INTERNATIONAL STANDARD

ISO 10553

First edition
2003-03-01

Horology — Procedure for evaluating the accuracy of quartz watches

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

Reference number
ISO 10553:2003(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 10553 was prepared by Technical Committee ISO/TC 114, *Horology*, Subcommittee SC 11, *Indication of accuracy*.

Horology — Procedure for evaluating the accuracy of quartz watches

1 Scope

This International Standard specifies the procedure for evaluating the accuracy of quartz watches, individually and by lots, 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 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 3158, *Timekeeping instruments — Symbolization of control positions*

ISO 3207:1975, *Statistical interpretation of data — Determination of a statistical tolerance interval*

3 Terms and definitions

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

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, labels, etc.

3.2
indicated accuracy classification
accuracy in standardized measuring conditions and affected by practical factors described in Clause 5 and evaluated in accordance with the methods specified in Clause 7

3.3
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 (in view of the fact that 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		
a	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 International Standard.

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 days)	1			23 ± 0,5	50 ± 5
		2				
		3				
II	Average daily rate (3 days)	4	E_{V3}	$M_B = \frac{E_{V6} - E_{V3}}{t_{dB}}$	23 ± 0,5	50 ± 5
		5				
		6				
III	Rest (24 days)	7	E_{V6}		23 ± 5	50 ± 20
		etc.				
		30				
IV	Stabilization (3 days)	31			23 ± 0,5	50 ± 5
		32				
		33				
V	Average daily rate (3 days)	34	E_{V33}	$M_M = \frac{E_{V36} - E_{V33}}{t_{dM}}$	23 ± 0,5	50 ± 5
		35				
		36				
VI	Rest (24 days)	37	E_{V36}		23 ± 5	50 ± 20
		etc.				
		60				
VII	Stabilization (3 days)	61			23 ± 0,5	50 ± 5
		62				
		63				
VIII	Average daily rate (3 days)	64	E_{V63}	$M_E = \frac{E_{V66} - E_{V63}}{t_{dE}}$	23 ± 0,5	50 ± 5
		65				
		66				
			E_{V66}			

NOTE t_d represents the period between the measurements of two states, equivalent to about 3 days; it is rounded to the nearest 1/1440th 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 per minute.

Table 3 — Temperature simulation test

Stage	Test	Days	Symbol		Test conditions	
			State s	Rate s/d	Temperature °C	Relative humidity %
I	Stabilization (1 day)	1			25 ± 0,5	⩽ 60
			E_{T1}			
II	Simulation (3 days)	2 3 4		$M_P = \frac{E_{T4} - E_{T1}}{t_{dP}}$	25 ± 0,5	
			E_{T4}			
III	Simulation (3 days)	5 6 7		$M_S = \frac{E_{T7} - E_{T4}}{t_{dS}}$	35 ± 0,5	
			E_{T7}			
IV	Simulation (3 days)	8 9 10		$M_A = \frac{E_{T10} - E_{T7}}{t_{dA}}$	25 ± 0,5	
			E_{T10}			
V	Simulation (3 days)	11 12 13	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 days; it is rounded to the nearest 1/1440th 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
$< 10^{-2}$	$< 10^{-3}$

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 days, and a year as 360 days.

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 the following equation:

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

See Annex B for an alternative definition of the coefficient value a.

c (s/d) shall be calculated using the following equation:

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

See Annex B for an alternative definition of the coefficient value c.

V_V (s) shall be calculated using the following equation:

$$V_V = \int_0^{360} c \ln(1+at)dt \tag{3}$$

The effect of seasonal changes in temperature on accuracy, V_T (s), shall be calculated using the following equation:

$$V_T = \frac{M_P + M_S + M_A + M_w}{4} \times 360 \tag{4}$$

The monthly rate, M_m (s/m) (monthly accuracy), shall be calculated using the following equation:

$$M_m = |V_T| / 12 \tag{5}$$

The annual rate, M_y (s/a), (annual accuracy), shall be calculated using the following equation:

$$M_y = |V_V + V_T| \tag{6}$$

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: ± 3, ± 5, ± 10, ± 15, ± 20, ± 30.

EXAMPLES Monthly accuracy classification evaluated in accordance with ISO 10553: ± 15 s/m.

Annual accuracy classification evaluated in accordance with ISO 10553: ± 20 s/a.

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 $V_{\mathrm{T}(i)}$ and $V_{\mathrm{V}(i)}$

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

The average value of $V_{\mathrm{T}(i)}$ is

$$\overline{V_\mathrm{T}} = \frac{1}{n}\sum_{i=1}^{n} V_{\mathrm{T}(i)} \tag{A.1}$$

where

i indicates the watch number;

n indicates the total number of watches.

The average value of $V_{\mathrm{V}(i)}$ is

$$\overline{V_\mathrm{V}} = \frac{1}{n}\sum_{i=1}^{n} V_{\mathrm{V}(i)} \tag{A.2}$$

The total average value is

$$\overline{V} = \overline{V_\mathrm{T}} + \overline{V_\mathrm{V}} \tag{A.3}$$

The standard deviation of $V_{T(i)}$ is

$$s_T = \sqrt{\frac{\sum_{i=1}^{n} (\overline{V_T} - V_{T(i)})^2}{n-1}} \tag{A.4}$$

The standard deviation of $V_{V(i)}$ is

$$s_V = \sqrt{\frac{\sum_{i=1}^{n} (\overline{V_V} - V_{V(i)})^2}{n-1}} \tag{A.5}$$

The standard deviation of the total average value is

$$s = \sqrt{{s_T}^2 + {s_V}^2} \tag{A.6}$$

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 the following equations:

$$A_m = \frac{\left|\overline{V_T}\right| + k_2 \cdot s_T}{12} \qquad A_y = \left|\overline{V}\right| + k_2 \cdot s \tag{A.7}$$

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 Table 7 of Annex B of ISO 3207:1975.

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 the equation in accordance with Annex A of ISO 3207:1975

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 Table 10 of Annex B of ISO 3207:1975.

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: $\geqslant A_m$

— for the indication of the average annual rate: $\geqslant A_y$

A.6 Indications

The accuracy classification shall be indicated in accordance with the values specified in Clause 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: ± 3, ± 5, ± 10, ± 15, ± 20, ± 30.

EXAMPLES Monthly accuracy classification evaluated in accordance with ISO 10553: ± 15 s/m.

Annual accuracy classification evaluated in accordance with ISO 10553: ± 20 s/a.

Annex B
(normative)

Evaluation of coefficients a and c from the differences of rates

The evaluation of coefficients a and c from the differences of rates is found by using the following equation:

$$\mu = \frac{M_\text{M} - M_\text{B}}{M_\text{E} - M_\text{B}} \tag{B.1}$$

a and γ are determined from Figures B.1 and B.2 respectively.

c is obtained by using the following equation:

$$c = \gamma \cdot (M_\text{E} - M_\text{B}) \tag{B.2}$$

Figure B.1 — Determination of *a*

Figure B.2 — Determination of γ

Annex C
(informative)

Reliability

The accuracy classification specified for quartz watches has been evaluated statistically by sampling in accordance with ISO 2859 (all parts).

The lot of sample watches has successfully completed a range of tests in accordance with ISO 10553.

These tests are static and are carried out at temperatures corresponding to those experienced in countries with a temperate climate. They take no account of disturbing incidents that can affect the rate of a watch when it is worn. The precision classification specified is thus to be considered as a theoretical indication of chronometric performances.

Bibliography

[1] ISO 2859 (all parts), *Sampling procedures for inspection by attributes*

ICS 39.040.10

Price based on 14 pages