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Hygrothermal performance of buildings — Calculation and presentation of climatic data —

Part 3: Calculation of a driving rain index for vertical surfaces from hourly wind and rain data

Performance hygrothermique des bâtiments — Calcul et présentation des données climatiques —

Partie 3: Calcul d'un indice de pluie battante pour surfaces verticales à partir de données horaires de vent et de pluie

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Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 15927-3 was prepared by the European Committee for Standardization (CEN) Technical Committee CEN/TC 89, *Thermal performance of buildings and building components*, in collaboration with Technical Committee ISO/TC 163, *Thermal performance and energy use in the built environment*, Subcommittee SC 2, *Calculation methods*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

ISO 15927 consists of the following parts, under the general title *Hygrothermal performance of buildings — Calculation and presentation of climatic data*:

— *Part 1: Monthly means of single meteorological elements*

— *Part 2: Hourly data for design cooling load*

— *Part 3: Calculation of a driving rain index for vertical surfaces from hourly wind and rain data*

— *Part 4: Hourly data for assessing the annual energy use for heating and cooling*

— *Part 5: Data for design heat load for space heating*

— *Part 6: Accumulated temperature differences (degree-days)*

Introduction

This part of ISO 15927 specifies two procedures for analysing data derived from hourly observations of wind and rainfall so as to provide an estimate in terms of both an annual average and short-term spells of the quantity of water likely to impact on a wall of any given orientation.

The first method, which uses hourly observations of wind and rainfall, is based closely on BS 8104 [1], which originated from a long series of measurements of driving rain on buildings in a wide range of locations within the UK. As such, the method applies to climates similar to those in the UK; in other regions, with very different climates, it is recommended that confirmation of its applicability be obtained by measurements of driving rain on representative buildings.

Where hourly observations of wind and rain are not available, the second procedure, based on the present weather code for rain and average wind speeds can be used.

In all cases, especially in mountainous areas, it is important that direct measurements of the rain impacting on building façades be made wherever possible.

Rain penetration around the edges of doors and windows or similar cracks in building façades depends on shorter periods of heavy rain and strong winds.

Hygrothermal performance of buildings — Calculation and presentation of climatic data —

Part 3: Calculation of a driving rain index for vertical surfaces from hourly wind and rain data

1 Scope

This part of ISO 15927 specifies two procedures for providing an estimate of the quantity of water likely to impact on a wall of any given orientation. It takes account of topography, local sheltering and the type of building and wall.

The first method, given in Clause 3 and based on coincident hourly rainfall and wind data, defines a means of calculating

— the annual average index, which influences the moisture content of an absorbent surface, such as masonry, and

— the spell index, which influences the likelihood of rain penetration through masonry and joints in other walling systems.

The second method, given in Clause 4 and based on average wind data and a qualitative recording of the presence and intensity of rain (the present weather code for rain), defines a means of calculating the spell length during which an absorbent material such as masonry is moistened, which has a 10 % probability of being exceeded in any year (commonly referred to as having a mean return period of 10 years).

A comparison between the two methods is given in informative Annex D.

Procedures are given to correct the results of both methods for topography, local sheltering and the type of building and wall.

The methods included in this part of ISO 15927 do not apply in

a) mountainous areas with sheer cliffs or deep gorges,

b) areas in which more than 25 % of the annual rainfall comes from severe convective storms,

c) areas and periods when a significant proportion of precipitation is made up of snow or hail.

2 Terms, definitions, symbols and units

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

2.1 Definitions

2.1.1
spell
period, or sequence of periods, of wind-driven rain on a vertical surface of given orientation

NOTE Further information about spells is given in Annex B.

2.1.2
airfield hourly index
quantity of driving rain that would occur on a vertical wall of given orientation per square metre of wall during 1 h at a height of 10 m above ground level in the middle of an airfield, at the geographical location of the wall

2.1.3
airfield annual index
airfield index for a given wall orientation totalled over one year

2.1.4
airfield spell index
airfield index for a given wall orientation totalled over the worst spell likely to occur in any three-year period

2.1.5
wall annual index

quantity of wind-driven rain per square metre at a point on a wall of given orientation, based on the airfield annual index and corrections for roughness, topography, obstruction and wall factors

2.1.6

wall spell index
quantity of wind-driven rain per square metre at a point on a given wall, based on the airfield spell index and corrections for roughness, topography, obstruction and wall factors

2.1.7
line of sight
horizontal view away from the wall, over a sector spanning about 25° either side of the normal to the wall

2.1.8
terrain roughness category
classification of the surface roughness upwind in terms of the average height and spacing of obstructions such as buildings, trees or hedges

2.1.9
roughness coefficient
factor that allows for the modification of the wind speed by the roughness of the terrain upwind of a wall

2.1.10
topography coefficient
factor that allows for the effect of local topography on the wind speed

2.1.11
obstruction factor
factor that relates to shelter from the very local environment and allows for obstructions such as buildings, fences and trees close to, and upwind of, the wall

2.1.12
wall factor
ratio of the quantity of water hitting a wall to the quantity passing through an equivalent unobstructed space, allowing for the characteristics of the wall

2.1.13
wall orientation
angle between north and line normal to a wall

2.1.14
convective storm
heavy precipitation in the form of showers or thunderstorms generally lasting less than 1 h

2.1.15
reference spell
period during which a wall oriented in any given direction is moistened, having a 10 % probability of being exceeded in any year

2.1.16
present weather code
numerical code used by meteorological observers to assess the weather conditions at the time of an observation

NOTE Present weather codes are given in the WMO Guide [2].

2.1.17
half day
twelve-hour period including the hours from 07:00 to 18:00 or from 19:00 to 06:00

2.2 Symbols and units

Symbol	Quantity	Unit
C_R	roughness coefficient	—
C_T	topography coefficient	—
D	hourly mean wind direction from north	°
H	effective height of feature	m
I_A	airfield annual index	l/m^2
I_S	airfield spell index	l/m^2
I_{WA}	wall annual index	l/m^2
I_{WS}	wall spell index	l/m^2
K_R	terrain factor	—
L	length	m
N	number of years of available data	—
O	obstruction factor	—
r	hourly rainfall total	mm
v	hourly mean wind speed	m/s
W	wall factor	—
x	horizontal distance	m
z	height above ground	m
z_0	roughness length	m
z_{min}	minimum height	m
Θ	wall orientation relative to north	°

3 Calculation of airfield indices from hourly wind and rain data

3.1 Sources of data

Data used for calculations according to this part of ISO 15927 shall have been measured by the methods specified by the World Meteorological Organization (see WMO Guide [2]).

3.2 Airfield annual index

For any location with at least 10 (and preferably 20 or 30) years of hourly values of wind speed, wind direction and rainfall, the annual index for wall orientation, Θ, is given by Equation (1).

$$I_{\mathrm{A}} = \frac{2}{9} \frac{\sum v r^{8/9} \cos(D - \Theta)}{N} \tag{1}$$

where the summation is taken over all hours for which $\cos(D - \Theta)$ is positive, i.e. all those occasions when the wind is blowing against the wall.

As the wind speed during rainfall is not generally the same as in dry weather, calculating the product of hourly averages of wind and rainfall is not strictly accurate, especially in showery weather. It has been shown, however, that the error is small and, in any case, several years of data for periods shorter than 1 h are available from very few places. Taking the product of the averages over days or months does lead to serious inaccuracies and should not be used for calculating driving rain indices.

3.3 Airfield spell index

For any location with at least 10 (and preferably 20 or 30) years of hourly values of wind speed, wind direction and rainfall, for each wall orientation, Θ, and for each spell of driving rain (see Annex B), calculate I'_{S} using Equation (2).

$$I'_{\mathrm{S}} = \frac{2}{9} \sum v r^{8/9} \cos(D - \Theta) \tag{2}$$

where the summation is taken over all hours in the spell for which $\cos(D - \Theta)$ is positive, i.e. all those occasions when the wind is blowing against the wall.

The 67 % percentile (i.e. the value for which 33 % of the I'_{S} values are higher) is found from the values of I'_{S} for all the spells within the period of available data.

The 67 % percentile defines the spell index, I_{S} (i.e. the maximum value of I'_{S} likely to occur once every three years).

4 Estimation of the effect of driving rain from average wind and present weather code for rain

The available data are divided into twelve-hour periods (07:00 – 18:00 and 19:00 – 06:00) called half days.

A half day is defined as “moistening” if all of the following conditions apply.

a) There is more than 4 mm of precipitation on a horizontal surface in the half day.

b) The present weather code reports some precipitation for at least three of the five three-hourly observations during the half day (i.e. at 06:00, 09:00, 12:00, 15:00 and 18:00 and at 18:00, 21:00, 00:00, 03:00 and 06:00).

NOTE Present weather codes of 50 or above indicate some form of precipitation.

c) The average wind speed during the half day is greater than 2 m/s.

d) The average wind direction during the half day is within ± 60° of the perpendicular to the wall, i.e. $|D - \Theta| \leqslant 60$.

Under these conditions, it is assumed that a wall surface will be wetted by driving rain, with subsequent water migration into the wall by capillarity.

A half day is defined as “drying” if all of the following conditions apply.

— The average atmospheric relative humidity during the half day is less than 70 %.

— The average wind speed during the half day is greater than 2 m/s.

— The average wind direction during the half day is within ± 60° of the perpendicular to the wall, i.e. $|D - \Theta| \leqslant 60$.

Under these conditions, it is assumed that the wind and atmospheric humidity allow the evaporation of water at the wall surface.

All other atmospheric conditions are considered neutral. A moistening half day is given the value “+1”, a drying half day “–1” and a neutral half day “0”.

The successive values are added to give a cumulative time series, with the constraint that the total does not fall below zero; a maximum value, equal to the length in half days of the longest moistening spell in the year, is deduced for each year and each wall orientation.

The cumulative distribution of annual maximum, established from N_Y years of meteorological data, is then fitted by a Gumbel function[1]. This is used to obtain the reference spell, which is the maximum spell occurring once every 10 years for a given meteorological station and a given wall orientation.

5 Calculation of wall indices

5.1 General

The airfield indices calculated in Clause 3 are the amounts that would be collected by a free-standing driving-rain gauge in flat open country. They are converted into wall indices (i.e. the amounts of rain that would impact on a real wall) by multiplying by the terrain roughness coefficient, C_R, the topography coefficient, C_T, the obstruction factor, O, and the wall factor, W, as given in Equations (3) and (4).

$$I_{WA} = I_A C_R C_T O W \tag{3}$$

$$I_{WS} = I_S C_R C_T O W \tag{4}$$

These corrections can also be applied to the reference spell derived from the method defined in Clause 4.

1) The cumulative distribution of annual maximum is fitted by the Gumbel function

$$F(X) = \exp\left[-\exp\left(-\frac{X-a}{b}\right)\right]$$

where a is the mode and b the dispersion parameter. $F(X)$ is the probability of X not being exceeded during one year.