shall be evaluated independently for each subclause. The evaluation of comfort by combination of 9.3.2 and 9.3.3 at the same time is not applicable. The evaluation of comfort as defined in 9.3.4 shall apply after finishing 9.3.2 or 9.3.3. The evaluation of comfort during stabilized operation shall be applied only for steady-state tests.

9.3.2 Changing the interior temperature setting

When changing the interior temperature setting (T_{ic}) by ΔT_{ic}, within the control settling time (t_{cs}), T_{im} shall stay within $T_{im}(0) + \Delta T_{ic}/2$ +/− (qi + IΔT_{ic}I/2). After t_{cs} $T_{im}(1)$ shall be within $T_{im}(0) + \Delta T_{ic}$ +/− qi.

— Quality limit q1: 1 K;

— Quality limit q2: 2 K.

t_{cs} shall be calculated as:

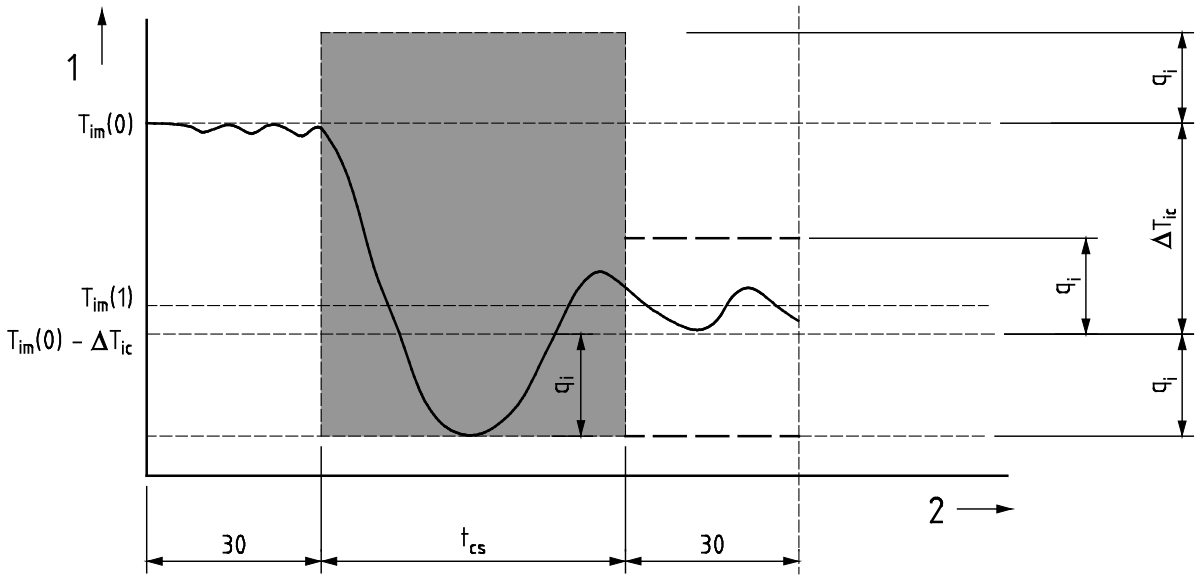
$$t_{cs} = \left|\Delta T_{ic}\right| \cdot 15 + 5 \text{ [min]} \quad (4)$$

The starting condition $T_{im}(0)$ is the average of T_{im} over the last 30 min. $T_{im}(1)$ is the average of T_{im} after t_{cs} over 30 min.

The worst deviation of the two criteria shall be taken into account for the evaluation.

The above requirement is applicable in the limit of the performances defined in 8.2 and 8.4.

After control settling time (t_{cs}), T_{im} shall conform to the requirements of 9.3.4 and 10.1.1.



Key

1	Temperature T_{im} [°C]	ΔT_{ic}	Variation of T_{ic} [K]
2	Time [min]	qi	Quality limit [K]
T_{im} (0)	Average of the mean interior temperature before changing temperature setting [°C]	t_{cs}	Control settling time [min]
T_{im} (1)	Average of the mean interior temperature after t_{cs} [°C]		

Figure 3 — Limits when changing the interior temperature (T_{ic})

9.3.3 Changing test parameter(s)

When changing a single test parameter within the system reaction time (t_{rs}) of 35 min, the difference between the maximum and the minimum values of T_{im} shall be less than or equal to:

— Quality limit q1: 1,5 K;

— Quality limit q2: 2,5 K.

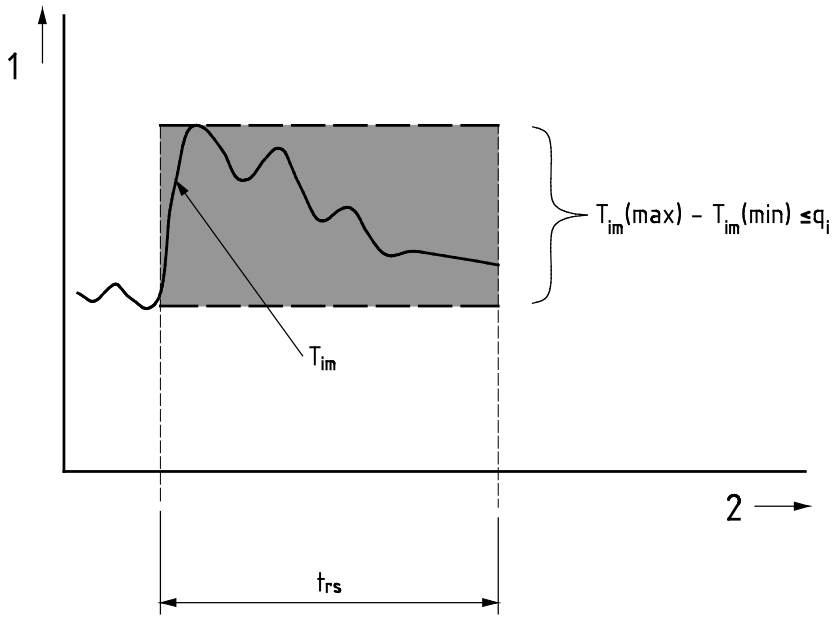
EXAMPLE Test parameters can include: T_{em}, wind speed, solar load, occupation.

For multiple parameter changes, within the system reaction time (t_{rs}) of 45 min, the difference between the maximum and the minimum values of T_{im} shall be less than or equal to:

— Quality limit q1: 2 K;

— Quality limit q2: 3 K.

After the system reaction time (t_{rs}), T_{im} shall conform to the requirements of 9.3.4 and 10.1.



Key

1	Temperature T_{im} [°C]	T_{im}	Mean interior temperature [°C]
2	Time [min]	$T_{im}(max)$	Maximum of T_{im} in t_{rs} [°C]
qi	Quality limit [K]	$T_{im}(min)$	Minimum of T_{im} in t_{rs} [°C]
t_{rs}	System reaction time [min]		

Figure 4 — Limits when changing test parameters

9.3.4 Stabilized conditions

Within every time window of 10 or 30 min (described below), the difference between the maximum and the minimum values of T_{im} shall be less than or equal to:

a) 10 min window:

   1) Quality limit q1: 1 K;

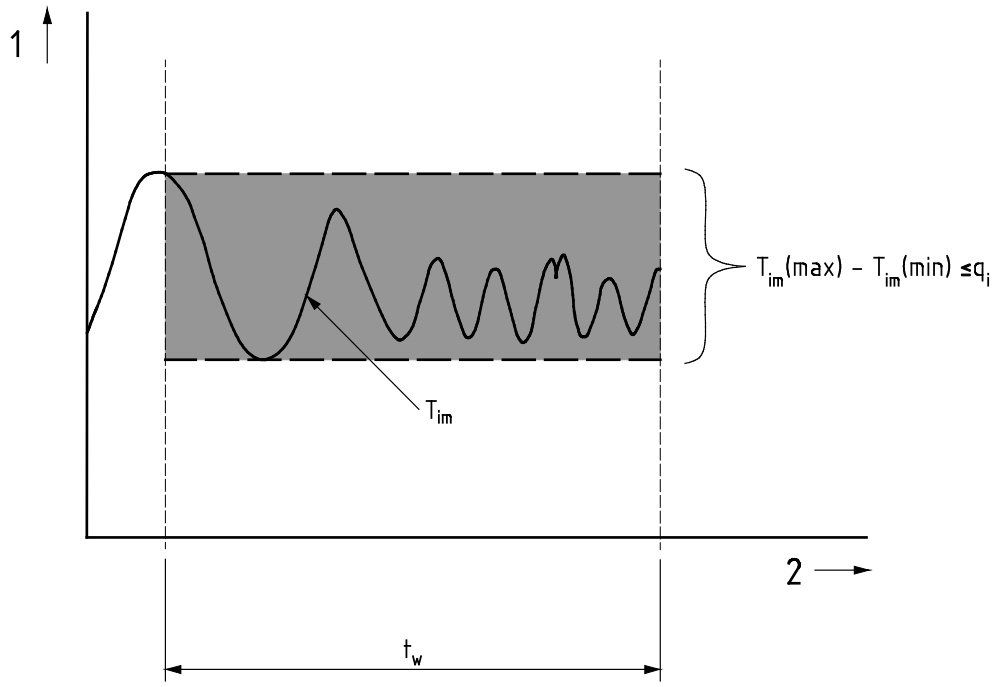
   2) Quality limit q2: 1,4 K;

b) 30 min window:

   1) Quality limit q1: 1,5 K;

   2) Quality limit q2: 2 K.

The worst deviation of the two criteria shall be used for the evaluation.



Key

1	Temperature T_{im} [°C]	T_{im}(min)	Minimum of T_{im} in time window t_w
2	Time [min]	qi	Quality limit [K]
T_{im}	Mean interior temperature [°C]	t_w	Time window [min]
T_{im}(max)	Maximum of T_{im} in time window t_w		

Figure 5 — Stabilized conditions

10 Comfort conditions to be respected

10.1 Parameters in the comfort envelope

10.1.1 Temperatures in the comfort zones

The temperatures in the comfort zones shall be in accordance with Table 7.

NOTE The abbreviations used for the different parameters are indicated in informative Annex K.

Table 7 — Temperatures in the comfort zones

Parameter		Normal range		Extended range		Remarks
Range of the mean interior temperature (T_{im}) with respect to the interior temperature setting (T_{ic}) ($\Delta T_{\_NR\_ComZon}$ or $\Delta T_{\_ExR\_ComZon}$)	q1	1 K		1 K		
	q2	1,5 K		2 K		
Horizontal range of the extreme interior air temperatures ($\Delta T_{H\_NR\_ComZon}$ or $\Delta T_{H\_ExR\_ComZon}$)	q1	2 K		2 K		
	q2	2,8 K		3,5 K		
Vertical range of the extreme interior air temperatures for seated passengers ($\Delta T_{V\_NR\_Seat}$ or ($\Delta T_{V\_ExR\_Seat}$)	q1	3 K		3 K		q1. Check if all sensors per seat are in a range of 3 K q2. A temperature difference of 5 K / 8 K is permissible if the foot is the warmest point, otherwise a temperature difference of 3,5 K /4,5 K is allowed.
	q2	3,5 K	5,0 K	4,5 K	8,0 K	
Vertical range of the extreme interior air temperatures for standing passengers in bar areas and aisles of passengers saloons ($\Delta T_{V\_NR\_Stand}$ or $\Delta T_{V\_ExR\_Stand}$)	q1	3,5 K		3,5 K		q1. Check if both sensors are in a range of 3,5 K q2. A temperature difference of 6 K / 9 K is permissible if the foot is the warmest point, otherwise a temperature difference of 4 K / 5 K is allowed.
	q2	4 K	6 K	5 K	9 K	

10.1.2 Temperatures of the surfaces surrounding the comfort envelope

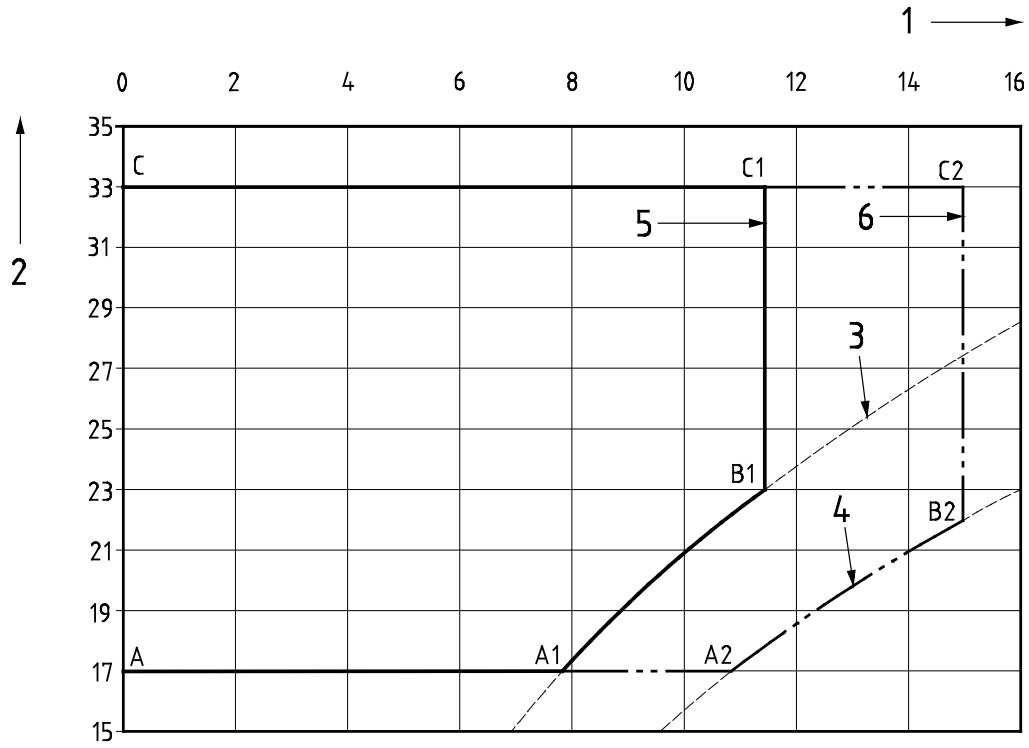
The temperatures of the surfaces shall be in accordance with Table 8.

Table 8 — Temperatures of the surfaces surrounding the comfort envelope

Surface		Normal range	Extended range	Remarks
Walls ($T_{S\_NR\_Wal}$ or $T_{S\_ExR\_Wal}$) and ceilings ($T_{S\_NR\_Cei}$ or $T_{S\_ExR\_Cei}$)	q1	7 K	9 K	Range of temperature with respect to mean interior temperature (T_{im})
	q2	9 K	11 K	
Window panes ($T_{S\_NR\_Win\_pa}$ or $T_{S\_ExR\_Win\_pa}$)	q1	10 K		Windows not exposed to sun radiation Range of temperature with respect to mean interior temperature (T_{im})
	q2	13 K	15 K	
	q1	15 K		Windows exposed to sun radiation Range of temperature with respect to mean interior temperature (T_{im})
	q2	18 K	20 K	
Window frame ($T_{S\_NR\_Win\_fr}$ or $T_{S\_ExR\_Win\_fr}$)	q1	12 K	15 K	Range of temperature with respect to mean interior temperature (T_{im})
	q2	13 K	16 K	
Floors – non heated ($T_{S\_NR\_Fl\_NH}$ or $T_{S\_ExR\_Fl\_NH}$)	q1	10 K	10 K	In comparison with the mean interior temperature (T_{im}), the range of temperature over the floor shall not exceed the mentioned values 3 h after the end of the preconditioning period and irrespective of the value of the exterior temperature.
	q2	12 K	14 K	
Floors – heated ($T_{S\_NR\_Fl\_H}$ or $T_{S\_ExR\_Fl\_H}$)	q1	≤ 27 °C	≤ 30 °C	Maximum permitted temperatures for heated floors
	q2	≤ 32 °C	≤ 34 °C	
In heating mode the values stated in 10.4 shall have priority with respect to the criteria stated in this table.				

10.1.3 Humidity of the air

The humidity of the air shall be within the values specified in Figure 6 irrespective of the interior air temperatures of comfort zones. The admissible comfort zone is situated in zones q1 and q2 of Figure 6 and Table 9.



Key

1 x absolute humidity [g/kg]
2 T_{im} mean interior temperature [°C]
3 relative humidity 65 %
4 relative humidity 90 %
5 q1 range
6 q2 range

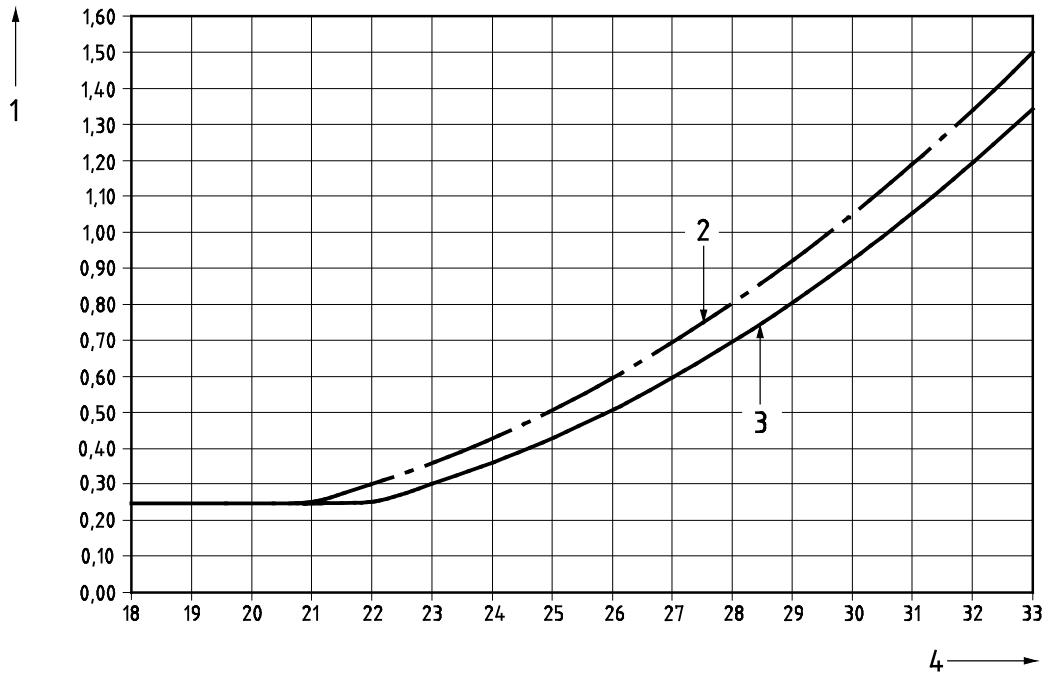
Figure 6 —Humidity limits

Table 9 — Humidity limits

Point	q1 range			q2 range		
	T_{im}	relative humidity	absolute humidity	T_{im}	relative humidity	absolute humidity
	°C	%	g/kg	°C	%	g/kg
A	17	0	0	17	0	0
A1	17	65	7,8			
A2				17	90	10,9
B1	23	65	11,5			
B2				22	90	15,0
C	33	0	0	33	0	0
C1	33	36	11,5			
C2				33	48	15,0

10.1.4 Air speed

The air speed in the comfort envelope shall be less than or equal to the values defined by the curves in Figure 7 and in accordance with Table 10.



Key

1 v air speed [m/s]
2 maximum allowed air speed for q2 limit [m/s]
3 maximum allowed air speed for q1 limit [m/s]
4 T_{im} mean interior temperature [°C]

Figure 7 — Air speed curves

Curve formula q1

$$T_{im} \leq 22\ °C: v = 0{,}25\ m/s \quad (5)$$

$$T_{im} > 22\ °C: v = (0{,}005\ 06\ T_{im}^2 - 0{,}179\ T_{im} + 1{,}74)\ m/s \quad (6)$$

Curve formula q2

$$T_{im} \leq 21\ °C: v = 0{,}25\ m/s \quad (7)$$

$$T_{im} > 21\ °C: v = (0{,}005\ 06\ (T_{im}+1)^2 - 0{,}179\ (T_{im}+1) + 1{,}74)\ m/s \quad (8)$$

Table 10 — Maximum allowed air speed for q1 and q2 limits

Surrounding temperature °C	**q1** m/s	**q2** m/s
18	0,25	0,25
19	0,25	0,25
20	0,25	0,25
21	0,25	0,25
22	0,25	0,30
23	0,30	0,36
24	0,36	0,43
25	0,43	0,51
26	0,51	0,60
27	0,60	0,70
28	0,70	0,80
29	0,80	0,92
30	0,92	1,05
31	1,05	1,19
32	1,19	1,34
33	1,34	1,50

10.1.5 Air quality

10.1.5.1 Fresh air

The minimum total volume flow of fresh air added by forced ventilation to the coach shall be in accordance with the values defined in Table 11 and Table 12 considering the maximum passenger load.

Table 11 — Vehicles with air conditioning device

Exterior temperature (T_{em})	**Minimum fresh air rate equivalent to + 20 °C and 50 % rel. hum, normal atmospheric pressure**
T_{em} < - 15 °C	10 m^3/h/passenger
- 15 °C ≤ T_{em} ≤ - 5 °C	15 m^3/h/passenger
- 5 °C < T_{em} ≤ + 26 °C	20 m^3/h/passenger
T_{em} > + 26 °C	15 m^3/h/passenger

Table 12 — Vehicles with heating and ventilation device

Exterior temperature (T_{em})	**Minimum fresh air rate equivalent to + 20 °C and 50 % rel. hum, normal atmospheric pressure**
T_{em} < - 15 °C	10 m^3/h/passenger
- 15 °C ≤ T_{em} ≤ - 5 °C	15 m^3/h/passenger
- 5 °C < T_{em}	20 m^3/h/passenger
T_{em} ≥ + 15 °C and T_{im} ≥ T_{ic} +1 K	30 m^3/h/ seat position or berth

The fresh air quantity may be reduced according to the real occupation for energy saving reason.

If an additional fresh air flow rate is required for special national conditions or for providing fresh air to annex areas, it shall be indicated in the technical specification.

NOTE 1 The uninterrupted minimum fresh airflow rate of 10 m^3/h per passenger as defined in Table 11 and Table 12 is sufficient to maintain the carbon dioxide levels within 5 000 ppm according to the TSI "Locomotives and passengers RST".

For pressure protection reasons it is possible to interrupt the fresh air flow. The evolution of CO_2 values shall be calculated as specified in Formula (9).

If the values are not given in the technical specification, the following values shall be used:

— C_{ext}: *400 ppm;*

— Q_{Pers}: *17,5 l/h (that corresponds to 32 g/h in normal conditions: + 20 °C and 50 % relative humidity, normal atmospheric pressure).*

NOTE 2 The evolution of CO_2 values allows to check the compliance with the TSI locomotives and passenger RST.

The temporal concentration variation inside the coach is governed by the following differential equation:

$$V\left[\frac{\partial(C_{\text{int}}(t))}{\partial t}\right]=\frac{\left[Qf\cdot C_{ext}\right]-\left[Qf\cdot C_{\text{int}}(t)\right]}{3\,600}+\frac{N\cdot Q_{Pers}}{1\,000\cdot 3\,600}\cdot 10^{6} \quad (9)$$

where

$C_{int(t)}$ CO_2 concentration in the coach at time t [ppm]

C_{ext} CO_2 concentration in the fresh air [ppm]

V free volume inside the coach, i.e. the air volume not taken up by the passengers [m^3]

Qf fresh air flow [m^3/h]

N number of persons

Q_{Pers} quantity of CO_2 generated by one person [l/h]

Transient events, such as the closing and opening times of pressure dampers or air conditioning installation and power supply failures, shall be considered for calculation of resulting CO_2 concentration.

10.1.5.2 Recirculated air

A recirculated air system shall ensure operation (even in a degraded condition) if the design of the vehicle could cause the fresh air intakes to be temporarily blocked.

In the case of composite vehicles (smoking, non-smoking), the air conditioning system should be designed to prevent the transfer of smoke from a smoking zone to a non-smoking zone in normal operation.

10.1.5.3 Particle filtration of the air

In the absence of any detail in the technical specification, the filter grade G4 in accordance with EN 779 is recommended for treated air.

10.2 Parameters in the annex areas

The temperature limits for the various annex areas shall be in accordance with Table 13.

Table 13 — Temperatures in the annex areas

Parameter		**Permissible temperature range**	**Remarks**
Range of mean temperature in the side corridor (T_{im}) with respect to the interior temperature setting (T_{ic}) ($\Delta T_{\_COOL\_Cor}$ or $\Delta T_{\_HEAT\_Cor}$)	limit heating	T_{ic}- 6 K ≤ T_{im} ≤ T_{ic}+2 K	T_{im} is the arithmetic mean of the temperatures measured 1,7 m above the floor
	limit cooling	T_{ic}- 2 K ≤ T_{im} ≤ T_{ic}+5 K	
Range of mean temperature in the vestibules (T_{im}) with respect to the interior temperature setting (T_{ic}) ($\Delta T_{\_COOL\_Ves}$ or $\Delta T_{\_HEAT\_Ves}$)	limit heating	+10 °C ≤ T_{im} ≤ T_{ic}+2 K	T_{im} is the arithmetic mean of the temperatures measured 1,7 m above the floor In addition, the mean temperature shall always be greater than 4 °C at 0,1 m above the floor
	limit cooling	T_{im} ≤ T_{ic}+8 K	
Range of interior air temperature in the washrooms ($\Delta T_{\_COOL\_Wash}$ or $\Delta T_{\_HEAT\_Wash}$), WC ($\Delta T_{\_COOL\_WC}$ or $\Delta T_{\_HEAT\_WC}$), with respect to the interior temperature setting (T_{ic})	limit heating	T_{ic}- 6 K ≤ T_{im} ≤ T_{ic}+2 K	Temperature measured at a point situated on the vertical geometric centre of the floor of these locations at a height of 1,1 m
	limit cooling	T_{ic}- 2 K ≤ T_{im} ≤ T_{ic}+5 K	
Range of interior air temperature in the nursery with respect to the interior temperature setting (T_{ic}) ($\Delta T_{\_COOL\_Nurs}$ or $\Delta T_{\_HEAT\_Nurs}$)	limit heating and cooling	T_{ic} ≤ T_{im} ≤ T_{ic}+4 K	Temperature measured at a point situated on the vertical geometric centre above the floor at a height of 1,1 m

The nursery and the WCs shall be designed to prevent the transfer of odours into the comfort envelopes.

10.3 Interior parameters in the catering service areas (galley zone)

The temperature limits in the catering service areas shall be in accordance with Table 14 and have been defined without any catering loads.

If the operator wants specific catering loads to be taken into account, the requirements and the loads shall be defined in the technical specifications.

Table 14 — Temperature limits for the annex areas

Parameter	**Normal range**		**Extended range**		**Remarks**
Range of the mean interior temperature (T_{im}) with respect to the interior temperature setting (T_{ic}) ($\Delta T_{\_NR\_Cat}$ or $\Delta T_{\_ExR\_Cat}$),	3,0 K				T_{im} is the arithmetic mean of the temperatures measured 1,7 m above the floor
Vertical range of the extreme interior air temperatures for the catering staff ($\Delta T_{V\_NR\_Cat}$ or $\Delta T_{V\_ExR\_Cat}$),	4,5 K	(if feet warmest) 6,0 K	5,5 K	(if feet warmest) 9,0 K	Difference between temperature sensors at 0,1 m and 1,7 m above the floor.

All other comfort parameters specified in 10.1 are not separately specified. Due to different technical designs of catering service areas, additional requirements should be described in the technical specification.

The catering service areas shall be designed to prevent the transfer of odours into the comfort envelopes.

10.4 Limits of temperature values

The surface temperatures shall be in accordance with Table 15.

Table 15 — Surface temperature limits

Parameter	**Normal range**	**Extended range**	**Remarks**
Temperature at the supply air outlets (T_{SUP_NR} or T_{SUP_ExR})	60 °C		On accessible outlets in normal mode (excluding pre-heating)
	65 °C		For pre-heating (not in service)
Surface heated sidewall temperature in contact with passenger in normal position ($T_{HS\_Pass\_NR}$ or $T_{HS\_Pass\_ExR}$)	27 °C	35 °C	Surface heated sidewall temperature in contact with passenger in normal position
Surface heated sidewall temperature not in contact with passenger in normal position ($T_{HS\_NoPass\_NR}$ or $T_{HS\_NoPass\_ExR}$)	35 °C	47 °C	Surface heated sidewall temperature not in contact with passenger in normal position
Minimum floor surface temperature for annex areas ($T_{S\_NR\_Fl}$ or $T_{S\_ExR\_Fl}$)	3 °C	3 °C	

11 Supplementary requirements

11.1 Heat transfer coefficient

NOTE The coefficient *k* has an impact on thermal comfort and on the performance of the heating and cooling installation. The coefficient *k* depends on the vehicle speed.

The coefficient k for the coach at standstill should be less than or equal to the values specified in Table 16:

Table 16 — Coefficient *k* for the coach at standstill

Winter zone (See informative Annex A)	**Coach**	
	Single Deck W/(m²K)	**Double Deck** W/(m²K)
I	2,0	2,5
II	1,6	2,2
III	1,2	2,0

For physically separated areas the corresponding coefficient *k* may be measured and analysed for information.

11.2 Solar factor *g* of the windows

This factor as defined in EN 410 should be less than 0,6.

11.3 Cleaning of air conditioning installation

A periodical cleaning of air treatment components and air guidance system surfaces should be possible. For this purpose easily accessible openings should be implemented.

12 Air movement tests

12.1 Air flow tests at standstill

12.1.1 Test conditions

The tests shall be carried out under the following conditions:

— vehicle stationary and protected from bad weather,

— altitude < 1 000 m above sea level,

— exterior air speed (wind) between 0 km/h and 5 km/h,

— exterior temperature between + 15 °C and + 30 °C.

12.1.2 Air flow rates

The flow rates of the fresh air supply shall be measured in accordance with 15.5.

It is recommended to measure also the flow rates of the exhaust air and the recirculated air and/or conditioned air and/or mixed air, if appropriate.

12.1.3 Visualization of the air flow direction

If appropriate, this can be visualized by the movement of smoke between the two relative areas.

In particular, this visualization should be made for the catering service areas, between the smoking and non-smoking zones in composite vehicles, WC/washrooms and the driver's cab in order to verify that the air conditioning installation is well designed for the avoidance of odour propagation.

12.2 Air flow tests when driving

If appropriate, measurements of air flow should be done during dynamic tests.

These results shall be compared with measurements taken on a stationary vehicle using the same equipment.

12.3 Air speed tests

12.3.1 Critical air speed

NOTE The purpose of these measurements is to find the most unfavourable seating positions in the comfort envelope.

As a minimum, the three worst seat positions by deck, or two worst seats by saloon (in case of separate saloons) shall be identified. This should be checked at least in cooling and heating mode at maximum supply air flow rates. Critical areas may initially be identified by flow visualization, following which measurement at head, shoulder, knee and foot is to be performed.

These measurements shall be performed without simulation of the thermal and volumetric effects of occupation.

12.3.2 Measurement of air speed during the climatic tests

During the climatic tests the air velocity measurements shall be recorded continuously at the most unfavourable seats (identified in accordance with 12.3.1) at head, shoulder, knee and foot in accordance with 15.4. The limits for the air speed however only apply for tests without thermal simulation of the occupation.

NOTE The heating elements, humidification equipment can affect measurements inside the passenger space. Air speed measurements taken during climatic tests with thermal simulation of the occupation in accordance with 16.2 are for information only.

13 Climatic tests

13.1 General remarks

A minimum schedule of tests, in accordance with normative Annex C shall be performed to enable the verification of comfort parameters, performance of the heating and cooling installation and the proper control functionality.

The order of the tests is not obligatory but shall be compatible with the physical characteristics of the climatic facility and the means of measurement.

Throughout the tests, all the values at the measuring points defined in Clause 17 shall be recorded continuously. The energy consumption and the power absorbed by both the air conditioning installation and the vehicle as a whole should be also recorded.

Should other equipment such as doors, WC equipment, power supply, lighting and special equipment need to be tested, these tests should not interfere in any way with the tests on the air conditioning systems.

13.2 Preheating test

The test conditions for preheating shall be in accordance with normative Annex C.

Before the start of the pre-heating test, the mean interior temperature (T_{im}) and the temperature of the interior surfaces shall be the same as the mean exterior temperature (T_{em}) and stabilized at ± 1 K for at least 1 h.

For coaches with stand by operation mode, a preheating test shall be foreseen at T_{em} of −10 °C starting from the stabilized stand by temperature T_{im} (at ± 1 K for at least 1 h) as defined in the technical specification.

The test ends when stabilized conditions have been achieved or a maximum time of 4 h is reached.

13.3 Precooling test

The test conditions for precooling shall be in accordance with normative Annex C.

Before the start of the precooling test, the mean interior temperature (T_{im}) and the temperature of the interior surfaces shall be the same as the mean exterior temperature (T_{em}) and stabilized at ± 1 K for at least 1 h. At this time, before starting the precooling test, the artificial sunlight equipment shall be switched on for 2 h, corresponding to the values specified in Table 3 with doors and windows closed.

The test ends when stabilized conditions have been achieved or a maximum time of 4 h is reached.

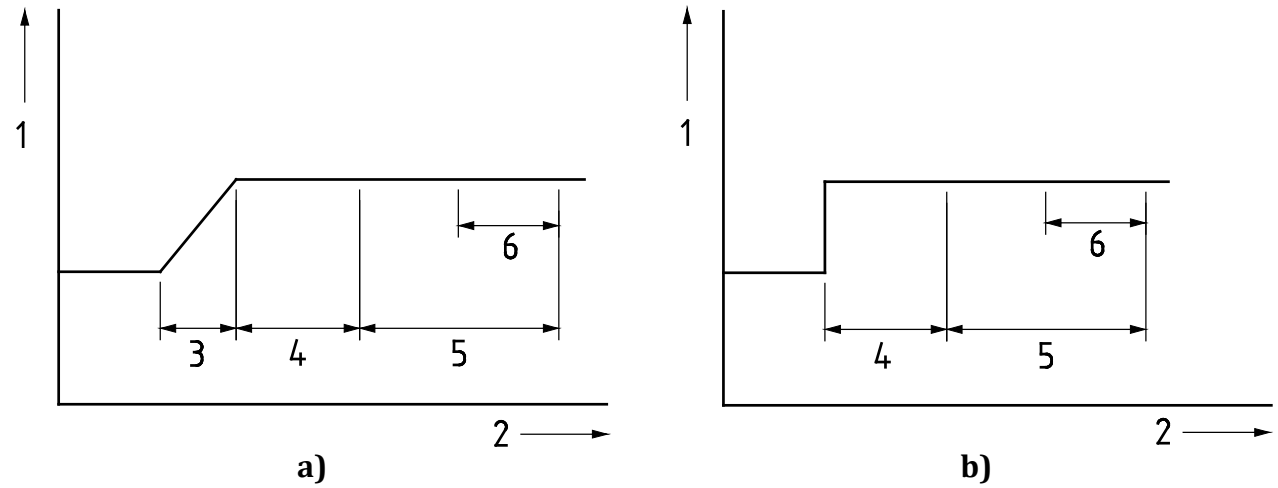
13.4 Regulation tests

13.4.1 Steady-state tests

Steady-state tests shall be performed to verify the thermal comfort parameters for a given set of internal and external parameters, see normative Annex C.

For transition periods (changing the exterior temperature between regulation tests) and for pre-test periods (stabilization period before start of test) the evaluation of comfort parameters need not be performed.

NOTE 1 Transition periods end when the exterior temperature has been achieved.



Key

1	changed parameter	4	t_{cs} or t_{rs}
2	time [min]	5	60 min steady-state test
3	transition period	6	30 min comfort parameter evaluation

Figure 8 — Test phases during steady-state tests for continuous (a) and discrete changes (b) of parameters

The 60 min steady-state test shall start after t_{cs} or t_{rs} as illustrated in Figure 8.

The results obtained for the last 30 min shall be evaluated in accordance with the comfort conditions.

The requirements specified in 9.3.2 shall be verified by changing the position of the temperature setting device from the normal setting to the maximum and minimum position.

In order to be able to check the behaviour of the regulation system and see how the temperatures in the particular compartments vary, it is recommended to set 20 % to 30 % of the compartments at maximum and the remainder to minimum. The same check shall be made with 70 % to 80 % of the temperature setting devices at maximum position and the remainder at minimum.

To check the effect of occupation, total or partial, on the regulation system, tests with a simulated occupation shall be carried out in accordance with 16.2.

NOTE 2 The tests performed in the presence of wind are intended to check the behaviour of the air conditioning installation and the tightness of the vehicle body, as well as the behaviour of the air extraction outlets.

The parameters to be evaluated for each test shall be in accordance with normative Annex C.

13.4.2 Intermediate tests

The intermediate tests shall be performed with a mean exterior temperature (T_{em}) that decreases or increases by 3 K/h and are intended to check the behaviour of the air conditioning installation and its control system during the transition from cooling mode to heating mode and vice-versa. The tests shall be performed both with and without supplementary disturbance caused by occupation and solar radiation of the vehicle.

NOTE The tests are also intended to record the start conditions of the modes of heating and/or ventilation and/or cooling.

The test shall start from stabilized conditions. To carry out this test, the corresponding mean exterior temperature (T_{em}) shall be stabilized for 30 min.

The tests end when the mean exterior temperature (T_{em}) has reached its final value.

The parameters for evaluation shall be in accordance with normative Annex C.

13.4.3 Tests for typical daily profiles

Three tests shall be performed, for typical summer, winter and spring/autumn days and are intended to check the behaviour of the air conditioning installation and its control system.

The typical daily profile tests shall be carried out with a setting for mean exterior temperature, wind speed, solar load, relative humidity and occupation in accordance to the test program given in normative Annex I.

The test shall start from stabilized conditions. To perform this test, the corresponding mean exterior temperature (T_{em}) shall be stabilized for 30 min. The tests are completed when the final parameter set has been reached.

The evaluation shall be done for T_{im} by applying the values of the extended q2 range specified in 10.1.1.

13.5 Functionality tests

The tests are intended to check the functionality:

— under extreme conditions in heating and cooling mode as defined in Table 4 and Table 5,

— in degraded mode operation in heating and cooling,

— in stand-by operation.

— if the air conditioning system is fitted with a pressure protection system, functional tests for evaluation of deviation of T_{im} should be performed. The test procedure should be agreed between customer and supplier.

For the evaluation, the functionality of the system shall be checked, however there is no evaluation of comfort parameters under these test conditions unless otherwise defined in the technical specification.

14 Supplementary tests

14.1 Determination of the heat transfer coefficient

14.1.1 Purpose of the test

The purpose of the test is to measure the coefficient k.

14.1.2 Calculation

The global coefficient k shall be calculated using the following formula:

$$k = \frac{P}{A_e \times (T_{im} - T_{em})} \tag{11}$$

where

A_e is the developed exterior surface of the assembly including walls, ceiling, floor and ends of the structure for all or part of the vehicle under consideration. This shall include windows, doors and openings.

P is the thermal power released inside the vehicle, necessary to maintain constantly the difference in absolute value between the mean interior temperature (T_{im}) measured at 1,1 m, of all or part of the vehicle in accordance with normative Annex E, and the mean exterior temperature (T_{em}).

14.1.3 Procedure

The openings for fresh air and exhaust air shall be sealed, but not insulated.

The air conditioning installation shall be isolated. The vehicle shall be without power (except for the batteries), the doors and the windows are closed. Unsealed gangways are normally only blocked by the vehicle door. Gangways without a vehicle door or sealed gangways shall be blocked by a temporary panel with a thermal transmission coefficient less than 0,5 W/(m^{2}K).

It is necessary to provide a heating installation independent of that of the vehicle, controllable to a low output in the vehicle interior (and) distributed in the comfort envelope and/or annex areas. The uniformity of the temperatures inside the vehicle shall be guaranteed by fans. The power consumption of the system and the fans shall be recorded separately.

All the measured data shall be recorded at least every 1 min.

The value of the temperature difference $|T_{im} - T_{em}|$ shall be (25 ± 5) K. It is recommended that this test is carried out with T_{em} = + 5 °C ± 2 K.

The output of the heating system and of the ventilation is maintained constant, the determination of the coefficient k is possible after stabilization of the temperatures:

— The values of T_{em} and $|T_{im} - T_{em}|$ shall be determined and averaged over a period of 30 min. The variation of these values, over a minimum period of 3 h shall be less than 0,1 K.

— The range of temperatures relating to different points of measurement (interior and exterior) shall be less than 2 K.

The coefficient k is calculated using the measurements taken during the last hour of temperature stabilization.

14.2 Thermography

A thermography test is recommended for evaluation of the thermal insulation quality of the vehicle.

15 Methods of measurement – Measuring instruments

15.1 General remarks

The recording should be continuous, with a minimum base sampling rate of one measurement per minute for all values recorded.

15.2 Temperatures

15.2.1 Air temperature

The measuring devices shall be Class S in accordance with EN ISO 7726:2001, Table 2, and exhibit a maximum drift of ± 0,25 K over the duration of recording.

15.2.2 Surface temperatures

In order to measure the real operational surface temperatures, the difference between the influence of radiation, convection and heat conduction on the sensors and on the measured surface shall be minimized. The applied method of measurement shall be validated to ensure a correct measurement

The class of measuring devices should be identical to that in 15.2.1.

15.3 Relative humidity

The class of measuring devices shall be Class C in accordance with EN ISO 7726:2001, Table 2.

15.4 Air speed

For evaluation in accordance with 10.1.4, values shall be averaged for a period of one minute with a minimum sample rate of 1 Hz.

The measuring instruments used should be Class C of EN ISO 7726:2001, Table 2.

15.5 Airflow rate

The airflow should be determined using a calibrated system of measurement that enables results to be recorded with a minimum accuracy of 10 % (it is not necessary to carry out a continuous recording of these measurements). At the same time the exterior temperature and the barometric pressure should be recorded. The airflow rates shall be measured with fan operation only.

15.6 Simulated speed of the vehicle

The speed of the air around the vehicle is to be determined by a calibrated system of measurement which enables the recording of results with a minimum accuracy of ± 1 m/s.

15.7 Equivalent solar energy

The measurement of the equivalent solar energy shall be achieved by a calibrated system of measurement. This measurement shall be carried out in accordance with the procedure described in normative Annex D.

15.8 Energy consumption and power rating

The measurements should be carried out within an accuracy of 2,5 %.

16 Characteristics of the test equipment

16.1 General remarks

To meet the requirements of this document the tests shall be performed in an appropriate facility with suitable test equipment.

16.2 Occupation

The simulation of the occupation, total or partial, of the conditioned space shall be achieved in accordance with the curves of Figure J.1.

For the simulation of sensible heat, heating equipment of low radiance with a surface temperature less than 40 °C should be used.

The simulation of the latent heat is carried out by the production of water vapour. The sensible heat introduced by the equipment producing the vapour shall be incorporated in the total balance of sensible heat.

16.3 Temperature and uniformity of the climatic chamber

The temperature of the climatic chamber shall satisfy the following temperature requirements:

- Variation of temperature (T_{em}) during the tests in steady-state conditions shall be ≤ 0,5 K.
- When changing T_{em} a minimum change rate of 3 K/h shall be reached.
- Regulation accuracy during changing temperature conditions shall be +/− 1 K.
- Without thermal load the range of temperatures measured at the points defined in informative Annex H shall be ≤ 2 K for all wind speeds.
- For vehicle tests at standstill the wind speed shall be below 15 km/h

16.4 Relative humidity

Variation of the relative humidity during the test shall be ≤ 5 %.

16.5 Simulation of wind speed

Suitable aerodynamic fairings (streamlining) upstream and downstream are necessary to simulate the aerodynamic conditions around the train or rake. The wind speed measured shall be corrected to take into account the effects of the walls of the climatic chamber and to obtain a heat flux equivalent to that in service operation.

During wind speed tests, the aerodynamic effects of the wind tunnel on the pressure and velocity field around the vehicle shall be taken into consideration and should be compensated as far as possible.

16.6 Equivalent solar energy

The equipment to simulate the equivalent solar energy based on the terrestrial radiation index "global insulation" of 1 120 W/m² in accordance with the CIE 85 should be composed of lamps whose characteristics conform to Table 17:

Table 17 — Characteristics of equipment

Wavelength Nanometer	**Percentage of total radiation compared with terrestrial radiation given in** CIE 85 %	**Allowable variation** %
280 – 400	6,1	±3
400 – 800	51,8	±5
800 – 3 000	42,1	±5

The simulation of sun load by internal heaters is not permitted.

17 Distribution of measuring points

17.1 Distribution of sensors in the vehicle

17.1.1 Comfort envelope temperature measuring points

These are defined in normative Annex E, normative Annex F and normative Annex G.

17.1.2 Surface temperature measuring points

The measurements should be taken in the same compartments or zones as specified in normative Annex F.

a) Ceilings:

The temperature shall be measured at the geometric centre of the zones as defined in normative Annex F. Measuring points may be adapted to avoid the direct influence of the air diffusion or light systems.

b) Floors:

The temperature shall be measured at a minimum of three different seat positions as defined in normative Annex F, below the foot measuring position of normative Annex G.

c) Glass:

The temperature shall be measured at the geometric centre of the pane(s) making up the window.

d) Window frames:

The temperature shall be measured at the height of the passenger shoulder level. For windows not close to a seat, the temperature shall be measured at the middle of each vertical member of the window frame. In the absence of a window frame the measurement is not applicable.

e) Walls:

1) Walls laterally adjacent to a seat:

The temperature shall be measured at a minimum of two seat positions (sun and shade side of the vehicle) at shoulder and knee level (in accordance with normative Annex G) and at a position adjacent to an arm rest.

2) Other walls (adjacent to a local annex):

The temperature shall be measured as close as possible to the geometric centre of the wall.

17.1.3 Supply air outlet temperature measuring points

The temperature is measured at the hottest point (determined by preliminary tests).

17.1.4 Comfort envelope air speed measuring points

The measuring points for each of the continuously measured positions shall be located at the head (seated position), shoulder, knee and foot in accordance with the locations shown in normative Annex G.

17.1.5 Comfort envelope relative humidity measuring points

The relative humidity shall be measured at the geometric centre of the compartments or zones defined in normative Annex F.

17.2 Climatic chamber sensors distribution

The measuring points for the mean exterior temperature T_{em}, the relative humidity and the air speed shall be defined by the operator of the climatic chamber.

NOTE A possible arrangement is included in informative Annex H.

Annex A
(informative)

Grouping of countries in climatic zones

Table A.1 — Climatic zones in function of country

Country	Winter zone	Summer zone
Austria	II	II
Belgium	II	II
Bulgaria	II	II
Croatia	II	II
Cyprus	I	I
Czech Republic	II	II
Denmark	II	II
Estonia	III	III
Finland	III	III
France	II	II
Germany	II	II
Greece	I	I
Hungary	II	II
Iceland	III	III
Ireland	I	III
Italy	II	I
Latvia	III	III
Lithuania	III	III
Luxemburg	II	II
Malta	I	I
Netherlands	II	II
Norway	III	III
Poland	III	II
Portugal	I	I
Romania	II	II
Slovakia	II	II
Slovenia	II	II
Spain	I	I
Sweden	III	III
Switzerland	II	II
Turkey	I	I
UK	I	III
Former Yugoslav Republic of Macedonia	II	II

Annex B
(normative)

Calculation method of the overall conformity level CL

This annex defines how to determine the conformity level based on the values measured for the parameters considered in each test as indicated in Annex C (criteria to be taken into account for evaluation).

For each single result X_{ijk}, a single conformity level Y_{ijk} is calculated as:

$$Y_{ijk} = \begin{cases} 100\% & \text{if} \quad X_{ijk} \le q1_j \\ 0\% & \text{if} \quad X_{ijk} > q2_j \\ 100\% - \dfrac{X_{ijk} - q1_j}{q2_j - q1_j} \times 100\% & \text{if} \quad q1_j < X_{ijk} \le q2_j \end{cases} \tag{B.1}$$

The specific conformity level $Y_{ij,s}$ for zone s in a single test i for a single comfort parameter j is calculated as the weighted mean of all relevant single conformity levels Y_{ijk}:

$$Y_{ij,s} = \sum_{k=1}^{n} w_{ijk} Y_{ijk} \tag{B.2}$$

where

n is the number of measuring points in zone s.

The weighting factor w_{ijk} for each measurement point and parameter j per comfort zone is given in Table B.1.

Table B.1 — Weighting factor

Comfort Parameter j	Weighting factor w_{ijk}
Range of T_{im} with respect to T_{ic}	1
Horizontal range of the extreme air interior temperatures	1
Vertical range of the extreme interior air temperatures for seated and standing passengers	1 / number of measured seats
Surface temperatures:	
• Walls	0,3 / number of wall measuring points
• Ceilings	0,1 / number of ceiling measuring points
• Window panes	If window frames are accessible by passengers: 0,25 / number of window pane measuring points If window frames are not accessible by passengers: 0,30 / number of window pane measuring points
• Window frames	If window frames are accessible by passengers: 0,05 / number of window frame measuring points If window frames are not accessible by passengers: 0,00 measuring point
• Floors	0,30 / number of floor measuring points
Humidity	1 / number of measuring points
Air speed	1 / number of measuring points
Quality of regulation:	
• Set point change (ΔT_{ic}) / Parameter change	0,5
• Stabilized operation	0,5

The conformity level of a single test CL_i is calculated as the arithmetic mean of all relevant specific conformity levels $Y_{ij,s}$ for that test weighted by the number of seats m_s per zone s:

$$CL_i = \frac{1}{n \cdot m} \sum_{j=1}^{n} \sum_{s=1}^{t} m_s Y_{ij,s} \tag{B.3}$$

where

n is the number of parameters j,

t is the number of measured comfort zones and

m is the sum of all seats in all measured comfort zones.

The conformity level CL_{SS} for steady-state tests is calculated as the arithmetic mean of all relevant conformity levels CL_i for the steady-state tests:

$$CL_{SS} = \frac{1}{n}\sum_{i=1}^{n} CL_i \text{ for all steady-state tests} \quad \text{(B.4)}$$

where

n is the number of steady-state tests.

NOTE If a test has no criteria to be taken into account for evaluation, it is not considered for the calculation of CL_{SS}.

The conformity level CL_{Int} for intermediate tests is calculated as the arithmetic mean of all relevant conformity levels CL_i for the intermediate tests:

$$CL_{Int} = \frac{1}{n}\sum_{i=1}^{n} CL_i \text{ for all intermediate tests} \quad \text{(B.5)}$$

where

n is the number of intermediate tests.

The conformity level CL_{TDP} for daily profile tests is calculated as the arithmetic mean of all relevant conformity levels CL_i for the typical daily profile tests:

$$CL_{TDP} = \frac{1}{n}\sum_{i=1}^{n} CL_i \text{ for all typical daily profile tests} \quad \text{(B.6)}$$

where

n is the number of typical daily profile tests.

The overall conformity level CL is calculated as the weighted mean of the conformity level CL_{SS} for steady-state, CL_{Int} for intermediate and CL_{TDP} for typical daily profile tests. The weighting is 70 % for steady-state, 20 % for intermediate and 10 % for daily profile tests:

$$CL = \left(0{,}7 \times CL_{SS} + 0{,}2 \times CL_{Int} + 0{,}1 \times CL_{TDP}\right) \quad \text{(B.7)}$$

Annex C
(normative)

Tests for verification of comfort parameters

Table C.1 — Type tests for climatic zone I, II and III according to informative Annex A (Winter and Summer)

Description of tests	Test no. or new test	Mean temperature climatic chamber °C	Rel. humidity climatic chamber %	Passenger load %	Sun radiation W/m²	Wind speed km/h	Set point	Criteria		Remarks
								to be taken into account for evaluation	to be checked	
k-value	1	5 ± 2	-	0	0	0–15			k	
k-value	2	5 ± 2	-	0	0	Max.			k	
Preheating	3	0	-	0	0	Min.	Normal		T_{im} = 18 °C	§ 8.1 Preheating time recorded
Steady-state	4	0	-	0	0	Min.	Normal	All		
Steady-state	5	0	-	100	0	Max.	Normal	All except air speeds		
Steady-state	6	0	-	100	0	Min.	Normal	All except air speeds		
Steady-state	7	0	-	all except 3 comp.	0	Min.	Normal	All except air speeds inside occupied compartments.		These tests only apply to compartment vehicles

Description of tests	Test no. or new test	Mean temperature climatic chamber °C	Rel. humidity climatic chamber %	Passenger load %	Sun radiation W/m²	Wind speed km/h	Set point	Criteria		Remarks
								to be taken into account for evaluation	to be checked	
Steady-state	8	0	-	at least 3 comp.	0	Min.	Normal	All except air speeds inside occupied compartments.		
Stabilization	9	0		0	0	Min.	Normal	None		
Steady-state	10	0	-	0	0	Min.	20 % to 30 % of devices: Maximum, others Minimum	All		
Steady-state	11	0	-	0	0	Min.	20 % to 30 % of devices: Minimum, others Maximum	All		
Functional - standby operation	12	−10	-	0	0	Min.	Normal	None	T_{im}	This test will be performed if required in customer specification (§8.5) Test is finished after demonstration of functionality, this means supporting the target temperature(s) for 1 h after achieving the threshold
Preheating from standby operation	13	−10	-	0	0	Min.	Normal	None	T_{im}	This test will be performed if required in customer specification (§8.5) This test will be performed immediately after the standby operation test. The test ends when stabilized condition has been achieved.

Description of tests	Test no. or new test	Mean temperature climatic chamber °C	Rel. humidity climatic chamber %	Passenger load %	Sun radiation W/m²	Wind speed km/h	Set point	Criteria		Remarks
								to be taken into account for evaluation	to be checked	
Steady-state	14	−10	-	0	0	Min.	Normal	All		-
Door opening test	15	−10	-	0	0	Min. / Max.	Normal	None	T_{im}	min. three door sequences[a]
Stabilization	16	−10	-	0	0	Min.	Normal	None		
Steady-state	17	−10	-	0	0	Min.	Maximum	All		
Functional degraded mode	18	−10	-	0	0	Min.	Normal	None	T_{im}	if applicable as defined in the technical specification according to the system layout. Simulates e.g. defect of one air conditioning if two installed per vehicle or blocked filter
Steady-state	19	n.a. (I) −20 (II) −40 (III)	-	0	0	Min.	Normal	All		-
Steady-state	20	−10 (I) −20 (II) −40 (III)	-	100	0	Max.	Normal	All except vertical ranges (10.1.1, 10.1.3, 10.3) and air speeds		Worst case for passenger depended fresh air regulation.
Steady-state	21	−10 (I) −20 (II) −40 (III)	-	0	0	Max.	Normal	All		

Description of tests	Test no. or new test	Mean temperature climatic chamber °C	Rel. humidity climatic chamber %	Passenger load %	Sun radiation W/m²	Wind speed km/h	Set point	Criteria		Remarks
								to be taken into account for evaluation	to be checked	
Performance	22	−10 (I) −20 (II) −40 (III)	-	0 or 100	0	Max.	Max.	None	T_{im}	The worst case (tests 20 or 21) defines the passenger load. This test can be removed if the criterion defined in chapter 8.2 has been checked in test number 20 or 21.
Functional extreme	23	−15 (I) −25 (II)) −45 (III)	-	0	0	Min.	Normal	None	T_{im}	⇩3 K/h + 1h at final temperature T_{em}. operating limit, only stable function
Steady-state	24	5	-	0	0	Min.	Normal	All		
Steady-state	25	5	-	100	0	Min.	Normal	All		
Steady-state	26	5	-	100	500	Min.	Normal	All except air speeds		
Steady-state	27	5	-	100	500	Max.	Normal	All except air speeds		
Steady-state	28	10	-	50	0	Min.	Normal	All except air speeds		Simulates before departure, passengers sitting down. Fresh air volume according to passenger load, distribution of passenger load uniform
Steady-state	29	10	-	50	500	Min.	Normal	All except air speeds		Simulates the arrival in an open station
Steady-state	30	10	-	100	500	Min.	Normal	All except air speeds		

Description of tests	Test no. or new test	Mean temperature climatic chamber °C	Rel. humidity climatic chamber %	Passenger load %	Sun radiation W/m²	Wind speed km/h	Set point	Criteria		Remarks
								to be taken into account for evaluation	to be checked	
Steady-state	31	15	90	50	0	Min.	Normal	All except air speeds		Simulates rainy day with high humidity
Steady-state	32	15	90	100	0	Min.	Normal	All except air speeds		
Steady-state	33	15	90	100	500	Min.	Normal	All except air speeds		
Steady-state	34	15	90	100	500	Min.	Minimum	All except air speeds		
Stabilization	35	15	90	100	500	Min.	Normal	None		
Steady-state	36	15	80	0	0	Min.	Normal	All		Simulates arrival in station
Intermediate	37	15 = > 5	80	0	0	Min.	Normal	All except quality of regulation		↓ 3 K/h
Intermediate	38	5 = > 22	80	0	0	Min.	Normal	All except quality of regulation		↑ 3 K/h
Steady-state	39	22	80	0	0	Min.	Normal	All		
Stabilization	40	22	80	100	0	Min.	Normal	None		These tests only apply to compartment vehicles
Steady-state	41	22	80	100	0	Min.	20 % to 30 % of devices: Maximum, others Minimum	All except air speeds		

Description of tests	Test no. or new test	Mean temperature climatic chamber °C	Rel. humidity climatic chamber %	Passenger load %	Sun radiation W/m²	Wind speed km/h	Set point	Criteria		Remarks
								to be taken into account for evaluation	to be checked	
Steady-state	42	22	80	100	0	Min.	20 % to 30 % of devices: Minimum, others Maximum	All except air speeds		
Steady-state	43	22	80	100	0	Min.	Normal	All except air speeds		
Steady-state	44	22	80	100	500	Min.	Normal	All except air speeds		
Intermediate	45	22 = > 5	80 = >	100	0	Min.	Normal	All except quality of regulation and air speeds		
Intermediate	46	5 = > 28	= > 70	100	500	Min.	Normal	All except quality of regulation and air speeds		
Steady-state	47	28	70 (I) 70 (II) 45 (III)	50	0	Min.	Normal	All except air speeds		
Steady-state	48	28	70 (I) 70 (II) 45 (III)	50	0	Min.	Minimum	All except air speeds		
stabilization	49	28	70 (I) 70 (II) 45 (III)	50	600	Min.	Normal	None		

Description of tests	Test no. or new test	Mean temperature climatic chamber °C	Rel. humidity climatic chamber %	Passenger load %	Sun radiation W/m²	Wind speed km/h	Set point	Criteria		Remarks
								to be taken into account for evaluation	to be checked	
Steady-state	50	28	70 (I) 70 (II) 45 (III)	100	600	Min.	Normal	All except air speeds		
Steady-state	51	28	70 (I) 70 (II) 45 (III)	100	600	Min.	20 % to 30 % of devices: Maximum, others Minimum	All except air speeds		These tests only apply to compartment vehicles
Steady-state	52	28	70 (I) 70 (II) 45 (III)	100	600	Min.	20 % to 30 % of devices: Minimum, others Maximum	All except air speeds		
Stabilization	53	28	70 (I) 70 (II) 45 (III)	100	600	Min.	Normal	None		
Steady-state	54	28	70 (I) 70 (II) 45 (III)	at least 3 comp.	600	Max.	Normal	All except air speeds inside occupied compartments		
Steady-state	55	28	70 (I) 70 (II) 45 (III)	all except 3 comp.	600	Max.	Normal	All except air speeds inside occupied compartments		

Description of tests	Test no. or new test	Mean temperature climatic chamber °C	Rel. humidity climatic chamber %	Passenger load %	Sun radiation W/m²	Wind speed km/h	Set point	Criteria		Remarks
								to be taken into account for evaluation	to be checked	
Steady-state	56	40 (I) 35 (II) n.a. (III)	40 (I) 50 (II) n.a. (III)	50	0	Min.	Normal	All except air speeds		
Door opening test	57	40 (I) 35 (II) 28 (III)	40 (I) 50 (II) 45 (III)	50	0	Min. / Max.	Normal	None	T_{im}	Min. three door sequences[a]
Steady-state	58	40 (I) 35 (II) n.a. (III)	40 (I) 50 (II) n.a. (III)	100	0	Max.	Normal	All except air speeds		
Steady-state	59	40 (I) 35 (II) n.a. (III)	40 (I) 50 (II) n.a. (III)	100	800 (I) 700 (II) n.a. (III)	Min.	Normal	All except air speeds		
Performance	60	40 (I) 35 (II) 28 (III)	40 (I) 50 (II) 45 (III)	100	800 (I) 700 (II) 600 (III)	Min.	Min	None	T_{im}	The test can be removed if the criterion defined in chapter 8.4 has been checked in tests number 50 or 59.
Functional degraded mode	61	40 (I) 35 (II) 28 (III)	40 (I) 50 (II) 70 (III)	100	800 (I) 700 (II) 600 (III)	Min.	Normal	None	T_{im}	if applicable as defined in the technical specification according to the system layout. Simulates e.g. defect of one air conditioning if two installed per vehicle, or any failure agreed with the customer, or blocked filter

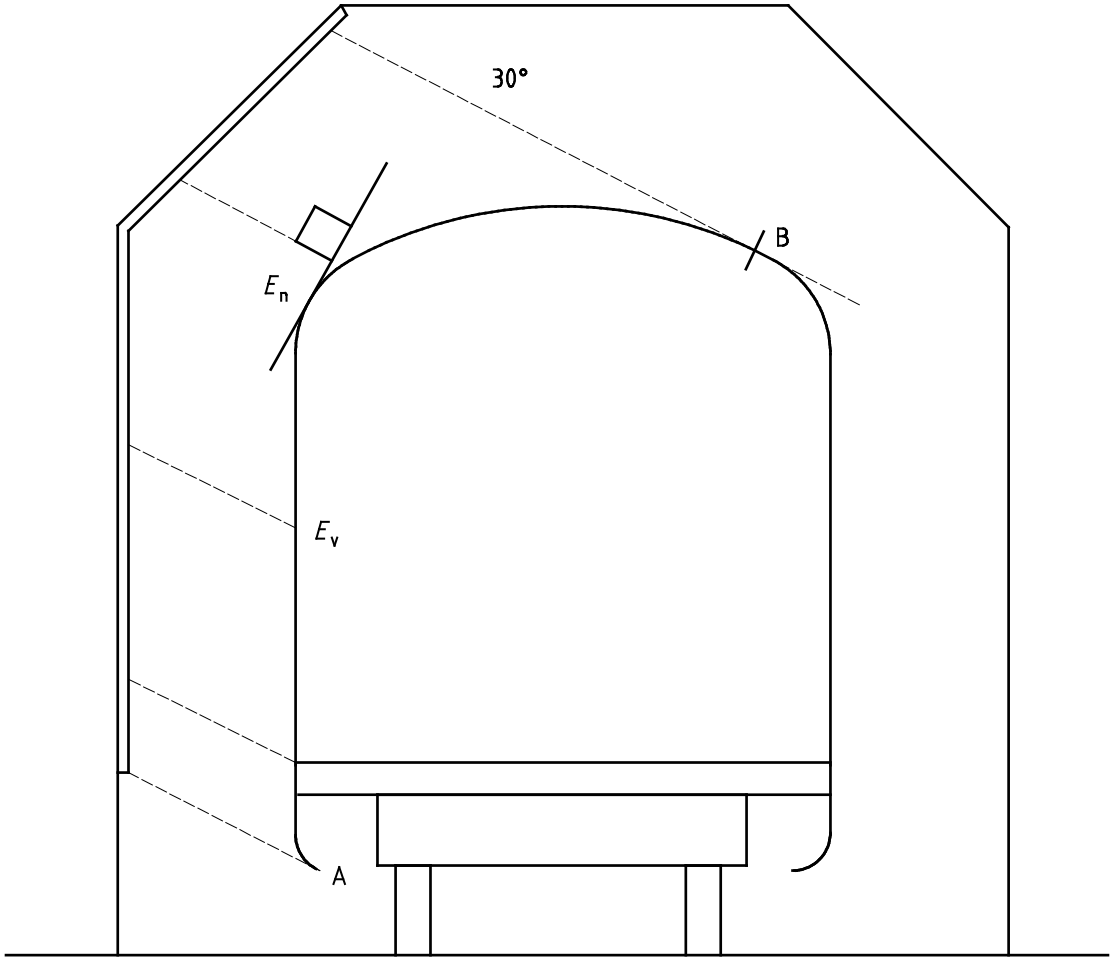
Description of tests	Test no. or new test	Mean temperature climatic chamber °C	Rel. humidity climatic chamber %	Passenger load %	Sun radiation W/m²	Wind speed km/h	Set point	Criteria		Remarks
								to be taken into account for evaluation	to be checked	
Functional standby operation	62	40 (I) 35 (II) 28 (III)	40 (I) 50 (II) 70 (III)	0	800 (I) 700 (II) 600 (III)	Min.	Normal	None	T_{im}	This test will be performed if required in customer specification (§8.5) Test is finished after demonstration of functionality, this means supporting the target temperature(s) for 1 h after achieving the threshold
Precooling from standby operation	63	40 (I) 35 (II) 28 (III)	40 (I) 50 (II) 70 (III)	0	800 (I) 700 (II) 600 (III)	Min.	Normal	None	T_{im}	This test will be performed if required in customer specification (§8.5) This test will be performed immediately after the standby operation test. The test ends when stabilized condition has been achieved.
Steady-state	64	45 (I) 40 (II) 33 (III)	35 (I) 40 (II) 30 (III)	100	800 (I) 700 (II) 600 (III)	Min.	Normal	None	T_{im}	stable function 100 % capacity
Functional	65	50 (I) 45 (II) 38 (III)	25 (I) 30 (II) 25 (III)	100	800 (I) 700 (II) 600 (III)	Min.	Normal	None	T_{im}	⇑ 3 K/h + 1h at final temperature T_{em} operating limit, only stable function
Typical daily profile (Winter)	66	−5 - +3	45 - 75	0 - 100	0 - 400	Min.-Max.	Normal	T_{im}		See normative Annex I.
Typical daily profile (Spring or Autumn)	67	+5 - +25	30 - 70	0 - 100	0 - 700	Min.-Max.	Normal	T_{im}		See normative Annex I.

Description of tests	Test no. or new test	Mean temperature climatic chamber °C	Rel. humidity climatic chamber %	Passenger load %	Sun radiation W/m²	Wind speed km/h	Set point	Criteria		Remarks
								to be taken into account for evaluation	to be checked	
Typical daily profile (Summer)	68	+20 - +36	30 - 70	0 - 100	200 - 700	Min.-Max.	Normal	T_{im}		See normative Annex I.
Wind speed: Max. - maximum speed; Min. - minimum speed < 15 km/h Normal: corresponds to the set point at middle position										
[a] 3 sequences of 60 s doors open and 19 min doors closed on one side of the train										

Test sequence required for certain starting conditions
Other tests, no thermal comfort requirements to be fulfilled
Signature of changed parameter
Only valid for compartment coaches

Annex D
(normative)

Equivalent solar energy (Simulation of solar exposure)



Key

E_n = Equivalent solar energy on a surface perpendicular to the radiation

E_v = cos(30°) * E_n = 0,866 * E_n = Equivalent solar energy on the surface of the vehicle(D.1)

E_n is defined in 7.1 and Annex C

Figure D.1 — Solar energy definition

Whatever type of vehicle, it is recommended that solar radiation is available between points A and B (compartments on the side of the lamps for compartmented vehicles).

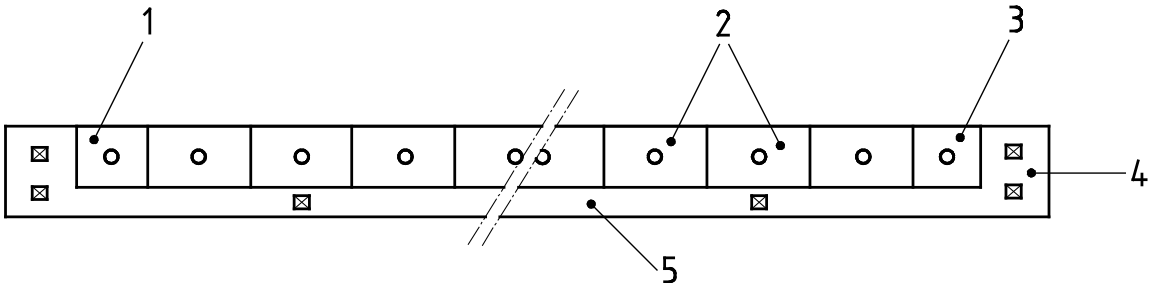
The bank of solar radiation lamps shall be at minimum, the same length as the vehicle on test.

The measurement of the equivalent solar energy shall be taken on the middle face of the vehicle side wall.

Annex E
(normative)

Location of the measuring points used for the determination of the mean interior temperature in the comfort envelope (T_{im}), horizontal range of the extreme interior air temperatures and the measuring point location in the local annexes

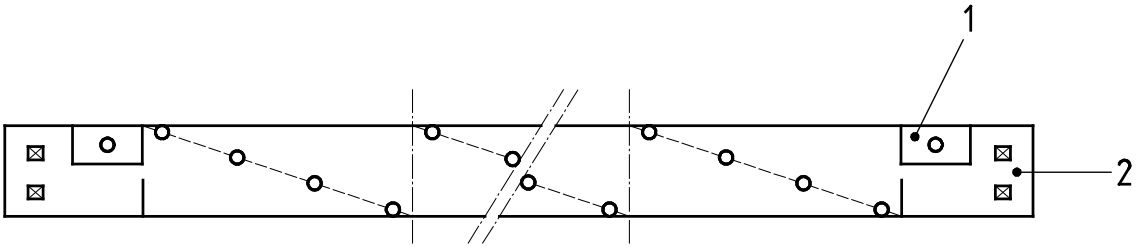
The sensors shall respect the locations defined in Figure E.1 or E.2.



Key

1 local annex (1,1 m)
2 compartments (1,1 m)
3 local annex (1,1 m)
4 vestibule (0,1 and 1,7 m)
5 corridor (0,1 and 1,7 m)
□ measuring points 0,1 m above the floor
○ measuring points 1,1 m above the floor
× measuring points 1,7 m above the floor

Figure E.1 — Compartmented coaches



Key

1 local annex (1,1 m)
2 vestibule (0,1 and 1,7 m)
□ measuring points 0,1 m above the floor
○ measuring points 1,1 m above the floor
measuring points 1,7 m above the floor

Figure E.2 — Open saloon coaches

Compartment measuring points:

— At the geometric centre of each compartment.

Open saloon measuring points:

— On the diagonal shown in Figure E.2 (the coach is divided into three equal parts).

Corridor measuring points (compartmented coaches):

— On the longitudinal centre-line of the corridor, facing the centre of the second compartment and the one before last compartment.

Vestibule measuring points:

— On the centre-line of the passenger (access) doors and at 0,5 m from them.

Local annex measuring points:

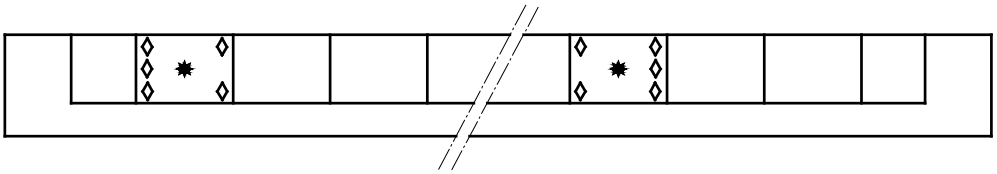
— At the geometric centre of the space.

For vehicles not included in the above categories (sleeper, restaurant coaches or coaches with different type of saloon), one should determine, by analogy, representative measuring points.

Annex F
(normative)

Location of the measuring points used for the determination of the vertical ranges of the extreme interior air temperatures and relative humidity across the comfort envelope

The sensors shall respect the locations defined in Figure F.1 or F.2.

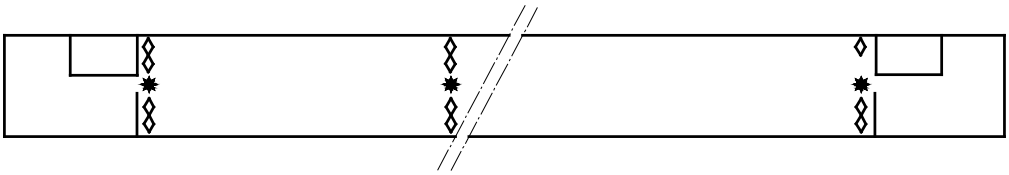


Key

◊ Measuring point as per normative Annex G

✶ Geometric centre of the measurement zone

Figure F.1 — Compartmented coaches



Key

◊ Measuring point as per normative Annex G

✶ Geometric centre of the measurement zone

Figure F.2 — Open saloon coaches

Location of the measuring points:

— See Annex G.

Position of the measuring points in compartmented coaches:

— At positions designated by a ◊ in a compartment adjacent to the vestibule.

— At positions designated by a ◊ in a compartment situated 2/3 down the length of the coach.

— At the position designated by a ✶ at 1,7 m above the floor for humidity.

Position of the measuring points in open saloon coaches:

— At positions designated by a ◊ in the row adjacent to the vestibule.

— At positions designated by a ◊ in a row situated in about the middle of the largest saloon.

— At the position designated by a ✶ at 0,1 m and 1,7 m above the floor for temperature (for vertical **range of the extreme interior air temperatures** at positions of standing passengers), and at 1,7 m above the floor for humidity. The vertical range of the extreme interior air temperatures for seated passengers air temperatures shall be measured at head, shoulders, knees and feet.

For vehicles not included in the above categories (sleeper or restaurant coaches) or different layout, one should determine, by analogy, representative measuring points. This includes also double deck coaches which should be treated as two separate coaches.

Annex G
(normative)

Location of the measuring points used for the determination of the variation of internal temperatures within the comfort envelope

Table G.1 — Measuring points

Dimensions in metres

◊	Measuring points (see normative Annex F.)
○	Head
□	Shoulders (0,2 m from centre)
▽	Knees (0,2 m from centre)
△	Feet (0,15 m from centre)

The sensors shall respect the locations defined in Figure G.1 or G.2.

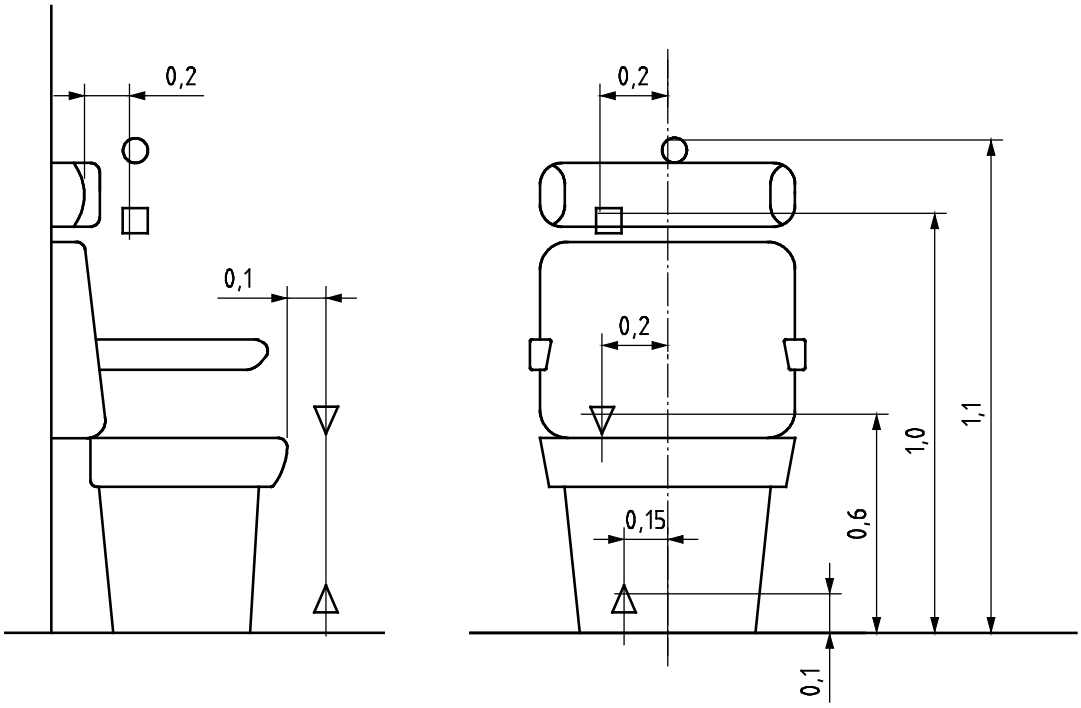


Figure G.1 — Seats

Dimensions in metres

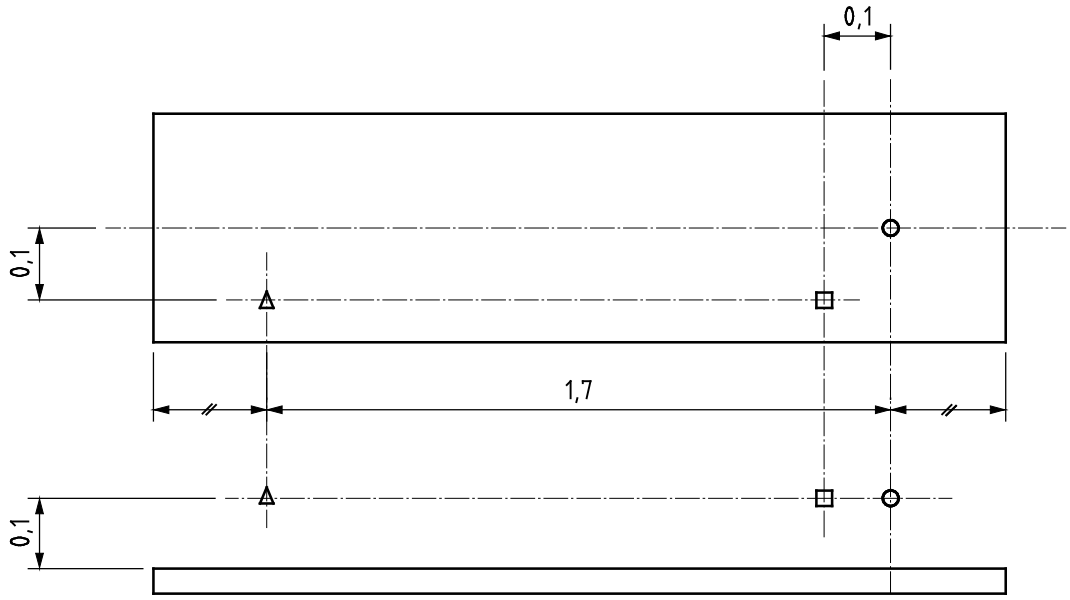


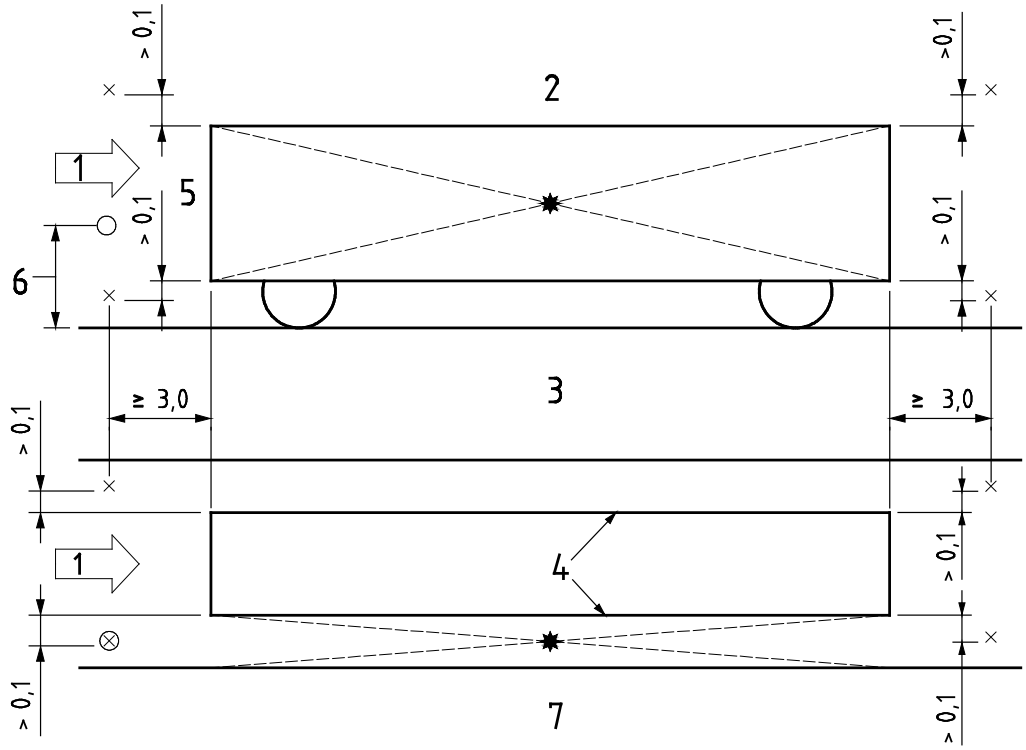
Figure G.2 — Sleeping berths

Annex H
(informative)

Location of the sensors in the climatic chamber

The sensors shall respect the locations defined in Figure H.1.

Dimensions in metres



Key

1	wind	6	fresh air intake height
2	top of Roof	7	wall of climatic chamber
3	top of Rail	×	temperature sensors (8)
4	vehicle exterior faces	○	humidity sensor (1)
5	end of composition	✶	air speed sensor (1)

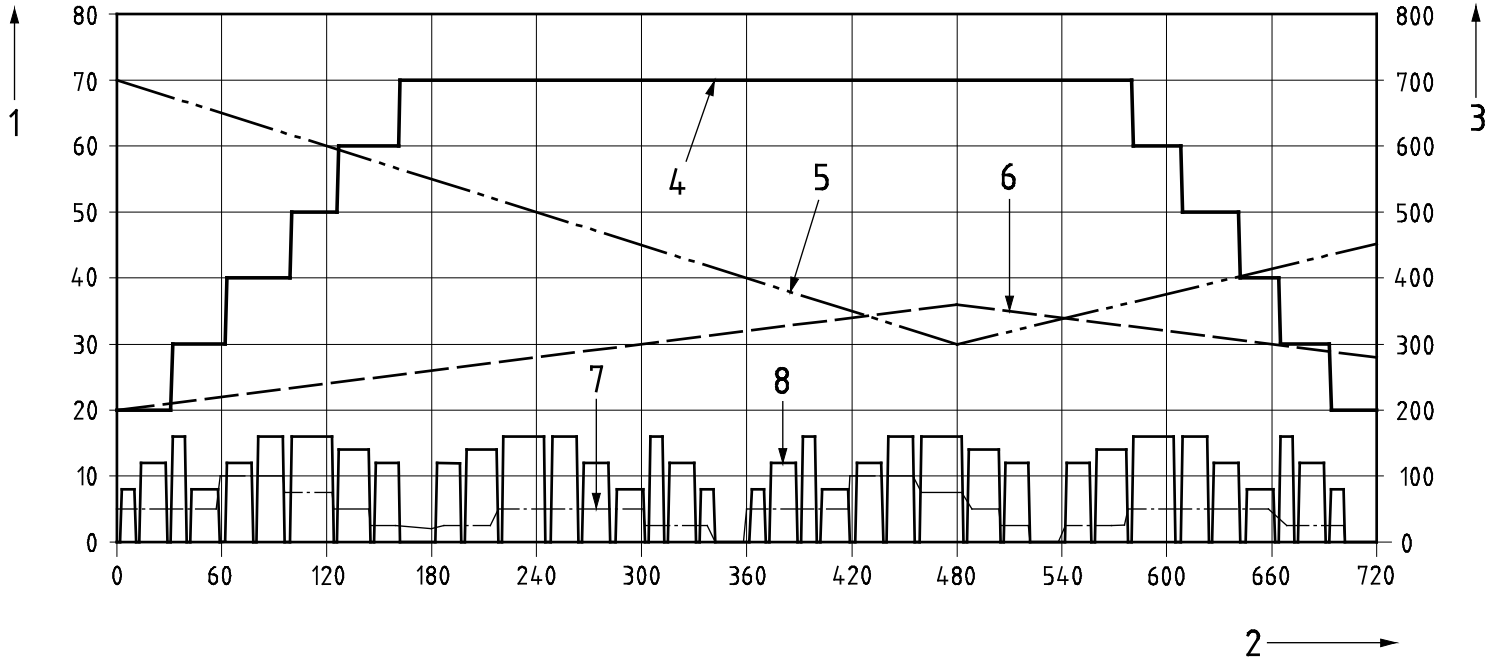
Figure H.1 — Measuring points

T_{em} is the arithmetic mean of the eight temperature measuring points.

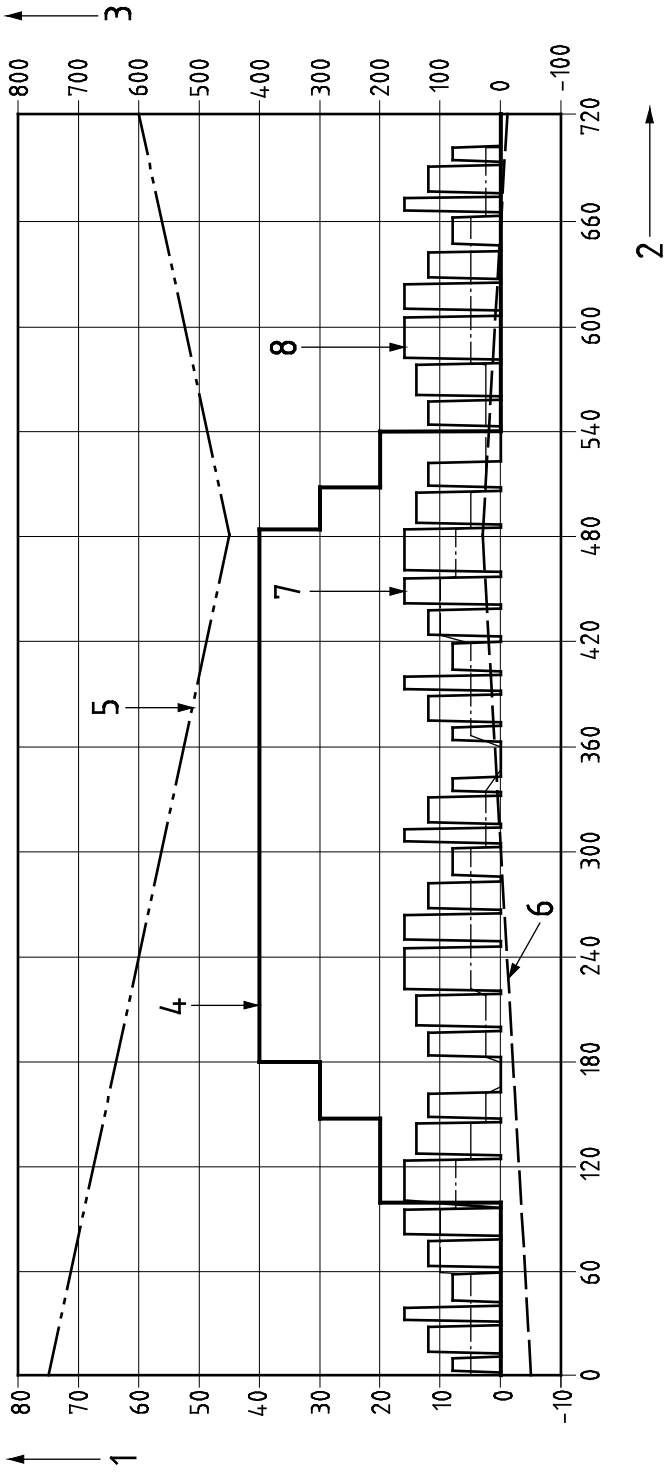
Annex I
(normative)

Typical daily profiles

The conditions for the daily profile tests shall be adjusted in accordance with Table I.1 and Figure I.1 a) for summer, Figure I.1 b) for winter and Figure I.1 c) for spring and autumn.



a) Summer


1
2
3
4
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7
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80
70
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40
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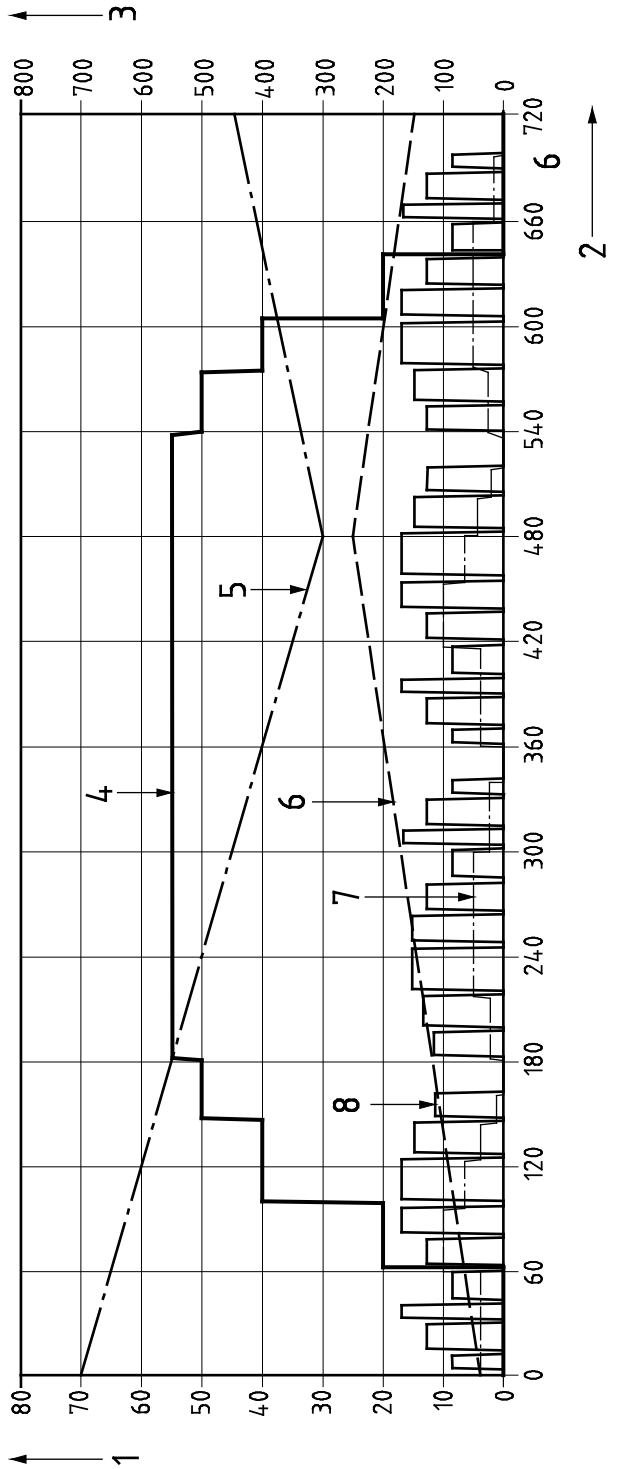
10
0
-10
800
700
600
500
400
300
200
100
0
-100
0
60
120
180
240
300
360
420
480
540
600
660
720

b) Winter



c) Spring and Autumn

Key

1 mean exterior temperature (T_{em}) [°C] / Relative humidity [%]
2 time [min]
3 solar radiation [W/m²] / Wind speed [km/h] / Passenger load [%]
4 solar radiation [W/m²]
5 relative humidity [%]
6 mean exterior temperature (T_{em}) [°C]
7 passenger load [%]
8 wind speed [km/h]

Figure I.1 — Typical daily profile

Table I.1 — Data of typical daily profile

			Summer			Winter			Spring and Autumn		
Time	**Wind speed**	**Pass. Load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**
min	km/h	%	°C with gradient ± 2 K/h	% with gradient ± 5 %/h	W/m²	°C with gradient ± 2 K/h	% with gradient ± 3,33 %/h	W/m²	°C with gradient ± 2 K/h	% with gradient ± 5 %/h	W/m²
0	0	50	20,00	70,00	200	−5,00	75,00	0	5,00	70,00	0
2	0	50	20,07	69,83	200	−4,97	74,88	0	5,08	69,83	0
3	80	50	20,10	69,75	200	−4,95	74,81	0	5,13	69,75	0
10	80	50	20,33	69,17	200	−4,83	74,38	0	5,42	69,17	0
11	0	50	20,37	69,08	200	−4,82	74,31	0	5,46	69,08	0
13	0	50	20,43	68,92	200	−4,78	74,19	0	5,54	68,92	0
14	120	50	20,47	68,83	200	−4,77	74,13	0	5,58	68,83	0
28	120	50	20,93	67,67	200	−4,53	73,25	0	6,17	67,67	0
29	0	50	20,97	67,58	200	−4,52	73,19	0	6,21	67,58	0
31	0	50	21,03	67,42	200	−4,48	73,06	0	6,29	67,42	0
32	160	50	21,07	67,33	300	−4,47	73,00	0	6,33	67,33	0
39	160	50	21,30	66,75	300	−4,35	72,56	0	6,63	66,75	0
40	0	50	21,33	66,67	300	−4,33	72,50	0	6,67	66,67	0
42	0	50	21,40	66,50	300	−4,30	72,38	0	6,75	66,50	0
43	80	50	21,43	66,42	300	−4,28	72,31	0	6,79	66,42	0
58	80	50	21,93	65,17	300	−4,03	71,38	0	7,42	65,17	0
59	0	100	21,97	65,08	300	−4,02	71,31	0	7,46	65,08	0
62	0	100	22,07	64,83	300	−3,97	71,13	0	7,58	64,83	0

			Summer			Winter			Spring and Autumn		
Time	**Wind speed**	**Pass. Load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**
min	km/h	%	°C with gradient ± 2 K/h	% with gradient ± 5 %/h	W/m²	°C with gradient ± 2 K/h	% with gradient ± 3,33 %/h	W/m²	°C with gradient ± 2 K/h	% with gradient ± 5 %/h	W/m²
63	120	100	22,10	64,75	400	−3,95	71,06	0	7,63	64,75	200
77	120	100	22,57	63,58	400	−3,72	70,19	0	8,21	63,58	200
78	0	100	22,60	63,50	400	−3,70	70,13	0	8,25	63,50	200
80	0	100	22,67	63,33	400	−3,67	70,00	0	8,33	63,33	200
81	160	100	22,70	63,25	400	−3,65	69,94	0	8,38	63,25	200
95	160	100	23,17	62,08	400	−3,42	69,06	0	8,96	62,08	200
96	0	75	23,20	62,00	400	−3,40	69,00	0	9,00	62,00	200
99	0	75	23,30	61,75	400	−3,35	68,81	0	9,13	61,75	200
100	160	75	23,33	61,67	500	−3,33	68,75	200	9,17	61,67	400
123	160	75	24,10	59,75	500	−2,95	67,31	200	10,13	59,75	400
124	0	50	24,13	59,67	500	−2,93	67,25	200	10,17	59,67	400
126	0	50	24,20	59,50	500	−2,90	67,13	200	10,25	59,50	400
127	140	50	24,23	59,42	600	−2,88	67,06	200	10,29	59,42	400
144	140	50	24,80	58,00	600	−2,60	66,00	200	11,00	58,00	400
145	0	25	24,83	57,92	600	−2,58	65,94	200	11,04	57,92	400
147	0	25	24,90	57,75	600	−2,55	65,81	200	11,13	57,75	400
148	120	25	24,93	57,67	600	−2,53	65,75	300	11,17	57,67	500
161	120	25	25,37	56,58	600	−2,32	64,94	300	11,71	56,58	500
162	0	0	25,40	56,50	700	−2,30	64,88	300	11,75	56,50	500

			Summer			Winter			Spring and Autumn		
Time	**Wind speed**	**Pass. Load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**
min	km/h	%	°C with gradient ± 2 K/h	% with gradient ± 5 %/h	W/m²	°C with gradient ± 2 K/h	% with gradient ± 3,33 %/h	W/m²	°C with gradient ± 2 K/h	% with gradient ± 5 %/h	W/m²
165	0	0	25,50	56,25	700	−2,25	64,69	300	11,88	56,25	500
179	0	0	25,97	55,08	700	−2,02	63,81	300	12,46	55,08	500
180	0	25	26,00	55,00	700	−2,00	63,75	400	12,50	55,00	500
182	0	25	26,07	54,83	700	−1,97	63,63	400	12,58	54,83	500
183	120	25	26,10	54,75	700	−1,95	63,56	400	12,63	54,75	550
196	120	25	26,53	53,67	700	−1,73	62,75	400	13,17	53,67	550
197	0	25	26,57	53,58	700	−1,72	62,69	400	13,21	53,58	550
199	0	25	26,63	53,42	700	−1,68	62,56	400	13,29	53,42	550
200	140	25	26,67	53,33	700	−1,67	62,50	400	13,33	53,33	550
217	140	25	27,23	51,92	700	−1,38	61,44	400	14,04	51,92	550
218	0	50	27,27	51,83	700	−1,37	61,38	400	14,08	51,83	550
220	0	50	27,33	51,67	700	−1,33	61,25	400	14,17	51,67	550
221	160	50	27,37	51,58	700	−1,32	61,19	400	14,21	51,58	550
244	160	50	28,13	49,67	700	−0,93	59,75	400	15,17	49,67	550
245	0	50	28,17	49,58	700	−0,92	59,69	400	15,21	49,58	550
248	0	50	28,27	49,33	700	−0,87	59,50	400	15,33	49,33	550
249	160	50	28,30	49,25	700	−0,85	59,44	400	15,38	49,25	550
263	160	50	28,77	48,08	700	−0,62	58,56	400	15,96	48,08	550
264	0	50	28,80	48,00	700	−0,60	58,50	400	16,00	48,00	550

			Summer			Winter			Spring and Autumn		
Time	**Wind speed**	**Pass. Load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**
min	km/h	%	°C with gradient ± 2 K/h	% with gradient ± 5 %/h	W/m²	°C with gradient ± 2 K/h	% with gradient ± 3,33 %/h	W/m²	°C with gradient ± 2 K/h	% with gradient ± 5 %/h	W/m²
266	0	50	28,87	47,83	700	−0,57	58,38	400	16,08	47,83	550
267	120	50	28,90	47,75	700	−0,55	58,31	400	16,13	47,75	550
281	120	50	29,37	46,58	700	−0,32	57,44	400	16,71	46,58	550
282	0	50	29,40	46,50	700	−0,30	57,38	400	16,75	46,50	550
285	0	50	29,50	46,25	700	−0,25	57,19	400	16,88	46,25	550
286	80	50	29,53	46,17	700	−0,23	57,13	400	16,92	46,17	550
301	80	50	30,03	44,92	700	0,02	56,19	400	17,54	44,92	550
302	0	25	30,07	44,83	700	0,03	56,13	400	17,58	44,83	550
304	0	25	30,13	44,67	700	0,07	56,00	400	17,67	44,67	550
305	160	25	30,17	44,58	700	0,08	55,94	400	17,71	44,58	550
312	160	25	30,40	44,00	700	0,20	55,50	400	18,00	44,00	550
313	0	25	30,43	43,92	700	0,22	55,44	400	18,04	43,92	550
315	0	25	30,50	43,75	700	0,25	55,31	400	18,13	43,75	550
316	120	25	30,53	43,67	700	0,27	55,25	400	18,17	43,67	550
330	120	25	31,00	42,50	700	0,50	54,38	400	18,75	42,50	550
331	0	25	31,03	42,42	700	0,52	54,31	400	18,79	42,42	550
333	0	25	31,10	42,25	700	0,55	54,19	400	18,88	42,25	550
334	80	25	31,13	42,17	700	0,57	54,13	400	18,92	42,17	550
341	80	25	31,37	41,58	700	0,68	53,69	400	19,21	41,58	550

			Summer			Winter			Spring and Autumn		
Time	**Wind speed**	**Pass. Load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**
min	km/h	%	°C with gradient ± 2 K/h	% with gradient ± 5 %/h	W/m²	°C with gradient ± 2 K/h	% with gradient ± 3,33 %/h	W/m²	°C with gradient ± 2 K/h	% with gradient ± 5 %/h	W/m²
342	0	0	31,40	41,50	700	0,70	53,63	400	19,25	41,50	550
345	0	0	31,50	41,25	700	0,75	53,44	400	19,38	41,25	550
345	0	0	31,50	41,25	700	0,75	53,44	400	19,38	41,25	550
359	0	0	31,97	40,08	700	0,98	52,56	400	19,96	40,08	550
360	0	50	32,00	40,00	700	1,00	52,50	400	20,00	40,00	550
362	0	50	32,07	39,83	700	1,03	52,38	400	20,08	39,83	550
363	80	50	32,10	39,75	700	1,05	52,31	400	20,13	39,75	550
370	80	50	32,33	39,17	700	1,17	51,88	400	20,42	39,17	550
371	0	50	32,37	39,08	700	1,18	51,81	400	20,46	39,08	550
373	0	50	32,43	38,92	700	1,22	51,69	400	20,54	38,92	550
374	120	50	32,47	38,83	700	1,23	51,63	400	20,58	38,83	550
388	120	50	32,93	37,67	700	1,47	50,75	400	21,17	37,67	550
389	0	50	32,97	37,58	700	1,48	50,69	400	21,21	37,58	550
391	0	50	33,03	37,42	700	1,52	50,56	400	21,29	37,42	550
392	160	50	33,07	37,33	700	1,53	50,50	400	21,33	37,33	550
399	160	50	33,30	36,75	700	1,65	50,06	400	21,63	36,75	550
400	0	50	33,33	36,67	700	1,67	50,00	400	21,67	36,67	550
402	0	50	33,40	36,50	700	1,70	49,88	400	21,75	36,50	550
403	80	50	33,43	36,42	700	1,72	49,81	400	21,79	36,42	550

			Summer			Winter			Spring and Autumn		
Time	**Wind speed**	**Pass. Load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**
min	km/h	%	°C with gradient ± 2 K/h	% with gradient ± 5 %/h	W/m²	°C with gradient ± 2 K/h	% with gradient ± 3,33 %/h	W/m²	°C with gradient ± 2 K/h	% with gradient ± 5 %/h	W/m²
418	80	50	33,93	35,17	700	1,97	48,88	400	22,42	35,17	550
419	0	100	33,97	35,08	700	1,98	48,81	400	22,46	35,08	550
422	0	100	34,07	34,83	700	2,03	48,63	400	22,58	34,83	550
423	120	100	34,10	34,75	700	2,05	48,56	400	22,63	34,75	550
437	120	100	34,57	33,58	700	2,28	47,69	400	23,21	33,58	550
438	0	100	34,60	33,50	700	2,30	47,63	400	23,25	33,50	550
440	0	100	34,67	33,33	700	2,33	47,50	400	23,33	33,33	550
441	160	100	34,70	33,25	700	2,35	47,44	400	23,38	33,25	550
455	160	100	35,17	32,08	700	2,58	46,56	400	23,96	32,08	550
456	0	75	35,20	32,00	700	2,60	46,50	400	24,00	32,00	550
459	0	75	35,30	31,75	700	2,65	46,31	400	24,13	31,75	550
460	160	75	35,33	31,67	700	2,67	46,25	400	24,17	31,67	550
480	160	75	36,00	30,00	700	3,00	45,00	400	25,00	30,00	550
483	160	75	35,90	30,19	700	2,95	45,19	400	24,88	30,19	550
484	0	50	35,87	30,25	700	2,93	45,25	300	24,83	30,25	550
486	0	50	35,80	30,38	700	2,90	45,38	300	24,75	30,38	550
487	140	50	35,77	30,44	700	2,88	45,44	300	24,71	30,44	550
504	140	50	35,20	31,50	700	2,60	46,50	300	24,00	31,50	550
505	0	25	35,17	31,56	700	2,58	46,56	300	23,96	31,56	550

			Summer			Winter			Spring and Autumn		
Time	**Wind speed**	**Pass. Load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**
min	km/h	%	°C with gradient ± 2 K/h	% with gradient ± 5 %/h	W/m²	°C with gradient ± 2 K/h	% with gradient ± 3,33 %/h	W/m²	°C with gradient ± 2 K/h	% with gradient ± 5 %/h	W/m²
507	0	25	35,10	31,69	700	2,55	46,69	300	23,88	31,69	550
508	120	25	35,07	31,75	700	2,53	46,75	200	23,83	31,75	550
521	120	25	34,63	32,56	700	2,32	47,56	200	23,29	32,56	550
522	0	0	34,60	32,63	700	2,30	47,63	200	23,25	32,63	550
525	0	0	34,50	32,81	700	2,25	47,81	200	23,13	32,81	550
525	0	0	34,50	32,81	700	2,25	47,81	200	23,13	32,81	550
539	0	0	34,03	33,69	700	2,02	48,69	200	22,54	33,69	550
540	0	25	34,00	33,75	700	2,00	48,75	0	22,50	33,75	500
542	0	25	33,93	33,88	700	1,97	48,88	0	22,42	33,88	500
543	120	25	33,90	33,94	700	1,95	48,94	0	22,38	33,94	500
556	120	25	33,47	34,75	700	1,73	49,75	0	21,83	34,75	500
557	0	25	33,43	34,81	700	1,72	49,81	0	21,79	34,81	500
559	0	25	33,37	34,94	700	1,68	49,94	0	21,71	34,94	500
560	140	25	33,33	35,00	700	1,67	50,00	0	21,67	35,00	500
577	140	25	32,77	36,06	700	1,38	51,06	0	20,96	36,06	500
578	0	50	32,73	36,13	700	1,37	51,13	0	20,92	36,13	400
580	0	50	32,67	36,25	700	1,33	51,25	0	20,83	36,25	400
581	160	50	32,63	36,31	600	1,32	51,31	0	20,79	36,31	400
604	160	50	31,87	37,75	600	0,93	52,75	0	19,83	37,75	400

			Summer			Winter			Spring and Autumn		
Time	**Wind speed**	**Pass. Load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**
min	km/h	%	°C with gradient ± 2 K/h	% with gradient ± 5 %/h	W/m²	°C with gradient ± 2 K/h	% with gradient ± 3,33 %/h	W/m²	°C with gradient ± 2 K/h	% with gradient ± 5 %/h	W/m²
605	0	50	31,83	37,81	600	0,92	52,81	0	19,79	37,81	400
608	0	50	31,73	38,00	600	0,87	53,00	0	19,67	38,00	400
609	160	50	31,70	38,06	500	0,85	53,06	0	19,63	38,06	200
623	160	50	31,23	38,94	500	0,62	53,94	0	19,04	38,94	200
624	0	50	31,20	39,00	500	0,60	54,00	0	19,00	39,00	200
626	0	50	31,13	39,13	500	0,57	54,13	0	18,92	39,13	200
627	120	50	31,10	39,19	500	0,55	54,19	0	18,88	39,19	200
641	120	50	30,63	40,06	500	0,32	55,06	0	18,29	40,06	200
642	0	50	30,60	40,13	400	0,30	55,13	0	18,25	40,13	200
645	0	50	30,50	40,31	400	0,25	55,31	0	18,13	40,31	200
646	80	50	30,47	40,38	400	0,23	55,38	0	18,08	40,38	0
661	80	50	29,97	41,31	400	−0,02	56,31	0	17,46	41,31	0
662	0	25	29,93	41,38	400	−0,03	56,38	0	17,42	41,38	0
664	0	25	29,87	41,50	400	−0,07	56,50	0	17,33	41,50	0
665	160	25	29,83	41,56	300	−0,08	56,56	0	17,29	41,56	0
672	160	25	29,60	42,00	300	−0,20	57,00	0	17,00	42,00	0
673	0	25	29,57	42,06	300	−0,22	57,06	0	16,96	42,06	0
675	0	25	29,50	42,19	300	−0,25	57,19	0	16,88	42,19	0
676	120	25	29,47	42,25	300	−0,27	57,25	0	16,83	42,25	0

			Summer			Winter			Spring and Autumn		
Time	**Wind speed**	**Pass. Load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**	**Mean temp. climatic chamber**	**Rel. humidity**	**Solar load**
min	km/h	%	°C with gradient ± 2 K/h	% with gradient ± 5 %/h	W/m²	°C with gradient ± 2 K/h	% with gradient ± 3,33 %/h	W/m²	°C with gradient ± 2 K/h	% with gradient ± 5 %/h	W/m²
690	120	25	29,00	43,13	300	−0,50	58,13	0	16,25	43,13	0
691	0	25	28,97	43,19	300	−0,52	58,19	0	16,21	43,19	0
693	0	25	28,90	43,31	300	−0,55	58,31	0	16,13	43,31	0
694	80	25	28,87	43,38	200	−0,57	58,38	0	16,08	43,38	0
701	80	25	28,63	43,81	200	−0,68	58,81	0	15,79	43,81	0
702	0	0	28,60	43,88	200	−0,70	58,88	0	15,75	43,88	0
705	0	0	28,50	44,06	200	−0,75	59,06	0	15,63	44,06	0
705	0	0	28,50	44,06	200	−0,75	59,06	0	15,63	44,06	0
719	0	0	28,03	44,94	200	−0,98	59,94	0	15,04	44,94	0
720	0	0	28,00	45,00	200	−1,00	60,00	0	15,00	45,00	0

NOTE The relative humidity does not need to be controlled according to Table I.1 in case of T_{em} < 10 °C.

Annex J
(normative)

Heat emission per person

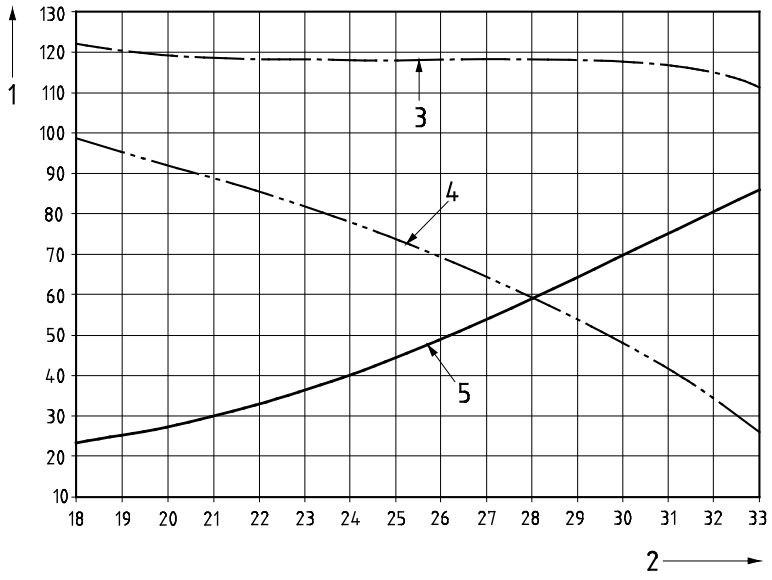
Sensible heat transfer of a person as a function of surrounding temperature T in Watt [W].

$$q_{sens}(T) = -7{,}0210 \cdot 10^{-6} \cdot T^6 + 9{,}3296 \cdot 10^{-4} \cdot T^5 - 5{,}0287 \cdot 10^{-2} \cdot T^4 + 1{,}3933 \cdot T^3 - 2{,}0714 \cdot 10 \cdot T^2 + 1{,}5103 \cdot 10^2 \cdot T - 2{,}7953 \cdot 10^2 \quad \text{(J.1)}$$

Latent heat transfer of a person as a function of surrounding temperature T in Watt [W].

$$q_{lat}(T) = -3{,}7788 \cdot 10^{-4} \cdot T^4 + 3{,}0997 \cdot 10^{-2} \cdot T^3 - 7{,}3326 \cdot 10^{-1} \cdot T^2 + 6{,}5731 \cdot T + 1{,}6525 \quad \text{(J.2)}$$

The sensible and latent heat exhausted by passenger shall respect the values defined in Table J.1 and in Figure J.1.



Key

1 heat emission [W]
2 surrounding temperature [°C]
3 total heat [W]
4 sensible heat [W]
5 latent heat [W]

Figure J.1 — Heat emitted by a seated person normally dressed

Table J.1 — Heat emitted by a seated person normally dressed

Surrounding temperature °C	**Sensible heat** W	**Latent heat** W	**Total heat** W
18	98,6	23,5	122,1
19	95,3	25,2	120,5
20	92,1	27,3	119,4
21	88,9	29,9	118,7
22	85,5	32,9	118,4
23	81,9	36,3	118,2
24	78,0	40,2	118,1
25	73,7	44,4	118,2
26	69,2	49,0	118,2
27	64,4	53,9	118,3
28	59,3	59,0	118,3
29	53,8	64,3	118,2
30	48,0	69,7	117,8
31	41,6	75,2	116,8
32	34,4	80,6	115,0
33	25,9	85,8	111,7

For simulation of the passenger load during tests, T_{im} shall be used as surrounding temperature to calculate the thermal passenger load.

NOTE Equations are valid between 18 °C and 33 °C.

Annex K
(informative)

Abbreviations

K.1 Surface temperatures: $T_{S\_Range\_Surface\ concerned}$

With Range: NR for Normal Range and ExR for Extended Range.

$T_{S\_NR\_Wal}$	or $T_{S\_ExR\_Wal}$	Walls
$T_{S\_NR\_Cei}$	or $T_{S\_ExR\_Cei}$	Ceiling
$T_{S\_NR\_Win\_pa}$	or $T_{S\_ExR\_Win\_pa}$	Window panel
$T_{S\_NR\_Win\_fr}$	or $T_{S\_ExR\_Win\_fr}$	Window frame
$T_{S\_NR\_Fl\_H}$	or $T_{S\_ExR\_Fl\_H}$	Heated floor
$T_{S\_NR\_Fl\_NH}$	or $T_{S\_ExR\_Fl\_NH}$	Non heated floor
$T_{S\_NR\_Fl}$	or $T_{S\_ExR\_Fl}$	Floor

K.2 Airflow: $\dot{V}_{\_Type\ of\ airflo}$

With type of airflow (in accordance with EN 13779):

$\dot{V}_{\_ODA}$	Fresh air
$\dot{V}_{\_RCA}$	Recirculation/Return air
$\dot{V}_{\_SUP}$	Supply air
$\dot{V}_{\_EHA}$	Exhaust air

K.3 Range of temperature: $\Delta T_{\_Mode\_Location}$

With Mode: COOL for cooling and HEAT for heating or NR for Normal Range and ExR for Extended Range.

$\Delta T_{\_COOL\_Cor}$	or $\Delta T_{\_HEAT\_Cor}$	Corridor
$\Delta T_{\_COOL\_Ves}$	or $\Delta T_{\_HEAT\_Ves}$	Vestibule
$\Delta T_{\_COOL\_Wash}$	or $\Delta T_{\_HEAT\_Wash}$	Washroom
$\Delta T_{\_COOL\_WC}$	or $\Delta T_{\_HEAT\_WC}$	WC
$\Delta T_{\_COOL\_Nurs}$	or $\Delta T_{\_HEAT\_Nurs}$	Nursery
$\Delta T_{\_NR\_Cat}$	or $\Delta T_{\_ExR\_Cat}$	Catering
$\Delta T_{\_NR\_ComZon}$	or $\Delta T_{\_ExR\_ComZon}$	Comfort zone

K.4 Gradients: ΔT Type of gradient_Range_Location

With Type of gradient: V for vertical gradient and H for horizontal gradient.

With Range: NR for Normal Range and ExR for Extended Range.

$\Delta T_{V\_NR\_Seat}$	or $\Delta T_{V\_ExR\_Seat}$	Vertical gradient for seated passengers
$\Delta T_{V\_NR\_Stand}$	or $\Delta T_{V\_ExR\_Stand}$	Vertical gradient for standing passengers
$\Delta T_{V\_NR\_Cat}$	or $\Delta T_{V\_ExR\_Cat}$	Vertical gradient for catering staff
$\Delta T_{H\_NR\_ComZon}$	or $\Delta T_{H\_ExR\_ComZon}$	Horizontal gradient for comfort zone

K.5 Others

T_{SUP_NR}	or T_{SUP_ExR}	Supply air temperature
$T_{HS\_Pass\_NR}$	or $T_{HS\_Pass\_ExR}$	Surface heated sidewall temperature in contact with passengers in normal position
$T_{HS\_NoPass\_NR}$	or $T_{HS\_NoPass\_ExR}$	Surface heated sidewall temperature not in contact with passengers in normal position

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 2008/57/EC

This European Standard has been prepared under a mandate given to CEN/CENELEC/ETSI by the European Commission and the European Free Trade Association to provide a means of conforming to Essential Requirements of the Directive 2008/57/EC.

Once this standard is cited in the Official Journal of the European Union under that Directive and has been implemented as a national standard in at least one Member State, compliance with the clauses of this standard given in Table ZA.1 for Locomotives and Passenger Rolling Stock confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding Essential Requirements of that Directive and associated EFTA regulations.

Table ZA.1 — Correspondence between this European Standard, the Commission regulation n°1302/2014 of 18 November 2014 concerning the technical specification for interoperability relating to the 'rolling stock locomotives and passenger rolling stock' of the rail system in the European Union (published in the Official Journal L 356, 12.12.2014, p.228) and Directive 2008/57/EC

Clause/ subclauses of this European Standard	Chapter/§/annexes of the TSI	Corresponding text, articles/§/annexes of the Directive 2008/57/EC	Comments
10.1.5 Air quality 10.1.5.1 Fresh air 10.1.5.2 Recirculated air Clause 12 Air movement tests 15.5 Airflow rate	4 Characterization of the rolling stock subsystem 4.2 Functional and technical specification of the sub-system 4.2.5 Passenger related item §4.2.5.8 Internal air quality 6 Assessment of conformity or suitability for use and 'ec' verification 6.2 Rolling stock subsystem 6.2.3 Particular assessment procedures for subsystems §6.2.3.12 Internal air quality	Annex III, Essential requirements 2.4 Rolling stock 2.4.1 Safety §8 2.4.3. Technical compatibility §3	

WARNING 1 — Presumption of conformity stays valid only as long as a reference to this European Standard is maintained in the list published in the Official Journal of the European Union. Users of this standard should consult frequently the latest list published in the Official Journal of the European Union.

WARNING 2 — Other Union legislation may be applicable to the products falling within the scope of this standard.

Bibliography

[1] EN 410, *Glass in building - Determination of luminous and solar characteristics of glazing*

[2] EN 779, *Particulate air filters for general ventilation - Determination of the filtration performance*

[3] EN 13779, *Ventilation for non-residential buildings - Performance requirements for ventilation and room-conditioning systems*

[4] CIE 85[1)], *Solar spectral irradiance*

1) To be purchased from: International Commission of Illumination, CIE Central Bureau, Babenbergerstr. 9/9A, A-1010 Vienna, Austria.

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