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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

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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).

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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.

 

# 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 |
|---|---|---|
| | | **Ageing** |
| $\alpha$ | $d^{-1}$ | 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 |
| | | **Temperature simulation** |
| $M_P$ | 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 |
| | | **Accuracy** |
| $M_m$ | 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 ±3 s/a and ±30 s/a.

**Table 2 — Ageing test**

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

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 440th 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<br>s | Rate<br>s/d | Temperature<br>°C | Relative humidity<br>% |
| I | Stabilization (1 d) | 1 | $\leftarrow E_{T1}$ | | 25 ± 0,5 | ≤60 |
| II | Simulation (3 d) | 2<br>3<br>4 | $\leftarrow E_{T4}$ | $M_P = \frac{E_{T4} - E_{T1}}{t_{dP}}$ | 25 ± 0,5 | |
| III | Simulation (3 d) | 5<br>6<br>7 | $\leftarrow E_{T7}$ | $M_S = \frac{E_{T7} - E_{T4}}{t_{dS}}$ | 35 ± 0,5 | |
| IV | Simulation (3 d) | 8<br>9<br>10 | $\leftarrow E_{T10}$ | $M_A = \frac{E_{T10} - E_{T7}}{t_{dA}}$ | 25 ± 0,5 | |
| V | Simulation (3 d) | 11<br>12<br>13 | $\leftarrow E_{T13}$ | $M_W = \frac{E_{T13} - E_{T10}}{t_{dW}}$ | 15 ± 0,5 | |

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 440th 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<br>s/d | Annual accuracy<br>s/d |
| $<10^{-2}$ | $<10^{-3}$ |

# 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):

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

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 ($d^{-1}$).

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.

 