INTERNATIONAL STANDARD

ISO 15927-6

First edition
2007-09-01

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

Part 6: Accumulated temperature differences (degree days)

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

Partie 6: Différences accumulées de la température (en degrés par jour)

Reference number
ISO 15927-6:2007(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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.

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

ISO 15927-6 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

Accumulated temperature differences are a relatively simple form of climatic data, useful as an index of climate severity as it affects energy use for space heating.

Calculation or estimation of accumulated temperature differences in this part of ISO 15927 is based on the concept of a base temperature. The base temperature reflects the point at which buildings begin to need heating to maintain the required internal temperatures. This is the external temperature below which the heating plant is assumed to come into operation. For some purposes, such as development of energy policy, the need is for a single base temperature that can be taken to represent an average value for the whole built stock and overall climate. For other purposes, it is better to determine a base temperature appropriate to an individual building and time of year.

This part of ISO 15927 meets these needs by including both exact and approximate methods of determining accumulated temperature differences to both standard and variable base temperatures. Some methods include the possibility of a threshold temperature (e.g. a daily mean air temperature lower than the base temperature, above which accumulated temperature differences are not counted). This approach is found in certain national methods of computation. It is, however, not covered in this part of ISO 15927 because it is considered to be less flexible than the methods given, in which accumulated temperature differences are assessed for a base temperature appropriate to the thermal performance of the building (taking account of other climatic conditions such as solar irradiation).

Accumulated temperature differences computed and presented in accordance with this part of ISO 15927 are suitable for various purposes including the following:

a) providing an index of climatic severity as it affects energy use for space heating (the comparison use);

b) monitoring the amount of energy used by a heating plant, and thus its efficiency (the energy management use);

c) comparing the actual energy consumption for heating in a specific period with the consumption in a standardized period in order to determine the measured rating (the energy modelling use);

d) predicting the economic consequences of different levels of energy efficiency (e.g. through thermal insulation) for the building stock as a whole or for different classes of building (the energy policy use).

Energy management [list item b)] requires new accumulated temperature difference data at regular intervals, such as meteorological station data or data representative of a climatic region, calculated to standard base temperatures, published for each month of the heating season as soon as these can be computed from verified meteorological observations.

Comparison, energy modelling and energy policy [list items a), c) and d)] require meteorological station data, data representative of a climatic region or mapped data, collected over many years (possibly giving extremes as well as mean values), to typify the severity of the climate of a locality, area or region. For list item b), accumulated temperature differences are best suited to modelling the energy performance of relatively small buildings with simple heating systems and controls, using “steady-state” thermal analysis. Modelling the performance of larger or more complex buildings can require more extensive climatological data sets, such as full or short “test reference years” which are outside the scope of this part of ISO 15927.

In principle the equations in this part of ISO 15927 can be reversed to deal with accumulated temperature differences for assessing energy use in cooling or air-conditioning buildings (“cooling degree-hours” or “cooling degree-days”). However, as the air conditioning demand depends as much on solar gain and external humidity as temperature, the results are not a reliable index of energy demand.

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

Part 6: Accumulated temperature differences (degree days)

1 Scope

This part of ISO 15927 specifies the definition, method of computation and method of presentation of data on accumulated temperature differences, used for assessing the energy used for space heating in buildings. These are normally expressed in degree-hours or degree-days, and such data are often referred to simply as "heating degree-hours" or "heating degree-days".

This part of ISO 15927 includes approximate methods for calculating accumulated temperature differences based on hourly or daily mean temperatures and for estimating monthly values to any base temperature, for use when data computed directly from meteorological air temperature records are not available.

In some countries, a threshold temperature different from the base temperature is used. This part of ISO 15927 does not cover this.

2 Normative references

The following referenced documents are indispensable for the application 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.

ISO 6243, *Climatic data for building design — Proposed system of symbols*

WMO Guide to Meteorological Instruments and Methods of Observation, No. 8., 6th Edition, 1996[1)]

3 Terms, definitions, symbols and units

3.1 Terms and definitions

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

3.1.1
hourly temperature difference
difference between a specified base temperature and the external air temperature during a given hour when the difference is positive, otherwise zero

1) World Meterorological Organization: http://www.wmo.ch/pages/catalogue/New%20HTML/frame/engfil/8.html

3.1.2
daily temperature difference
difference between a specified base temperature and the mean external air temperature during a given day when the difference is positive, otherwise zero

3.1.3
accumulated hourly temperature difference
sum of all hourly temperature differences over a given period, e.g. day, month, season, year

3.1.4
accumulated daily temperature difference
sum of all daily temperature differences over a given period, e.g. day, month, season, year

3.1.5
base temperature
any conventional temperature, for instance the internal design temperature less decrements due to internal and solar gains

3.1.6
daily maximum and daily minimum temperatures
maximum and minimum external dry-bulb temperatures during a day, which may be taken either as the highest and lowest of the 24 hourly mean temperatures, recorded from 01:00 to 24:00, or as the recorded extremes on a maximum/minimum thermometer

3.1.7
hourly mean temperature
average of instantaneous external air temperatures during an hour or, in the absence of continuous measurements, the air temperature measured at a particular moment (e.g. on the hour)

3.1.8
daily mean temperature
average of the hourly mean temperatures over a day or, if that is not available, the arithmetic mean of the daily maximum and minimum temperatures

NOTE See 4.6.

3.1.9
monthly mean temperature
long-term average of daily mean temperatures for a particular month (e.g. over a period of at least 10 years)

3.1.10
standard deviation of hourly mean temperature
standard deviation of hourly mean temperatures about the monthly mean temperature, based on long-term data

3.1.11
standard deviation of daily mean temperature
standard deviation of daily mean temperatures about the monthly mean temperature, based on long-term data

3.1.12
reference altitude
altitude above mean sea level to which accumulated hourly or daily temperature difference data refer

3.1.13
lapse rate of temperature
rate at which monthly mean temperature falls with increasing altitude

3.2 Symbols and units

Symbol	Quantity	Unit
$\theta_{\Sigma h}$	accumulated hourly temperature difference	K·h
$\theta_{\Sigma h(d)}$	accumulated hourly temperature difference expressed in degree-days	K·d
$\theta_{\Sigma d}$	accumulated daily temperature difference	K·d
L	lapse of temperature with altitude	K/m
N_M	number of days in a month	—
S_d	standard deviation of daily mean temperature about the monthly mean	K
S_h	standard deviation of hourly mean temperature about the monthly mean	K
z	altitude above reference level	m
$\Delta\theta_h$	hourly temperature difference	K
$\Delta\theta_d$	daily temperature difference	K
N_d	number of days in any period	—
N_h	number of hours in any period	—
θ_b	base temperature	°C
θ_{dx}	daily maximum temperature	°C
θ_{dn}	daily minimum temperature	°C
θ_{dm}	daily mean temperature	°C
θ_{hm}	hourly mean temperature	°C
θ_{Mm}	monthly mean temperature	°C

4 Direct calculation of accumulated temperature differences

4.1 General

The methods of calculation in 4.4 and 4.5 shall be used when accumulated temperature difference values can be derived directly from hourly or daily temperature data for a specified base temperature. They apply when the values are calculated to standard base temperatures and may be used in some cases for non-standard base temperatures.

Accumulated hourly temperature differences shall be calculated according to 4.4 when hourly data are available. When hourly data are not available, the approximate method given in 4.5, based on the maximum and minimum temperatures each day, may be used.

Accumulated daily temperature differences shall be calculated according to 4.6.

4.2 Sources of data

The temperatures used to calculate accumulated temperature difference values shall have been measured by the methods specified in *WMO Guide No.8.*

4.3 Standard base temperatures

The recommended standard base temperature is 12 °C.

Data may also be provided at other integer base temperatures.

NOTE Multiples of 2 °C, e.g. 10 °C, 12 °C, 14 °C, 16 °C, 18 °C, 20 °C are preferred.

4.4 Calculation of hourly temperature differences and accumulated hourly temperature differences

4.4.1 Calculation of hourly temperature differences

Hourly temperature differences, θ_{hm}, are calculated for each hour in the accumulation period using Equation (1) when $\theta_{hm} < \theta_b$, or Equation (2) when $\theta_{hm} \geqslant \theta_b$:

$$\Delta\theta_h(\theta_b) = (\theta_b - \theta_{hm}) \tag{1}$$

$$\Delta\theta_h(\theta_b) = 0 \tag{2}$$

4.4.2 Calculation of accumulated hourly temperature differences

The accumulated hourly temperature difference, $\theta_{\Sigma h}$, for a period of n hours is computed as the sum of the $\Delta\theta_h$ values for individual hours within the period under consideration as given in Equation (3):

$$\theta_{\Sigma h}\left(\theta_b\right) = \sum_{h=1}^{n} \Delta\theta_h(\theta_b) \tag{3}$$

The accumulated hourly temperature difference, $\theta_{\Sigma h(d)}\left(\theta_b\right)$, may be expressed in degree-days as given in Equation (4):

$$\theta_{\Sigma h(d)}\left(\theta_b\right) = \theta_{\Sigma h}\left(\theta_b\right)/24 \tag{4}$$

NOTE Monthly, seasonal and annual values are commonly computed.

4.5 Estimation of accumulated hourly temperature differences from daily maximum and minimum temperatures

4.5.1 Calculation of daily temperature differences

The daily temperature differences, $\Delta\theta_d(\theta_b)$, for each day in the accumulation period are calculated as follows:

a) when θ_{dx} is less than θ_b, as given in Equation (5) and shown in Figure 1:

$$\Delta\theta_d(\theta_b) = \theta_b - [0,5\ (\theta_{dx} + \theta_{dn})] \tag{5}$$

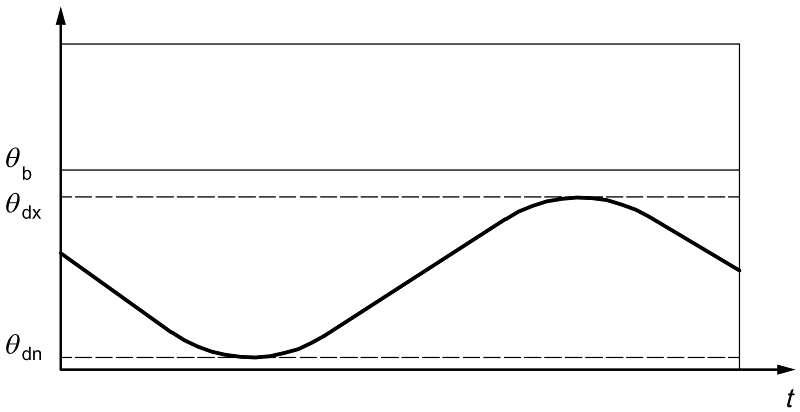


Figure 1 — $\theta_{dx} < \theta_b$

b) when θ_{dx} is greater than θ_b, but $(\theta_{dx} - \theta_b) < (\theta_b - \theta_{dn})$, as given in Equation (6) and shown in Figure 2:

$$\Delta\theta_d(\theta_b) = [0{,}5\ (\theta_b - \theta_{dn}) - 0{,}25\ (\theta_{dx} - \theta_b)] \qquad (6)$$

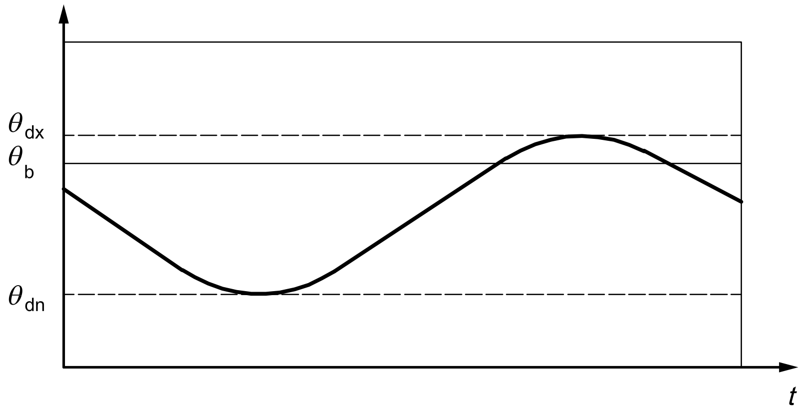


Figure 2 — $(\theta_{dx} - \theta_b) < (\theta_b - \theta_{dn})$

c) when θ_{dn} is less than θ_b, but $(\theta_{dx} - \theta_b) > (\theta_b - \theta_{dn})$, as given in Equation (7) and shown in Figure 3:

$$\Delta\theta_d(\theta_b) = [0{,}25\ (\theta_b - \theta_{dn})] \qquad (7)$$

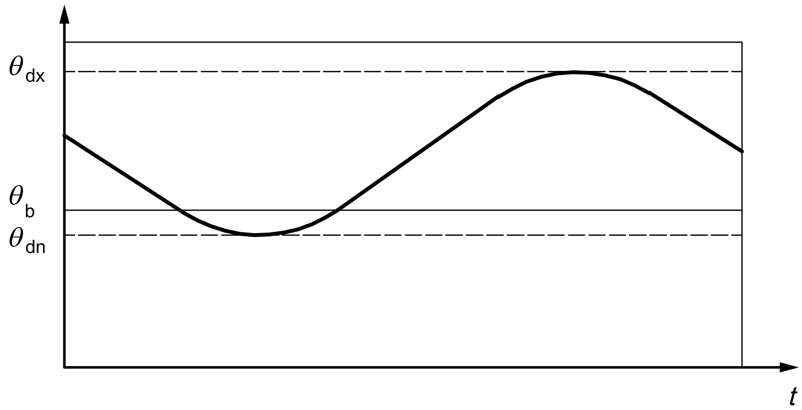


Figure 3 — $(\theta_{dx} - \theta_b) > (\theta_b - \theta_{dn})$

d) when θ_{dn} is equal to or greater than θ_b, as given in Equation (8):

$$\Delta\theta_d(\theta_b) = 0 \qquad (8)$$

4.5.2 Calculation of estimated degree-days

The estimated accumulated degree-days, $\theta_{\Sigma h(d)}$, for a period of n days is computed as the sum of $\Delta\theta_d$ values for individual days within the period under consideration as given in Equation (9):

$$\theta_{\Sigma h(d)}(\theta_b) = \sum_{d=1}^{n} \Delta\theta_d(\theta_b) \qquad (9)$$

NOTE Monthly, seasonal and annual totals are commonly computed.

4.6 Calculation of accumulated daily temperature differences

4.6.1 Calculation of daily temperature differences

The value, $\Delta\theta_d(\theta_b)$ for each day in the accumulation period is calculated according to Equation (10) when $\theta_{dm} < \theta_b$ or to Equation (11) when $\theta_{dm} \geqslant \theta_b$:

$$\Delta\theta_d(\theta_b) = (\theta_b - \theta_{dm}) \tag{10}$$

$$\Delta\theta_d(\theta_b) = 0 \tag{11}$$

The daily mean temperature, θ_{dm}, shall be calculated as given by Equation (12) where hourly data are available, otherwise by approved and acknowledged methods, for example from

— data measured at intervals of 3 h or 6 h,

— from daily maximum and minimum data as given by Equation (13),

— from instantaneous data at 07:30, 14:30 and 21:30 or at other similar times.

ISO 15927-1:2003 [1], 5.2.1 to 5.2.4, gives standardized methods for the calculation of daily mean temperatures as given by Equations (12) and (13):

$$\theta_{dm} = \sum_{h=1}^{24} \theta_{hm} / 24 \tag{12}$$

$$\theta_{dm} = \left(\theta_{dx} + \theta_{dn}\right)/2 \tag{13}$$

4.6.2 Calculation of accumulated daily temperature differences

The accumulated daily temperature difference, $\theta_{\Sigma d}$, for a period of n days is computed as the sum of $\Delta\theta_d$ values for individual days within the period under consideration as given by Equation (14):

$$\theta_{\Sigma d}\left(\theta_b\right) = \sum_{d=1}^{n} \Delta\theta_d\left(\theta_b\right) \tag{14}$$

NOTE Monthly, seasonal and annual totals are commonly computed.

5 Estimation of totals

5.1 Estimation of accumulated temperature differences to various base temperatures

It is often necessary to determine accumulated hourly or daily temperature difference totals to non-standard base temperatures, when full source data (hourly or daily time series of air temperature) are not available for direct calculation. Depending on the data available, there are two possible methods:

— interpolation between directly calculated $\theta_{\Sigma h}$ or $\theta_{\Sigma d}$ values, when these have been calculated to two base temperatures for the same period;

— when $\theta_{\Sigma h}$ or $\theta_{\Sigma d}$ values have been computed to only one base temperature, or when directly computed $\theta_{\Sigma h}$ or $\theta_{\Sigma d}$ values are not available, monthly $\theta_{\Sigma h}$ or $\theta_{\Sigma d}$ values can be estimated from climatological statistics on air temperature and its variability.

5.2 Interpolation

When $\theta_{\Sigma h}$ or $\theta_{\Sigma d}$ values have been computed, in accordance with Clause 4, to standard base temperatures separated by no more than 4 °C, linear interpolation may be used to estimate $\theta_{\Sigma h}$ or $\theta_{\Sigma d}$ values to any intermediate whole-number or fractional base temperature. For example, $\theta_{\Sigma d}$ values for a base temperature of 13,5 °C may be interpolated from computed values for base temperatures of 12 °C and 14 °C.

5.3 Estimation from climatological statistics

If neither hourly mean nor daily mean temperatures are available, estimated $\theta_{\Sigma h}$ and $\theta_{\Sigma d}$ values for monthly accumulation periods may be derived from climatological statistics using Equation (15) for degree-hours and Equation (16) for degree-days.

$$\theta_{\Sigma h}\left(\theta_{b}\right)=\frac{24N_{M}\left(\theta_{b}-\theta_{Mm}\right)}{1-\exp\left(-\sqrt{2\pi}\left(\theta_{b}-\theta_{Mm}\right)/S_{h}\right)} \tag{15}$$

$$\theta_{\Sigma d}\left(\theta_{b}\right)=\frac{N_{M}\left(\theta_{b}-\theta_{Mm}\right)}{1-\exp\left(-\sqrt{2\pi}\left(\theta_{b}-\theta_{Mm}\right)/S_{d}\right)} \tag{16}$$

Equations (15) and (16) are valid only for monthly accumulation periods. Annual totals shall be obtained as the sum of 12 monthly totals.

NOTE 1 If $\theta_{b}=\theta_{Mm}$, Equations (15) and (16) become 24 $N_{M}\ S_{h}/\sqrt{2\pi}$ and $N_{M}\ S_{d}/\sqrt{2\pi}$, respectively.

NOTE 2 Monthly temperature data tabulated in accordance with ISO 15927-1 [1] include θ_{Mm} and S_{d}. Annex A gives a method for estimating S_{d} and S_{h} from monthly degree-days or degree-hours, which can be used when the basic data are not available.

6 Reference altitude

All accumulated temperature difference data relate to a reference altitude. This may be either

a) the altitude of the location, e.g. a meteorological station, at which the original air temperature data were recorded,

b) a generalized altitude for accumulated temperature difference data applying to an area or region, which may be mean sea level, or

c) the actual altitudes over an area of land, in the case of accumulated temperature difference isopleths on maps.

A correction is needed to estimate accumulated temperature difference values at altitudes other than that at which the original air temperature data were recorded. This factor (the “lapse rate” for $\theta_{\Sigma h}$ and $\theta_{\Sigma d}\Sigma_{d}$) shall be determined from monthly means of local meteorological records. For each month of the year, the lapse rate, L, shall be determined from records of stations at different altitudes, z, above some reference altitude, z_0, which is usually sea level, using Equation (17).

$$L=[\theta_{Mm}(z_0)-\theta_{Mm}(z)]/(z-z_0) \tag{17}$$

This lapse rate is then used to correct the temperatures used to calculate the parameters described in Clauses 4 and 5.

7 Accuracy and presentation of data

7.1 Information to be given with all accumulated temperature difference data

The following information shall be given:

— unit of measurement (K·h or K·d);

— base temperature;

— except for isopleths on maps, the reference altitude in metres above mean sea level.

7.2 Correction for altitude

Where an altitude correction has been applied in preparing data, the presentation shall include the statement "Values corrected to mean sea level" or "Values corrected to a reference altitude of x m", as appropriate.

Where data need to be converted by the user from a reference altitude, the correction factor shall be stated, e.g. as a change in monthly or annual $\theta_{\Sigma\mathrm{h}}$ and $\theta_{\Sigma\mathrm{d}}$ values for each 100 m change in altitude.

7.3 Other information to be given as appropriate

7.3.1 Data for the period immediately preceding

This shall be presented in tabular form, stating for each locality, area or region the $\theta_{\Sigma\mathrm{h}}$ and $\theta_{\Sigma\mathrm{d}}$ values for the period concerned, together with a stated long-term mean value for the same period of the year (where available).

7.3.2 Statistical data for long periods

Statistical data, such as means, extremes and measures of variability of $\theta_{\Sigma\mathrm{h}}$ and $\theta_{\Sigma\mathrm{d}}$, shall, where possible, be based on measurements recorded over a continuous period of at least 20 years; in all cases the period shall be stated. One or more of the following totals shall be given:

— annual totals;

— seasonal totals (the assumed heating season being stated);

— monthly totals.

The data may be presented either as tables or on maps.

Totals represented as isopleths ("contours") on maps shall be rounded to the following increments:

a) Map scales 1:500 000 or smaller

  — Annual or seasonal totals: multiples of 2 000 K·h or 200 K·d;

  — Monthly totals: multiples of 500 K·h or 50 K·d.

b) Map scales larger than 1:500 000

  — Annual or seasonal totals: multiples of 2 000 K·h or 200 K·d;

  — Monthly totals: multiples of 200 K·h or 20 K·d.

7.3.3 Data representing a geographical area or region

Data intended to apply to an area or region can be either

— the $\theta_{\Sigma h}$ and $\theta_{\Sigma d}$ values for a single meteorological station, deemed to typify the climate of the area or region;

— the average of the $\theta_{\Sigma h}$ and $\theta_{\Sigma d}$ values for several representative meteorological stations, stated together with an appropriate altitude.

Annex A
(informative)

Estimation of monthly accumulated temperature differences from climatological statistics

The method for estimating daily accumulated temperature differences given in 5.3 is based on that proposed by Hitchin [2].

A graphical representation is shown in Figure A.1. $\theta_{\Sigma d}(\theta_b)$ is obtained by multiplying the value on the ordinate by the number of days in the period.

In most cases the value of S is unknown, although the values of θ_{Mm} and $\theta_{\Sigma d}$ for a standard base temperature, $\theta_{b,std}$, are readily available from weather bureau publications. An estimate of S can be obtained by plotting pairs of $\theta_{\Sigma d}$ $(\theta_{b,std})$ and $\theta_{b,std} - \theta_{Mm}$ in Figure A.1.

An example of the procedure is shown in Table A.2 for New York, USA. $\theta_{\Sigma d}$ values computed directly from a TRY weather tape using $\theta_b = 18{,}3$ °C are compared with those calculated using the method in 5.3 with average daily temperatures from the TRY weather tape and the standard deviation estimated to be 3 °C (see Table A.2).

Similar results were obtained for other American and British cities. It appears that the Hitchin [2] method provides a good estimate of $\theta_{\Sigma d}$ at other base temperatures on a monthly basis. This result is probably due to the fact that θ_{Mm} is a good estimate of the monthly temperature and S is relatively small on a monthly basis.

Table A.1 — Values of $\theta_{\Sigma d} \cdot (\theta_b)/N$ as a function of $\theta_b - \theta_{Mm}$ and the standard deviation

Values in degrees Celsius

$\theta_b - \theta_{Mm}$	**Standard deviation** S					
	0	2	4	6	8	10
− 10	0	0	0,02	0,16	0,46	0,89
− 8	0	0	0,05	0,29	0,71	1,24
− 6	0	0	0,14	0,53	1,08	1,71
− 4	0	0,03	0,36	0,93	1,6	2,32
− 2	0	0,18	0,8	1,53	2,3	3,07
0	0	0,8	1,6	2,39	3,19	3,99
2	2	2,18	2,8	3,53	4,3	5,07
4	4	4,03	4,36	4,93	5,6	6,32
6	6	6	6,14	6,53	7,08	7,71
8	8	8	8,05	8,29	8,71	9,24
10	10	10	10,02	10,16	10,46	10,89

Table A.2 — Actual versus estimated values of accumulated temperature difference for New York, USA (actual based on TRY weather data)

Values in Kelvin hours

Month	θ_b = 7,22 °C		θ_b = 12,78 °C		θ_b = 18,33 °C	
	TRY	**Hitchin[2]**	**TRY**	**Hitchin[2]**	**TRY**	**Hitchin[2]**
1	7,11	7,11	12,64	12,64	18,2	18,2
2	6,58	6,6	12,13	12,13	17,69	17,69
3	3,27	2,8	8,08	8	13,55	13,55
4	0,49	0,17	3,13	2,33	7,59	7,4
5	0	0	0,22	0,17	2,32	2,32
6	0	0	0	0	0,07	0,21
7	0	0	0	0	0,04	0,03
8	0	0	0	0	0	0,06
9	0	0	0	0,02	0,59	0,52
10	0,02	0,02	0,81	0,55	4,1	4,05
11	1,26	0,68	4,9	4,42	9,87	9,85
12	5,22	5,21	10,7	10,7	16,25	16,25

If the data indicate $S = 0$ °C, Σ_d can be estimated simply as given in Equation (A.1):

$$\theta_{\Sigma d} = N\,(\theta_b - \theta_{Mm}) \text{ if } (\theta_b - \theta_{Mm}) > 0 \quad \text{(A.1)}$$

If S is not equal to 0, however, errors caused by Equation (A.1) can be large, especially when θ_b is less than or equal to θ_{Mm}. This is because there are many days when the daily average temperature falls below θ_b in spite of the fact that the average temperature for the period indicates otherwise.

In summary, if $\theta_{\Sigma d}$ values to various base temperatures are not available, an estimate can be obtained using Equation (A.1) provided that the average outdoor temperature for the period of interest and the standard deviations of daily average temperature are known. Average temperatures are usually readily available, but the availability of the standard deviation data is less likely. An estimate of the standard deviation of the periods of interest can be made as follows.

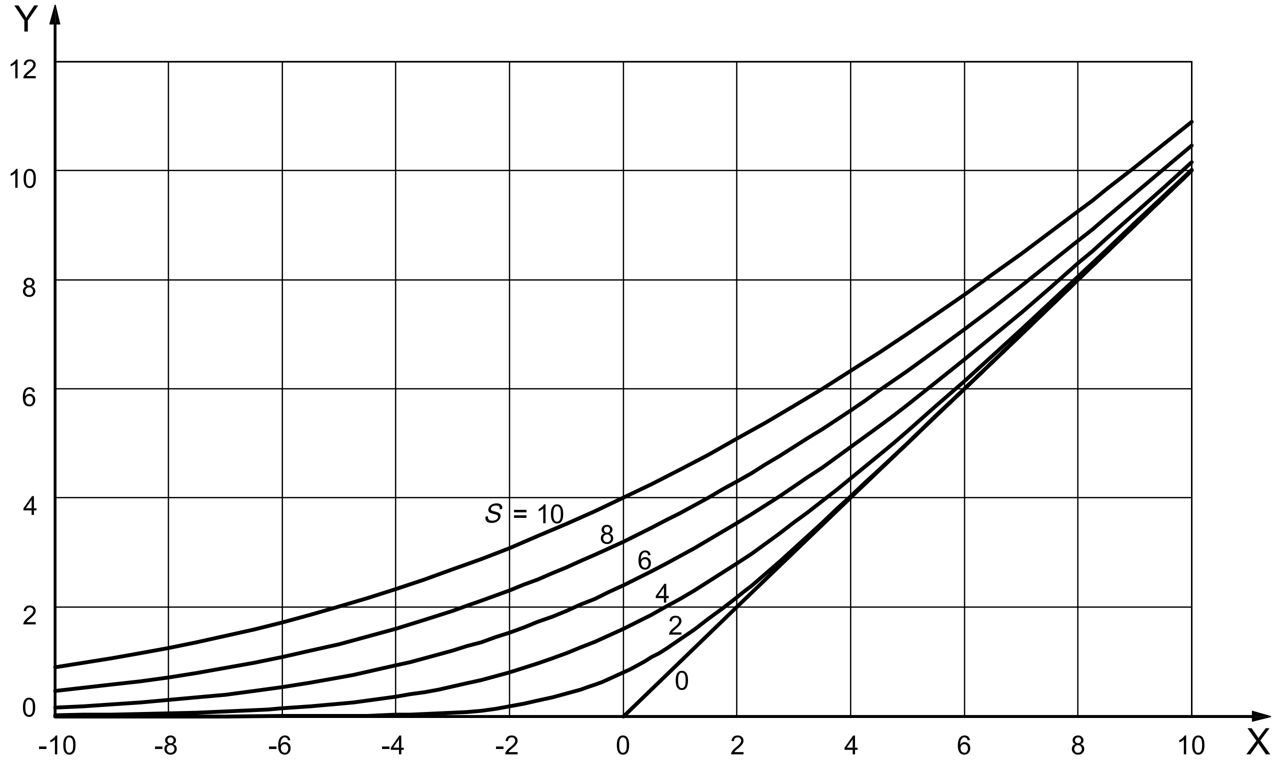
a) Obtain average temperature and $\theta_{\Sigma d}$ data for a known base temperature for each month of the year.

b) Plot these data on the generalized $\theta_{\Sigma d}$ presentation shown in Figure A.1.

c) Select the standard deviation, S, which correlates best with the data.

d) Calculate the constant, k.

e) Calculate $\theta_{\Sigma d}$ at the desired base temperature using Equation (A.1), Table A.1 or the graphical representation shown in Figure A.1.



Key

X $\theta_b - \theta_{Mm}$, expressed in degrees Celsius

Y $\theta_{\Sigma d} / N$

Figure A.1 — Generalized $\theta_{\Sigma d}$ relationship with respect to the base temperature, average temperature and standard deviation

Bibliography

[1] ISO 15927-1:2003, *Hygrothermal performance of buildings — Calculation and presentation of climatic data — Part 1: Monthly means of single meteorological elements*

[2] HITCHIN, E.R. Estimated Monthly Degree-Days, *Building Services Engineering Research and Technology*, Vol. 4, No. 4, pp. 159-162, 1983

ICS 07.060; 91.120.10

Price based on 13 pages