TECHNICAL REPORT

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Indication of accuracy of quartz watches

Indication 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 main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 10553, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 114, *Horology*, Subcommittee SC 11, *Indication of accuracy*.

This document is being issued in the type 2 Technical Report series of publications (according to subclause G.4.2.2 of part 1 of the ISO/CEI Directives, 1992) as a "prospective standard for provisional application" in the field of indication of accuracy of quartz watches because there is an urgent need for guidance on how standards in this field should be used to meet an identified need.

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This document is not to be regarded as an "International Standard". It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the ISO Central Secretariat.

A review of this type 2 Technical Report will be carried out not later than two years after publication with the options of: extension for another two years; conversion into an International Standard; or withdrawal.

Annex A of this Technical Report is for information only.

Introduction

The accuracy of quartz watches is generally mentioned in advertisements, catalogues, brochures, labels, operating manuals and other technical guides; however, the specifications of the accuracy vary among manufacturers as well as among countries. Therefore, a proposal has been made to establish an International Standard with the aim to standardize the method for indicating the accuracy of quartz watches. By applying this International Standard, manufacturers in all countries will be able to determine the accuracy of their quartz watches on the basis of a recognized and uniform procedure, thus avoiding any confusion on the matter. Such a standard would be advantageous to the manufacturers as well as to the users. Moreover, it would facilitate commercial transactions and would offer consumer protection.

In preparation of a proposal for a future International Standard on the indication of accuracy, the members of ISO/TC 114/SC 11 discussed the following problems:

— the technical meaning of the values of the accuracy;

— the methods of tests and criteria for evaluation; and

— unification of the ways to define accuracy.

During this time, important tests were carried out by SC 11 on the correlation that may exist between the accuracy of the quartz watch observed through tests of short duration — tests that were executed in several countries — and the accuracy of the quartz watch when it is worn by the user. Proposals based on the results of such experiments have been made by Switzerland, Germany and Japan. These proposals were the subject of discussion at the time of international sessions of ISO/TC 114/SC 11, resulting in the proposal SC11N62.

However, because of a number of technical problems, the countries could not agree to the proposal of the Secretariat. The SC 11 thus has temporarily abandoned the idea to establish an International Standard and has summarized the results of discussions conducted to this date in a type 2 Technical Report.

Unanimity was not reached due to the following technical problems:

a) Divergences as to the accuracy obtained in the measurement of states at the time of tests; opinions differed regarding quartz watches without thermal compensation. These opinions were as follows:

   1) The initial regulation of the daily operation of a lot of quartz watches determines the distribution of the accuracy. This means that the distribution of the accuracy of the initial regulation carried out at room temperature is similar to that obtained through tests specified in this Technical Report.

This type of test is meaningless for quartz watches without thermal compensation.

2) If the deviation of the regulation is extended, the distributions of the accuracy and of the regulation will be the same. However, there are differences in the mean values. Therefore, it is important to execute such tests. If the deviation of the regulation is small, the deviation of the distribution of the accuracy obtained at the time of the test will be more important than that of the regulation. Therefore, the accuracy of the quartz watch may be evaluated through tests described in this Technical Report.

b) The possibility to develop an instrument to measure the states (thus ensuring the accuracy specified in this Technical Report) as well as a constant-temperature chamber for the control of quartz watches of high accuracy with thermal compensation or provided with a high-frequency quartz resonator, was studied.

Regarding the instrument for measuring the states and the constant-temperature chamber, the following opinions were presented and no agreement was reached.

1) It is difficult to measure accurately the accuracy of high-precision quartz watches. In order to ensure an error of less than 10^{-3} s in the measurement of the state, it should be possible to carry out measurements of 10^{-9} s. To our knowledge there is no instrument available on the market that would allow the measurement of state with this accuracy. Also, in order to evaluate ageing effects, the measurement temperature must be maintained at approximately ± 0,1 °C and must be maintained stable for three periods of 3 days. Installations with such capabilities are few and are not easy to use (phases II, IV and VI, see 6.3).

2) In order to measure the accuracy of high-precision quartz watches, an instrument is needed that satisfies the requirements in 1). This type of instrument is not very expensive and is found on the market.

c) Method for statistical evaluation of the accuracy of a lot. A discussion was begun regarding the adoption of normal or abnormal distribution of rates obtained at the time of tests. A proposal to adopt the method specified in ISO 3207 and to adopt this International Standard in the case of abnormal distribution as well as in the case of normal distribution was made. As a counter-proposal, a method was suggested based on the distribution of cumulative frequencies, for which one can obtain a confidence interval at 95 % determining the accuracy of the lot, following smoothing of the curve. The discussion treated only the normality of the distribution and agreement was not reached. If the abnormal distribution should be adopted, in addition a method of convenient smoothing should be found.

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Indication of accuracy of quartz watches

1 Scope

This Technical Report describes a proposed method for the evaluation of the accuracy of quartz watches. It applies to quartz watches whose accuracy is indicated by the manufacturer. It defines the term "accuracy" and specifies test methods for its evaluation.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Technical Report. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Technical Report are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 3158:1976, *Timekeeping instruments — Symbolization of control positions.*

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

3 Definitions

For the purposes of this Technical Report, the following definitions apply.

3.1 quartz watches with accuracy indication: Quartz watches, whose accuracy when worn is specified in their individual instruction manual, catalogue, tag or by other means of indication.

3.2 indicated accuracy when worn: Accuracy when worn under normal conditions and affected by the practical factors described in clause 4, evaluated in accordance with the methods specified in clause 7.

4 Practical factors affecting accuracy

4.1 General

The main factors affecting the accuracy of a quartz watch when worn are temperature and ageing. The influence of other variables, such as humidity and voltage, is very small. Accordingly, temperature tests and ageing tests are used to evaluate the accuracy when worn.

4.2 Actual accuracy when worn

The actual accuracy of quartz watches when worn will differ depending upon temperature variations due to differences in how the watch is worn and in climatic conditions of the place of use.

4.3 Influence of temperature on accuracy

The influence of temperature on the accuracy is determined based on the change in average temperature from season to season.

4.4 Accidents or abnormal environment

Quartz watches which have been subject to accidents such as dropping, or abnormal environments, such as exposure to a high magnetic field or to extremely high or low temperatures, are not covered by this Technical Report.

5 Symbols

5.1 Ageing

a Coefficient of the logarithmic function applied, expressed per day;

c Coefficient of the logarithmic function applied, expressed in seconds per day;

t Time interval, expressed in days;

M_B Average daily rate for the first three days (Stage II) of the ageing test, expressed in seconds per day;

M_M Average daily rate for the middle three days (Stage IV) of the ageing test, expressed in seconds per day;

M_E Average daily rate for the last three days (Stage VI) of the ageing test, expressed in seconds per day;

V_V Variation in state over one year due to ageing, expressed in seconds.

5.2 Temperature simulation

$\overline{M}_P$ Average daily rate in simulation of spring, expressed in seconds per day;

$\overline{M}_S$ Average daily rate in simulation of summer, expressed in seconds per day;

$\overline{M}_A$ Average daily rate in simulation of autumn, expressed in seconds per day;

$\overline{M}_W$ Average daily rate in simulation of winter, expressed in seconds per day;

V_T Variation in state over one year due to seasonal changes in temperature, expressed in seconds.

5.3 Accuracy of a lot

V Total variation in state over one year, expressed in seconds;

A_m Monthly rate of a lot, expressed in seconds per month;

A_y Annual rate of a lot, expressed in seconds per year;

n Number of samples tested.

5.4 Average values and standard deviations

$\overline{M}_m = \frac{1}{12n} \sum_{i=1}^{n} V_{T(i)}$ Average value of cumulative variation in rate $[V_{T(i)}]$ due to change in temperature, where i is the i^{th} sample tested.

$\overline{M}_v = \frac{1}{12n} \sum_{i=1}^{n} V_{V(i)}$ Average value of cumulative variation in rate $[V_{V(i)}]$ due to ageing.

$\overline{M} = \overline{M}_m + \overline{M}_v$ Total average cumulative variation in rate.

$s_m = \left[\frac{\sum_{i=1}^{n} (M_m - \frac{1}{12} V_{T(i)})^2}{n-1} \right]^{1/2}$ Standard deviation of cumulative variation in rate $[V_{T(i)}]$ due to seasonal change in temperature.

$s_v = \left[\frac{\sum_{i=1}^{n} (\overline{M}_V - \frac{1}{12} V_{V(i)})^2}{n-1} \right]^{1/2}$ Standard deviation of cumulative variation in rate $[V_{V(i)}]$ due to ageing.

$s = \left(s_m^2 + s_v^2\right)^{1/2}$ Standard deviation of total rate variation.

6 Test methods

6.1 Kind of test

The test should be performed as a homologation test.

6.2 General test conditions

6.2.1 The average daily rate is obtained by the difference between two successive states divided by the number of days of observation.

6.2.2 Control positions shall keep CH in all the programmes (see ISO 3158).

6.2.3 In order to eliminate any residual influence of temperature in the initial ageing test, maintain the order of testing, i.e. carry out first the ageing test, next the temperature simulation test.

6.2.4 The number of samples from each lot should be $\geqslant 30$. The confidence interval of standard deviation requires a minimal size of the lot.

6.3 Ageing test program

Stage	Test sequence	Time interval (d)	Atmospheric test conditions	
			Temperature °C	Relative humidity %
I	Trial run	3	23 ± 0,5 (see NOTE 1)	< 60
II	Measurement of average daily rate, M_B	3		
III	Running time between measurements	27		
IV	Measurement of average daily rate, M_M	3		
V	Running time between measurements	27		
VI	Measurement of average daily rate, M_E	3		

NOTES

1 Each difference between the average temperature for three days of stages II, IV and VI shall be within ± 0,1 °C.

2 The equipment for the determination of daily rate shall allow successive determinations of state with an accuracy of better than 10^{-3} s.

6.4 Temperature simulation test program

Stage	Test sequence	Time interval (d)	Atmospheric conditions	
			Temperature °C	Relative humidity %
I	Trial run	1	25 ± 0,5	(see NOTE 1)
II	Measurement of average daily rate in simulation of spring, $\overline{M}_P$	3	25 ± 0,5	
III	Measurement of average daily rate in simulation of summer, $\overline{M}_S$	3	35 ± 0,5	
IV	Measurement of average daily rate in simulation of autumn, $\overline{M}_A$	3	25 ± 0,5	
V	Measurement of average daily rate in simulation of winter, $\overline{M}_W$	3	15 ± 0,5	

NOTES

1 The relative humidity shall be less than 60 % at 25 °C , and will vary as the temperature changes.

2 Temperature changes shall be carried out at a rate ⩾ 10 °C/20 min.

3 The equipment for measurement of state for temperature simulation shall be accurate to 10^{-2} s for monthly rates and 10^{-3} s for annual rates.