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Federal Institute of Metrology METAS

METAS-N001

Requirements for certification of movements and mechanical watches resistant to magnetic fields of 1.5 T (15 000 G)

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This document is a translation. In case of ambiguity, the information in the French version shall prevail.

CONTENTS

1 Introduction

This document (hereinafter: the Requirements) describes a certification process for fully mechanical watches. The certification is focussed primarily on water resistance, chronometric performance, resistance to magnetic fields and power reserve of the watches.

The certification is based on a test of every movement and every watch by the applicant (or the authorised representative). The testing processes are independently monitored by the Federal Institute of Metrology (METAS). METAS is the certifying body. METAS audits the quality system and the testing processes implemented by the applicant and monitors them on an ongoing basis. First of all, this monitoring involves analysing the results obtained by the applicant. Secondly, sample checks are performed by METAS.

This document consists of two parts. Part A describes the technical requirements that each watch must fulfil in order to obtain certification. Part B describes the organisational requirements for monitoring by METAS of the applicant's quality system and verification processes.

2 Conditions for certification and designation

The watch must fulfil the following conditions:

1. The watch must be "Swiss Made" and meet the requirements set out in the latest version in force of the Ordinance of 23 December 1971 on the Use of "Switzerland" or "Swiss" for Watches (SR 232.119).
2. The movement must satisfy the criteria for a "chronometer" according to the standard ISO 3159:2009 and the relevant tests must have been performed by a laboratory with ISO/IEC 17025:2017 accreditation.
3. The movement and the watch must undergo test cycles (see Chapter 6) and satisfy certain technical criteria (see Chapter 7).
4. METAS monitors the results from the testing laboratory by performing statistical analysis and sample checks (see Chapter 9).
5. The testing laboratory must have a quality system that is approved by METAS (see Chapter 10).

If all of these conditions are satisfied, the watch that was tested is certified as compliant in accordance with these Requirements. The watch may then bear the designation "MASTER CHRONOMETER Certified 15 000 Gauss" (or "MASTER CHRONOMETER").

For watches that have obtained MASTER CHRONOMETER certification, the applicant may use the following trademarks on the watches or in the commercial documentation:

a)

Registration number 684356

b)

Registration number 684511

c)

Part A: Technical requirements

3 Definitions

3.1 Terminology

3.1.1 Applicant

The applicant is the legal entity that manufactures and markets watches that are subject to certification.

3.1.2 Testing laboratory

The testing laboratory is the entity that performs the tests defined according to the requirements in this document on the entire production lot certified by METAS. This can be the applicant's in-house laboratory or the laboratory of a third-party entity commissioned by the applicant and acting under the applicant's sole responsibility.

3.2 Measured quantities

3.2.1 Time measured H

The time measured refers to the time displayed by the watch.

Note: The time given by the reference clock is designated as H_R and the time measured by the watch tested as H_{DUT}.

3.2.2 State E

The state of the watch is obtained by subtracting the time measured by the reference clock H_R from the time measured by the watch tested H_{DUT}.

$$E = H_{DUT} - H_R$$

The state is expressed in seconds (s).

In case of an instantaneous rate, it is also possible to measure the deviation in time between the position of a signal generated by the watch tested and the position of a corresponding reference signal.

3.2.3 Daily precision P_{Ji}

The daily precision (also known as the daily rate) indicates by how much time the watch tested is fast (>0) or slow (<0) with respect to the reference clock. The daily precision is calculated by subtracting the state of the watch tested at time t_1 from the state of the watch tested at time t_2 and referencing the result to 24 h. To measure the daily precision, the t_2 - t_1 interval must be between 23 h and 26 h.

$$P_{Ji} = \frac{E_i(t_2) - E_i(t_1)}{t_2 - t_1}$$

The daily precision is expressed in seconds per day (s/d).

3.2.4 Average daily precision $\overline{P_J}$

The average daily precision (also known as the average daily rate) $\overline{P_J}$ is the arithmetic average of the daily precisions for cycles 2, 4, 5 and 6 (see Chapter 6).

$$\overline{P_J} = \frac{P_{J1} + P_{J2} + P_{J3} + P_{J4}}{4}$$

The average daily precision is expressed in seconds per day (s/d).

3.2.5 Instantaneous rate

The instantaneous rate indicates by how much the tested instrument is fast (>0) or slow (<0) with respect to the reference clock. The instantaneous rate is calculated by subtracting the state of the tested instrument at time t_1 from the state of the tested instrument at time t_2 and referencing the result to 24 h. To measure an instantaneous rate, the t_2 - t_1 interval must be a minimum of 30 s. The stabilisation time prior to taking the first state of the watch must be at least 20 s.

$$M_i = \frac{E_i(t_2) - E_i(t_1)}{t_2 - t_1}$$

The instantaneous rate is expressed in seconds per day (s/d).

3.2.6 Deviation from the daily precision E_M

The deviation from the daily precision E_M gives the absolute value of the change in the daily precision after exposing the watch to a magnetic field of 1.5 T.

$$E_M = \left| P_{J3} - P_{J2} \right|$$

The deviation from the daily precision E_M is expressed in seconds per day (s/d).

3.2.7 Power reserve R_M

The power reserve is the amount of time declared by the applicant during which the watch can operate without adding energy to the barrel spring. The power reserve is expressed in hours (h).

3.2.8 Deviation from the instantaneous rate D_E

The deviation from the instantaneous rate D_E gives the absolute value of the deviation between the average instantaneous rates when the watch is fully wound (0 h, M_i) and at 2/3 of the power reserve ($M_{i\text{-}1/3}$).

$$D_E = \left| \frac{\sum_{i=1}^{6} M_i}{6} - \frac{\sum_{i=1}^{6} M_{i-1/3}}{6} \right|$$

The deviation from the instantaneous rate D_E is expressed in seconds per day (s/d).

3.2.9 Deviation from the instantaneous rate D_P

The deviation from the instantaneous rate D_P gives the difference between the largest and smallest instantaneous rate at different positions.

$$D_P = \max(M_1 : M_6) - \min(M_1 : M_6)$$

The deviation from the instantaneous rate D_P is expressed in seconds per day (s/d).

4 Watch categories

The watches tested are categorised according to the fitting characteristics of the movement:

Category	Fitting diameter D / mm	Fitting surface S / mm^2
1$_a$	D > 26	S > 531
1$_b$	20 < D ≤ 26	314 < S ≤ 531
2	D ≤ 20	S ≤ 314

5 Conditions set for the tests

5.1 Climatic conditions in the testing laboratory

The ambient temperature in the testing laboratory must remain at 23°C ± 3°C.

During cycle 10 (see Chapter 6), the environment in the testing laboratory must comply with the standards ISO 22810:2010 and ISO 6425:2018.

During cycles 1 to 9, the relative humidity in the testing laboratory must remain between 30% and 70%, except in the storage area at 33°C where a relative humidity of under 30% is allowed.

5.2 State of the movements and watches

The movements and watches tested must be in their final configuration (movement with all additional modules; watches as they will be offered for sale).

Throughout the entire duration of the tests, the hand position is not defined.

Auxiliary mechanisms for which the functions may be interrupted (chronograph, etc.) will be switched on for cycles 2 to 7. For the other cycles, the applicant may choose whether such mechanisms should be switched on, regardless of whether the measurement is carried out with or without the chronograph function. However, if cycle 8 is measured without using the chronograph function, cycle 9 must also be measured without that function. This rule also applies in the opposite case. The applicant must inform METAS in writing which measurements should be performed with or without using the chronograph function.

5.3 Order of the test cycles

The sequencing of the positions during the test is not critical for measuring the instantaneous rates and the daily precisions.

Cycle 1 must be carried out first. The sequencing of cycles 2 to 10 is not critical. However, cycles 2 to 6 as well as cycles 8 and 9 must be carried out in the order given.

Cycles 6, 8 and 9 may be carried out in parallel (as described in section 6.6).

5.4 Measurement uncertainty

The measurement instruments and procedures must ensure extended measurement uncertainties for each criterion according to the following equation:

$$U_c \leq \frac{T_c}{C_m}$$

U_c: Extended measurement uncertainty ($k = 2$) for the criterion

T_c: Tolerance for the criterion

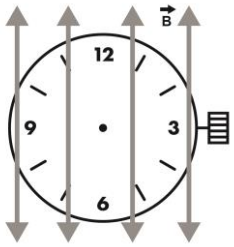
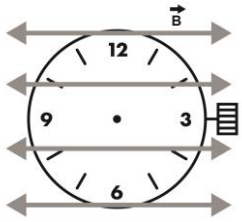
C_m: Measurement capability index. C_m must be ≥ 5.

6 Test cycles

The measurements required to evaluate the different criteria are obtained by carrying out the following cycles:

6.1 Cycle 1

1. Wind up the movement.
2. Expose the movement to a magnetic field according to the following procedure:

Axis of the magnetic field	Illustration[1]	Magnetic field / T	Minimum time / s
6 h – 12 h		1.5	30
9 h – 3 h		1.5	30

The tolerance for the magnetic field is 0/+0.20 T. The magnetic field must be uniform within the entire volume occupied by the movement.

3. Check criterion S_1:
   The movement must not stop during each of the two passes in the magnetic field.
4. Demagnetise the movement.

6.2 Cycle 2

1. Wind up the watch.
2. Note the state of the watch: E_1.
3. Subject the watch to the following sequence:

Position of the watch[2]	Simulation time / min	Temperature / °C
CH	300 ± 30	33 ± 2
9H	180 ± 30	33 ± 2
FH	180 ± 30	33 ± 2
3H	180 ± 30	33 ± 2
3H	300 ± 30	23 ± 2
CH	300 ± 30	23 ± 2

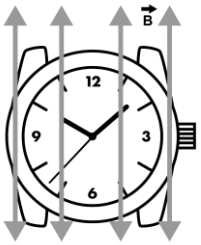
[1] The shown magnetic field gives the axis, the vector can be in one direction or the opposite

[2] Positions of the watch according to ISO 3158:2018.

4. Note the state of the watch: E_2.
5. Calculate the daily rate P_{J1}.

6.3 Cycle 3

1. Wind up the watch.
2. Subject the watch to a magnetic field according to the following procedure:

Axis of the magnetic field	Illustration[3]	Magnetic field / T	Minimum time / s
6 h – 12 h		1.5	30

The tolerance for the magnetic field is 0/+0.20 T. The magnetic field must be uniform within the entire volume occupied by the watch.

3. Check criterion S_2:
   The watch must not stop during the test when exposed to the magnetic field.

6.4 Cycle 4

1. Note the state of the watch: E_1.
2. Subject the watch to the following sequence:

Position of the watch	Simulation time / min	Temperature / °C
CH	300 ± 30	33 ± 2
9H	180 ± 30	33 ± 2
FH	180 ± 30	33 ± 2
3H	180 ± 30	33 ± 2
3H	300 ± 30	23 ± 2
CH	300 ± 30	23 ± 2

3. Note the state of the watch: E_2.
4. Calculate the daily rate P_{J2}.

6.5 Cycle 5

1. Wind up the watch.
2. Demagnetise the watch.
3. Note the state of the watch: E_1.

[3] The shown magnetic field gives the axis, the vector can be in one direction or the opposite

4. Subject the watch to the following sequence:

Position of the watch	Simulation time / min	Temperature / °C
CH	300 ± 30	33 ± 2
9H	180 ± 30	33 ± 2
FH	180 ± 30	33 ± 2
3H	180 ± 30	33 ± 2
3H	300 ± 30	23 ± 2
CH	300 ± 30	23 ± 2

5. Note the state of the watch: E_2.
6. Calculate the daily rate P_{J3}.

6.6 Cycle 6

1. Wind up the watch.
2. Carry out cycle 8 if desired (see 5.3). In this case, the winding up is that of point 1 above (cycle 6).
3. Note the state of the watch: E_1.
4. Subject the watch to the following sequence:

Position of the watch	Simulation time / min	Temperature / °C
CH	300 ± 30	33 ± 2
12H	180 ± 30	33 ± 2
FH	180 ± 30	33 ± 2
6H	180 ± 30	33 ± 2
6H	300 ± 30	23 ± 2
CH	300 ± 30	23 ± 2

5. Note the state of the watch: E_2.
6. Calculate the daily rate P_{J4}.
7. Carry out cycle 9 if cycle 8 was carried out under point 2 below (cycle 8). In this case, the winding up is that of point 1 above (cycle 6).

6.7 Cycle 7

1. Wind up the watch (or as a continuation of a previous cycle).
2. Let the watch run according to the following parameters:

Simulation time / h
According to power reserve

3. Check criterion R_M:
   The watch runs for a duration corresponding to the power reserve declared by the manufacturer.

6.8 Cycle 8

1. Wind up the watch.
2. Subject the watch to the following sequence:

Measure-ment no.	Position of the watch	Minimum stabilisation time / s	Minimum measurement time / s
M_1	3H	20	30
M_2	6H	20	30
M_3	9H	20	30
M_4	12H	20	30
M_5	CH	20	30
M_6	FH	20	30

The measurement must be carried out within 2 h after winding up the watch.

3. Calculate the deviation from the instantaneous rate D_P.

6.9 Cycle 9

1. Wind up the watch. If cycle 9 is carried out after cycle 8, the winding-up operation will be combined with that for cycle 8.
2. Operate the watch at 65% to 75% of the power reserve declared by the manufacturer (1/3 of power reserve remaining).
3. Subject the watch to the following sequence:

Measurement no.	Position of the watch	Minimum stabilisa-tion time / s	Minimum measurement time / s
$M_{1\text{-}1/3}$	3H	20	30
$M_{2\text{-}1/3}$	6H	20	30
$M_{3\text{-}1/3}$	9H	20	30
$M_{4\text{-}1/3}$	12H	20	30
$M_{5\text{-}1/3}$	CH	20	30
$M_{6\text{-}1/3}$	FH	20	30

4. Calculate the deviation from the instantaneous rate D_E.

6.10 Cycle 10

1. Subject the watch to the sequence of water overpressure tests according to the table below (depending on declared pressure for watch):

Declared pressure	Step 1		Transition	Step 2		Transition	Step 3		Reference
	Overpressure / bar	Duration / min	Duration / min	Overpressure	Duration / min	Duration / min	Overpressure / bar	Duration / min	
3 bar < p ≤ 5 bar	0	3	1	p	10	1	0	3	ISO 22810:2010
5 bar < p < 30 bar	0	3	1	p	20	1	0	10	
p ≥ 30 bar without unidirectional rotating bezel									
p ≥ 10 bar with unidirectional rotating bezel	0	30	<10	p + 25%	120	<10	0.3	60	ISO 6425:2018

2. Check criterion W:
   The watch head must pass the condensation test in accordance with paragraph 4.2 of the standard ISO 22810:2010 or an equivalent method[4].

[4] Equivalence with ISO 22810:2010 shall be demonstrated for any alternative method.

7 Acceptance criteria

Each watch tested must meet the following requirements depending on its category:

Criterion	Unit	Requirements by category		
		1_a	*1_b*	*2*
S_1	–	Movement does not stop when exposed to a magnetic field during entire test		
$\overline{P_J}$	s/d	$0 \leq \overline{P_J} \leq 5$	$0 \leq \overline{P_J} \leq 6$	$0 \leq \overline{P_J} \leq 7$
S_2	–	Watch does not stop when exposed to a magnetic field during entire test		
E_M	s/d	$E_M \leq 5$	$E_M \leq 5$	$E_M \leq 5$
R_M	–	Watch still operates at the value of its declared power reserve		
D_E	s/d	$D_E \leq 8$	$D_E \leq 10$	$D_E \leq 12$
D_P	s/d	$D_P \leq 12$	$D_P \leq 14$	$D_P \leq 16$
W	–	Watch can withstand a defined overpressure (depending on certification process)		

8 Rules in case of intervention during certification

1. A correction of the movement cancels the results of the certification. Every cycle in the test must be repeated.
2. In the event of a one-off intervention on the movement, all of the test cycles must be repeated except the one relating to criterion S_1. In particular, adjustment of the rate of the movement and replacement of a component of the movement with an identical component (same size and same material) are considered as one-off interventions.

   For example: replacing the date module or an automatic module, etc.

   Note: Installing and removing the winding stem and/or screws and clamps for the casing are considered as an intervention on the watch head and are covered by point 3.
3. In the event of an intervention on the watch head that involves opening the back of the watch (uncasing/casing, replacing the dial/hands), test cycle 10 for criterion W (water resistance) must be repeated.
4. In the event of an intervention on the watch without opening the back (polishing, installation of a wristlet, etc.), the certification results are not void. None of the tests need to be repeated.

Part B: Organisational requirements

In order to validate the results of the measurements carried out by the testing laboratory, METAS is required to monitor the testing laboratory on an ongoing basis. This entails the following:

1. METAS sets up a monitoring plan for the results (see Chapter 9);
2. The testing laboratory sets up a quality management system which must be successfully audited by METAS (see Chapter 10).

9 Monitoring plan

METAS implements its monitoring on two different levels. On the one hand, METAS performs statistical analysis of the results of the measurements carried out by the testing laboratory. On the other hand, METAS performs sample checks.

9.1 Statistical analysis of the results

The testing laboratory provides all of its measurement results to METAS. Then, METAS performs statistical analysis on the results in order to detect potential flaws. Furthermore, METAS records:

1. The serial number of the movement used for the “chronometer” certification according to the standard ISO 3159:2009;
2. The serial number of the watch head that went through the tests described in Chapter 6.

9.2 Sample checks

Sample checks for the criteria P_J, S_2, E_M, R_M, D_E and D_P are carried out by METAS according to the standard ISO 2859-1:2014 with an S4-AQL1 level of inspection by default. METAS may adapt the sampling method in agreement with the laboratory and the applicant. The S_1 and W criteria are assessed at random. This ensures that the certification measurements are performed correctly by the testing laboratory. METAS will notify the applicant of the test results. In the event of non-compliance, three actions may be required depending on the situation:

1. The applicant analyses the cause of non-compliance and suggests improvements;
2. METAS performs additional measurements on watches of its own choice that are made available by the applicant;
3. METAS performs an audit to analyse the reason for non-compliance.

10 Quality management system

The testing laboratory must implement a quality management system (quality system) that is approved and subject to monitoring by METAS.

10.1 Description of the quality system

The quality system must adequately define the following:

1. The verification processes;
2. The calibration processes for the instruments used;
3. The qualifications and training of the staff in charge of the verifications; and
4. The archiving of the results.

10.1.1 Verification processes

The testing laboratory must suitably document the verification processes that allow it to assess the technical criteria set out in Part A of this document.

10.1.2 Calibration processes for the instruments used

The testing laboratory must suitably document the calibration processes for the measurement instruments used to determine the criteria D_E, D_P, P_J and E_M. The instruments must be periodically calibrated. The interval specified in the testing laboratory’s documentation must ensure that the measurement uncertainties are traceable and adequate (as defined in §2.41 of VIM) [7]. The testing laboratory must provide METAS with its calculation of the measurement uncertainties. The GUM [8] is the basis for

calculating the measurement uncertainties. These calculations are used to control the measurement resources and to realise statistical monitoring of the measurements. The testing laboratory must suitably document the processes for monitoring the performance of the equipment used to determine the criteria S_1, S_2 and W. The measurement instruments that are used to monitor this equipment must be periodically calibrated.

10.1.3 Staff in charge of the verifications

The testing laboratory must have a list of persons in charge of the verifications. For each person, relevant factors must be specified that demonstrate the technical skills required for the testing (such as basic training, continuing education, etc.).

10.1.4 Archiving the results

The testing laboratory must have a description of its system for archiving the results. This must specify the location and duration of archiving. The raw data from the cycles must be stored for at least one year. The evaluation of the criteria for each watch must be stored for at least ten years.

10.2 Monitoring of the quality system by METAS

10.2.1 Evaluation

METAS audits the quality system and the testing processes implemented by the testing laboratory in order to assess whether these processes are under control. If needed, METAS may issue a certificate stating that the laboratory meets the requirements set out in Chapter 10.1 of this document.

The testing laboratory certification is valid for three years.

10.2.2 Interim audits

Between two evaluations, METAS carries out regular audits (at least once per year) to ensure that the testing laboratory maintains and applies its quality system. An audit report is provided to the testing laboratory. The audits are scheduled such that all of the testing processes can be evaluated every three years.

10.2.3 Access to testing laboratories

At any time, METAS may request a visit to the testing laboratory's premises. During these visits, METAS can, if necessary, carry out or order tests on watches to verify the correct operation of the quality system. METAS will provide the testing laboratory with a report on its visit along with a test report if any tests were performed.

10.2.4 Access to information

The applicant must ensure that METAS can access all of the relevant information, including:

1. The quality system described in Chapter 10.1;
2. Proof that conditions 1 and 2 from Chapter 2 are met;
3. Proof that the technical criteria discussed in Chapter 7 are satisfied for each movement and each watch.

10.2.5 Changes to the quality system

The testing laboratory must inform METAS of any intended changes to the quality system. METAS will assess the proposed changes and decide whether the modified quality system will continue to meet the conditions set out in Chapter 10.1.

11 Rights to this document and revision

11.1 Rights to this document

11.2 Revision

11.2.1 Requests for revision

All requests for revision of the Requirements should be sent to METAS in writing and include the following information:

- A proposed modification;
- A justification; and
- A presentation of the impacts the modification will have.

Requests for revision that do not meet these formal requirements will be returned by METAS to their authors for correction.

Requests for revision may be submitted in any official language of Switzerland or in English.

11.2.2 Consultation

METAS informs all companies producing watches that are certified according to the Requirements of any requests for revision. These companies are then invited to take a position in writing on the proposed revisions.

Any modification or revision of the Requirements requires approval by METAS as well as by each company that has produced watches certified according to the Requirements for over 12 months.

Note: During the first 12 months after the Requirements enter into force, any modifications or revisions are made by mutual agreement between METAS and the companies producing watches certified according to the Requirements.

References

[1] ISO 3159:2009: Timekeeping instruments – Wrist-chronometers with spring balance oscillator

[2] ISO 3158:2018: Timekeeping instruments – Symbolisation of control positions

[3] ISO 22810:2010: Horology – Water-resistant watches

[4] ISO 6425:2018: Horology – Divers' watches

[5] ISO/IEC 17025:2017: General requirements for the competence of testing and calibration laboratories

[6] ISO 2859-1:2014: Sampling procedures for inspection by attributes – Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection

[7] VIM: International vocabulary of metrology – Basic and general concepts and associated terms (VIM), ISO/IEC GUIDE 99:2007

[8] GUM: Evaluation of measurement data – Guide to the expression of uncertainty in measurement, JCGM 100:2008