

INTERNATIONAL STANDARD



**Classification of environmental conditions –
Part 3-2: Classification of groups of environmental parameters and their
severities – Transportation and handling**



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severities – Transportation and handling**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

CLASSIFICATION OF ENVIRONMENTAL CONDITIONS –

Part 3-2: Classification of groups of environmental parameters and their severities – Transportation and handling

FOREWORD

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This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 60721-3-2 has been prepared by IEC technical committee 104: Environmental conditions, classification, and methods of test.

This third edition cancels and replaces the second edition, published in 1997, and constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) Clause 1: reworded and added handling.
- b) Clause 2: updated normative references.
- c) Clause 3: updated definitions.
- d) Clause 4: reworded and simplified.
- e) Clause 5: revised and updated. Several classes have been replaced by completely new classes based on the use of new information obtained from referenced Technical Reports.
- f) Table 1 through Table 5: updated.
- g) Table 6 deleted.
- h) Old annexes A to C removed except Clause A.3 that is incorporated in Clause 0.
- i) New Annex A.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
104/773/FDIS	104/783/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60721 series, published under the general title *Classification of environmental conditions*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

The contents of the corrigendum of November 2018 have been included in this copy.

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CLASSIFICATION OF ENVIRONMENTAL CONDITIONS –

Part 3-2: Classification of groups of environmental parameters and their severities – Transportation and handling

1 Scope and object

This part of IEC 60721 classifies the groups of environmental parameters and their severities to which a product is subjected while being transported ~~from one place to another after being made ready for dispatch from the manufacturing factory~~ and handled.

The most commonly used methods of transportation and handling have been taken into account, including the following:

- road transport: cars, ~~lorries~~, trucks, ~~animals~~, ~~conveyors~~;
- rail transport: trains, trams, ~~conveyors~~;
- water transport, inland and maritime: ships, ~~hovercraft~~, ~~conveyors~~;
- air transport: aircraft, ~~conveyors~~, jet, propeller, helicopter;
- ~~vertical transport~~ handling equipment: cranes, transport lifts, cableways, ~~persons~~;
- conveyors;
- hand trollies.

The environmental conditions specified in this document are those ~~met by the product being transported~~ that the product can be exposed to while transported and handled. If the product is packaged, the environmental conditions apply to the package containing the product. ~~Only severe conditions, which may be harmful to products, are included.~~ If the product is unpackaged, the environmental conditions apply to the product.

Conditions for storage are given in IEC 60721-3-1.

~~The object of this standard is to classify groups of environmental parameters and their severities to which a product will be exposed when being transported on ground, water and in air, including loading and unloading.~~

~~A limited number of classes of environmental conditions are given, covering a broad field of application. The user of this standard should select the lowest classes necessary covering each of the conditions of the intended transportation. Some guidance for this is given in annex A.~~

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60721-1, *Classification of environmental conditions – Part 1: Environmental parameters and their severities*

~~IEC 721-1: 1990, Classification of environmental conditions — Part 1: Environmental parameters and their severities~~
~~Amendment 1 (1992)~~
~~Amendment 2 (1995)~~

~~IEC 721-2-1: 1982, Classification of environmental conditions — Part 2: Environmental conditions appearing in nature — Temperature and humidity~~
~~Amendment 1 (1987)~~

~~IEC 721-3-0: 1984, Classification of environmental conditions — Part 3: Classification of groups of environmental parameters and their severities — Introduction~~
~~Amendment 1 (1987)~~

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60721-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

weather-protected

~~The product, packed or unpacked, is contained within an enclosure which affords some protection from the environment, ranging from a temperature controlled container to a waterproof cover placed over the product. Ventilation ranges from controlled air flow to the raising of part of a waterproof cover to allow for natural air flow.~~
 protected from the influences of meteorological conditions

3.2

non-weather-protected

~~The product, packed or unpacked, is not protected in any way from the environment.~~
 not protected from the influences of meteorological conditions

4 General

~~Reference to IEC 721-3-0 is strongly recommended in order to avoid misuse of the classes defined in other sections of IEC 721-3.~~

~~The severities specified are those which will have a low probability of being exceeded. All specified values are maximum or limit values. These values may be reached, but do not occur permanently. Depending on the situation, there may be different frequencies of occurrence related to a certain period of time. Such frequencies of occurrence have not yet been included in this standard, but should be considered for any environmental parameter. They should additionally be specified, if applicable.~~

~~Information on the duration and frequency of occurrence is given, as clause 6, in amendment 1 to IEC 721-3-0.~~

~~Attention is drawn to the fact that combinations of the environmental parameters given may increase the effect on a product. This applies especially to the presence of high relative humidity in addition to biological conditions, or to conditions of chemically or mechanically active substances.~~

A product may be subjected to a range of environmental conditions during its lifetime. These conditions have been separated into classes described in IEC 60721-3-0. The classes given may be used for defining the maximum short-term environmental stresses on a product. However, they do not provide information regarding the long-term or total lifetime environmental stresses a product may experience. This means that no reliability or lifetime assessment is possible based on these classes alone. Refer to IEC 60721-2 (all parts) and applicable technical reports (IEC TR 62130, IEC TR 62131-2, IEC TR 62131-3, IEC TR 62131-4 and IEC TR 62131-5) for further information on actual environmental conditions.

A product may be simultaneously exposed to a number of environmental parameters. For example, solar radiation and temperature, temperature and humidity, as well as vibration and temperature change. Combinations of the environmental parameters given may increase the stress effect on a product. Therefore, combined conditions should be considered in the design and evaluation of a product.

Products should be designed to survive and operate in different environments. Basically, they will be affected by environmental influences in two ways:

- by the effects of short-term extreme environmental conditions which may directly cause malfunction or destroy the product;
- by the effect of long-term subjection to non-extreme environmental stresses which may slowly degrade the product and finally cause malfunction or destruction of the product.

Short-term extreme environmental conditions may occur at any time in a product's life. A product may be unaffected by an extreme condition when it is new but fail when it is subjected to the same condition after being used for a long period of time due to the effect of ageing. The order in which the environmental conditions are applied may affect the results of an evaluation.

It is important for the product specification, when referring to a certain class in IEC 60721-3 (all parts), to define whether the product is required to be capable of operating or only to survive without permanent damage when being exposed to the conditions described by the class.

The environmental classes may be used as a basis for the selection of design and test severities with respect to the consequence of failure. Information contained in IEC 60721-3 (all parts) may be used as a means to help establish expected requirements for use, storage, transportation, etc., and in the development of relevant specifications. The selected severities used for testing should attempt to produce the effects of the actual environment.

EXAMPLE 1 A high temperature test on a heat dissipating product is designed to simulate the thermal effect of subjecting a product to conditions of high air temperature, solar radiation and other possible heat sources dependent on the application.

EXAMPLE 2 In a mechanical shock test, the product can be subjected to mechanical shocks of simple pulse shapes (e.g., half-sine), while the actual conditions cannot be described by such simple pulses.

It is recognized that extreme or special environmental conditions may exist which require consideration of severities that are not addressed by this document.

5 Classification of groups of environmental parameters and their severities

5.1 General

A ~~limited~~ number of classes for climatic conditions (K), special climatic conditions (Z), biological conditions (B), chemically active substances (C), mechanically active substances (S) and mechanical conditions (M) are specified.

~~See also clause 6.~~

~~The basis of these classes is explained in clause A.2 of annex A.~~

~~Climatic conditions in tropical areas as specified in classes 2K6 and 2K7 are explained in annex C.~~

~~The combination of the lowest classes 2K1/2B1/2C1/2S1/2M1 forms the conditions to which a product will be subjected when being transported under very restricted conditions. The combination of the highest classes 2K5/2B3/2C3/2S3/2M3 covers transportation under a very wide variety of conditions including very severe conditions.~~

~~A class with higher digit conditions normally includes all classes with lower digits.~~

~~For certain parameters it has not yet been possible to give quantitative values of severities.~~

~~A summary of the conditions covered by the classes is given in clause A.3 of annex A.~~

This classification allows for a number of possible combinations of environmental conditions which bear upon products wherever stored. It represents the real situation concerning world-wide conditions of storage due to local influences of open-air climate, etc. For certain environmental parameters, it has not yet been possible to specify quantitative severities.

For a given location or product, reference should be made to the total set of classes as defined in 5.2 through 5.6, for example:

~~2K2/2B1/2C2/2S2/2M3~~

2K13/2B3/2C2/2S6/2M5

5.2 K Climatic conditions

NOTE The classes defined in previous versions of this document have been replaced with new classes as a result of recent efforts at collecting information regarding climatic conditions. Those results are contained in Technical Reports referenced in this document.

When selecting appropriate classes, attention should be paid to the fact that the climatic conditions in weather-protected locations may depend on the open-air (non-weather-protected) conditions, especially air temperature and solar radiation, and the type of transportation enclosure.

The following conditions are specified in Table 1.

- 2K10 applies to fully air conditioned enclosed transportation. Air temperature and humidity control is used continuously to maintain the required conditions.
- 2K11 applies to weather-protected transportation with limited temperature control and no humidity control.
- 2K12 applies to weather-protected transportation without temperature and humidity controls in unventilated enclosures in arid, temperate, tropical and cold climates. Polar climate is excluded. The product may be transported in heated, pressurized aircraft holds.
- 2K13 applies to non-weather-protected transportation in temperate, tropical, and cold climates. Arid and polar climates are excluded.
- 2K14 applies to transportation in non-weather-protected transportation worldwide (including arid and polar climates). This also includes transportation in unpressurized aircraft holds. The product may be subjected to sea waves when being transported on open decks of ships.

Table 1 – Classification of climatic conditions

Environmental	Unit	Class								
parameter		2K1	2K2	2K3	2K4	2K5	2K5H	2K5L	2K6 ⁶⁾	2K7 ⁶⁾
a) Low air temperature	°C	+5	-25	-25	-40	-65	-25	-65	+5	-20
b) High air temperature, air in unventilated enclosures ¹⁾	°C	No	+60	+70	+70	+85	+85	+70	+70	+85
c) High air temperature, air in ventilated enclosures or outdoor air ²⁾	°C	+40	+40	+40	+40	+55	+55	+40	+40	+55
d) Change of temperature, air/air ³⁾	°C	No	-25/+25	-25/+30	-40/+30	-65/+30	-25/+30	-65/+30	+5/+30	-20/+30
e) Change of temperature, air/water ³⁾	°C	No	No	+40/+5	+40/+5	+55/+5	+55/+5	+40/+5	+40/+5	+55/+5
f) Relative humidity, not combined with rapid temperature changes	% °C	75 +30	75 +30	95 +40	95 +45	95 +50	95 +50	95 +45	95 +45	95 +50
g) Relative humidity, combined with rapid temperature changes: air/air at high relative humidity ³⁾	% °C	No	No	95 -25/+30	95 -40/+30	95 -65/+30	95 -25/+30	95 -65/+30	95 +5/+30	95 -20/+30
h) Absolute humidity, combined with rapid temperature changes: air/air at high water content ⁴⁾	g/m ³ °C	No	No	60 +70/+15	60 +70/+15	80 +85/+15	80 +85/+15	60 +70/+15	60 +70/+15	80 +85/+15
i) Low air pressure	kPa	70	70	70	70	30	30	30	30	30
j) Change of air pressure	kPa/min	No	No	No	No	6	6	6	6	6
k) Movement of surrounding medium, air	m/s	No	No	20	20	30	30	30	30	30
l) Precipitation, rain	mm/min	No	No	6	6	15	15	6	15	15
m) Radiation, solar	W/m ²	700	700	1120	1120	1120	1120	1120	1120	1120
n) Radiation, heat	W/m ²	No	No	600	600	600	600	600	600	600
o) Water from sources other than rain ⁵⁾	m/s	No	No	1	1	3	3	3	3	3
p) Wetness	None	No	No	Conditions of wet surfaces						

1) The high temperature of the surface of a product may be influenced by both the surrounding air temperature given here and the solar radiation through a window or other opening.

2) The high temperature of the surface of a product is influenced by the surrounding air temperature given here and the solar radiation defined below.

3) A direct transfer of the product between the two temperatures given is presumed.

4) The product is assumed to be subjected to a rapid decrease of temperature only (no rapid increase). The figures of water content apply to temperatures down to the dew point; at lower temperatures the relative humidity is assumed to be approximately 100 %.

5) The figure indicates the velocity of water and not the height of water accumulated.

6) Further information on classes 2K6 (tropical damp) and 2K7 (tropical dry) is given in annex C.

Environmental parameter	Unit	Classification				
		Weather-protected			Non-weather-protected	
		2K10	2K11	2K12	2K13	2K14
a) Low air temperature	°C	+20 ⁶⁾	+5	–45	–45	–50
b) High air temperature	°C	+25 ⁶⁾	+40	+70	+45 ⁹⁾	+50 ⁹⁾
c) Low relative humidity ¹⁾	%	20	5	4	4	4
d) High relative humidity ¹⁾	%	75	85	100	100	100
e) Low absolute humidity ¹⁾	g/m ³	4	1	0,5	0,02	0,003
f) High absolute humidity ¹⁾	g/m ³	15	25	29	35	35
g) Rate of change of temperature ²⁾	°C/min	0,1	0,5	1,0	1,0	1,0
h) Low air pressure ³⁾	kPa	70	70	70	70	30
i) High air pressure ³⁾	kPa	106	106	106	106	106
j) Solar radiation	W/m ²	No	No	⁸⁾	1090	1090
k) Heat radiation	Not specified	None	None	None	None	None
l) Movement of surrounding air ⁴⁾	m/s	0,5	1,0	1,0	⁷⁾	⁷⁾
m) Condensation	Not specified	No	No	Yes	Yes	Yes
n) Precipitation (rain, snow, hail, etc.)	Not specified	No	No	No	Yes	Yes
o) Rain intensity	mm/min	None	None	None	3,3	3,3
p) Driving rain	m/s	None	None	None	⁷⁾	⁷⁾
q) Snow load	kg/m ²	None	None	None	100	100
r) Low rain temperature ⁵⁾	°C	None	None	None	+5	+5
s) Water from sources other than rain	Not specified	No	No	Dripping Water	¹⁰⁾	¹⁰⁾
t) Formation of ice and frost (including freeze-thaw)	Not specified	No	No	Yes	Yes	Yes
u) Temperature shock	Not specified	No	No	Yes	Yes	Yes

¹⁾ The low and high relative humidity levels are limited by the low and high absolute humidity, so that, for example, for environmental parameters a) and c), or b) and d), the severities given in Table 1 do not occur simultaneously.

²⁾ Averaged over a period of time of 5 min.

³⁾ The value of 70 kPa represents a limit for open-air conditions, normally at an altitude of 3 000 m. In some geographical areas, open-air conditions may occur at higher altitudes. Conditions in mines are not considered.

⁴⁾ A cooling system based on non-assisted convection may be disturbed by adverse movement of surrounding air.

⁵⁾ This rain temperature should be considered together with high air temperature b) and solar radiation j). The cooling effect of the rain has to be considered in connection with the surface temperature of the product.

⁶⁾ These are air-conditioned locations with a tolerance of ±2 °C on stated temperature value.

⁷⁾ If applicable, a special value should be selected based on expected transportation mode (e.g., lorry, open decks of ships).

⁸⁾ Thermal effect of solar radiation is included in the temperature.

⁹⁾ Thermal effect of solar radiation is not included in the temperature.

¹⁰⁾ Sources of water other than rain are encompassed by driving rain.

5.3 B Biological conditions

No quantitative severity has been specified for the following conditions. The specified parameters of Table 2 are typical, but may not be complete.

- 2B1 applies to transportation in areas without risks from mould growth and attack by animals, or in compartments with environmental controls in place to prevent mould growth and attack by animals.
- 2B2 applies to transportation in areas where mould growth and attacks of animals, except termites, may occur.
- 2B3 applies to transportation in areas where attacks by termites may additionally occur.

Table 2 – Classification of biological conditions

Environmental parameter	Unit	Class		
		2B1	2B2	2B3
a) <i>Flora</i>	None	No	Presence of mould, fungus, etc.	
b) <i>Fauna</i>	None	No	Presence of rodents or other animals harmful to products:	
			excluding termites	including termites

Biological parameter	Class		
	2B1	2B2	2B3
None	Negligible	Presence of mould, fungus, etc.	
		Presence of rodents and other animals harmful to products	
		excluding termites	including termites

5.4 C Chemically active substances

The contamination of the natural atmosphere is mainly caused by chemical emissions from industrial activities, motor-driven vehicles, and heating systems. A further chemical influence is caused by aerosols of sea and road salts. Contamination may affect the product's function and materials. The parameters shown in Table 3 are estimates based on information available at the time of publication. It is recommended that reference be made to local or regional information specific to an area of interest when establishing requirements.

See Annex A for additional information.

- 2C1 applies to transportation and handling in rural and some urban areas with low industrial activity and moderate traffic, and areas where there is either no salt mist or there are protections in place to protect the product from salt mist. This also applies to handling indoors.
- 2C2 applies to transportation and handling in areas with normal levels of contaminants as experienced in urban areas with industrial activity scattered over the whole area, or with heavy traffic. This includes transportation in areas where salt mist is present including maritime transport of containers but not transport on open decks of ships.
- 2C3 applies to transportation and handling in areas that are in the immediate vicinity of industrial sources with chemical emissions, and transportation on open decks of ships.

Table 3 – Classification of chemically active substances

Environmental parameter	Unit	Class		
		2C1	2C2	2C3
a) Sea salts	None	No	Conditions of salt mist	Conditions of salt water
b) Sulphur dioxide	mg/m ³	0,1	1,0 (0,3)	10 (5,0)
	cm ³ /m ³	0,037	0,37 (0,11)	3,7 (1,85)
c) Hydrogen sulphide	mg/m ³	0,01	0,5 (0,1)	10 (3,0)
	cm ³ /m ³	0,0071	0,36 (0,071)	7,1 (2,1)
d) Nitrogen oxides (expressed in the equivalent values of nitrogen dioxides)	mg/m ³	0,1	1,0 (0,5)	10 (3,0)
	cm ³ /m ³	0,052	0,52 (0,26)	5,2 (1,56)
e) Ozone	mg/m ³	0,01	0,1 (0,05)	0,3 (0,1)
	cm ³ /m ³	0,005	0,05 (0,025)	0,15 (0,05)
f) Hydrogen chloride	mg/m ³	0,1	0,5 (0,1)	5,0 (1,0)
	cm ³ /m ³	0,066	0,33 (0,066)	3,3 (0,66)
g) Hydrogen fluoride	mg/m ³	0,003	0,03 (0,01)	2,0 (0,1)
	cm ³ /m ³	0,0036	0,036 (0,012)	2,4 (0,12)
h) Ammonia	mg/m ³	0,3	3,0 (1,0)	35 (10)
	cm ³ /m ³	0,42	4,2 (1,4)	49 (14)
NOTES 1—The figures given are maximum values, occurring over a 30 min period per day. 2—The figures within brackets are the expected long-term mean values. 3—The values given in cm³/m³ have been calculated from the values given in mg/m³ and refer to 20 °C and 101,3 kPa. 4—The table uses rounded values.				

Environmental parameter	Unit ¹⁾	Class				
		2C1	2C2		2C3	
		Maximum value	Mean value	Maximum value ²⁾	Mean value	Maximum value ²⁾
a) Salt mist to include sea and road salts	None	No	Yes		Yes	
b) Saltwater	None	No	No		Yes	
c) Sulphur dioxide	mg/m ³	0,1	0,3	1,0	5,0	10
	cm ³ /m ³	0,037	0,11	0,37	1,85	3,7
d) Hydrogen sulphide	mg/m ³	0,01	0,1	0,5	3,0	10
	cm ³ /m ³	0,0071	0,071	0,36	2,1	7,1
e) Hydrogen chloride	mg/m ³	0,1	0,1	0,5	1,0	5,0
	cm ³ /m ³	0,066	0,066	0,33	0,66	3,3
f) Hydrogen fluoride	mg/m ³	0,003	0,01	0,03	0,1	2,0
	cm ³ /m ³	0,0036	0,012	0,036	0,12	2,4
g) Ammonia	mg/m ³	0,3	1,0	3,0	10	35
	cm ³ /m ³	0,42	1,4	4,2	14	49

h) Ozone	mg/m ³ cm ³ /m ³	0,01 0,005	0,05 0,025	0,1 0,05	0,1 0,05	0,3 0,15
i) Nitrogen oxides (expressed in equivalent values of nitrogen dioxide)	mg/m ³ cm ³ /m ³	0,1 0,052	0,5 0,26	1,0 0,52	3,0 1,56	9,0 4,68
1) The values given in cm³/m³ have been calculated from the values given in mg/m³ referenced to a temperature of 20 °C and a pressure of 101,3 kPa. The table uses rounded values. 2) Mean values are expected long-term values. Maximum values are limit or peak values occurring over a period of time that is typically not more than 30 min per day.						

5.5 S Mechanically active substances

NOTE The classes defined in previous versions of this document have been replaced with new classes as a result of recent efforts at collecting information regarding mechanically active substances.

Dust and sand are classified together, as the effects caused by these environmental conditions are similar. These conditions are specified in Table 4.

- 2S1 applies to transportation and handling where precautions have been taken to minimize the presence of dust and sand.
- 2S5 applies to transportation and handling with limited precautions to minimize the presence of dust and sand such as enclosed transport.
- 2S6 applies to non-enclosed transportation and handling in close proximity to dust and sand sources without special precautions to minimize the presence of dust and sand.
- 2S7 applies to transportation and handling in areas with driven dust and sand.

Table 4 – Classification of mechanically active substances

Environmental parameter	Unit	Class		
		2S1	2S2	2S3
a) Sand in air	g/m ³	No	0,1	10
b) Dust sedimentation	mg/(m ² .h)	No	3,0	3,0

Environmental parameter	Unit	Class			
		2S1	2S5	2S6	2S7 ¹
a) Sand in air	mg/m ³	None	30	300	1 000
b) Dust in air	mg/m ³	None	0,2	5,0	15
c) Dust (sedimentation rate)	mg/(m ² .h)	None	15	40	80
¹⁾ If applicable, a special value should be selected based on expected transportation mode.					

5.6 M Mechanical conditions

NOTE The classes defined in previous versions of this document have been replaced with new classes as a result of recent efforts at collecting information regarding mechanical conditions. Those results are contained in Technical Reports referenced in this document.

Mechanical conditions described in this document encompass those conditions that may exist during transportation and handling. The conditions do not represent test severities. Vibration and mechanical shock environments are depicted in Figures 1 and 2, respectively, and described in Table 5.

- 2M4 applies to handling, transport by rail, river, sea, air (jet aircraft only) and road transport using good vehicles on good roads. This category includes transport of goods within ISO containers.
- 2M5 includes those conditions described by 2M4 plus road transport using poor vehicles and/or on poor roads as well as handling using trolleys with no suspension.
- 2M6 includes those conditions described by 2M4 and 2M5, plus transport by air in propeller aircraft and helicopter.

Table 5 – Classification of mechanical conditions

The mechanical conditions given apply to items placed on the floor of the transport compartment.

Environmental parameter	Unit	Class		
		2M1	2M2	2M3
a) Stationary vibration – sinusoidal ¹⁾ –:				
displacement amplitude	mm	3,5	3,5	7,5
acceleration amplitude	m/s ²	10 15	10 15	20 40
frequency range	Hz	2-9 9-200 200-500	2-9 9-200 200-500	2-8 8-200 200-500
b) Stationary vibration – random ¹⁾ –:				
acceleration spectral density	m ² /s ³	1 0,3	1 0,3	3 1
frequency range	Hz	10-200 200-2000	10-200 200-2000	10-200 200-2000
c) Non-stationary vibration – including shock ²⁾ –:				
Shock response spectrum – type I, – peak acceleration – â	m/s ²	100	100	300
Shock response spectrum – type II, – peak acceleration – â	m/s ²	No	300	1000
d) Free fall:				
mass less than 20 kg	m	0,25	1,2	1,5
mass 20 kg to 100 kg	m	0,25	1,0	1,2
mass more than 100 kg	m	0,1	0,25	0,5
e) Toppling:				
mass less than 20 kg	None	Toppling around any of the edges		
mass 20 kg to 100 kg	None	No	Toppling around any of the edges	
mass more than 100 kg	None	No	No	Toppling around any of the edges
f) Rolling, pitching: angle ³⁾	degree	No	±35	±35
period	s	No	8	8
g) Steady-state acceleration	m/s ²	20	20	20

<i>h) Static load</i>	kPa	5	10	10
¹⁾ —The frequency range may be limited to 200 Hz for transportation on parts of the vehicle with high internal damping— ²⁾ —See figure 1. ³⁾ —An angle of 35° only occurs temporarily, but angles up to 22,5° can be reached for long periods of time.				

Environmental parameter	Unit	Class							
		2M4			2M5			2M6	
<i>a) Stationary vibration, random:</i>									
acceleration power spectral density	(m/s ²) ² / Hz	10 ²⁾	1,0	0,5	30	3,0	1	10	5
frequency range ¹⁾	Hz	2 to 3	10 to 20	50 to 2 000	2 to 3	10 to 20	500 to 2 000	5 to 200	500 to 2 000
<i>b) Non-stationary vibration including shock:³⁾</i> Shock 1 ⁴⁾		Figure 2 Curve 4 (equivalent to a half sine pulse of 100 m/s ² and 11 ms duration)			Figure 2 Curve 3 (equivalent to a half sine pulse of 300 m/s ² and 11 ms duration)			Figure 2 Curve 3 (equivalent to a half sine pulse of 300 m/s ² and 11 ms duration)	
Shock 2 ⁴⁾		Figure 2 Curve 2 (equivalent to a half sine pulse of 300 m/s ² and 6 ms duration)			Figure 2 Curve 1 (equivalent to a half sine pulse of 1 000 m/s ² and 6 ms duration)			Figure 2 Curve 1 (equivalent to a half sine pulse of 1 000 m/s ² and 6 ms duration)	
<i>c) Free fall:</i> mass less than 20 kg	m	0,25			1,2			1,5	
mass 20 kg to 100 kg	m	0,25			1,0			1,2	
mass more than 100 kg	m	0,1			0,25			0,5	
<i>d) Toppling:</i> mass less than 20 kg	None	Toppling around any of the edges			Toppling around any of the edges			Toppling around any of the edges	
mass 20 kg to 100 kg					Toppling around any of the edges			Toppling around any of the edges	
mass more than 100 kg					No			Toppling around any of the edges	
<i>e) Rolling, pitching:</i> angle ⁵⁾ period	degrees	No			±35			±35	
		No			8			8	
<i>f) Steady-state acceleration</i>	m/s ²	20			20			20	
<i>g) Static load</i>	kPa	5			10			10	

Environmental parameter	Unit	Class		
		2M4	2M5	2M6
1) When transport only occurs by rail, river, sea and road, the upper frequency considered may be reduced to 500 Hz for products that are not sensitive to vibration excitations above 500 Hz. 2) The low frequency stationary vibration random component arises from the influence of land vehicle suspension systems. The component is included for design purposes but is not always included in vibration test specifications. 3) For land vehicles, these shocks can occur simultaneously with the stationary vibration random conditions. 4) Both shocks would normally be used to encompass different aspects of the shock environment. 5) An angle of 35° may only occur temporarily. An angle of up to 22,5° can be reached for long periods of time.				

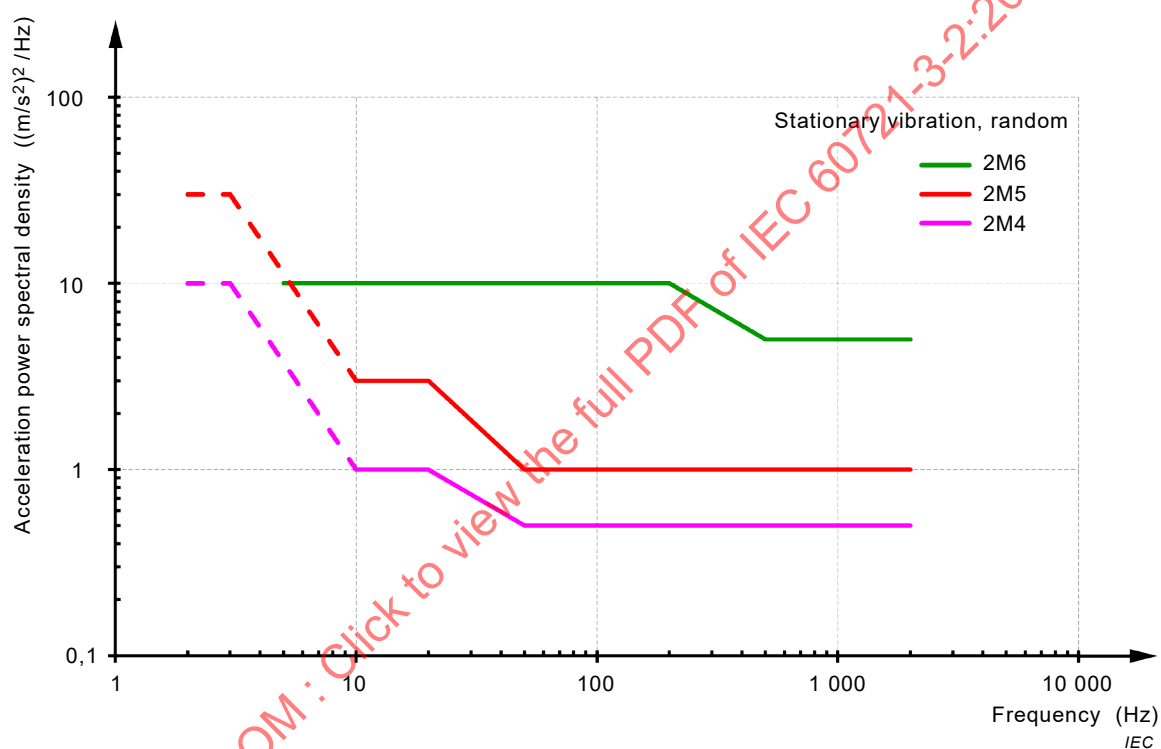


Figure 1 – Consolidation of vibration conditions

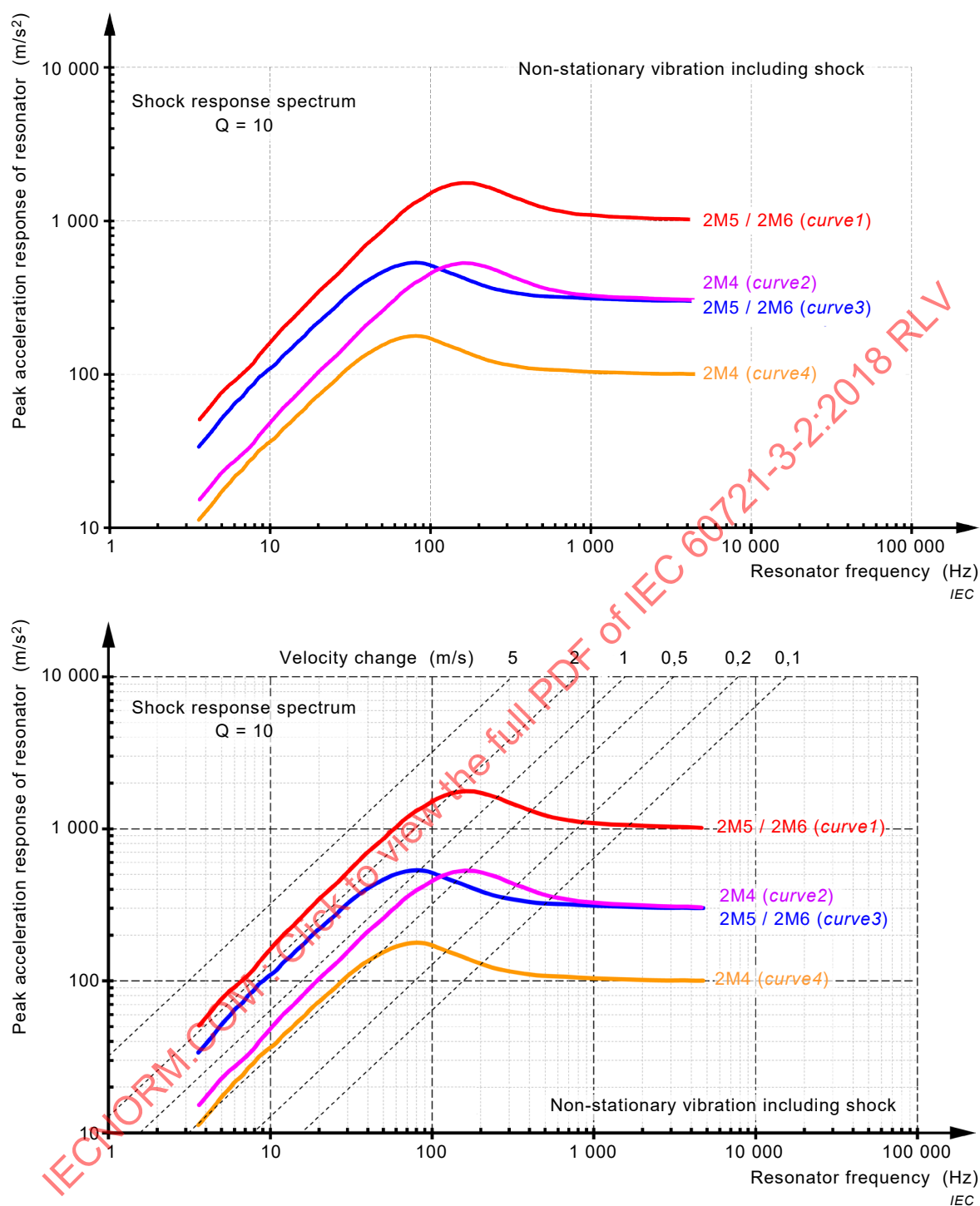


Figure 2 – Consolidation of mechanical conditions

6 Sets of environmental condition class combinations

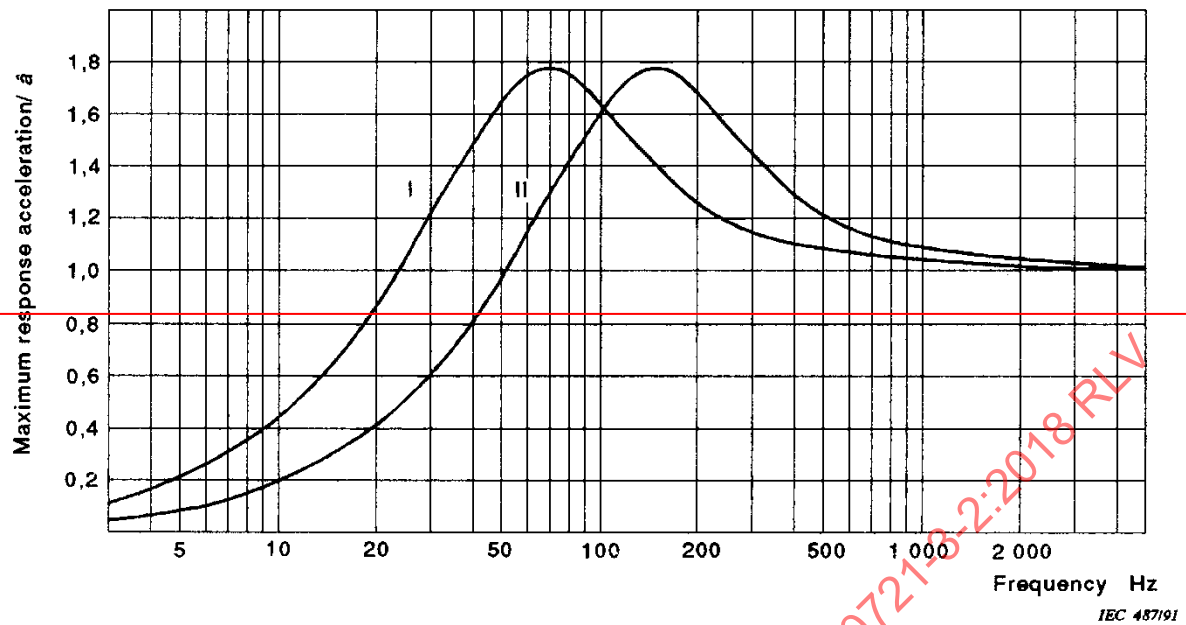
As indicated in clause 5, the classification allows a number of possible combinations of environmental conditions bearing on products wherever used. The number of possibilities, and thus the flexibility, is therefore very great. In practice, however, this flexibility is not always an advantage when, for instance, environmental condition specifications for a certain location are drawn up by different parties, invariably producing small but disturbing divergencies.

In order to limit the possibilities to general cases, standard sets of class combinations may be selected from table 6. For a given location or product, reference may then be made to this standard, for example IE22. Only when conditions are not considered to be covered by this specification, is reference made to each class as indicated in clause 5. Alternatively, if some severities of parameters deviate from that or those of the class combination, this should be expressed by the addition to the set designation of the following phrase: “but ... (parameter) ... (severity and unit)”, for example IE22 but sand 10 g/m³.

Annex B gives a summary of conditions covered by the sets of class combinations.

Table 6 — Sets of environmental class combinations

Condition	Set of class combinations			
	IE21	IE22	IE23	IE24
Climatic	2K2	2K3	2K4	2K5
Biological	2B2	2B2	2B2	2B2
Chemically active substances	2C2	2C2	2C2	2C2
Mechanically active substances	2S2	2S2	2S2	2S3
Mechanical	2M1 ¹⁾	2M1	2M2	2M3
¹⁾ The conditions of footnote 1 of table 5 are valid.				



Example of durations for half-sine pulse:

Spectrum type I: duration 11 ms
Spectrum type II: duration 6 ms

**Figure 1 — Model shock response spectra
(first order maximax shock response spectra)**
For explanation see note 6 relating to table 1 of IEC 721-1

Annex A (informative)

Survey of conditions affecting the choice of environmental parameters and their severities

A.1 General

In this annex the basis of the classes is explained. A survey of conditions affecting the choice of environmental parameters and their severities is given, together with a summary of the conditions covered by each class, including samples of application.

A.2 Survey of conditions

For each environmental parameter the various possible conditions which will result in different levels of environmental conditions are presented. An effort has been made to arrange the conditions in order of increasing severities.

The first column of the tabulated subclauses A.2.1 to A.2.5 describes the conditions. In the vertical columns headed "Class" the letter "x" indicates the conditions covered by the class. The lowest class covering a certain condition may be found by reading horizontally from that condition to the first "x" encountered.

The procedure of finding an appropriate class as described above is valid for all the subclauses, but the first part of subclause A.2.1 contains the additional factor of type of climate to which attention has to be paid.

The lowest class covering a certain condition can thus be found by reading vertically down the relevant type of climate column to the first "x" in the horizontal line of the relevant condition, then reading horizontally to the right to the first "x" encountered as previously described.

The types of climate are described in IEC 721-2-1 and are:

Extremely Cold (except the Central Antarctic)

Cold

Cold Temperate

Warm Temperate

Warm Dry

Mild Warm Dry

Extremely Warm Dry

Warm Damp

Warm Damp, Equable

It should be noted that the fact that a certain condition referred to in this annex is covered by a certain class does not necessarily mean that the class describes, for each single parameter, the lowest environmental severity needed to cover the condition.

NOTE—Accidental incidents are not included. In certain cases the possibility of their occurrence may, however, need to be taken into account. An example is damage of package in the hold of a ship due to leaking fluid from a neighbouring container.

~~A.2.1 K Climatic conditions~~

		Type of climate									Class						
Condition of transportation	Unit	Extremely Cold	Cold	Cold Temperate	Warm Temperate	Warm Dry	Mild Warm Dry	Extremely Warm Dry	Warm Damp	Warm Damp, Equable	2K1	2K2	2K3	2K4	2K5	2K5H	2K5L
a) Low air temperature	°C										+5	-25	-25	-40	-65	-25	-65
Weatherprotected with heating (protected against freezing)		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Non-weatherprotected, or weatherprotected without heating, or heated aircraft holds only		x	x	x	x	x	x	x	x	x		x	x	x	x	x	x
Unheated aircraft holds		x	x	x	x	x	x	x	x	x					x		x
b) High air temperature in unventilated enclosures	°C										No	+60	+70	+70	+85	+85	+70
Unventilated enclosures		x	x	x	x	x	x	x	x	x			x	x	x	x	x
c) High air temperature in ventilated enclosures or outdoor air	°C										+40	+40	+40	+40	+55	+55	+40
Weatherprotected with temperature control		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Weatherprotected with ventilation, or non-weatherprotected		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
d) Change of temperature, air/air	°C										No	-25/+25	-25/+30	-40/+30	-65/+30	-25/+30	-65/+30
Products not moved between outdoors and indoors		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Products moved between outdoors and indoors, or from unheated aircraft holds to outdoors		x	x	x	x	x	x	x	x	x			x	x	x	x	x

A.2.1 K Climatic conditions (continued)

		Type of climate									Class						
Condition of transportation	Unit	Extremely Cold	Cold	Cold Temperate	Warm Temperate	Warm Dry	Mild Warm Dry	Extremely Warm Dry	Warm Damp	Warm Damp, Equable	2K1	2K2	2K3	2K4	2K5	2K5H	2K5L
e) Change of temperature air/water ¹⁾	°C										No	No	+40/+5	+40/+5	+55/+5	+55/+5	+40/+5
Protected from rain, or not subjected to water from other sources		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Subjected to rain or water jets directly after being subjected to solar radiation		*	*	*	*	*	*	*	*	*			*	*	*	*	*
f) Relative humidity, not combined with rapid temperature change	% °C										75 +30	75 +30	95 +40	95 +45	95 +50	95 +50	95 +45
Humidity-controlled-weatherprotected-conditions		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Heated and ventilated-weatherprotected-conditions, or non-weatherprotected-conditions		*	*	*	*	*	*	*	*	*			*	*	*	*	*
Weatherprotected, unventilated compartments with wet floors and/or walls, subjected to solar radiation		*	*	*	*	*	*	*	*	*				*	*	*	*
g) Relative humidity, combined with rapid temperature changes air/air at high relative humidity	% °C										No No	No No	95 -25/+30	95 -40/+30	95 -65/+30	95 -25/+30	95 -65/+30
Products not moved between outdoors and indoors, or negligible temperature changes		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Products moved between outdoors and indoors, or products moved from aircraft holds to outdoors		*	*	*	*	*	*	*	*	*			*	*	*	*	*
h) Absolute humidity, combined with rapid temperature changes air/air at high water content ²⁾	g/ m ³ °C										No No	No No	60 +70/+15	60 +70/+15	80 +85/+15	80 +85/+15	60 +70/+15
In enclosures subjected to rain or water jets after being subjected to solar radiation		*	*	*	*	*	*	*	*	*			*	*	*	*	*

~~A.2.1 K Climatic conditions (concluded)~~

[illegible]

A.2.2 B Biological conditions

Condition of transportation		Class		
		2B1	2B2	2B3
a) Flora		No	Presence of mould, fungus, etc.	
Areas with negligible risks of growth of mould, fungus, etc., or protected from growth of mould, fungus, etc.		x	x	x
Areas with risks of growth of mould, fungus, etc. No protection from growth of mould, fungus, etc.			x	x
b) Fauna		No	Presence of rodents or other animals harmful to products:	
			excluding termites	including termites
Areas with negligible attacks of termites, rodents and other animals, which may damage the product, or protected from animals		x	x	x
Areas with risks of attacks by rodents and other animals excluding termites. No protection from animals			x	x
Areas with risks of attacks of animals including termites				x

A.2.3 C Chemically active substances

Condition of transportation		Class		
		2C1	2C2	2C3
a) Sea salts		No	Conditions of salt mist	Conditions of salt water
Indoors, weatherprotected (including indoor sea transport)		x	x	x
Non-weatherprotected, land transport			x	x
Non-weatherprotected, sea transport				x
b) Sulphur dioxide	mg/m ³	— 0,1	— 1,0	— 10
c) Hydrogen sulphide	mg/m ³	— 0,01	— 0,5	— 10
d) Nitrogen oxides	mg/m ³	— 0,1	— 1,0	— 10
e) Ozone	mg/m ³	— 0,01	— 0,1	— 0,3
f) Hydrogen chloride	mg/m ³	— 0,1	— 0,5	— 5,0
g) Hydrogen fluoride	mg/m ³	— 0,003	— 0,03	— 2,0
h) Ammonia	mg/m ³	— 0,3	— 3,0	— 35
Areas without industry or permanent motor traffic, not in the vicinity of industrial areas, or enclosed spaces in areas with moderate industrial activities and traffic		x	x	x
Areas with normal industrial activities not including industry with emissions of large quantities of chemical pollutants			x	x
Areas with industrial sources with high chemical emission				x

A.2.4 ~~S Mechanically active substances~~

Condition of transportation		Class		
		2S1	2S2	2S3
a) Sand in air	g/m³	No	0,1	10
b) Dust sedimentation	mg/(m²·h)	No	3,0	—3,0
Weatherprotected and protected from particles. Cleaning does not include sweeping of dusty floors		*	*	*
Weatherprotected but not protected from particles. Dusty places subjected to sweeping and other dusting activities. Non-weatherprotected and not protected from particles. Worldwide except sand deserts			*	*
Non-weatherprotected and not protected from particles. Worldwide				*

A.2.5 ~~M Mechanical conditions~~

Condition of transportation		Class		
		2M1	2M2	2M3
a) Stationary vibration, sinusoidal:				
displacement amplitude	mm	3,5	3,5	7,5
acceleration amplitude	m/s²	10 15	10 15	20 40
frequency range	Hz	2-9-9-200-200-500	2-9-9-200-200-500	2-8-8-200-200-500
Propeller aircraft. Ships. Air-cushioned road vehicles, air-cushioned trailers, other road vehicles in areas with well-developed road systems, trains with soft suspension, fork-lift trucks		*	*	*
Road vehicles in areas without well-developed road systems, trailers, trains with hard suspension				*
b) Stationary vibration, random:				
acceleration spectral density	m²/s³	1 — 0,3	1 — 0,3	3 — 1
frequency range	Hz	10-200 200-2000	10-200 200-2000	10-200 200-2000
Jet aircraft. Air-cushioned road vehicles, air-cushioned trailers, other road vehicles in areas with well-developed road systems, trains with soft suspension, fork-lift trucks (only 10 Hz to 500 Hz)		*	*	*
Road vehicles in areas without well-developed road systems, trailers, trains with hard suspension (only 10 Hz to 500 Hz)				*

A.2.5 M Mechanical conditions (continued)

Condition of transportation		Class		
		2M1	2M2	2M3
<i>c) Non-stationary vibration, including shock:</i>				
shock response spectrum type I peak acceleration $\dot{a}$	m/s ²	100	100	300
shock response spectrum type II peak acceleration $\dot{a}$	m/s ²	No	300	1000
Aircraft, ships, air-cushioned road vehicles		*	*	*
Road vehicles in areas with well-developed road systems, air-cushioned trailers, trains with specially designed buffers to reduce shocks, fork-lift trucks			*	*
Road vehicles in areas without well-developed road systems, trailers, trains (including shunting)				*
<i>d) Free fall:</i>				
mass under 20 kg	m	0,25	1,2	1,5
mass 20 kg to 100 kg	m	0,25	1,0	1,2
mass over 100 kg	m	0,1	0,25	0,5
Loading and unloading only with mechanical means (cranes, fork-lift trucks, conveyors, etc.). Risk of dropping not taken into account.		*	*	*
Manual loading and unloading of items of mass under 20 kg. Transport on animals			*	*
Manual loading and unloading of items of mass up to 100 kg. Transport on animals				*
<i>e) Toppling:</i>				
mass under 20 kg		Toppling around any of the edges		
mass 20 kg to 100 kg		No	Toppling around any of the edges	
mass over 100 kg		No	No	Toppling around any of the edges
Items of mass under 20 kg: subjected to toppling. Items of mass over 20 kg: not subjected to toppling, loading and unloading only by mechanical means		*	*	*
Items of mass 20 kg to 100 kg: subjected to toppling, manual loading and unloading. Items of mass over 100 kg: not subjected to toppling, loading and unloading only by mechanical means			*	*
Items of mass over 100 kg: subjected to toppling				*
<i>f) Rolling, pitching:</i>				
angle	degree	No	±35	±35
period	s	No	8	8
Not transported by ships		*	*	*
Transported by ships			*	*

~~A.2.5 M Mechanical conditions (end)~~

Condition of transportation		Class		
		2M1	2M2	2M3
g) Steady-state acceleration	m/s²	20	20	20
All kinds of transport including aircraft		x	x	x
h) Static load	kPa	5	10	10
Subjected to load from stacking, maximum height 3,5 m		x	x	x
Subjected to load from stacking maximum height 7 m			x	x

~~A.3 Summary of conditions covered by the classes~~

~~This summary contains a description of the complete classification and refers to examples of application.~~

~~A.3.1 K Climatic conditions~~

~~These conditions are covered by nine class notations as follows:~~

~~2K1 2K1 covers in general terms transportation in weatherprotected, heated and ventilated conditions. The high air temperatures are limited to those within the general open air climates¹⁾. The conditions of humidity of the worldwide open air climates are not more severe than in the general open air climates and therefore, such a limitation is not made for the humidity conditions.~~

~~The product is not moved between cold outdoor and warm indoor conditions.~~

~~The product may be exposed to solar radiation through a window or other opening. It is not placed close to heating elements and not subjected to water from splashing, wet walls, etc.~~

~~2K2 In addition to the conditions covered by 2K1, 2K2 includes weatherprotected conditions without heating in the general open air climates, excluding Cold and Cold Temperate climates. Transportation in ventilated enclosures is included.~~

~~The product may be transported in heated, pressurized aircraft holds.~~

~~2K3 In addition to the conditins covered by 2K2, 2K3 includes transportation in unventilated enclosures and in non-weatherprotected conditions with restrictions to the general open air climates, excluding Cold and Cold Temperate climates. Transportation by air only in heated, pressurized holds is included.~~

~~The product may be moved between cold outdoor and warm indoor conditions. It may be exposed to direct solar radiation, precipitation and splashing water.~~

~~The product may be placed on a wet floor and inside an enclosure, which is subjected to sunshine, rain, etc. Outdoor exposure does not include subjection to sea waves. The product may be placed close to heating elements.~~

¹⁾ IEC 721-2-1 defines the types and groups of climates.

~~2K4 In addition to the conditions covered by 2K3, 2K4 includes non-weatherprotected transportation in Cold-Temperate climate.~~

~~2K5 In addition to the conditions covered by 2K4, 2K5 includes transportation in unventilated enclosures and in non-weatherprotected conditions worldwide, also including transportation in unpressurized aircraft holds. The product may be subjected to sea waves when being transported on open decks of ships and may also be subjected to water jets from cleaning.~~

~~2K5H Class 2K5H is similar to 2K5, but the low temperature condition is the same as that of class 2K3.~~

~~2K5L Class 2K5L is similar to 2K5, but the high temperature conditions are the same as those of class 2K4.~~

~~2K6 Class 2K6 represents the conditions covered by the Warm-Damp and Warm-Damp Equable types of open-air climate (tropical damp type of climate, in areas with tropical rainforests).~~

~~2K7 Class 2K7 represents the conditions covered by the Warm-Dry, Mild Warm-Dry and Extremely Warm-Dry types of open-air climate (tropical dry type of climate, in areas near the tropics such as deserts).~~

~~A.3.2 B Biological conditions~~

~~These conditions are covered by three class notations as follows:~~

~~2B1 2B1 covers transportation in areas without particular risks of biological attacks (from flora or fauna). This includes transportation in compartments of such construction that mould-growth, attacks of animals, etc., are not probable.~~

~~2B2 In addition to the conditions covered by 2B1, 2B2 includes areas and conditions where mould-growth, attacks of animals except termites may occur.~~

~~2B3 In addition to the conditions covered by 2B2, 2B3 includes areas where attacks of termites may occur.~~

~~A.3.3 C Chemically active substances~~

~~These conditions are covered by three class notations as follows:~~

~~2C1 2C1 covers all cases of transportation, where the product is placed indoors in such a way that it is protected from salt mist. Transportation only takes place in areas with moderate industrial activities and traffic.~~

~~2C2 In addition to the conditions covered by 2C1, 2C2 also includes outdoor transportation except sea transport on open decks of ships. Transportation also takes place in areas with normal industrial activities, excluding those where large quantities of chemical pollutants are emitted.~~

~~2C3 2C3 covers all transport conditions including transportation by ships, unprotected from salt mist, and in areas with very high levels of chemical pollutants.~~

~~A.3.4 S Mechanically active substances~~

~~These conditions are covered by three class notations as follows:~~

~~2S1 — 2S1 covers all cases of transportation, where the product is placed indoors, protected from sand and dust.~~

~~2S2 — In addition to the conditions covered by 2S1, 2S2 also includes outdoor transportation as well as indoor, where sweeping of dusty floors is taken into account. Transportation in sand desert areas is not included.~~

~~3S3 — In addition to the conditions covered by 2S2, 2S3 also includes outdoor transportation in sand desert areas.~~

~~A.3.5 — M — Mechanical conditions~~

~~These conditions are covered by three class notations as follows:~~

~~2M1 — 2M1 covers mechanical loading as well as transportation in aircraft, lorries and air-cushioned trucks and trailers.~~

~~2M2 — In addition to the conditions covered by 2M1, 2M2 includes transportation in all kinds of lorries and trailers in areas with well-developed road systems. It also includes transportation by trains with specially designed shock reducing buffers and by ships.~~

~~2M3 — In addition to the conditions covered by 2M2, 2M3 includes all other kinds of transportation, also in areas without well-developed road systems.~~

Annex B (informative)

Summary of conditions covered by the sets of class combinations

This annex contains a condensed description of the complete classification for four standardized environmental condition cases.

For a more detailed description see annex A.

The general environmental conditions are covered by four set notations as follows:

- IE21 This set covers transportation in ventilated enclosures and weatherprotected conditions, if by air only in heated, pressurized holds; with risk of mould growth and attacks by animals except termites; in areas with normal industrial activities excluding those with large quantities of chemical pollutants; excluding sand desert areas; in aircraft, lorries and air-cushioned trucks and trailers (on parts of the vehicle with high internal damping).
- IE22 In addition to the conditions covered by IE21, IE22 covers transportation in unventilated enclosures and non-weatherprotected conditions in lorries and air-cushioned trucks and trailers; on parts of the vehicle without high internal damping.
- IE23 In addition to the conditions covered by IE22, IE23 includes transportation in all kinds of lorries and trailers; in areas with well-developed road systems; by train with specially designed shock-reducing buffers and by ships.
- IE24 In addition to the conditions covered by IE23, IE24 covers transportation worldwide including in unpressurized aircraft holds; products exposed to sea waves if transportation on open decks of ships, or to water jets for cleaning; transportation in sand desert areas; in areas without well-developed road systems.

Annex C (informative)

Explanation of the environmental conditions in tropical areas as specified in classes 2K6 and 2K7

C.1 General

The tropics are the areas within the Northern and Southern tropics (between 23°27' south and 23°27' north). In tropical areas the following types of open air climate, as specified in IEC 721-2-1, apply:

- Warm Dry (WDr)
- Mild Warm Dry (MWDr)
- Extremely Warm Dry (EWDr)
- Warm Damp (WDa)
- Warm Damp Equable (WDaE)

The tropics are the zones of the earth in which during daytime, high temperatures, frequently combined with high precipitation, prevail. In these areas seasonal changes are scarcely pronounced.

The tropical climate extends from warm damp climatic conditions in tropical rainforests at the equator to the warm dry climate in the deserts near the tropics. Consequently, two types of tropical climate should be distinguished:

- *tropical dry* as a combination of the Warm Dry, Mild Warm Dry and Extremely Warm Dry types of climate, and
- *tropical damp* as a combination of the Warm Damp and Warm Damp Equable types of climate.

There are also regions where the climate, owing to the particular altitude, deviates considerably from the usual conditions of these latitudes, for example solar radiation and air pressure, or ice and snow on mountain summits. In many areas in the tropics, environmental conditions are identified by uniform conditions and in other regions by very extreme climatic conditions:

Balanced conditions:

- minimum daily temperature fluctuations of less than 1 °C and annual temperature fluctuations of maximum 6 °C;
- balanced duration of daylight periods between 10,5 h and 13,5 h;
- uniform intensity of solar radiation;
- balanced conditions for an abundant fauna.

Extreme conditions:

- precipitation: rainfall the whole year round near the equator, heavy rainfall during certain periods of the year near the tropics;
- tropical cyclones in sea areas: wind velocities of 30 m/s with peaks attaining more than 60 m/s, for example in typhoons in the Western Pacific and in hurricanes in the Caribbean Sea;
- unfavourable soil conditions: erosion of humus and minerals in areas with heavy rainfalls;

- ~~— rapid drying of soil in the desert as a result of high temperatures and strong winds;~~
- ~~— lush vegetation in tropical rainforests, less dense vegetation in mountain forests;~~
- ~~— grass areas of savannahs and steppes, absence of vegetation in the desert.~~

C.2 Climatograms

~~Climatograms for the two classes describing climatic conditions in tropical areas are given in figure C.1. They are based on the mean value of annual extreme values of air temperature and humidity for the types of climate specified in C.1 above.~~

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Annex A (informative)

Chemically active substances

The values given in this classification have been taken from surveys over several years. Maximum values are given, because direct influence of higher concentrations over a short period of time normally causes more damage to material which cannot regenerate. Mean values are given additionally, because their influence may be important for the long-term effect on internal parts of the products.

In practice, not all contaminants (parameters) classified in this document are present simultaneously. Furthermore, the probability is low that the concentrations of those contaminants actually present increase simultaneously and homogeneously. Depending on the local situation, there are often higher values of one contaminant only. The values specified for class 2C1 will normally be experienced in rural areas and areas with low industrial activity. The values specified for class 2C2 are experienced in urban areas. Therefore the severity of each of these two classes shall be considered as the requirements for the combined effect of all parameters stated. The severities of class 2C3, however, cannot be combined as the requirement for the combined effect of all parameters stated in order to avoid any uneconomical overdesign. For that class, it is possible to select only the severities of those single parameters which might be relevant in the case of application. If single parameters of class 2C3 are selected for the description of the chemically active substances present at a location, the severities of class 2C2 are valid for all other parameters which are not specially named.

Chemically active liquids and chemically active solids other than sea salts or road salts are not considered in this document.

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IEC TR 62131-5, *Environmental conditions – Vibration and shock of electrotechnical equipment – Part 5: Equipment during storage and handling*

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Classification of environmental conditions –
Part 3-2: Classification of groups of environmental parameters and their
severities – Transportation and handling**

**Classification des conditions d'environnement –
Partie 3-2: Classification des groupements des agents d'environnement et de
leurs sévérités – Transport et manutention**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

CLASSIFICATION OF ENVIRONMENTAL CONDITIONS –

Part 3-2: Classification of groups of environmental parameters and their severities – Transportation and handling

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60721-3-2 has been prepared by IEC technical committee 104: Environmental conditions, classification, and methods of test.

This third edition cancels and replaces the second edition, published in 1997, and constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) Clause 1: reworded and added handling.
- b) Clause 2: updated normative references.
- c) Clause 3: updated definitions.
- d) Clause 4: reworded and simplified.

- e) Clause 5: revised and updated. Several classes have been replaced by completely new classes based on the use of new information obtained from referenced Technical Reports.
- f) Table 1 through Table 5: updated.
- g) Table 6 deleted.
- h) Old annexes A to C removed except Clause A.3 that is incorporated in Clause 5.
- i) New Annex A.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
104/773/FDIS	104/783/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60721 series, published under the general title *Classification of environmental conditions*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

The contents of the corrigendum of November 2018 have been included in this copy.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

CLASSIFICATION OF ENVIRONMENTAL CONDITIONS –

Part 3-2: Classification of groups of environmental parameters and their severities – Transportation and handling

1 Scope and object

This part of IEC 60721 classifies the groups of environmental parameters and their severities to which a product is subjected while being transported and handled.

The most commonly used methods of transportation and handling have been taken into account, including the following:

- road transport: cars, trucks;
- rail transport: trains, trams;
- water transport, inland and maritime: ships;
- air transport: aircraft, jet, propeller, helicopter;
- handling equipment: cranes, transport lifts, cableways, persons;
- conveyors;
- hand trollies.

The environmental conditions specified in this document are those that the product can be exposed to while transported and handled. If the product is packaged, the environmental conditions apply to the package containing the product. If the product is unpackaged, the environmental conditions apply to the product.

Conditions for storage are given in IEC 60721-3-1.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60721-1, *Classification of environmental conditions – Part 1: Environmental parameters and their severities*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60721-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

weather-protected

protected from the influences of meteorological conditions

3.2

non-weather-protected

not protected from the influences of meteorological conditions

4 General

A product may be subjected to a range of environmental conditions during its lifetime. These conditions have been separated into classes described in IEC 60721-3-0. The classes given may be used for defining the maximum short-term environmental stresses on a product. However, they do not provide information regarding the long-term or total lifetime environmental stresses a product may experience. This means that no reliability or lifetime assessment is possible based on these classes alone. Refer to IEC 60721-2 (all parts) and applicable technical reports (IEC TR 62130, IEC TR 62131-2, IEC TR 62131-3, IEC TR 62131-4 and IEC TR 62131-5) for further information on actual environmental conditions.

A product may be simultaneously exposed to a number of environmental parameters. For example, solar radiation and temperature, temperature and humidity, as well as vibration and temperature change. Combinations of the environmental parameters given may increase the stress effect on a product. Therefore, combined conditions should be considered in the design and evaluation of a product.

Products should be designed to survive and operate in different environments. Basically, they will be affected by environmental influences in two ways:

- by the effects of short-term extreme environmental conditions which may directly cause malfunction or destroy the product;
- by the effect of long-term subjection to non-extreme environmental stresses which may slowly degrade the product and finally cause malfunction or destruction of the product.

Short-term extreme environmental conditions may occur at any time in a product's life. A product may be unaffected by an extreme condition when it is new but fail when it is subjected to the same condition after being used for a long period of time due to the effect of ageing. The order in which the environmental conditions are applied may affect the results of an evaluation.

It is important for the product specification, when referring to a certain class in IEC 60721-3 (all parts), to define whether the product is required to be capable of operating or only to survive without permanent damage when being exposed to the conditions described by the class.

The environmental classes may be used as a basis for the selection of design and test severities with respect to the consequence of failure. Information contained in IEC 60721-3 (all parts) may be used as a means to help establish expected requirements for use, storage, transportation, etc., and in the development of relevant specifications. The selected severities used for testing should attempt to produce the effects of the actual environment.

EXAMPLE 1 A high temperature test on a heat dissipating product is designed to simulate the thermal effect of subjecting a product to conditions of high air temperature, solar radiation and other possible heat sources dependent on the application.

EXAMPLE 2 In a mechanical shock test, the product can be subjected to mechanical shocks of simple pulse shapes (e.g., half-sine), while the actual conditions cannot be described by such simple pulses.

It is recognized that extreme or special environmental conditions may exist which require consideration of severities that are not addressed by this document.

5 Classification of groups of environmental parameters and their severities

5.1 General

A number of classes for climatic conditions (K), special climatic conditions (Z), biological conditions (B), chemically active substances (C), mechanically active substances (S), and mechanical conditions (M) are specified.

This classification allows for a number of possible combinations of environmental conditions which bear upon products wherever stored. It represents the real situation concerning world-wide conditions of storage due to local influences of open-air climate, etc. For certain environmental parameters, it has not yet been possible to specify quantitative severities.

For a given location or product, reference should be made to the total set of classes as defined in 5.2 through 5.6, for example:

2K13/2B3/2C2/2S6/2M5

5.2 K Climatic conditions

NOTE The classes defined in previous versions of this document have been replaced with new classes as a result of recent efforts at collecting information regarding climatic conditions. Those results are contained in Technical Reports referenced in this document.

When selecting appropriate classes, attention should be paid to the fact that the climatic conditions in weather-protected locations may depend on the open-air (non-weather-protected) conditions, especially air temperature and solar radiation, and the type of transportation enclosure.

The following conditions are specified in Table 1.

- 2K10 applies to fully air conditioned enclosed transportation. Air temperature and humidity control is used continuously to maintain the required conditions.
- 2K11 applies to weather-protected transportation with limited temperature control and no humidity control.
- 2K12 applies to weather-protected transportation without temperature and humidity controls in unventilated enclosures in arid, temperate, tropical and cold climates. Polar climate is excluded. The product may be transported in heated, pressurized aircraft holds.
- 2K13 applies to non-weather-protected transportation in temperate, tropical, and cold climates. Arid and polar climates are excluded.
- 2K14 applies to transportation in non-weather-protected transportation worldwide (including arid and polar climates). This also includes transportation in unpressurized aircraft holds. The product may be subjected to sea waves when being transported on open decks of ships.

Table 1 – Classification of climatic conditions

Environmental parameter	Unit	Classification				
		Weather-protected			Non-weather-protected	
		2K10	2K11	2K12	2K13	2K14
a) Low air temperature	°C	+20 ⁶⁾	+5	−45	−45	−50
b) High air temperature	°C	+25 ⁶⁾	+40	+70	+45 ⁹⁾	+50 ⁹⁾
c) Low relative humidity ¹⁾	%	20	5	4	4	4
d) High relative humidity ¹⁾	%	75	85	100	100	100
e) Low absolute humidity ¹⁾	g/m ³	4	1	0,5	0,02	0,003
f) High absolute humidity ¹⁾	g/m ³	15	25	29	35	35
g) Rate of change of temperature ²⁾	°C/min	0,1	0,5	1,0	1,0	1,0
h) Low air pressure ³⁾	kPa	70	70	70	70	30
i) High air pressure ³⁾	kPa	106	106	106	106	106
j) Solar radiation	W/m ²	No	No	8)	1090	1090
k) Heat radiation	Not specified	None	None	None	None	None
l) Movement of surrounding air ⁴⁾	m/s	0,5	1,0	1,0	7)	7)
m) Condensation	Not specified	No	No	Yes	Yes	Yes
n) Precipitation (rain, snow, hail, etc.)	Not specified	No	No	No	Yes	Yes
o) Rain intensity	mm/min	None	None	None	3,3	3,3
p) Driving rain	m/s	None	None	None	7)	7)
q) Snow load	kg/m ²	None	None	None	100	100
r) Low rain temperature ⁵⁾	°C	None	None	None	+5	+5
s) Water from sources other than rain	Not specified	No	No	Dripping Water	10)	10)
t) Formation of ice and frost (including freeze-thaw)	Not specified	No	No	Yes	Yes	Yes
u) Temperature shock	Not specified	No	No	Yes	Yes	Yes

1) The low and high relative humidity levels are limited by the low and high absolute humidity, so that, for example, for environmental parameters a) and c), or b) and d), the severities given in Table 1 do not occur simultaneously.

2) Averaged over a period of time of 5 min.

3) The value of 70 kPa represents a limit for open-air conditions, normally at an altitude of 3 000 m. In some geographical areas, open-air conditions may occur at higher altitudes. Conditions in mines are not considered.

4) A cooling system based on non-assisted convection may be disturbed by adverse movement of surrounding air.

5) This rain temperature should be considered together with high air temperature b) and solar radiation j). The cooling effect of the rain has to be considered in connection with the surface temperature of the product.

6) These are air-conditioned locations with a tolerance of ±2 °C on stated temperature value.

7) If applicable, a special value should be selected based on expected transportation mode (e.g., lorry, open decks of ships).

8) Thermal effect of solar radiation is included in the temperature.

9) Thermal effect of solar radiation is not included in the temperature.

10) Sources of water other than rain are encompassed by driving rain.

5.3 B Biological conditions

No quantitative severity has been specified for the following conditions. The specified parameters of Table 2 are typical, but may not be complete.

- 2B1 applies to transportation in areas without risks from mould growth and attack by animals, or in compartments with environmental controls in place to prevent mould growth and attack by animals.
- 2B2 applies to transportation in areas where mould growth and attacks of animals, except termites, may occur.
- 2B3 applies to transportation in areas where attacks by termites may additionally occur.

Table 2 – Classification of biological conditions

Biological parameter	Class		
	2B1	2B2	2B3
None	Negligible	Presence of mould, fungus, etc. Presence of rodents and other animals harmful to products	
		excluding termites	including termites

5.4 C Chemically active substances

The contamination of the natural atmosphere is mainly caused by chemical emissions from industrial activities, motor-driven vehicles, and heating systems. A further chemical influence is caused by aerosols of sea and road salts. Contamination may affect the product's function and materials. The parameters shown in Table 3 are estimates based on information available at the time of publication. It is recommended that reference be made to local or regional information specific to an area of interest when establishing requirements.

See Annex A for additional information.

- 2C1 applies to transportation and handling in rural and some urban areas with low industrial activity and moderate traffic, and areas where there is either no salt mist or there are protections in place to protect the product from salt mist. This also applies to handling indoors.
- 2C2 applies to transportation and handling in areas with normal levels of contaminants as experienced in urban areas with industrial activity scattered over the whole area, or with heavy traffic. This includes transportation in areas where salt mist is present including maritime transport of containers but not transport on open decks of ships.
- 2C3 applies to transportation and handling in areas that are in the immediate vicinity of industrial sources with chemical emissions, and transportation on open decks of ships.

Table 3 – Classification of chemically active substances

Environmental parameter	Unit ¹⁾	Class				
		2C1	2C2		2C3	
		Maximum value	Mean value	Maximum value ²⁾	Mean value	Maximum value ²⁾
a) Salt mist to include sea and road salts	None	No	Yes		Yes	
b) Saltwater	None	No	No		Yes	
c) Sulphur dioxide	mg/m ³	0,1	0,3	1,0	5,0	10
	cm ³ /m ³	0,037	0,11	0,37	1,85	3,7
d) Hydrogen sulphide	mg/m ³	0,01	0,1	0,5	3,0	10
	cm ³ /m ³	0,0071	0,071	0,36	2,1	7,1
e) Hydrogen chloride	mg/m ³	0,1	0,1	0,5	1,0	5,0
	cm ³ /m ³	0,066	0,066	0,33	0,66	3,3
f) Hydrogen fluoride	mg/m ³	0,003	0,01	0,03	0,1	2,0
	cm ³ /m ³	0,0036	0,012	0,036	0,12	2,4
g) Ammonia	mg/m ³	0,3	1,0	3,0	10	35
	cm ³ /m ³	0,42	1,4	4,2	14	49
h) Ozone	mg/m ³	0,01	0,05	0,1	0,1	0,3
	cm ³ /m ³	0,005	0,025	0,05	0,05	0,15
i) Nitrogen oxides (expressed in equivalent values of nitrogen dioxide)	mg/m ³	0,1	0,5	1,0	3,0	9,0
	cm ³ /m ³	0,052	0,26	0,52	1,56	4,68
¹⁾ The values given in cm ³ /m ³ have been calculated from the values given in mg/m ³ referenced to a temperature of 20 °C and a pressure of 101,3 kPa. The table uses rounded values. ²⁾ Mean values are expected long-term values. Maximum values are limit or peak values occurring over a period of time that is typically not more than 30 min per day.						

5.5 S Mechanically active substances

NOTE The classes defined in previous versions of this document have been replaced with new classes as a result of recent efforts at collecting information regarding mechanically active substances.

Dust and sand are classified together, as the effects caused by these environmental conditions are similar. These conditions are specified in Table 4.

- 2S1 applies to transportation and handling where precautions have been taken to minimize the presence of dust and sand.
- 2S5 applies to transportation and handling with limited precautions to minimize the presence of dust and sand such as enclosed transport.
- 2S6 applies to non-enclosed transportation and handling in close proximity to dust and sand sources without special precautions to minimize the presence of dust and sand.
- 2S7 applies to transportation and handling in areas with driven dust and sand.

Table 4 – Classification of mechanically active substances

Environmental parameter	Unit	Class			
		2S1	2S5	2S6	2S7 ¹
a) Sand in air	mg/m ³	None	30	300	1 000
b) Dust in air	mg/m ³	None	0,2	5,0	15
c) Dust (sedimentation rate)	mg/(m ² ·h)	None	15	40	80
¹⁾ If applicable, a special value should be selected based on expected transportation mode.					

5.6 M Mechanical conditions

NOTE The classes defined in previous versions of this document have been replaced with new classes as a result of recent efforts at collecting information regarding mechanical conditions. Those results are contained in Technical Reports referenced in this document.

Mechanical conditions described in this document encompass those conditions that may exist during transportation and handling. The conditions do not represent test severities. Vibration and mechanical shock environments are depicted in Figures 1 and 2, respectively, and described in Table 5.

- 2M4 applies to handling, transport by rail, river, sea, air (jet aircraft only) and road transport using good vehicles on good roads. This category includes transport of goods within ISO containers.
- 2M5 includes those conditions described by 2M4 plus road transport using poor vehicles and/or on poor roads as well as handling using trolleys with no suspension.
- 2M6 includes those conditions described by 2M4 and 2M5, plus transport by air in propeller aircraft and helicopter.

Table 5 – Classification of mechanical conditions

Environmental parameter	Unit	Class							
		2M4			2M5			2M6	
a) Stationary vibration, random:									
acceleration power spectral density	(m/s ²) ² /Hz	10 ²⁾	1,0	0,5	30	3,0	1	10	5
frequency range ¹⁾	Hz	2 to 3	10 to 20	50 to 2 000	2 to 3	10 to 20	500 to 2 000	5 to 200	500 to 2 000
b) Non-stationary vibration including shock: ³⁾		Figure 2 Curve 4 (equivalent to a half sine pulse of 100 m/s ² and 11 ms duration)			Figure 2 Curve 3 (equivalent to a half sine pulse of 300 m/s ² and 11 ms duration)			Figure 2 Curve 3 (equivalent to a half sine pulse of 300 m/s ² and 11 ms duration)	
Shock 1 ⁴⁾									
Shock 2 ⁴⁾		Figure 2 Curve 2 (equivalent to a half sine pulse of 300 m/s ² and 6 ms duration)			Figure 2 Curve 1 (equivalent to a half sine pulse of 1 000 m/s ² and 6 ms duration)			Figure 2 Curve 1 (equivalent to a half sine pulse of 1 000 m/s ² and 6 ms duration)	

Environmental parameter	Unit	Class		
		2M4	2M5	2M6
<i>c) Free fall:</i>				
mass less than 20 kg	m	0,25	1,2	1,5
mass 20 kg to 100 kg	m	0,25	1,0	1,2
mass more than 100 kg	m	0,1	0,25	0,5
<i>d) Toppling:</i>				
mass less than 20 kg	None	Toppling around any of the edges	Toppling around any of the edges	Toppling around any of the edges
mass 20 kg to 100 kg			Toppling around any of the edges	Toppling around any of the edges
mass more than 100 kg			No	Toppling around any of the edges
		No	No	
<i>e) Rolling, pitching:</i>	degrees	No	±35	±35
angle ⁵⁾ period		No	8	8
<i>f) Steady-state acceleration</i>	m/s ²	20	20	20
<i>g) Static load</i>	kPa	5	10	10
1) When transport only occurs by rail, river, sea and road, the upper frequency considered may be reduced to 500 Hz for products that are not sensitive to vibration excitations above 500 Hz. 2) The low frequency stationary vibration random component arises from the influence of land vehicle suspension systems. The component is included for design purposes but is not always included in vibration test specifications. 3) For land vehicles, these shocks can occur simultaneously with the stationary vibration random conditions. 4) Both shocks would normally be used to encompass different aspects of the shock environment. 5) An angle of 35° may only occur temporarily. An angle of up to 22,5° can be reached for long periods of time.				

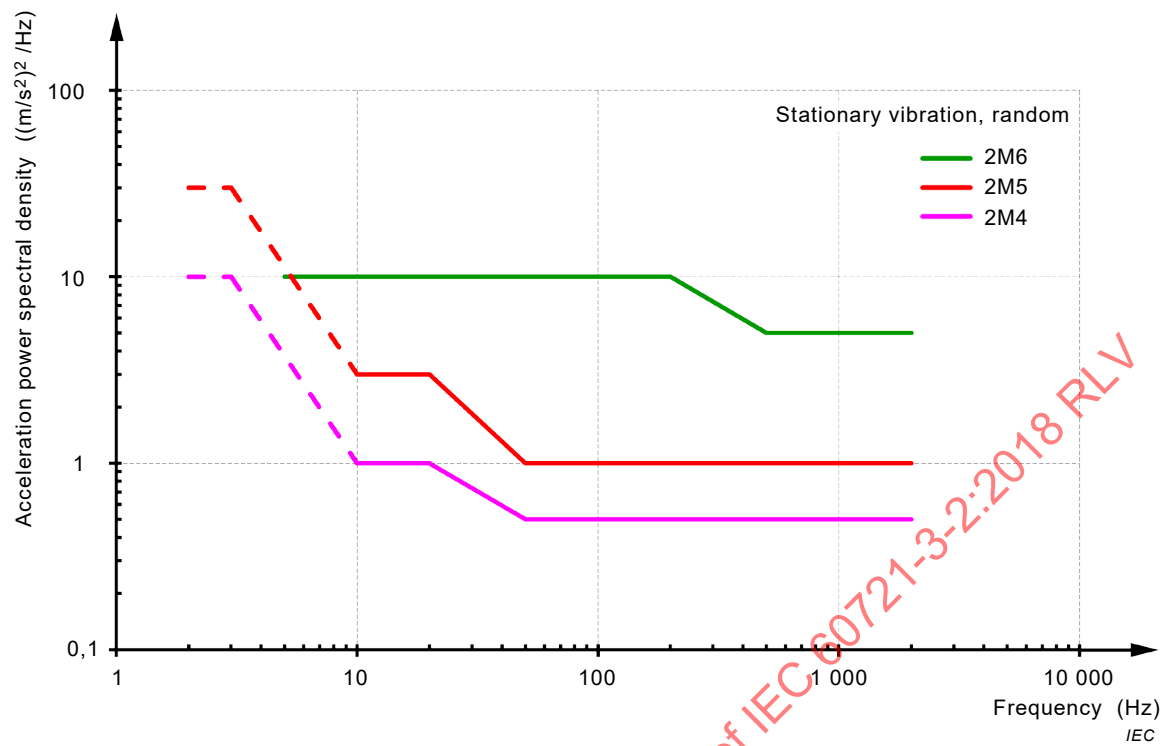


Figure 1 – Consolidation of vibration conditions

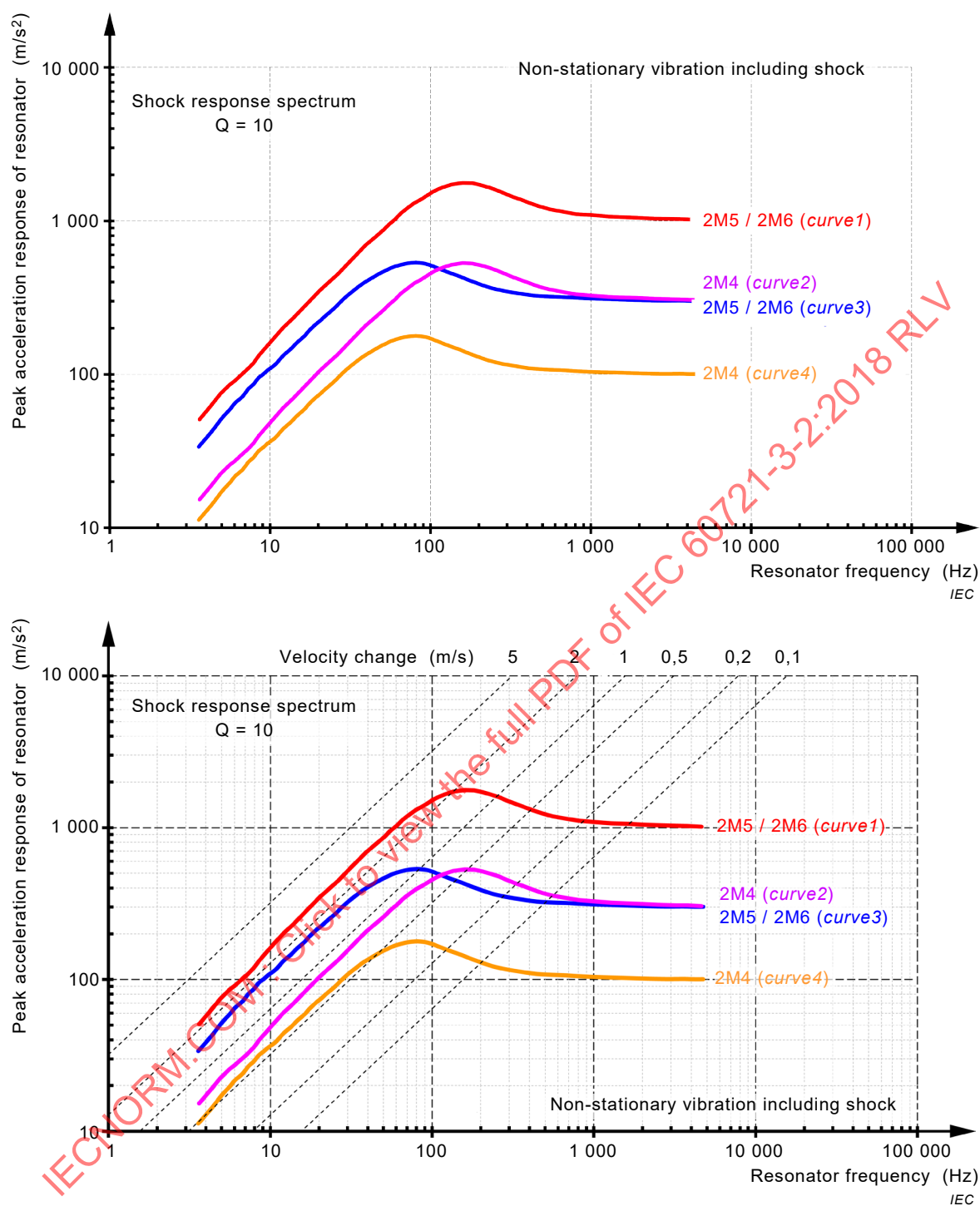


Figure 2 – Consolidation of mechanical conditions

Annex A (informative)

Chemically active substances

The values given in this classification have been taken from surveys over several years. Maximum values are given, because direct influence of higher concentrations over a short period of time normally causes more damage to material which cannot regenerate. Mean values are given additionally, because their influence may be important for the long-term effect on internal parts of the products.

In practice, not all contaminants (parameters) classified in this document are present simultaneously. Furthermore, the probability is low that the concentrations of those contaminants actually present increase simultaneously and homogeneously. Depending on the local situation, there are often higher values of one contaminant only. The values specified for class 2C1 will normally be experienced in rural areas and areas with low industrial activity. The values specified for class 2C2 are experienced in urban areas. Therefore the severity of each of these two classes shall be considered as the requirements for the combined effect of all parameters stated. The severities of class 2C3, however, cannot be combined as the requirement for the combined effect of all parameters stated in order to avoid any uneconomical overdesign. For that class, it is possible to select only the severities of those single parameters which might be relevant in the case of application. If single parameters of class 2C3 are selected for the description of the chemically active substances present at a location, the severities of class 2C2 are valid for all other parameters which are not specially named.

Chemically active liquids and chemically active solids other than sea salts or road salts are not considered in this document.

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

CLASSIFICATION DES CONDITIONS D'ENVIRONNEMENT –

**Partie 3-2: Classification des groupements des agents d'environnement
et de leurs sévérités –
Transport et manutention**

AVANT-PROPOS

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Cette troisième édition annule et remplace la deuxième édition, parue en 1997. Elle constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- a) Article 1: reformulation et ajout de la manutention.
- b) Article 2: mise à jour des références normatives.

- c) Article 3: mise à jour des définitions.
- d) Article 4: reformulé et simplifié.
- e) Article 5: révisé et mis à jour. Plusieurs catégories ont été remplacées par des catégories complètement nouvelles sur la base de nouvelles informations obtenues à partir des rapports techniques référencés.
- f) Tableau 1 au Tableau 5: mise à jour.
- g) Tableau 6 supprimé.
- h) Suppression des anciennes annexes A à C à l'exception de l'Article A.3 qui est intégré dans l'Article 5.
- i) Nouvelle Annexe A.

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
104/773/FDIS	104/783/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

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