BRITISH STANDARD

BS ISO 12819:2009

Methods of evaluation of the battery life of a battery-powered watch

ICS 39.040.10

British Standards

National foreword

This British Standard is the UK implementation of ISO 12819:2009. It supersedes BS ISO 12819:1999 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee STI/53, Specifications and test methods for jewellery and horology.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Methods of evaluation of the battery life of a battery-powered watch

Méthodes d'évaluation de l'autonomie de fonctionnement d'une montre à pile

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Foreword

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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.

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 12819 was prepared by Technical Committee ISO/TC 114, *Horology*.

This second edition cancels and replaces the first edition (ISO 12819:1999) and Technical Corrigendum ISO 12819:1999/Cor.1:1999, which have been technically revised.

Methods of evaluation of the battery life of a battery-powered watch

1 Scope

This International Standard specifies two methods for determining the battery life of a battery-powered watch and specifies the labelling to be used by the manufacturers or the distributors to inform the users.

According to the available information, either the theoretical battery life or the practical battery life must be calculated using the equations given in this International Standard.

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 6426-2, *Horological vocabulary — Part 2: Technical and commercial definitions*

IEC 60086-3, *Primary batteries — Part 3: Watch batteries*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 6426-2 and the following apply.

3.1
battery life
operating duration of a battery-powered watch, as determined by the characteristics of the battery and the movement

NOTE The battery life starts when the battery is inserted and starts powering the movement of the watch and lasts until the point when the voltage falls below the level required for operation and the watch stops.

3.2
practical battery life
AP
calculation of the battery life, taking in account the self-discharge current of the battery during storage and operation

3.3
theoretical battery life
AT
calculation of the battery life assuming an ideal battery with no self-discharge of current

4 General

4.1 Parameters

The following parameters influence the calculation:

- the type of battery used;
- the type of movement used;
- the operating and environmental conditions.

4.2 Types of battery life

This International Standard considers two types of battery life, the practical battery life and the theoretical battery life.

4.3 Operating mode

The operating mode may be normal or economic. Some watches have a device that permits the reduction of the power consumption during storage. The operating modes shall be described on the documents supplied with the watch.

4.4 Environmental conditions

The values below are valid for normal environmental conditions as follows:

- a temperature of (28 ± 2) °C;
- a relative humidity of (50 ± 10) %.

5 Current consumption of a watch

5.1 Mean current consumed (I_m)

The mean current, I_m, is the average of currents consumed by the oscillator and the display of time of day function(s) excluding all additional functions. The mean current is expressed in microamperes (µA).

For a movement with an analogical display, the consumption shall be measured over a large number of pulses of the motor.

For a movement with a digital display, the consumption shall be measured when a mean number of digits is operating.

5.2 Capacity of the battery (C)

The capacity of the battery used to determine the battery life of a watch shall conform to the value specified by the manufacturer of batteries and controlled by the watch manufacturer, in accordance with IEC 60086-3. The capacity, C, is expressed in milliampere hours (mAh).

5.3 Self-discharge currents (I_{as}, I_{ad})

5.3.1 Self-discharge current in storage (I_{as})

When a battery is stored, it sustains an annual loss which affects capacity. Loss of capacity depends on the type of battery and the storage temperature and humidity. It is equivalent to the mean self-discharge current in storage, I_{as}, expressed in microamperes according to Equation (1):

$$I_{as} = \frac{\Delta C_s}{8,76} \quad (1)$$

NOTE The value 8,76 is the ratio between the number of hours in the year (8 760) and the conversion rate from milliamperes to microamperes (1 000).

The value ΔC_s is usually supplied by the battery manufacturer. In the case of lack of information, the values given in Annex A shall be used. ΔC_s is expressed in milliampere hours (mAh).

5.3.2 Self-discharge current in use (I_{ad})

When the same battery discharges, the average self-discharge current, I_{ad}, expressed in microamperes, may be different. It is determined by Equation (2):

$$I_{ad} = K \cdot I_{as} \quad (2)$$

NOTE The value K depends on the type and size of the battery as well as the operating conditions (e.g. temperature).

The value K is usually supplied by the battery manufacturer. In the case of lack of information, the values given in Annex A shall be used.

5.4 Current consumption of additional functions (I_f)

The mean current, I_f, consumed over a day by an additional function is calculated by Equation (3):

$$I_f = \frac{i_f \cdot t}{86\ 400} \quad (3)$$

where

I_f is the mean current expressed in microamperes (µA);

i_f is the additional current consumption due to the function, expressed in microamperes (µA);

t is the time of use of the function in one day, expressed in seconds (s).

The usual values of t for additional functions used for the determination of I_f are those, expressed in seconds, that are usually mentioned in the user's instructions for each product. In the absence of these values, in most cases the values given in Table A.1 are conventionally selected.

NOTE The values are approximate and may change over a wide range from one user to another. They are of interest only for comparison between products.

6 Calculation of battery life

6.1 Practical battery life (AP): method I

The practical battery life, AP, expressed in years, is determined by Equation (4), based on a linear decrease of the battery capacity:

$$AP = \frac{C - (n \cdot \Delta C_\text{s})}{8{,}76\left(I_\text{m} + I_\text{ad} + \sum I_\text{f}\right)} \tag{4}$$

where n is the storage duration of the battery, expressed in years, from its manufacture until it is placed in the watch.

For comparison between products, the watch manufacturer shall use, at his own discretion, the values n = 1 or n = 0,5.

For the battery life indication, the watch manufacturer shall take into consideration the intrinsic battery life, of which indicative values are given in B.3.

Another method of calculation for the practical battery life (method II) is described in B.4.

6.2 Theoretical battery life (AT)

The theoretical battery life, AT, expressed in years, is determined by Equation (5):

$$AT = \frac{C}{8{,}76\left(I_\text{m} + \sum I_\text{f}\right)} \tag{5}$$

7 Labelling

The indication of the practical, AP, or of the theoretical, AT, battery life of a watch shall be expressed in years and, if necessary, this value shall be rounded to the half year immediately below the calculated value. However, if this value is below 2 years, it shall be expressed in months.

The following wording shall be used in the documents supplied with the watch:

> *"The practical (or theoretical) battery life of this watch, determined in accordance with the method specified in ISO 12819, with a (producer, capacity) battery, reference ....., is ... years (or months)."*

Annex A
(normative)

Self-discharge currents

A.1 General

The following numerical values for calculating factors ΔC_S and K (see 5.3) shall be used when information is not supplied by the battery manufacturer.

A.2 Values for ΔC_S

$\Delta C_S = 0{,}05C$ for silver oxide batteries;

$\Delta C_S = 0{,}02C$ for lithium batteries;

where C is the nominal capacity of the battery.

The factors 0,05 and 0,02 express the agreed yearly loss of capacity according to the type of battery.

A.3 Values for K

$K = 1$ for an unworn watch or one that is stored at a temperature < 23 °C;

$K = 2$ for a worn watch, i.e. one that is subjected to temperatures between 28 °C and 30 °C.

A.4 Daily use of the additional functions; agreed values

Table A.1 — Agreed values

Function	Daily use t s
A) Display lighting	20
B) Alarm strike	20
C) Hour strike	12
D) Timer strike	20
E) Function strike	12
F) Chronograph	3 600
G) Calculator	1 800
H) Electronic hand-setting (alarm or time zone)	20

Annex B
(normative)

Practical battery life (AP)

B.1 Intrinsic lifetime of a battery

Battery technology is constantly being developed. The current reference values are as follows:

a) silver oxide batteries:

— of height $\leqslant$ 2,15 mm: 3 years;

— of height $>$ 2,15 mm: 4 years;

b) lithium batteries: 5 years to 10 years.

NOTE The use of higher intrinsic lifetime values is made at the discretion of the watch manufacturer.

B.2 Statistical determination of the practical battery life (AP)

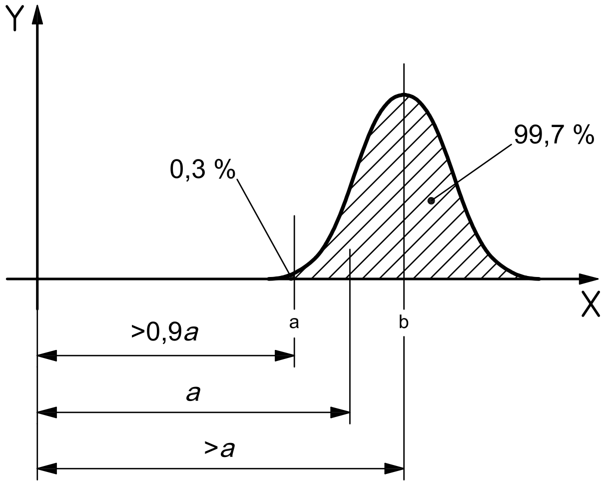
For the determination of the practical battery life, AP, its statistical distribution should be considered.

When the mean value of battery life is over "a" year, and the minimum battery life is higher than "0,9a", then the practical battery life to consider is "a" year.

$AP_{\text{mean}} \geqslant a$ AP_{mean} : mean of battery life

$AP_{\text{min}} \geqslant 0{,}9a$ AP_{min} : minimum battery life

The practical battery life is distributed according to a normal distribution, and the minimum battery life, AP_{min}, is $AP_{99,7}$ where $AP_{99,7}$ means practical battery life in which 99,7% of watches will work.



Key

X practical battery life

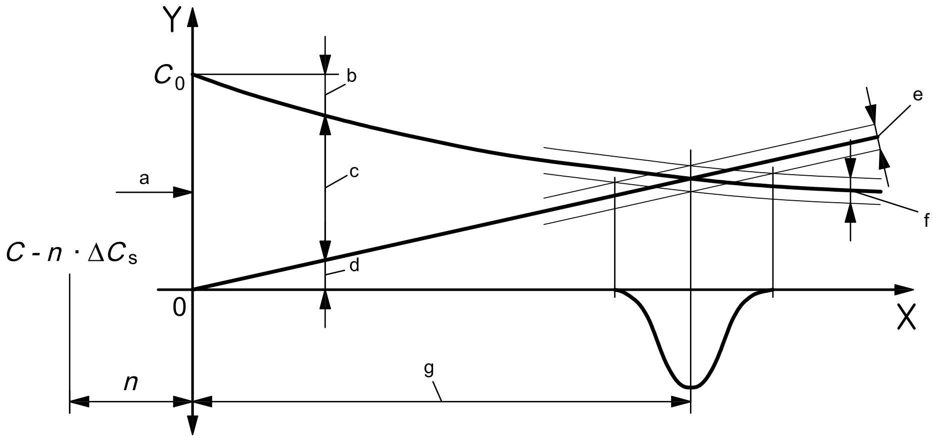
Y frequency

[a] AP_{min}.

[b] AP_{mean}.

Figure B.1 — Determination of practical battery life, AP, and distribution — Relation between a and AP_{mean}

B.3 Practical battery life (AP) Method I



Key

X time

Y capacity

[a] Storage.

[b] Self-discharge.

[c] $C_{available}$.

[d] C_{used}.

[e] Consumption and distribution.

[f] Capacity of the battery and distribution.

[g] AP_{mean}.

Figure B.2 — Relation between practical battery life, AP, and capacity, C, of the battery

When the self-discharge is constant, the decrease of the battery's capacity is also constant.

Considering this assumption, Equation (B.1) is used:

$$AP = \frac{C - \left(n \cdot \Delta C_{\mathrm{s}}\right)}{8{,}76\left(I_{\mathrm{m}} + I_{\mathrm{ad}} + \sum I_{\mathrm{f}}\right)} \tag{B.1}$$

where

I_{m} is the mean current consumed by the movement;

I_{ad} is the self-discharge current in use;

I_{f} is the current consumption of additional functions.

B.4 Practical battery life (AP) Method II

When the self-discharge is proportional (by fixed rate) to the remaining capacity, Equations (B.2) and (B.3) should be considered for the determination of the practical battery life, AP:

$$AP = \frac{1}{\beta}\ln\left[\frac{\beta\left(C - 0{,}5 \cdot \Delta C_{\mathrm{s}}\right)}{8{,}76\left(I_{\mathrm{m}} + \sum I_{\mathrm{f}}\right)} + 1\right] \tag{B.2}$$

$$\beta = -\frac{\ln\left(1 - \alpha\right)}{n'} \tag{B.3}$$

where

n' is the time, expressed in years;

β is the proportional factor of self-discharge;

α is the mean rate of self-discharge over n' years.

Equation (B.2) for the determination of the practical battery life, AP, is prepared by the following process.

The ratio between capacity reduction and time ($\mathrm{d}c/\mathrm{d}t$) is expressed as addition of “self-discharge that is proportionate to the remaining capacity, C” and “consumption current I ($I_{\mathrm{m}} + \sum I_{\mathrm{f}}$)”.

Therefore, when β is the ratio for self-discharge,

$$\frac{\mathrm{d}c}{\mathrm{d}t} = -\left(\beta C + I\right) \tag{B.4}$$

When transformed

$$\mathrm{d}t = \frac{-1}{\beta C + I}\mathrm{d}c$$

and integrated

$$t = -\frac{1}{\beta}\ln\left(\beta C + I\right) + C'$$

When $t = 0$, put C_0 for C, then:

$$C' = \frac{1}{\beta}\ln\left(\beta C_0 + I\right)$$

therefore

$$t = -\frac{1}{\beta}\ln\left(\beta C + I\right) + \frac{1}{\beta}\ln\left(\beta C_0 + I\right)$$

$$t = \frac{1}{\beta}\ln\left(\frac{\beta C_0 + I}{\beta C + I}\right)$$

When $C = 0$, t is expressed as below:

$$t = \frac{1}{\beta}\ln\left(\frac{\beta C_0}{I} + 1\right)$$

To define the practical battery life, AP:

$C_0 = \dfrac{C - 0{,}5 \cdot \Delta C_s}{8{,}76}$: capacity of the battery after 0,5 year storage.

NOTE The value 8,76 is the ratio between the number of hours in the year (8 760) and the conversion rate from milliamperes to microamperes (1 000).

$I = \left(I_m + \sum I_f\right)$: mean current of movement, I_m, + current consumption of additional functions, I_f

then Equation (B.2) becomes

$$AP = \frac{1}{\beta}\ln\left[\frac{\beta\left(C - 0{,}5 \cdot \Delta C_s\right)}{8{,}76\left(I_m + \sum I_f\right)} + 1\right]$$

Thus, β is the proportional factor of self-discharge,

$$\beta = -\frac{\ln\left(1 - \alpha\right)}{n'} \tag{B.3}$$

where α is the mean value of self-discharge in n' years.

Equation (B.3) is then as given below:

in the equation $\dfrac{\mathrm{d}c}{\mathrm{d}t} = -\left(\beta C + I\right)$, put consumption current $I = 0$, (B.4)

then $\dfrac{\mathrm{d}c}{\mathrm{d}t} = -\beta C$

and integrate to $C = C_0 \cdot e^{-\beta \cdot t}$

Replace C by C_t after t years,

$$\frac{C_t}{C_0} = e^{-\beta \cdot t}$$

transform:

$$\beta = -\frac{\ln(C_t / C_0)}{t}$$

put:

$$\frac{C_t}{C_0} = 1 - \alpha \text{ , } t = n'$$

then $\beta = -\dfrac{\ln(1 - \alpha)}{n'}$ (B.3)

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