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Watch cases and accessories — Gold alloy coverings —

Part 3:
Abrasion resistance tests of a type of coating on standard gauges

Boîtes de montres et leurs accessoires — Revêtements d'alliage d'or — Partie 3: Essais de résistance à l'abrasion d'un type de revêtement sur éprouvettes normalisées

Reference number
ISO 3160-3:1993(E)

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.

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.

International Standard ISO 3160-3 was prepared by Technical Committee ISO/TC 114, *Horology*, Sub-Committee SC 6, *Precious metal coverings*.

ISO 3160 consists of the following parts, under the general title *Watch cases and accessories — Gold alloy coverings*:

— *Part 1: General requirements*

— *Part 2: Determination of fineness, thickness, corrosion resistance and adhesion*

— *Part 3: Abrasion resistance tests of a type of coating on standard gauges*

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Watch cases and accessories — Gold alloy coverings —

Part 3:
Abrasion resistance tests of a type of coating on standard gauges

1 Scope

This part of ISO 3160 specifies two test methods for wear and tear to be applied to a gold alloy coating in order to determine the degree of resistance to wear of this type of coating. The test methods are applicable to a standard gauge and not directly to objects treated with the tested type of coating. The quality level is compared to that of a standard gauge.

This part of ISO 3160 describes:

— dimensions and characteristics of the standard gauge,

— standard coating,

— test methods,

— determination of wear, and

— qualitative comparison scales.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 3160. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 3160 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 2361:1982, *Electrodeposited nickel coatings on magnetic and non-magnetic substrates — Measurement of coating thickness — Magnetic method.*

ISO 2819:1980, *Metallic coatings on metallic substrates — Electrodeposited and chemically deposited coatings — Review of methods available for testing adhesion.*

ISO 3160-1:1982, *Watch cases and accessories — Gold alloy coverings — Part 1: General requirements.*

ISO 3160-2:1992, *Watch cases and accessories — Gold alloy coverings — Part 2: Determination of fineness, thickness, corrosion resistance and adhesion.*

ISO 3497:1990, *Metallic coatings — Measurement of coating thickness — X-ray spectrometric methods.*

ISO 3543:1981, *Metallic and non-metallic coatings — Measurement of thickness — Beta backscatter method.*

ISO 4516:1980, *Metallic and related coatings — Vickers and Knoop microhardness tests.*

ISO 4524-5:1985, *Metallic coatings — Test methods for electrodeposited gold and gold alloy coatings — Part 5: Adhesion tests.*

3 Definitions

For the purposes of this part of ISO 3160, the following definitions apply.

3.1 wear: Deterioration caused by use through mechanical removal of material.

3.2 abrasion: Wear of a material by a hard substance through friction.

3.3 abrasion resistance: Capacity to endure wear of a material by a hard substance through friction.

3.4 adhesion: Strength of the bond between a coating and its substrate, expressed as the force per unit area required to separate them.

4 Standard gauge and coatings

4.1 Standard gauge

4.1.1 Dimensions (see figure 1)

The standard gauge shall have the following dimensions:

- diameter of the flat reference surface: $d_1 = 18$ mm
- total diameter: $d_2 = 24$ mm $\pm$ 0,2 mm
- total thickness: $e = 12$ mm $\pm$ 0,2 mm
- radius of connection of the flat reference surface with the side: $R = 3$ mm $\pm$0,1 mm

Dimensions in millimetres

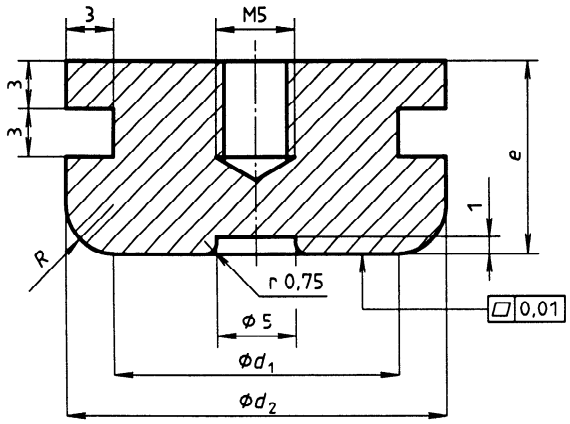

Figure 1 — Details of the standard gauge

4.1.2 Characteristics

The arithmetical mean deviation of the roughness profile, R_a, of the reference surface shall be a maximum of 0,5 µm before application of the covering.

The basic material of the standard gauge shall be a copper alloy, lead free, with a minimal Vickers hardness of 120 HV 0,2 (see ISO 4516).

4.2 Standardized reference coating (Watts nickel) on a standardized gauge designed for abrasion tests

This coating, deposited directly onto the gauge, is designed to measure the wear depth caused by the items used in the tests described in 5.1 and 5.2.

NOTES

1 If the thickness is measured by X-ray fluorescence, a non-coated standardized gauge of the same material should be available in order to determine the zero point, as well as a nickel-plated gauge of known thickness used as a standard.

2 If the thickness of the nickel coating is measured by the beta-ray backscatter method, a sufficient undercoating (for example gold or gold alloy) can be provided under the nickel; some standardized gauges should be provided, having the same undercoating and coated with known thicknesses of nickel, close to the one to be measured.

The coating bath shall have the following composition:

— nickel sulfate hexahydrate ($NiSO_4 \cdot 6H_2O$):	300 g/l
— nickel chloride hexahydrate ($NiCl_2 \cdot 6H_2O$):	60 g/l
— boric acid (H_3BO_3):	40 g/l
— saccharine (sodium salt):	0,025 g/l

The working conditions shall be as follows:

— pH:	3,5 to 4,5
— temperature:	50 °C
— density of current:	2 A/dm^2 to 3 A/dm^2

This coating shall have a thickness of between 5 µm and 10 µm, measured on the reference surface, and a Vickers hardness of between 220 and 240 HV 0,01.

4.3 Characteristics of the undercoat applied under the gold alloy coating to be tested

The bath used for the undercoating applied under the gold alloy coating to be tested shall be identical to that described in 4.2 with the exception of the percentage of saccharine (sodium salt) which shall be 1 g/l, in order to obtain a brilliant coating.

4.4 Adhesion of the gold alloy coating to be tested

The gold alloy coating to be tested shall have a good degree of adhesion, which can be checked by one of the methods described in ISO 2819 and ISO 4524-5.

5 Test methods

Two tests shall be applied to two standardized sample gauges. Each sample shall undergo one of the two tests defined in 5.1 and 5.2.

5.1 Abrasion test limited to the reference surface, in a damp environment, by friction on an abrasive disc

Carry out the test as follows.

The test-piece can be fixed either on the groove in the rim or on the tapping M5, both for electrodeposition and for the wear test.

Ensure the free rotation of the test-piece around its axis and guarantee that the reference surface and the abrasive disc are parallel.

Use a water-resistant polyester disc, covered by an abrasive mineral of grain size 4 µm.

Use a load of 2,5 N (including the weight of the gauge).

Apply friction at a speed of 0,5 m/s at the centre of the gauge, by stages of 500 m.

Change the disc after every stage of 500 m.

Carry out the test in a damp lubricating environment, consisting of an aqueous solution of 5 % sodium sulfo-ricinoleate, applied drop by drop with a flow of 36 ml/h.

The test shall be conducted until a wear of 3 µm ± 10 % is obtained.

5.2 Multidirectional abrasion test on the gauge, in a damp environment, with abrasive mineral substances and chemical agents

This test shall be carried out with the help of a container made of organic synthetic material with a minium content of 2,5 l. The container has a vibrating and rotating movement or a composite movement. It shall be filled up to 60 % with a mixture made up of the following.

a) Abrasive chips, in ceramic, with a cylindrical shape, cut at 45° at each extremity (see figure 2), made of corundum-agglomerated grains having the following characteristics:

   — dimensions: diameter of 3 mm length of 9 mm

   — hardness: 6 Mohs to 7 Mohs

   — granulometry: 125 µm

   — preliminary wear: 50 h

   — maximum duration of use: 500 h

b) Water and a surface-active agent:

   — proportions: 200 ml water and 6 ml concentrated surface-active agent for a volume of 1 l of abrasive chips.

Dimensions in millimetres

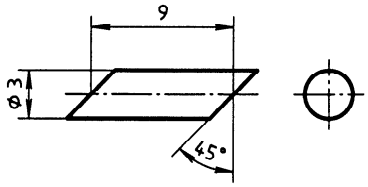

Figure 2 — Details of an abrasive chip in ceramic

Other abrasive mixtures can be used, provided that the obtained results remain within the limits fixed below.

The machine shall be adjusted so that the wear comes to 3 µm ± 10 % on the flat reference surface of a standardized test-piece which has a coating of Watts nickel deposited according to the details given in 4.2, over a period of time between 10 h and 20 h.

The gauging shall be checked at regular intervals in order to stay within the limits of thickness fixed for a set period of testing.

The gauge or gauges shall be fixed in the centre of the abrasive mixture.

6 Determination of wear

The measurements of wear shall be made on the flat reference surface, in four points located at 90° to each other, on a circle with an approximate radius of 6 mm.

6.1 Tests limited to the reference surface detailed in 5.1

The wear, expressed in micrometres, shall be measured after every step of 500 m by one of the following non-destructive methods:

a) beta-ray backscatter method rays according to ISO 3543;

b) X-ray fluorescence method according to ISO 3497;

c) magnetic method for measurement of thickness according to ISO 2361.

At the end of the test, a control shall be made by metallographic cutting.

6.2 Multidirectional tests detailed in 5.2

6.2.1 Several measurements (a minimum of three) are necessary to determine the time which brings a wear of 3,0 µm ± 10 %.

6.2.2 The measuring method shall be adapted to the accuracy required to measure the wear of 3 µm of Watts nickel with a tolerance of ± 10 % (following the magnetic method specified in ISO 2361 or the X-ray fluorescence method specified in ISO 3497).

6.2.3 The same accuracy is required in measuring the wear of the deposit of gold alloy to be tested by one of the following methods:

a) beta-ray backscatter method according to ISO 3543;

b) X-ray fluorescence method according to ISO 3497;

c) magnetic method for measurement of thickness according to ISO 2361.

7 Scale of comparison

7.1 Quality index resulting from wear tests limited to the reference surface (I_1)

The quality index, I_1, for the wear tests limited to the reference surface of the gold alloy coatings to be tested is defined by the ratio between the necessary distance covered to obtain a wear of 3 µm on the gold alloy coating to be tested and that necessary to obtain the same wear of 3 µm on the standard Watts nickel coating. The ratio between the necessary times to obtain this 3 µm wear may also be taken in account, since the test is performed at a constant speed.

The algebraic formula is as follows:

$$I_1 = \frac{100D}{D_0} = \frac{100t}{t_0}$$

where

I_1 is the quality index for tests limited to the reference surface;

D is the distance covered for a wear of 3 µm on the gold alloy coating to be tested;

D_0 is the distance covered for a wear of 3 µm on the standard Watts nickel coating;

t is the time necessary for a wear of 3 µm on the gold alloy coating to be tested;

t_0 is the time necessary for a wear of 3 µm on the standard Watts nickel coating.

7.2 Quality index resulting from multidirectional wear test (I_2)

The quality index, I_2, for multidirectional wear tests of the gold alloy coatings to be tested is defined by the ratio between the time necessary to obtain a wear of 3 µm on the gold alloy coating to be tested and that necessary to obtain the same wear of 3 µm on the standard Watts nickel coating.

The algebraic formula is as follows:

$$I_2 = \frac{100T}{T_0}$$

where

I_2 is the quality index for multidirectional tests;

T is the time necessary for a wear of 3 µm on the gold alloy coating to be tested;

T_0 is the time necessary for a wear of 3 µm on the standard Watts nickel coating.

7.3 Average quality index (Q)

The average between the quality indexes I_1 and I_2 gives an average quality index Q of the gold alloy coating according to the following formula:

$$Q = \frac{I_1 + I_2}{2}$$

NOTE 3 The average quality index of a gold alloy coating having the same wear resistance quality as a Watts nickel coating is 100.

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