IEC 60721-2-2

Edition 2.0 2012-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Classification of environmental conditions –
Part 2-2: Environmental conditions appearing in nature – Precipitation and wind

Classification des conditions d'environnement –
Partie 2-2: Conditions d'environnement présentes dans la nature – Précipitations et vent

IEC 60721-2-2:2012

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

Useful links:

IEC publications search - www.iec.ch/searchpub

The advanced search enables you to find IEC publications by a variety of criteria (reference number, text, technical committee,…).
It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available on-line and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary (IEV) on-line.

Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Liens utiles:

Recherche de publications CEI - www.iec.ch/searchpub

La recherche avancée vous permet de trouver des publications CEI en utilisant différents critères (numéro de référence, texte, comité d'études,…).
Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

Just Published CEI - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications de la CEI. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 30 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (VEI) en ligne.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

IEC 60721-2-2

Edition 2.0 2012-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Classification of environmental conditions –
Part 2-2: Environmental conditions appearing in nature – Precipitation and wind

Classification des conditions d'environnement –
Partie 2-2: Conditions d'environnement présentes dans la nature – Précipitations et vent

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX **M**

ICS 19.040 ISBN 978-2-83220-570-9

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

CLASSIFICATION OF ENVIRONMENTAL CONDITIONS –

Part 2-2: Environmental conditions appearing in nature – Precipitation and wind

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.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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

This second edition cancels and replaces the first edition, published in 1988, and constitutes a technical revision.

The main changes with regard to the previous edition are as follows:

– subclause Precipitation: simplified; data not possible to validate are removed;
– subclause Wind: text rewritten;
– Table 1 simplified and aligned with definition used by [1][1];
– subclause Hail: data added; formula changed; formula for impact energy added;

[1] References in square brackets refer to the Bibliography.

– subclause Snow: text changed and aligned with definitions used by [1];
– Table 3 removed;
– subclause Normal rain: text has been modified and numeric values removed;
– subclause Driving rain: text has been modified and numeric values removed;
– subclause Formation of ice: text has been modified and numeric values removed;
– subclause Drifting snow: text added;
– subclause Wind force: formula changed;
– Figure 1 to 5 removed.

The text of this standard is based on the following documents:

FDIS	Report on voting
104/583/FDIS	104/596/RVD

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

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

A list of all parts in the IEC 60068 series, under the general title *Classification of environmental conditions*, can be found on the IEC website.

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

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

CLASSIFICATION OF ENVIRONMENTAL CONDITIONS –

Part 2-2: Environmental conditions appearing in nature – Precipitation and wind

1 Scope

This part of IEC 60721 presents fundamental properties, quantities for characterization, and a classification of environmental conditions dependent on precipitation and wind relevant for electrotechnical products.

It is intended to be used as background material when selecting appropriate severities of parameters related to precipitation and wind for product applications.

When selecting severities of parameters related to precipitation and wind for product application, the values given in IEC 60721-1 should be applied.

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 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

Terms and definitions are defined, in context, throughout the present standard.

4 General

4.1 Introductory remark

The atmosphere of the Earth is in permanent motion. It is locally heated, cooled and moistened. The resulting gradients in density create high and low pressure areas. The equalizing winds do not blow directly from high to low pressure areas, but are deflected by Coriolis force due to the rotation of the Earth.

The continuous horizontal movement may cause slow upward motion over wide areas, or surface heating may give more localized updrafts in thermals. The air cannot maintain its water content in vaporous form if the reduction of pressure and temperature is sufficient, and precipitation may form. As an example, an air mass at +20 °C temperature is able to contain water in a quantity of 17,3 g/m^3 in vaporous form. If it cools to 0 °C the maximum water content is only 4,8 g/m^3.

4.2 Precipitation

The specific kind of precipitation (rain, hail or snow) is a result of complicated processes in the clouds.

Formation of raindrops or ice crystals depends on various conditions, for instance vertical air currents, temperature distribution, and the resulting course of droplets or ice crystals within the cloud.

4.3 Wind

Wind is defined as lateral movement of the Earth's atmosphere from high-pressure areas to low-pressure areas.

Winds are often referred to by their strength and the direction from which the wind is blowing. Gusts are short bursts of high speed wind. Winds of long duration have various names associated with their average strength, such as breeze, gale, storm, hurricane and typhoon. Wind occurs on a scale ranging from thunderstorm flows, lasting tens of minutes, through local breezes generated by heating of land surfaces and lasting a few hours, to global winds resulting from the difference in absorption of solar energy between the climate zones on Earth. The two main causes of large scale atmospheric circulation are the differential heating between the equator and the poles and the rotation of the planet.

5 Characteristics

5.1 Rain

Rain is characterized by the following physical parameters:

– rain intensity measured in millimetres per hour (as the height accumulated on a horizontal surface without drain);
– drop size distribution; typical 1 mm to 2 mm in diameter, in thunderstorms the size could be up to 5 mm to 8 mm;
– falling velocity distribution; typical 2 m/s to 12 m/s;
– raindrop temperature.

Other parameters such as dissolved impurities due to air pollution, sea salts, etc., are not considered here, even though they may have important effects on products.

A survey of characteristic parameters for different types of rain is given in Table 1 below, in accordance with [1].

Table 1 – Characteristics of rain (average over long periods)

Type of rain	Rain intensity upper limit mm/h
Very light rain	0,25
Light rain	1,0
Moderate rain	4,0
Heavy rain	16
Very heavy rain	50
Extreme rain	>50

The raindrop temperature will normally be the same as the wet bulb temperate of an aspirated psychrometer but deviations may occur, for instance in a rain established from ice crystals or at the beginning of a period of rainfall.

5.2 Hail

Hail is characterized by the following physical parameters of the hailstones:

- diameter; typical 5 mm to 15 mm;
- density; typical large hail greater than 800 kg/m^3 and small hail less than 800 kg/m^3;
- falling velocity;
- impact energy;
- typical drag coefficient (C_d) is 0,6 but depends on hail size, irregularities in shape and in surface roughness [2].

Only stones of larger diameter are considered here because of their damaging effect but stones of smaller diameter are by far the most frequent [1].

The falling velocity is determined by the formula:

$$v = \sqrt{\frac{2 \times W}{C_d \times \rho_0 \times A}}$$

where

v is the falling velocity in metres per second;

W is the weight (mass·acceleration);

C_d is the drag coefficient;

ρ_0 is the atmospheric density in kg per cubic metres;

A is the frontal area in square metres.

ρ_0 = 1,225 kg/m^3 (standard atmosphere for dry air at sea level and at +15 °C).

The impact energy is then calculated from the mass (diameter, density) and the falling velocity.

The impact energy is determined by the formula:

$$E = \frac{\mathrm{m} \times v^2}{2}$$

where

E is the impact energy in Joules;

m is the mass of the hail in kg;

v is the falling velocity in metres per second.

Table 2 gives the characteristics of hailstones with diameters from 20 mm upwards.

Table 2 – Characteristics of hailstones

Diameter mm	Mass g	Falling velocity m/s	Impact energy J
20	4	18	1
50	59	28	24
60	102	31	49
70	162	34	91
80	241	36	155
90	344	38	248
100	471	40	378
NOTE Values are in round figures.			

The following values are used in Table 2:

C_d = 0,6;

ρ = 900 kg/m^3 (for hailstones).

5.3 Snow

Snow is generated as snow crystals are formed by freezing water droplets. If blown by strong winds, however, snow crystals are broken and abraded into small particles. Freshly fallen snow has a density ranging from 70 kg/m^3 to 150 kg/m^3 whereas the density of old snow could be in a range of 400 kg/m^3 to 500 kg/m^3, even up to 910 kg/m^3. If the density exceeds 910 kg/m^3, snow is considered as ice. Firm snow will normally have a density of 600 kg/m^3. Wind exposure will often increase the density by breaking the snow flakes; temperature will also increase the density. Density will also increase over time due to settling [1].

5.4 Wind

Wind speed is greatly influenced by details of the local landscape and height above the ground. The greater the roughness of the ground surface, the more the wind speed close to this surface is reduced; thus there may be considerable differences between wind speeds near the ground surface and those at greater heights above the ground surface.

6 Classification

6.1 General

Rain, hail, snow and wind may have various effects on products, either separately, mutually combined or in combination with other environmental parameters.

Some examples of single and combined parameters are given below.

6.2 Normal rain

Rain occurs with very different intensities which vary considerably with latitude, climate and season. Generally, the highest rates occur in tropical thunderstorms and in hurricane-type storms.

Normal rain consists of drops of different sizes and velocities. The characteristics of the drops depend mainly on the temperature and the moisture content in the atmosphere. These atmospheric features result in partial or complete vaporization of the falling drops. In general, higher ground temperatures and higher relative humidity give greater median drop size.

Consequently, tropical rain generally consists of drops larger than those of rain in, for example, a north European location.

6.3 Driving rain

Driving rain is a combination of rain and wind. The wind adds a horizontal velocity component to the falling velocity, and may further create underpressure in an encapsulation. The rain itself may also create such underpressure by cooling due to low rain temperature.

6.4 Formation of ice

6.4.1 General

Formation of ice occurs as a combination of rain falling on a surface cooled below 0 °C (for example, due to radiation towards a clear night sky), or by super-cooled raindrops freezing at impact.

6.4.2 Air hoar

Air hoar is formed when moist air contacts a surface cooled below 0 °C and sublimes on it. Air hoar usually forms when wind velocity is low. It consists of needle-like crystals and its adhesion to the surface is weak.

6.4.3 Rime

Rime is formed as a result of repeated impinging and freezing of super-cooled water droplets carried by the wind against an object. It has a very characteristic appearance of "shrimp tails" because the points where it attaches to an object are small and grow windwards. Its color is white and it has a granular structure. Rime can occur simultaneously with snow causing a huge covering of snow on a suitable object.

6.4.4 Clear ice

Clear ice is formed when supercooled raindrops freeze on a surface. It is hard and either opaque or transparent. It can form a layer-like structure of opaque and transparent layers with small air bubbles inside the structure. Clear ice has no particular visible structure. It is compact, its density is high and its adhesion force is strong. Clear ice is formed when the temperature is low and wind velocity is high.

6.4.5 Glaze ice

Glaze ice is formed when supercooled raindrops fall on a surface and a waterfilm is formed before freezing. Its density is high as well as its adhesion, and it has no air bubbles.

6.4.6 Process of ice formation

The type of formation of ice depends on

– air temperature,
– wind velocity,
– diameter of supercooled water droplets,
– liquid water content.

The formation of ice on a cylinder-shaped surface depends on

– the radius of the cylinder,
– wind velocity,
– water drop size.