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## Horology — Procedure for evaluating the accuracy of quartz watches

*Horlogerie — Procédure d'évaluation de la précision des montres à  
quartz*

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## 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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 114, *Horology*, Subcommittee SC 11, *Indication of accuracy*.

This second edition cancels and replaces the first edition (ISO 10553:2003), which has been technically revised with the following changes:

- Addition of ISO 16269-6:2014 and deletion of ISO 3207:1975 in [Clause 2](#);
- Deletion of the **indicated accuracy classification** definition;
- Adaptation of the Normal and Abnormal distributions ([A.4.1](#) and [A.4.2](#)) according to ISO 16269-6:2014;
- Addition of keys after [Figures B.1](#) and [B.2](#).

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

# Horology — Procedure for evaluating the accuracy of quartz watches

## 1 Scope

This document specifies the procedure for evaluating the accuracy of quartz watches, individually and by lots (see [Annex A](#) which presents the methods for statistical evaluation of accuracy by lot), and the relationship between the accuracy tested and the accuracy classification given by the manufacturer.

It applies to quartz watches having accompanying documents on which the accuracy classification is indicated.

## 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.

ISO 3158, *Timekeeping instruments — Symbolization of control positions*

ISO 16269-6:2014, *Statistical interpretation of data — Part 6: Determination of statistical tolerance intervals*

## 3 Terms and definitions

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

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

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

### 3.1

#### **quartz watch with accuracy indication**

quartz watch, the accuracy classification of which is indicated in its accompanying documents, such as operating instructions, prospectus and, labels

### 3.2

#### **display**

accuracy classification indications showing the hours and minutes and having at least one component displaying the seconds to enable the state to be checked

Note 1 to entry: The accuracy classification is expressed in seconds.

## 4 Symbols and units

The symbols and units for ageing, temperature simulation and accuracy are given in [Table 1](#).

Table 1 — Symbols and units of measurement

Symbol	Unit	Term
<b>Ageing</b>		
$\alpha$	d <sup>-1</sup>	coefficient of the logarithmic function applied
$c$	s/d	coefficient of the logarithmic function applied
$t_d$	d	time interval
$M_B$	s/d	average daily rate for the first three days of the ageing test (stage II)
$M_M$	s/d	average daily rate for the middle three days of the ageing test (stage V)
$M_E$	s/d	average daily rate for the last three days of the ageing test (stage VIII)
$V_V$	s	variation in state over one year due to ageing
<b>Temperature simulation</b>		
$M_P$	s/d	average daily rate in simulation of spring
$M_S$	s/d	average daily rate in simulation of summer
$M_A$	s/d	average daily rate in simulation of autumn
$M_W$	s/d	average daily rate in simulation of winter
$V_T$	s	variation in state over one year due to seasonal changes in temperature
<b>Accuracy</b>		
$M_m$	s/m	monthly rate
$M_y$	s/a	annual rate

## 5 Practical factors affecting accuracy

### 5.1 General

The main factors affecting the operating accuracy of quartz watches are temperature and ageing. Accordingly, these two factors are taken into account when evaluating the accuracy. The influence of other factors, such as mechanical impacts, magnetic fields, humidity and supply voltage is low.

### 5.2 Accuracy

The accuracy of quartz watches depends upon temperature variations due to the climatic conditions in the places of use.

### 5.3 Influence of temperature on accuracy

Watches are subject to the influence of the ambient temperature, which is variable according to the seasons and geographical location of the wearer.

It is not possible to specify absolutely temperatures simulating seasonal variations in all locations. The effects of temperature on accuracy are calculated arbitrarily at levels corresponding to the average seasonal temperature in temperate climates.

### 5.4 Accidents or abnormal environment

Accidents which quartz watches may suffer such as dropping, exposure to a strong magnetic field or extremely high or low temperatures are not covered by this document.

## 6 Types of measurement

To evaluate the accuracy of quartz watches in accordance with the procedure described in [Clause 7](#), the condition of the component which displays the seconds shall be measured (this measuring procedure

has the advantage of taking the oscillator variance into consideration and of checking the display kinematic chain).

## 7 Test methods

### 7.1 General test conditions

**7.1.1** The average daily rate is obtained by calculating the difference between two successive states divided by the number of days of observation according to the test programmes described in [7.2](#) and [7.3](#).

**7.1.2** The position of the timepieces throughout all the test programmes shall be with the dial facing upwards (CH), in accordance with ISO 3158.

**7.1.3** In order to eliminate any residual influence of temperature in the initial ageing test, the ageing test shall be performed first followed by the temperature simulation test.

**7.1.4** The number of samples from each batch should be greater than or equal to 30. The confidence interval of standard deviation requires a minimum lot size.

### 7.2 Ageing test programme

The test specified in [Table 2](#) shall only apply to watches having an indicated accuracy included between  $\pm 3$  s/a and  $\pm 30$  s/a.

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Table 2 — Ageing test

Stage	Test	Days	Symbol		Test conditions	
			States	Rate s/d	Temperature °C	Relative humidity %
I	Stabilization (3 d)	1	←E <sub>V3</sub>		23 ± 0,5	50 ± 5
		2				
		3				
II	Average daily rate (3 d)	4	←E <sub>V6</sub>	$M_B = \frac{E_{V6} - E_{V3}}{t_{dB}}$	23 ± 0,5	50 ± 5
		5				
		6				
III	Rest (24 d)	7			23 ± 5	50 ± 20
		etc.				
		30				
IV	Stabilization (3 d)	31	←E <sub>V33</sub>		23 ± 0,5	50 ± 5
		32				
		33				
V	Average daily rate (3 d)	34	←E <sub>V36</sub>	$M_M = \frac{E_{V36} - E_{V33}}{t_{dM}}$	23 ± 0,5	50 ± 5
		35				
		36				
VI	Rest (24 d)	37			23 ± 5	50 ± 20
		etc.				
		60				
VII	Stabilization (3 d)	61	←E <sub>V63</sub>		23 ± 0,5	50 ± 5
		62				
		63				
VIII	Average daily rate (3 d)	64	←E <sub>V66</sub>	$M_E = \frac{E_{V66} - E_{V63}}{t_{dE}}$	23 ± 0,5	50 ± 5
		65				
		66				

NOTE  $t_d$  represents the period between the measurements of two states, equivalent to about 3 d; it is rounded to the nearest 1/1 440<sup>th</sup> of a day.

The following measurements shall be taken if the actual temperature variations during stages II, V and VIII influence the ageing measurements.

- a) Measure the temperature characteristics of the watch at 23 °C.
- b) Correct the daily rates measured during stages II, V and VIII on the basis of actual temperatures and temperature characteristics given in [Table 2](#) for each phase.

### 7.3 Temperature simulation test programme

The temperature simulation test programme is given in [Table 3](#).

The temperature gradient shall be greater than 0,5 °C/min.

**Table 3 — Temperature simulation test**

Stage	Test	Days	Symbol		Test conditions	
			State s	Rate s/d	Temperature °C	Relative humidity %
I	Stabilization (1 d)	1	←E <sub>T1</sub>		25 ± 0,5	≤60
II	Simulation (3 d)	2				
		3	$M_P = \frac{E_{T4} - E_{T1}}{t_{dP}}$	25 ± 0,5		
4						
III	Simulation (3 d)	5	←E <sub>T4</sub>	$M_S = \frac{E_{T7} - E_{T4}}{t_{dS}}$	35 ± 0,5	
		6				
		7				
IV	Simulation (3 d)	8	←E <sub>T7</sub>	$M_A = \frac{E_{T10} - E_{T7}}{t_{dA}}$	25 ± 0,5	
		9				
		10				
V	Simulation (3 d)	11	←E <sub>T10</sub>	$M_W = \frac{E_{T13} - E_{T10}}{t_{dW}}$	15 ± 0,5	
		12				
		13				←E <sub>T13</sub>

NOTE  $t_d$  represents the period between the measurements of two states, equivalent to about 3 d; it is rounded to the nearest 1/1 440<sup>th</sup> of a day.

**7.4 Uncertainty of measurement**

The methods used for the measurement of state shall satisfy the following criteria concerning an uncertainty of measurement as specified in [Table 4](#).

**Table 4 — Criteria for uncertainty of measurement**

Accuracy classification indicated	
Monthly accuracy s/d	Annual accuracy s/d
<10 <sup>-2</sup>	<10 <sup>-3</sup>

## 8 Calculation of accuracy

### 8.1 General

The accuracy calculated shall be expressed in terms of monthly rates (monthly difference) or annual rates (annual difference).

The units are seconds per month (s/m) or seconds per year (s/a).

A month shall be taken as 30 d, and a year as 360 d.

### 8.2 Calculation of the effect of ageing on accuracy

For  $|M_E - M_B| < 5 \times 10^{-3}$  s/d,  $V_V$  shall be considered as equal to 0 s.

$a$  ( $d^{-1}$ ) shall be calculated using [Formula \(1\)](#):

$$\frac{M_M - M_B}{M_E - M_B} = \frac{\ln(1+30a)}{\ln(1+60a)} \quad (1)$$

where

$M_M$  is the average daily rate, expressed in seconds per day (s/d), for the middle three days of the ageing test (stage V);

$M_B$  is the average daily rate, expressed in seconds per day (s/d), for the first three days of the ageing test (stage II);

$M_E$  is the average daily rate, expressed in seconds per day (s/d), for the last three days of the ageing test (stage VIII);

$\alpha$  is the coefficient of the logarithmic function applied, expressed in 1 per day ( $d^{-1}$ ).

See [Annex B](#) for an alternative definition of the coefficient value  $a$ .

$c$  (s/d) shall be calculated using [Formula \(2\)](#):

$$c = \frac{M_E - M_B}{\ln(1+60\alpha)} \quad (2)$$

where

$c$  is the coefficient of the logarithmic function applied, expressed in seconds per day (s/d);

$M_B$  is the average daily rate, expressed in seconds per day (s/d), for the first three days of the ageing test (stage II);

$M_E$  is the average daily rate, expressed in seconds per day (s/d), for the last three days of the ageing test (stage VIII);

$\alpha$  is the coefficient of the logarithmic function applied, expressed in 1 per day ( $d^{-1}$ ).

See [Annex B](#) for an alternative definition of the coefficient value  $c$ .

$V_V$  (s) shall be calculated using [Formula \(3\)](#):

$$V_V = \int_0^{360} c \ln(1+\alpha t) dt \quad (3)$$

where

$V_V$  is the variation in state, expressed in seconds (s), over one year due to ageing;

$c$  is the coefficient of the logarithmic function applied, expressed in seconds per day (s/d);

$\alpha$  is the coefficient of the logarithmic function applied, expressed in 1 per day (d<sup>-1</sup>).

The effect of seasonal changes in temperature on accuracy,  $V_T$  (s), shall be calculated using [Formula \(4\)](#):

$$V_T = \frac{M_P + M_S + M_A + M_W}{4} \times 360 \quad (4)$$

where

$V_T$  is the variation in state, expressed in seconds (s), over one year due to seasonal changes in temperature;

$M_P$  is the average daily rate, expressed in seconds per day (s/d), in simulation of spring;

$M_S$  is the average daily rate, expressed in seconds per day (s/d), in simulation of summer;

$M_A$  is the average daily rate, expressed in seconds per day (s/d), in simulation of autumn;

$M_W$  is the average daily rate, expressed in seconds per day (s/d), in simulation of winter.

The monthly rate,  $M_m$  (s/m) (monthly accuracy), shall be calculated using [Formula \(5\)](#):

$$M_m = |V_T| / 12 \quad (5)$$

where

$M_m$  is the monthly rate, expressed in seconds per month (s/m);

$V_T$  is the variation in state, expressed in seconds (s), over one year due to seasonal changes in temperature.

The annual rate,  $M_y$  (s/a), (annual accuracy), shall be calculated using [Formula \(6\)](#):

$$M_y = |V_V + V_T| \quad (6)$$

where

$M_y$  is the annual rate, expressed in seconds per year (s/a);

$V_V$  is the variation in state, expressed in seconds (s), over one year due to ageing;

$V_T$  is the variation in state, expressed in seconds (s), over one year due to seasonal changes in temperature.

## 9 Relationship between the calculated accuracy and the accuracy classification indicated

The relationship between the calculated accuracy and the accuracy classification indicated as defined in [Clause 10](#) is as follows.

- a) For the indication of the average monthly rate,  $M_m$  (s/m) shall be within the limits of the accuracy classification indicated.
- b) For the indication of the average annual rate,  $M_y$  (s/a) shall be within the limits of the accuracy classification indicated.

## 10 Indication of the accuracy classification

The accuracy classification shall be indicated on the basis of the values defined in [Clause 9](#).

The accuracy classification shall be indicated as  $\pm x$  seconds per month (s/m) or as  $\pm x$  seconds per year (s/a).

The accuracy classification indication shall be chosen among the following values:  $\pm 3$ ,  $\pm 5$ ,  $\pm 10$ ,  $\pm 15$ ,  $\pm 20$ ,  $\pm 30$ .

EXAMPLES Monthly accuracy classification evaluated in accordance with this document  $\pm 15$  s/m.

Annual accuracy classification evaluated in accordance with this document  $\pm 20$  s/a.

## 11 Reliability

Reliability is explained in [Annex C](#).

## Annex A (normative)

### Statistical evaluation of accuracy

#### A.1 Field of application

This Annex specifies the methods for statistical evaluation of accuracy by lot.

#### A.2 Explanation of symbols

##### A.2.1 Accuracy by lot

The symbols and units relative to accuracy per lot are given in [Table A.1](#).

**Table A.1 — Accuracy by lot**

Symbol	Unit	Term
$V$	s	Total variation in state over one year
$A_m$	s/m	Monthly accuracy for the lot
$A_y$	s/a	Annual accuracy for the lot

##### A.2.2 Average values and standard deviations of $V_{T(i)}$ and $V_{V(i)}$

The symbols and units relative to average values and standard deviations of  $V_{T(i)}$  and  $V_{V(i)}$  are given below.

The average value of  $V_{T(i)}$  is given by [Formula \(A.1\)](#):

$$\bar{V}_T = \frac{1}{n} \sum_{i=1}^n V_{T(i)} \quad (\text{A.1})$$

where

$i$  indicates the watch number;

$n$  indicates the total number of watches.

The average value of  $V_{V(i)}$  is given by [Formula \(A.2\)](#):

$$\bar{V}_V = \frac{1}{n} \sum_{i=1}^n V_{V(i)} \quad (\text{A.2})$$

The total average value is given by [Formula \(A.3\)](#):

$$\bar{V} = \bar{V}_T + \bar{V}_V \quad (\text{A.3})$$

The standard deviation of  $V_{T(i)}$  is given by [Formula \(A.4\)](#):

$$s_T = \sqrt{\frac{\sum_{i=1}^n (\bar{V}_T - V_{T(i)})^2}{n-1}} \quad (\text{A.4})$$

The standard deviation of  $V_{V(i)}$  is given by [Formula \(A.5\)](#):

$$s_V = \sqrt{\frac{\sum_{i=1}^n (\bar{V}_V - V_{V(i)})^2}{n-1}} \quad (\text{A.5})$$

The standard deviation of the total average value is given by [Formula \(A.6\)](#):

$$s = \sqrt{s_T^2 + s_V^2} \quad (\text{A.6})$$

### A.3 Test methods

The test methods are specified in [Clause 7](#).

### A.4 Accuracy evaluation method by lot

#### A.4.1 Normal distribution

If the variations of accuracy values follow the normal distribution, then the monthly accuracy,  $A_m$ , and the annual accuracy,  $A_y$ , for the lot tested shall be calculated using [Formula \(A.7\)](#):

$$A_m = \frac{|\bar{V}_T| + k_2 \cdot s_T}{12}$$

$$A_y = |\bar{V}| + k_2 \cdot s \quad (\text{A.7})$$

where

$k_2$  is a coefficient with a confidence level of 0,95;

$n$  is the number of watches tested.

Details concerning  $n$  and  $k_2$  are specified in ISO 16269-6:2014, Table C.2.

The sample plan is given in [Table A.2](#).

Table A.2 — Sample plan

$n$	$k_2$	$n$	$k_2$	$n$	$k_2$
5	4,21	17	2,49	50	2,07
6	3,71	18	2,45	60	2,02
7	3,40	19	2,42	70	1,99
8	3,19	20	2,40	80	1,97
9	3,03	22	2,35	90	1,94
10	2,91	24	2,31	100	1,93
11	2,82	26	2,27	150	1,87
12	2,74	28	2,24	200	1,84
13	2,67	30	2,22	250	1,81
14	2,61	35	2,17	300	1,80
15	2,57	40	2,13	400	1,78
16	2,52	45	2,09	500	1,76

#### A.4.2 Abnormal distribution

If the accuracy values do not follow the normal distribution, then  $A_m$  or  $A_y$  shall be calculated using [Formula \(A.7\)](#) in accordance with ISO 16269-6:2014, Annex G.

where

$A_m$  is the maximum value of  $V_{T(i)}/12$ ;

$A_y$  is the maximum value of  $V_{T(i)} + V_{V(i)}$ .

The size of the sample shall be calculated in accordance with ISO 16269-6:2014, Tables E.1 and E.2.

#### A.5 Relationship between the calculated accuracy and the accuracy classification indicated

The relationship between the calculated accuracy and the accuracy classification indicated is as follows:

- for the indication of the average monthly rate:  $\geq A_m$
- for the indication of the average annual rate:  $\geq A_y$

#### A.6 Indications

The accuracy classification shall be indicated in accordance with the values specified in [A.5](#).

The accuracy classification shall be indicated as  $\pm x$  seconds per month (s/m) or as  $\pm x$  seconds per year (s/a).

The accuracy classification indication shall be chosen among the following values:  $\pm 3$ ,  $\pm 5$ ,  $\pm 10$ ,  $\pm 15$ ,  $\pm 20$ ,  $\pm 30$ .

EXAMPLES Monthly accuracy classification evaluated in accordance with this document  $\pm 15$  s/m.

Annual accuracy classification evaluated in accordance with this document  $\pm 20$  s/a.

## Annex B (informative)

### Evaluation of coefficients $\alpha$ and $c$ from the differences of rates

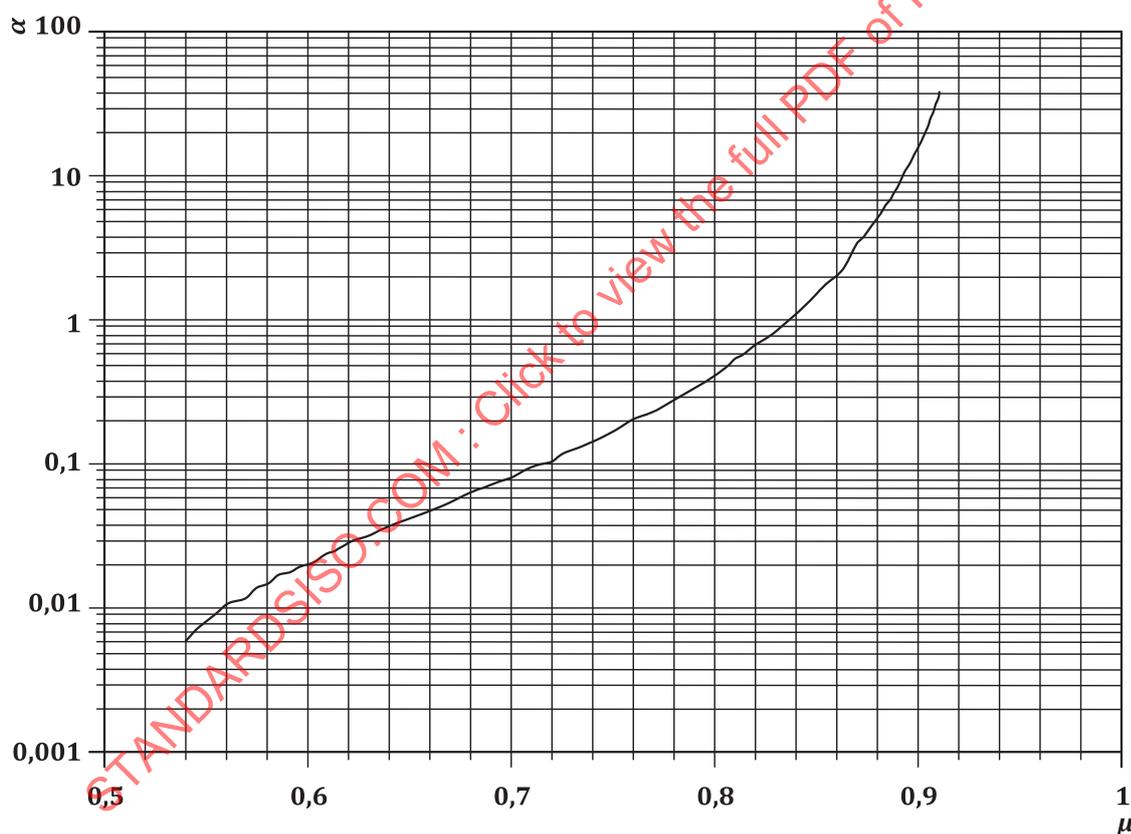
The evaluation of coefficients  $\alpha$  and  $c$  from the differences of rates is found by using [Formula \(B.1\)](#):

$$\mu = \frac{M_M - M_B}{M_E - M_B} \quad (\text{B.1})$$

$\alpha$  and  $\gamma$  are determined from [Figures B.1](#) and [B.2](#) respectively.

$c$  is obtained by using [Formula \(B.2\)](#):

$$c = \gamma \cdot (M_E - M_B) \quad (\text{B.2})$$



#### Key

$\mu$  the differences of rates

$\alpha$  coefficient of the logarithmic function applied

**Figure B.1 — Determination of  $\alpha$**