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**Calibration and test method for
force-proving instruments**

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry, through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by Japan Measuring Instruments Federation (JMIF)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS B 7602: 2002** is replaced with this Standard.

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Calibration and test method for force-proving instruments

Introduction

This Japanese Industrial Standard was established in 1983 and to this day has gone through two revisions. The last revision was made in 2002, and it has been revised this time to demarcate the scope sharply from that of **JIS B 7612-1 : 2008** (*Load cells for weighing instruments — Part 1 : Analog load cells*) which was established after the above last revision.

The corresponding International Standard has not yet been published at this moment.

1 Scope

This Standard specifies a static calibration method for force-proving instruments other than those used in static verification of uniaxial testing machines and a static performance test method for force transducers other than load cells for weighing instruments. This Standard shall be applied to force-proving instruments including force transducers in which the force is determined by measuring the elastic deformation (hereafter referred to as “deflection”) of a loaded member or a physical quantity which is proportional to it.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitutes provisions of this Standard. The most recent edition of the standard (including amendments) indicated below shall be applied.

JIS Z 8103 *Glossary of terms used in measurement*

3 Terms and definitions, symbols and units

For the purpose of this Standard, the terms and definitions given in **JIS Z 8103** together with the following apply. The symbols, units and indications used in this Standard shall be in accordance with table 1.

3.1 force transducer

devices to prove the magnitude of force by converting the deflection of members applied force or physical quantity proportional to it to electric signal using strain gauge, piezo-electric element and the like, excluding the indicator

3.2 force-proving instruments

whole assembly from the force transducer through to, and including, the indicator

Table 1 Symbols, units and indications

Symbol	Unit	Indication
F_N	N	maximum calibration force
F_c	N	maximum capacity of the force transducer
F_l	N	value added with frame load to unloaded condition (referred to as initial load)
F	N	indication reference standard or true force of at each measuring point when measured with increasing test force
F'	N	indication reference standard or true force of at each measuring point when measured with decreasing test force
F_i	N	reading of a force-proving instrument at each measuring point when measured with increasing test force
F'_i	N	reading of a force-proving instrument at each measuring point when measured with decreasing test force
$\bar{F}_i, \bar{F}$	N	arithmetic average of measured values F_i and F for the same point of force measuring
$F_{\max}, F_{\min}$ $F'_{\max}, F'_{\min}$	N	maximum or minimum of F_i and F for the same point of force measuring
i_0	a)	reading on the indicator before application of force
i_f	a)	reading on the indicator after removal of force
X	a)	deflection with increasing test force
X'	a)	deflection with decreasing test force
$\bar{X}, \bar{X}'$	a)	average value of deflection
$X_{\max}$	a)	maximum deflection
$X_{\min}$	a)	minimum deflection
X_a	a)	computed value of deflection using calibration equation
X_N	a)	deflection corresponding to maximum calibration force
r	a)	resolution of the indicator
b	%	relative repeatability error
f_0	%	relative zero error
f_c	%	relative interpolation error
a	%	relative resolution
v	%	relative reversibility error
q	%	relative indication error
θ	a)	rated output
θ_n	a)	output when the maximum capacity loaded in the n -th measuring range
θ_{0n}	a)	output when unloaded or initial loaded just before the n -th calibration
$\Delta\theta_L$	a)	the maximum difference between the average value of three outputs for series with increasing test force and the value on reference line against the same test force obtained in three series of reversibility calibration
L	%R.O ^{b)}	linearity
$\Delta\theta_H$	a)	the maximum difference between the average values of three outputs against the same test force for each series with increasing force and with decreasing force obtained in three series of reversibility calibration
H	%R.O ^{b)}	hysteresis error
$\Delta\theta_R$	a)	the maximum difference among outputs against the same test force for the series with increasing force
R	%R.O ^{b)}	repeatability
θ_{ta}	a)	output at the time about 5 s after the load reached maximum capacity in the measuring range
θ_{tb}	a)	output at the time when the deviation from θ_{ta} becomes maximum during 30 min after loading

Table 1 (concluded)

Symbol	Unit	Indication
C	%R.O ^{b)}	creep
θ_{0a}	a)	output at the time about 5 s after the load removed
θ_{0b}	a)	output at the time about 30 min after the load removed
C_R	%R.O ^{b)}	creep recovery
t_h	°C	test temperature on high-temperature side (temperature close to the upper limit of temperature range)
t_l	°C	test temperature on low-temperature side (temperature close to the lower limit of temperature range)
θ_h	a)	average of outputs when unloaded at test temperature on high-temperature side
θ	a)	rated output at the standard test temperature
θ_l	a)	average of outputs when unloaded at test temperature on low-temperature side
T_0	%R.O ^{b)} /°C	temperature characteristics of zero point
θ_h	a)	rated outputs at the test temperature on high-temperature side
θ_l	a)	rated outputs at the test temperature on low-temperature side
T_R	%/°C	temperature characteristics of output
g_L	m/s ²	gravity acceleration at the calibration site
ρ_{air}	kg/m ³	air density
ρ_m	kg/m ³	density of weight
Notes a) For indicator, such indication units as N, mV/V, mm, A, scale, and micro strain may be used. b) % to rated output		

4 General

Calibration consists of applying precisely-known forces to an elastic body and recording the data of deflection of the force-proving instrument from the indicator.

5 Characteristics of force-proving instrument

5.1 Identification of the force-proving instrument

All the elements of the force-proving instrument (including the cables for electrical connection) shall be individually and uniquely identified, e.g. by the name of manufacturer, the model, and the serial number. For the force transducer, the maximum working force shall be indicated.

5.2 Application of force

The force transducer and its loading fittings shall be designed so as to ensure axial application of force, whether in tension or compression.

5.3 Measurement of deflection

Measurement of the deflection of the loaded member of the force transducer may be carried out by mechanical, electrical, optical or other means with adequate accuracy and stability.

6 Condition of calibration and test

6.1 Environmental condition

The environment for calibration or test shall be as follows. In addition, the influences of magnetic field, electric field and vibration shall be noted.

- a) The calibration or test shall be performed at a temperature stable to within $\pm 1^\circ\text{C}$, this temperature shall be within the range of 18°C to 28°C and shall be recorded. Sufficient time shall be allowed for the force-proving instrument and the force transducer to attain a stable temperature.

Force transducers shall be energized for at least 30 min before calibration.

NOTE : When it is known that the force-proving instruments and the force transducer be not temperature-compensated, care should be taken to ensure that temperature variations do not affect the calibration or test.

- b) The atmosphere pressure shall be in the range of 950 hPa to 1 050 hPa. If pressure variations affect the measurement, calibration or test shall not be carried out.
- c) Humidity shall be measured and recorded. In addition, the humidity shall be not more than 75 % and care shall be taken to ensure that dew condensation does not occur.
- d) The value of the acceleration gravity which has been measured on the test site or calculated shall be used.

6.2 Variable voltage test

This test is left to the discretion of the calibration service. For force-proving instruments and force transducer requiring an electrical supply, verify that the variation of $\pm 10\%$ of the line voltage has no significant effect. This verification can be carried out by means of a force transducer simulator or by another appropriate method.

6.3 Requirements for installation of force-proving instrument and force transducer

The following items shall be assured of

- a) The force-proving instrument and the force transducer shall be installed such that its main axis is aligned with the direction of test force on the loading axis. Test force shall be applied along its sensitive axis so as not to have an impact on the force-proving instruments and the force transducer, and then removed. Appropriate compression pads, joints, fittings and the like, if used, shall not affect the output when the test force is applied.
- b) Because the purpose of this calibration or test is not to examine the affect which mounting or dismounting the force-proving instrument and the force transducer on calibration or test machine gives to the measurement performance, specific care shall be taken to mounting of the force-proving instrument and the force transducer on calibration or test machine.
- c) The parameters such as surface roughness, flatness, scratch and eccentricity shall be considered to prevent other errors than inherent error from entering. And the loading condition shall be set in accordance with the requirements of the manufac-

turer of the force-proving instrument and the force transducer.

6.4 Calibration and test equipment

The calibration and test equipment shall be as follows.

- a) The calibration and test equipment used in the loading test of the force-proving instrument and the force transducer shall be traceable to national standards.
- b) The force (F) produced by the value of standard mass (m) and gravity acceleration (g_L) at the calibration or test site shall be calculated from the following equation (1).

$$F = m \times g_L \times \left[1 - \frac{\rho_{\text{air}}}{\rho_m} \right] \dots\dots\dots (1)$$

6.5 Calibration of indicator

The indicator to be used in the performance test of the force transducer shall be calibrated on a periodic basis.

6.6 Overloading test

At least one overloading test shall be done by the manufacturer before the instrument is released for calibration or test. The force-proving instrument and the force transducer are subjected, four times in succession, to an overload that should exceed the maximum force by a minimum of 8 % and a maximum of 12 %. Overloading is maintained for a period of 1 min to 1.5 min.

7 Calibration and loading test

7.1 Preparation

In the practice of the calibration and loading test, confirm each condition specified in clause 6, and take the following items into account.

- a) **Initial load** The initial load such as loading frame shall not be applied 10 % or over of rated capacity of the force-proving instrument and the force transducer. If the initial load has been applied 10 % or over, the value shall be noted in a certificate.
- b) **Electrical stability** The force-proving instrument and the force transducer which carry out electrical measurement shall be preliminarily energized to stabilize electrically for the time specified by the manufacturer.
- c) **Cable** Cables to the force-proving instrument and the force transducer for electrical measurement shall be connected so that their mass, length, etc. shall not affect the test results.

In the test for temperature characteristics, the coupling parts such as cables shall be maintained at the same temperature as that of the force transducer. The indicator shall be maintained at a room temperature.

- d) **Coupling parts** The effect of temperature variation of the coupling parts shall be considered in the determination of test results.

7.2 Test sequence

The performance of force transducer shall be tested as the following sequence.

- a) When all the tests including calibration are carried out on the same equipment, the sequence shall be as shown in figure 1.
- b) When the creep test is carried out by other equipment than that for general loading tests, the sequence shall be as shown in figure 2.

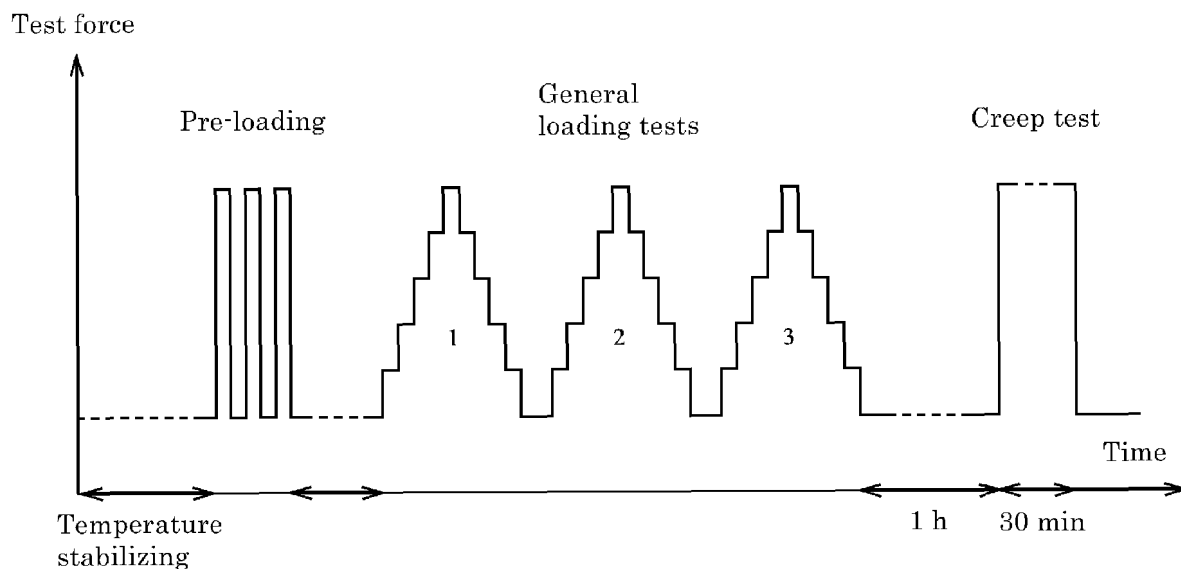


Figure 1 Test sequence on the same equipment

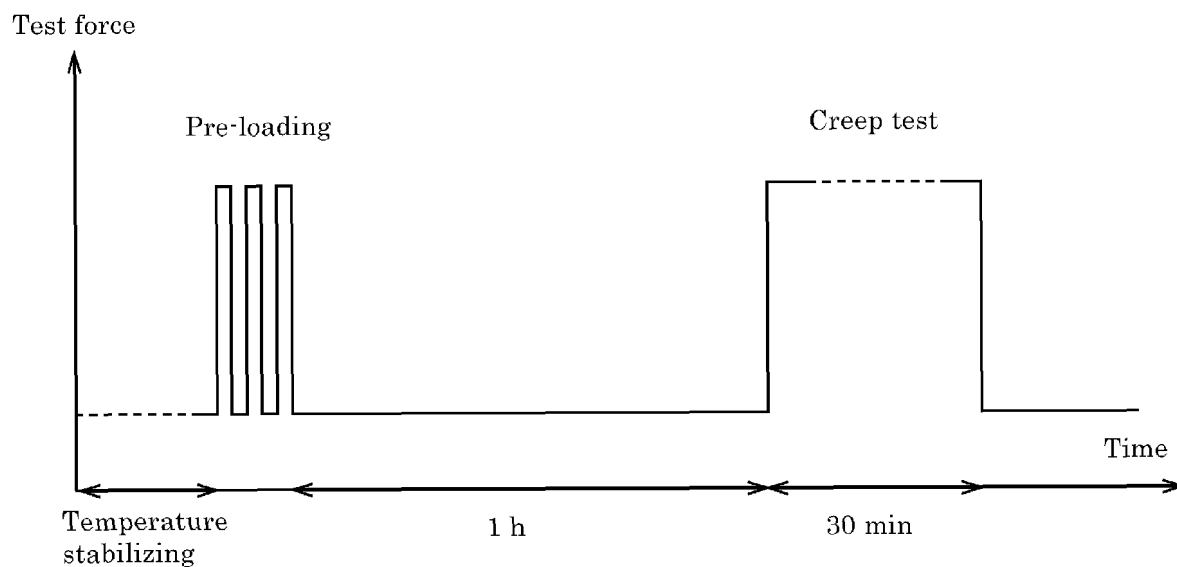


Figure 2 Test sequence when only the creep test is carried out