ITTC Quality System Manual

Sample Work Instructions

Work Instructions

Calibration of Chronometers with Pointer Indication

7.6 Control of Inspection, Measuring and Test Equipment

7.6-02 Sample Work Instructions

7.6-02-06 Calibration of Chronometers with Pointer Indication

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Updated / Edited by	Approved
Quality Systems Group of the 28th ITTC	23rd ITTC 2002
Date: 07/2017	Date: 09/2002

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Source:

Verification regulation of time interval measuring instrument with needle indication (trial usage)

[Issued on May 31, 1995 and put into effect since May 1, 1996 by National Technical Bureau - **JJG 237—95, National Measuring Verification Regulation of People's Republic of China**]

Calibration of Chronometers with Pointer Indication

1. PURPOSE

This working instruction can be applied to the verification of a time interval-measuring instrument with a pointer indicator when newly manufactured, when in use and after repair.

2. INTRODUCTION

Chronometer means a time interval measuring instrument, with a pointer on its dial for indicating the time interval measurement value.

The fundamental principle of these **chronometers** is that the pointer may be rotated by the main vibration source by a mechanical driving device. There is a fixed relationship between the angle of rotation and the frequency of the main vibration source.

At present, the most widely used **chronometer**s are a mechanical stopwatch, or an electronic stopwatch.

3. TECHNICAL REQUIREMENTS

3.1 Measuring Resolution Ratio

The dials of **chronometer** can be separated into two or three, outer and inner dials, with two or three pointers of different sizes. The time interval indicated by the smallest scale on the outer disk is named as resolution ratio. Where it can be 10ms, 10ms or 100ms.

3.2 Measuring Error

Measuring error may be given in the way of absolute error as one of the following two forms:

- The measuring error may be given when the measuring values equal the full-scale values of the inner and outer disks respectively.
- Measuring error = T × accuracy of the frequency of the main vibration source + ΔT

where

T is the measured time interval

ΔT is the error caused by the inaccuracy of the mechanical driving device and the scale dial, and is called the inherent error.

3.3 Qualification of some chronometers

The requirements of the time measuring error for mechanical stopwatches are shown in Table 1.

1.1.1 Measuring range and the maximum inherent error of the electric stopwatch are shown in Table 2.

Table 1

item		average travel-time difference of minute dial				maximum travel-time difference of second dial			
grade	Pulsation value of second hand	2min	4min	15min	30min	3s	6s	30s	60s
excellent	0.01	±0.24				±0.1			
	0.02		±0.3				±0.1		
	0.1			±0.4				±0.2	
	0.2				±0.6				±0.35
First grade	0.1			±0.5				±0.25	
	0.2				±0.1				±0.4
qualified	0.1			±0.8				±0.25	
	0.2				±1.6				±0.4

Note:

A) The average travel-time difference of minute dial is the average value of the measurement errors, measured several times from the standard time interval of the minute dial full scale value, within the prescribed effective working time of the spring.
B) The maximum travel-time difference of second dial is the maximum value of the measurement errors, measured several times from the standard time interval of the second dial full scale value within the prescribed effective working time of the spring.

Table 2

Type of stopwatch	Measuring Range (s)	Maximum inherent error (ms)
401	0~60	6
405	0~600	
407 (408)	0~10	30

The measuring error of chronometers should meet the technical requirements of their own standard.

4. CALIBRATION CONDITION

4.1 Environmental Conditions

A) Environmental temperature: 20±5℃
B) Relative humidity: ≤80%
C) Power supply: ~220(1±10%)V, 50Hz
D) There should not be any electro-magnetic interference or mechanical vibration, which affects the working of chronometer.

4.2 Equipment for Calibration

A) Standard time interval generator (or time calibrator)
Its range and function can meet the requirement of the calibrated **chronometer**s. Its error should be less than or equal to one-tenth of the measuring error of the calibrated **chronometer**s.
B) Stopwatch fixture with electro-magnet.

5. SUBJECT AND METHOD OF CALIBRATION

5.1 Examination of the Exterior and Normal Working

5.1.1 Mechanical damage

A calibrated **chronometer** should not have any mechanical damage, which affects the normal usage of the instrument.

5.1.2 Pointer and dial

The dial looks flat. The scale appears fine and clear. There is not any contact or friction between the pointer and the dial or the pointer and the glass, when the pointer moves.

5.1.3 Zero position

A standard time interval is stipulated for the variety of functions of the **chronometer** being checked, whether normal or not. When the pointer goes back at the zero position, the absolute difference value between the pointer position and the zero scale should not exceed the values given in the specification.

5.2 Calibration of the Measuring Error

5.2.1 Selection of the calibration value

The full-scale values of the various dials.

5.2.2 The calibration number

The full-scale value of the outermost dial should be calibrated three times. The others, twice. The arithmetic average will be taken as the value for each calibration value.

5.2.3 Selection of the measuring functions

A) For the chronometer, which only has one mechanical contact.

- the duration of the contact closing.
- the duration of the off-contact.
- the time interval between two consecutive contact closings.
- the time interval between two consecutive contact closing.

B) For a chronometer, which has two mechanical contacts: besides the above four functions in clause a), the following should also be calibrated.

- - the time interval between the closing of the first and the second contacts.
- - the time interval between the opening of the first and the second contacts.

C) all the functions of the mechanical stopwatch.

5.2.4 Calibration of a time interval measuring instrument with pointer indicator.

The instruments are connected as shown in Fig. 1.

The connection between two instruments should meet the requirement of the specification.

The calibration values, number and the measuring functions can be selected as mentioned in the above clauses.

5.2.5 Calibration of a mechanical stopwatch

The instruments are connected shown in Fig.2

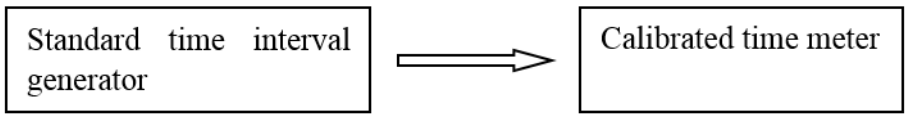

Fig. 1

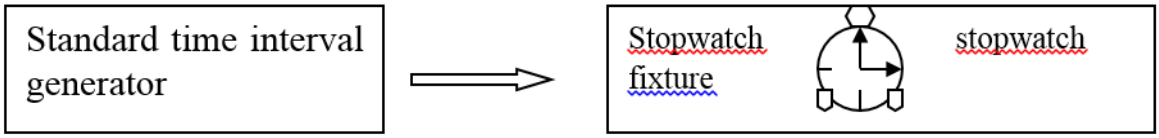

Fig. 2

Table 3

number	Tick value of the second hand (s)	running time stopwatch should reach before calibration (s)	Required effective working time of spring
1	0.01	20	10 min
2	0.02	20	20 min
3	0.1	180	3 h
4	0.2	180	h

A) Wind the watch. Start the stopwatch and let it run continuously. Its running time should not be less than that required in the third column of Table 3.
B) The stopwatch is fixed in the fixture and calibrated within the required effective working time of the spring, shown in Table 3.
Standard time interval generator sends out the time interval between two continuous closings (i.e. turn on – turn off) of the contact
C) The measuring error of the full-scale value of the second dial should be given as the maximum error. That of the full-scale value of the minute dial should be given as the average error.
D) The above calibration should be carried out with the dial in the horizontal and vertical positions.

5.2.6 Calibration of an electronic stopwatch
Standard time interval is generated by 50 Hz signal of the power supply. The instruments are connected as shown in Fig.3.

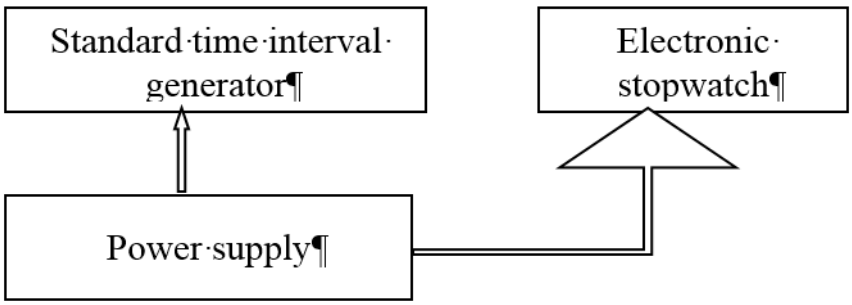

Fig.3

The measuring functions can be selected on the basis of the special functions of the electronic stopwatch.

A) With the functions mentioned in the clauses 4.2.4.a) and b):
In the “continuity” the duration of one contact closing and the time interval between two off-contacts should be selected.
In the “contacting character”, the time interval between two off-contacts should be selected.
B) Only with the functions mentioned in item 4.2.4.a):
The duration of the of-contact should be selected.
C) The inherent measuring error of the electronic stopwatch should be given as the “maximum measuring error”.

5.2.7 The mean measuring error can be calculated by formula (1):

$$\overline{\Delta T} = \frac{1}{N}\sum_{i=1}^{N}(T_i - \Delta l_i) - T_0 \qquad (1)$$

where

T_i the measured value of the calibrated chronometer, every time

Δl_i the value indicated by the pointer from the zero position of the dial, after the needle goes back at the zero position,at the left as"-", at the right as "+".

T_0 standard time interval

N the number of times each calibrated value is measured.

$\overline{\Delta T}$ average value of the measuring errors.

5.2.8 The maximum measuring error can be calculated by formula (2):

$$\Delta T_{\max} = |(T_i - \Delta l_i) - T_0|_{\max} \qquad (2)$$

where,

$\Delta T_{\max}$ the maximum measuring error

T_i , same as in formula (1)

Δl_i same as in formula (1)

T_0 same as in formula (1)

6. CALIBRATION RESULT AND THE CALIBRATION PERIOD

6.1 Presentation

$\overline{\Delta T}$ and $\Delta T_{\max}$ should be given in the calibration report on the basis of the format shown in the Appendices.

6.2 Protocol

For the chronometers which meet the requirement of this working instruction through calibration, a calibration protocol will be supplied: For those which do not meet the requirement, an advice note of the calibration result will be supplied, with the non-compliance pointed out.

6.2.1 Calibration Period

The calibration period of the chronometer can be determined on the using condition, but not over one-year.

Appendix A. CALIBRATION RESULTS OF MECHANICAL STOPWATCH

Stopwatch position	Dial vertical		Dial horizontal	
Calibrated time	s	min	s	min
Average travel-time difference $\overline{\Delta T}$ of minute dial				
Maximum travel-time difference ΔT_{max} of second dial				
remark				

Appendix B. APPENDIX 2 CALIBRATION RESULTS OF ELECTRONIC STOPWATCH

Measured function	Standard T_0	Inherent measuring errorΔT_{max}

Note: The measuring error in application $= \pm \left(T \frac{F-50}{F} \right) + |\Delta T|_{max}$

Where, F is the frequency of the test signal used for the measurements.