ITTC Quality System Manual

Sample Work Instructions

Work Instructions

Calibration of Load Cells

7.6	Control of Inspection, Measuring and Test Equipment
7.6-02	Sample Work Instructions
7.6-02-09	Calibration of Load Cells

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Table of Contents

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Verification regulation of load cell
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Calibration of Load Cells

1. PURPOSE

This procedure can be applied to the calibration of strain gauge load cells for force measuring and weighing in both directions tension-, compression - or tension and compression serving dual purpose (hereinafter referred to as load cell). It applies to new load cells, to gauges in service, and after repair. The calibration of other type of electric measuring load cells can be carried out in reference to this work instruction.

2. TECHNICAL REQUIREMENTS

2.1 Label

The load cell and its suspensions should be steadily fastened in a solid box. The name of the producer (or the producer sign), type, specification, production number, production date of the load cell should be marked on its nameplate.

2.2 General Condition

The load cell and its suspensions shouldn't have any surface default which could affect its technical performance. The mounting parts should be all available. Normally they are not allowed to be exchanged.

The load cell should work well at room conditions.

2.3 Classification.

The classification of the grade of the load cell is shown in Table 1. The assessment period of the stability should be normally taken as 3 months, half year or one year, not less than 3 months.

2.4 Basic Characteristics.

The following 17 basic technical characteristics should be normally stated and available for each load cell.

2.4.1 Load characteristics:

nominal loading, safe overload capacity, sensitivity, linearity, hysteresis, repeatability and stability. The allowable error of sensitivity should be given for new or repaired load cells.

2.4.2 Electric characteristics:

input resistance, output resistance, insulation resistance, zero output, rated voltage.

2.4.3 Temperature characteristics:

influence of zero point temperature, influence of temperature on output, temperature compensation range.

Table 1 Classification: Grade of Load Cells

<table>
<tr><td colspan="3">Grade</td><td colspan="3">High precision</td><td colspan="2">Precision</td><td colspan="2">Normal</td><td rowspan="2">Name</td></tr>
<tr><td colspan="3" rowspan="3">Code name</td><td colspan="3">A</td><td colspan="2">B</td><td colspan="2">C</td></tr>
<tr><td>0.02S</td><td>0.03S</td><td>0.05S</td><td>0.1S</td><td>0.3S</td><td>0.5S</td><td>1S</td><td>For cells with stability index given</td></tr>
<tr><td>0.02</td><td>0.03</td><td>0.05</td><td>0.1</td><td>0.3</td><td>0.5</td><td>1</td><td>For cells without stability index given</td></tr>
<tr><td rowspan="7">Allowable error</td><td rowspan="6">I</td><td>L</td><td rowspan="6">±0.02</td><td rowspan="6">±0.03</td><td rowspan="6">±0.05</td><td rowspan="6">±010</td><td rowspan="6">±0.30</td><td rowspan="3">±0.50</td><td rowspan="3">±1.0</td><td rowspan="6">L — linearity (%FS)
H — hysteresis (%FS)
R — repeatability (%FS)
S_t — influence of temperature output (%FS/10K)
Z_t — influence of zero point temperature (%FS/10K)
C_p — creep (%FS/30min)</td></tr>
<tr><td>H</td></tr>
<tr><td>R</td></tr>
<tr><td>S_t</td><td>/</td><td>/</td></tr>
<tr><td>Z_t</td><td>/</td><td>/</td></tr>
<tr><td>C_p</td><td>/</td><td>/</td></tr>
<tr><td>II</td><td>S_b</td><td>±0.04</td><td>±0.06</td><td>±0.10</td><td>±0.20</td><td>±0.60</td><td>±1.0</td><td>±2.0</td><td>S_b — stability of sensitivity (%FS/×month)</td></tr>
</table>

Note:

(1) If the load cells of A and B grade temporarily cannot be calibrated covering the six main indexes of the allowable error I shown in Table 1, because of the limitation of the calibration condition, it is allowed that the grade may be determined on the basis of the calibration results of 4 indexes --- L、H、R、Z_t.

(2) If it is difficult to rapidly increase loading or to keep the load constant by use of the standard force exerting machine or the loading equipment, the creep recovery C_r is allowed to be used instead of the creep C_p. Its allowable error is the same as the one of C_p.

Table 2

Grade	A	B	C
Allowable error (%FS)	±1.0	±2.0	±5.0

2.4.4 Creep characteristics:

The manufacturer should normally supply 17 basic technical characteristics for each load cell. Normally the following 9 properties should be calibrated: sensitivity *S*, linearity *L*, hysteresis *H*, repeatability *R*, zero output *Z*, influence of zero point temperature Z_t, influence of output temperature S_t, creep C_p (or creep recovery C_r) and stability S_b. **Note:** If the requirements of this clause temporarily cannot be met because of the limitation of the calibration condition, the manufacturer must at least supply the other 14 basic technical characteristics except stability, influence of output temperature and creep. The metrological department must at least calibrate the 5 technical characteristics of *S*、*L*、*H*、*R* and *Z*. The zero output of the load cell *Z* should comply with the data in Table 2.

2.5 Drift

At indoor conditions the percentage of the zero drift over the rated output of the load cell should over a time of 2 hours not exceed half of the acceptble error I shown in Table 1.

2.6 Other Relevant Technical Characteristics

The other relevant technical characteristics of the load cell (such as overload capacity, influence of non-axial load, natural frequency, circulation life, influence of external magnetic fields, vibration resistance property) should meet the requirements of the relevant technical documents (such as relevant national standards, shop instructions etc.).

3. CALIBRATION CONDITIONS

3.1 Standard Calibration Condition.

The calibration must be carried out under the following conditions:

a) Ambient temperature: 20±2°.
b) Relative humidity: ≤70%.
c) Atmospheric pressure: 90~106 kPa (680~800mmHg)

Note: (1) If the above standard calibration condition cannot be met, the calibration can be carried out under the following room conditions which should then be noted in the calibration report with the calibration result. The ambient temperature change must not exceed 1° per hour during the load cell calibration. This note is also suitable as standard calibration condition in any other item of this work instruction.

Room condition:

d) Temperature: 20±10°.
e) Relative humidity: ≤90%.
f) Atmospheric pressure: 90~106 kPa (680~800mmHg)

(2) Deviations of the relevant technical characteristics caused by the actual service condition should be noticed. The calibration results can be revised when necessary.

3.2 Loading condition

- The load cell should be installed in a way that ensures the alignment of its main shaft line and its loading shaft line so that the influence of a loading declination or eccentric loading is reduced to a minimum.
- Compression

1. The quality of the loading contact surface must be taken care of for any loading device. Both the support surface and the bottom surface of the load cell should be smooth without any rusty erosion, bruise and impurity.
2. The load cell should normally have high, or low pressure-bearing cushions.

- Tension. The two ends of the load cell should have proper connection elements installed.

3.3 Temperature balance period.

The load cell should be kept under the standard calibration conditions for a time long enough to make sure that its temperature is stable and corresponds to the required standard calibration condition. The period for the temperature balance is suggested to be not less than 8h.

3.4 Preheating.

Before the calibration the load cell, the display units, the load source and other accessories which are connected with it should be switched on for preheating the system The preheating duration should meet the specification of the manufacturer. The calibration should not be carried out until all parts are stable.

Note: Load cells , measuring meters or load sources for which no specification is available should normally be preheated for half to one hour.

3.5 Atmospheric pressure.

Changes of the atmospheric pressure which might obviously affect the zero output of the load cell should be noticed.

3.6 Relevant Technical Indices

The relevant technical indices of the standard force-exerting device or the loading device for the load cell calibration should be in principle three times those of the calibrated load cell. The proper standard force-measuring device and loading device should be selected on the basis of the calibration contents and the relevant indexes of the calibrated load cell.

3.7 Precision Indices

The precision indices of the used indication meters should be at least three times those of the calibrated load cell during calibration.

The precision indices of the used load source should be at least five times of those of the calibrated load cell during calibration.

3.8 Thermostat Container.

The adjustable temperature range of the thermostat container should not be less than the temperature compensation range of the load cell. It should normally be within –30~+70°. The range of variation of the temperature of the environment should normally not exceed ±1°. The temperature gradient should normally not exceed 3°/h.

4. ITEMS AND METHOD OF CALIBRATION
FIRST TIME CALIBRATION FOR A NEW LOAD CELL OR AFTER REPAIR

4.1 Preparations

- An exterior inspection can be done according to the requirement of item 2.2 of this procedure.
- The zero drift Z_d of the load cell within 2h should be measured after the load cell and its connected electronic devices have been preheated according item 3.4.

$$Z_d = \frac{\theta_{0\max} - \theta_{0\min}}{\theta_n} \cdot 100[\%FS] \tag{1}$$

where,

θ_{0max},θ_{0min} --- the maximum and the minimum value of the zero output during the measuring time respectively.

θ_n --- The rated output of the load cell.

Note: This index is normally measured for one time, at most three times. The mean value will be taken as the final result.

4.2 Calibration Method

The characteristics of the load cell can be calibrated according to the following procedures.

- The ambient conditions and the calibrating conditions should be compared and checked if they meet the requirements given in item 3.
- The load cell should be put on the standard force-exerting machine and preloaded three times, up to the nominal load and then returned to zero each time.

Note: This item may not be carried out when the execution for the load characteristics of the load cell is not required under the condition of preloading.

- The electric driving mechanism may be inspected or adjusted if necessary, the measuring range and the zero point of the indicating meter should be adjusted and the zero output should be read.
- On having pre-loaded three times, the formal calibration can start in one min.
- The load should be progressively increased up to the nominal one with the same increment. Each load step should be kept for a

certain time and the output value may be read when it has stabilized.

Notes:

1. The load keeping time is recommended to be 5s, 15s, 30s and 1min 30s. The selection should be noted.
2. The load increment may be not equal, when the loading condition of the standard force-exerting machine is limited. The first load step should normally be 10-20% of the nominal one.
3. The number of load steps must not be less than 5 (zero load is not included), 10 steps are recommended.

- Once the nominal load has been reached the same method can be used for progressive reducing. Each load step should be kept for a certain time and the output value may be read when it has stabilized.
- When the load returns to zero and stays there for 1 min., the zero output can then be read. The zero point of the indicating meter can be readjusted when necessary.
- The procedure of loading and unloading should be carried out at least three times.
- The relevant technical indices (see Figure 1) can be calculated from the following formulae with the above calibration result.

Zero output:

$$\theta_0 = \frac{1}{m}\sum_{j=1}^{m}\theta_{0j} \tag{2}$$

Expressed as percentage of the nominal output:

$$Z = \frac{\theta_0}{\theta_n}\times 100\left[\%\ of\ \ the\ rated\ output\right] \tag{3}$$

which is simplified as ~ %FS.

Output at the rated load:

$$\theta_{n0} = \frac{1}{m}\sum_{j=1}^{m}(\theta_{nfr} - \theta_{0j}) \tag{4}$$

Linearity:

$$L = \frac{\Delta\theta_L}{\theta_n}\times 100\quad[\%\mathrm{FS}] \tag{5}$$

Hysteresis

$$H = \frac{\Delta\theta_H}{\theta_n}\times 100\quad[\%\mathrm{FS}] \tag{6}$$

Repeatability

$$R = \frac{\Delta\theta_R}{\theta_n}\times 100\,[\%\mathrm{FS}] \tag{7}$$

where,

m number of the calibration adjusting cycles

θ_{0j} output reading at zero load at the time of the measuring at the j^{th} cycle (j=1, 2, …, m);

θ_{nfr} output reading at nominal load at the measuring of the j^{th} time;

$\Delta\theta_L$ the maximum value of the deviation between the mean advance calibration curve and the straight line of two mean end points;

$\Delta\theta_H$ the maximum value of the deviation between the return mean calibration curve and the advance one;

$\Delta\theta_R$ the maximum value of the output range at each load point during the repeat-calibration.

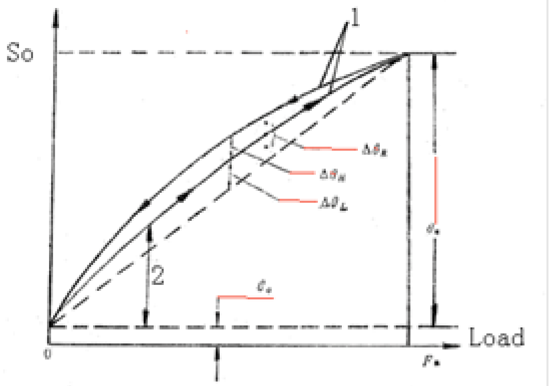

Figure 1

S_o output signal, F_n rated load, θ_n rated output, θ_0 zero output, $\Delta\theta_R$ repeatability, $\Delta\theta_H$ hysteresis, $\Delta\theta_L$ linearity,

1 calibration curves, 2 output

4.3 Asymmetry

After the loading – unloading procedure has been finished, load cells of grade A should be turned 3times around their main shaft line by 90^0 respectively, i.e. the angle between the pressure cushion position vector of the standard force-exerting machine and the load cell position vector (simplified as direction angle) should be changed from 0^0 to 90^0, 180^0, and 270^0. After each turn the load should be exerted on the load cell up to the nominal one, the rated output $\theta_{n\varphi}$ can be read. The arithmetic mean of $\theta_{n\varphi}$ at 4 direction positions (including 0^0 direction position) is taken as the rated output of the load cell θ_n. The rated output θ_n of load cells of grade B or C is $\theta_n = \theta_{n0}$.

4.4 Relative Deviation

The relative deviation S_e between the nominal sensitivity value S_0 and the actual measured one S can be calculated and judged whether it meets the requirement for the acceptable error of sensitivity with the following formulae:

$$S = \frac{\theta_n}{U} \text{ [mV/V]} \tag{8}$$

$$S_e = \frac{S_0 - S}{S} \times 100 \quad \text{[\%FS]} \tag{9}$$

where, U is the mean value of the voltage of the load cell.

4.5 Creep

Creep and creep recovery can be calibrated by the following procedures.

- The environmental condition and the calibrating condition should checked whether they meet the requirements given in chapter 3.
- The load cell should be installed on the standard force-exerting machine and pre-loaded three times, up to the nominal load and then returned to the zero point each time. The pre-load should not be exerted on a load cell, at least within 24 hours before the calibration if the exertion of the pre-load affects the calibration result.

- The electric drive may be inspected and adjusted if necessary, the measuring range and zero point of the indicating meter should be adjusted and the zero output should be read
- The rated load should be exerted as fast as possible (the loading duration should not usually exceed 5s, static weights are the best), after loading(5s~10s is recommended) the output should be read. Then the following outputs should read at fix time intervals within 30 min.
- The load should be unloaded as fast as possible (the unloading duration shouldn't usually exceed 5s), after unloading (5s~10s is recommended) the output should be read. Then the following outputs should be read in fix time intervals within 30 min.
- The relevant technical indices (see Figure 2) can be calculated by the following formulae

Creep $$C_P = \frac{\theta_2 - \theta_3}{\theta_n} \times 100 \quad [\%FS] \tag{10}$$

Creep recovery $$C_r = \frac{\theta_5 - \theta_6}{\theta_n} \times 100 \quad [\%FS] \tag{11}$$

Notes:

1. When creep C_P is given, the loading time (t_1-t_0) and the first reading time (t_2-t_1) should be recorded. When the creep recovery C_r is given, the unloading time (t_4-t_3) and the first reading time (t_5-t_4) should be noted.
2. This index is usually measured one time, at most 3 times. The mean value can be taken as the final result for this index. The time interval between two consecutive measurements should not be less than half an hour.

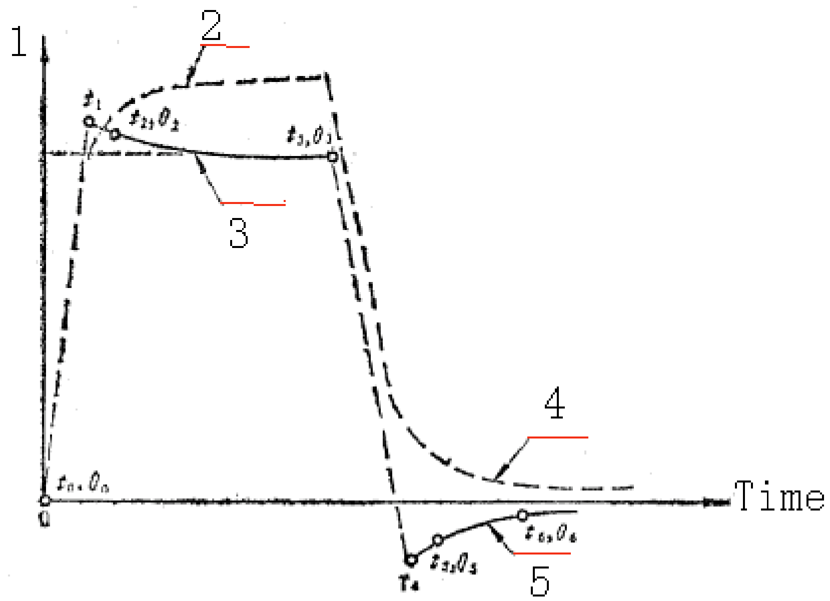

Figure 2

1 output, 2 positive creep, 3 negative creep, 4 positive creep recovery, 5 negative creep recovery
t_1-t_0 --- the duration from zero load to rated load;
t_2-t_1 --- the duration from the rated load being reached to the first reading (5~10s);
t_3-t_2 --- the duration of the creep observation (30 min);
t_4-t_3 --- the duration of unloading (nearly equals to t_1-t_0);
t_5-t_4 --- the duration between the zero load being reached and the first reading;
t_6-t_5 --- the duration of the creep recovery observation (30min);
$\theta_0,\theta_2,\theta_3,\theta_5,\theta_6$ --- the output readings relevant to the time t_0、t_2、t_3、t_5、t_6.

4.6 Influence of Temperature

The influences of the difference between the temperatures at zero point and at the output can be calibrated by the following procedure:

- The ambient condition and the calibration condition should be compared with the criteria given in chapter 3.
- The load cell should be kept in the thermostat container of the standard force-exerting machine (usually with an attached cable of the load cell).
- The load cell should be preloaded three times up to the nominal load and then returned to zero point each time. One min after the preloading, the formal calibration can start.

- The electric driving mechanism may be inspected and adjusted if necessary, the measuring range and zero point of the indicating meter should be adjusted and the zero output should be read.
- When the nominal load is exerted, reached and kept for 30s, the output should then be read. After that, the load cell should be unloaded down to zero and kept for 1 min, and then the zero output should be read. The electric driving mechanism and the zero point of the indicating meter may be re-adjusted if necessary, the zero output should be read again. This procedure should be continuously carried out at least three times.
- The temperature of the thermostat should be increased to the upper range for the load cell. After the temperature is really stable, the above procedures should be repeated.

Note: It is acceptable that the calibration can be carried out at a temperature lower than the upper limit if the temperature of the thermostat cannot reach the upper limit of the compensation temperature range.

- The temperature of the thermostat should be decreased to the lower limit of the compensation temperature range of the load cell. After the temperature is stable, the above loading and unloading procedures should be repeated.

Note: It is acceptable that the calibration can be carried out at a temperature higher than the lower limit if the temperature of the thermostat cannot reach the lower limit of the compensation temperature range.

- The temperature of the thermostat should be returned to the standard calibration condition. After the temperature is really stable, the above procedures should be repeated.
- The relevant technical indices can be calculated by the following formulae.

$$Z_{th} = \frac{\dfrac{\theta_{0h} - \theta_{0s}}{\theta_n}}{\dfrac{T_h - T_s}{10}} \times 100 \quad [\%FS/10K]$$

Influence of zero point temperature

$$Z_{tl} = \frac{\dfrac{\theta_{0l} - \theta_{0s}}{\theta_n}}{\dfrac{T_l - T_s}{10}} \times 100 \quad [\%FS/10K] \qquad (12)$$

$$S_{th} = \frac{\dfrac{(\theta_{nh} - \theta_{0h}) - (\theta_{ns} - \theta_{0s})}{\theta_n}}{\dfrac{T_h - T_s}{10}} \times 100 \quad [\%FS/10K]$$

Influence of output Temperature

$$S_{tl} = \frac{\dfrac{(\theta_{nl} - \theta_{0l}) - (\theta_{ns} - \theta_{0s})}{\theta_n}}{\dfrac{T_l - T_s}{10}} \times 100 \ [\%FS/10K]$$

(13)

Where,

T_h, T_s, T_l the upper limit temperature、standard calibration temperature and the low limit temperature by the time of calibration respectively;

$\theta_{0h}, \theta_{0s}, \theta_{0l}$ the relevant zero output average values of T_h, T_s and T_l respectively;

$\theta_{nh}, \theta_{ns}, \theta_{nl}$ the relevant output reading average values of T_h, T_s and T_l at the rated load respectively;

θ_n --- the rated output.

The bigger one of the absolute values of Z_{th} and Z_{tl} should be taken as the final influence value of the zero point temperature Z_t.

The bigger one of the absolute values of S_{th} and S_{tl} should be taken as the final influence value of the output temperature S_t.

Note:

(1) If the condition allows, the influences of the zero point temperature and the output temperature can better be calibrated separately.

(2) If the calibration results at the standard temperature reached before and after the temperature increasing and decreasing do not coincide, the calculation should be done using these two results. The bigger one of the absolute values should be taken as the final relevant temperature influence index.

4.7 Random Calibration.

For the same lot of load cells of the same type, same dimension, manufactured by the same factory, a random-calibration of zero drift, creep and influence of temperature is allowed. The random-calibration rate must be at least 10% (not less than 3 sets). The random-calibration is only usually suitable to the load cell of B and C grade. The indices of the worst one must be taken as the one of this lot of load cells.

4.8 Repeat Calibration.

The examination of the exterior, calibration of the load characteristics and the influence of asymmetry should be done during a load cell repeat-calibration. Z, L, H, R, the sensibility S_2 and the stability S_b of this calibration can be calculated upon the calibration results. S_b can be calculated by the following formula:

$$S_b = \frac{S_1 - S_2}{S_2} \times 100 \quad [\%FS] \qquad (14)$$

where, S_1 is the sensibility of the load cell measured during the last calibration.

Note: When the calibrator thinks that the change of the other relevant indices from the first time calibration might exceed the allowable error for the original grade, the re-calibration of these indices is suggested. The result of the re-calibration should be taken as one of the criteria for judging the grade of the load cell.

4.9 Check - Accept Calibration

New load cells should be in principle calibrated on the basis of above procedure (item 4.1 to 4.6). If the manufacturer and the user sign other agreements on checking and acceptance, the first calibration can be done following that agreement.

4.10 Treatment of calibration result and calibration period

4.10.1 Initial Calibration

For a load cell which is calibrated the first time, the grade can be determined upon the calibration results and a calibration certificate will be issued normally containing the following ten basic technical indices S, Z, L, H, R, Z_t, S_t, Cp, S_e, Z_d etc..

Note:

(1) If Z or Z_d from the calibration result exceed the values for the relevant grade determination in Table 1, the grade of the load cell grade can be lowered, or the grade stays undetermined with the above-mentioned ten basic technical indices given.

(2) The output mean values of the advance and the return may also be attached to the calibration results respectively based on the actual need .

4.10.2 Re-Calibration

For a load cell which is re-calibrated, the grade can be determined by a comparison of L, H, R, S_b obtained this time and Z_t, S_t, C_p (or C_r), Z_d obtained last time with the grade given in Table 1, then a calibration certificate will be issued containing six indices: S, Z, L, H, R, and S_b and the other technical indices which were obtained by the first calibration adopted. For the stability S_b, the calibration time interval (taken as ~%FS/×month or ~%FS/×year) should be noted.

The treatment of the calibration results can be done the same way as the initial calibration for a new load cell which has been calibrated according to paragraphs 4.1 - 4.6 . For a new load cell which has been calibrated according to a check-accept agreement between the manufacturer and the user, the final calibration results can be supplied upon the agreement, the grade can be determined using this work instruction as reference.

4.10.3 Calibration Period

The calibration period of the load cell can be divided into three months, half-year or one year depending on the calibration result of its stability.

Appendix A : **COVER PAGE FORMAT OF VERIFICATION CERTIFICATE**

Cover page format of verification certificate

(Name of calibrator)

Certificate of Calibration

Load cell Number________

Name of calibrated device ______________________________________
Type and specification ____
Manufacturer ____
Production number ____
Device number ____
Device owner ____
Grade of load cell ____
Director of laboratory _______________
Checker ___________________________
Calibration person __________________

Calibration date __________________

Valid to ________________________

Appendix B **: INSIDE PAGE FORMAT OF VERIFICATION CERTIFICATE**

Inside page format of verification certificate

Measuring range_____ Room temperature____________°
Humidity___________% Atmospheric pressure__________kPa

Calibration Result

Sensitivity	S (mV/V)	
Zero output	Z (%FS)	
Linearity	L (%FS)	
Hysteresis	H (%FS)	
Repeatability	R (%FS)	
Influence of zero point temperature	Z_t (%FS/10K)	
Influence of temperature output	S_t (%FS/10K)	
Creep C_p (or creep recovery C_r)	(%FS/30min)	
drift of zero point	Z_d (%FS/ h)	
Deviation of sensitivity	S_e (%FS)	
Stability of sensitivity	S_b (%FS/ month)	

Indicating meter____
Standard force-exerting device________________________________
Driving load source____
Driving voltage____

Appendix C : CALIBRATION RECORD OF LOAD CHARACTER

Book number_____
Page____________

Temperature____°; Humidity____%; Atmospheric pressure____kPa;
Load cell owner_____; Manufacturer______; Type and specification_____; Production number_____
Visual examination: surface state_____; Driving voltage_____V, DC, _____Hz, AC, Variation_____; Preheat_____min;
Preloading_____times, upto_____tf, kgf, N; Appendage_____; Electric connecting pieces_____.

Output	Advance (mV, μV)																Return (mV, μV)							
Direction																								
Pull, press tf, kgf, N																								
Remark																								

Zero outputθ_0________mV, μV (Z________%FS) ; Sensitivity S________mV/V; Linearity L________%FS; Hysteresis H________%FS;
Repeatability R_____%FS; Stability S_b_____%FS/__month; Deviation of sensitivity S_e_____%FS. Indicating meter_____;

Driving load source_______； Standard force-exerting device_______； Calibrator________； Checker________； Date_______________

Appendix D **: CALIBRATION RECORD OF LOAD CHARACTER**

Book number_____
Page____________

Temperature____°； Humidity____%； Atmospheric pressure____kPa；
Load cell owner_____； Manufacturer______； Type and specification_____； Production number_____； Electric connector_____；
Visual examination: surface state_____； Driving voltage_____V, DC, _____Hz, AC, Variation_____V； Preheat_____min；
Preloading_____times, upto_____tf, kgf, N； Appendage_____.

Pull, press tf,kgf,N	Advance (mV,μV)								Return (mV,μV)					
	1	2	3	θ_i	R_i	$\hat{\theta}_i$	$\Delta\hat{\theta}_i$		1	2	3	θ'_i		H_i
Remark														

Zero output θ_0__________mV, μV (Z__________%FS) ； Sensitivity S___________mV/V； Linearity L___________%FS；
Hysteresis H_____%FS； Repeatability R_____%FS； Stability S_b_____%FS/__month； Deviation of sensitivity S_e_____%FS;

Temperature____°； Humidity____%； Atmospheric pressure____kPa； Indicating meter_____； Driving load source_____；
Standard force-exerting device____________； Calibrator____________； Checker____________； Date__________________

Appendix E : CALIBRATION RECORD OF ELECTRIC CHARACTER

Book number_____
Page____________

Cell owner	Producer	Type & spec	Production number	Input re-sistance (Ω)	Output re-sistance (Ω)	Insulation resistance (MΩ)	Temperature (°)	Humidity (%)	Atmospheric pressure (kPa)	Remark

Measuring devices_______, _______; Electric connector_______; Calibrator_______; Checker_______; Date_______________

Appendix F **: CALIBRATION RECORD OF TEMPERATURE CHARACTER**

Book number_____
Page____________

Load cell owner__________; Manufacturer__________; Type & specification__________; Production number___________

T / *θ* / F														
Remark														

Upper limit temperature_______°; Time of temperature rising_______min, h; High temperature duration_______min, h;
Low limit temperature_______°; Time of temperature reducing_______min, h; Low temperature duration_______min, h;
Influence of zero point temperature_____________%FS/10K; Influence of output temperature_____________%FS/10K;
Room temperature_______°; Humidity_________%; Atmospheric pressure_________kPa; Indicating meter_________;
Standard force-exerting device_____; Driving load source________; Driving voltage________V, DC, ________Hz, AC;
Thermostat container_____; Calibrator_____, Checker_____, Date__________________

Appendix G **: CALIBRATION RECORD OF CREEP**

Book number_____
Page____________

Load cell owner_____; Manufacturer______; Type & specification______; Production number______; Temperature______°; Humidity_______%; Atmospheric pressure_______kPa; Driving voltage_______V, DC_______Hz,AC; Preheat_______min, Variation_______V; Preloading_______times, up to_______ft, kgf,N

Calibrated items: C_p, C_r ; Register: $r=$ $\Delta t=$ s, min, h											Remark
Unit / Decade	0	1	2	3	4	5	6	7	8	9	
0											
1											
2											
3											
4											
5											
6											
7											
8											

Indicating meter______; Driving load source______; Standard force-exerting device______; Duration of loading t_i_______s; Duration of unloading t_d______s; Stable duration______s; Creep C_p______%FS/30min; Creep recovery C_r______%FS/30min

Calibrator________, Checker________, Date______________

Appendix H **: CALIBRATION RECORD OF NATURAL FREQUENCY**

Book number_____
Page____________

Order number	Unit	Manufacturer	Type & spec	Production number	Time index (ms/grid)	Amplitude index (V/grid)	Period number	Time (ms)	Natural frequency f_0 (Hz)	Remark

Driving load source_____; Driving voltage_____V; Recording device______; Driving method_____;
Wave pattern quality____; Temperature_____°; Humidity_____%; Atmospheric pressure______kPa;
Calibrator______, Checker______, Date__________

Appendix I **: CALIBRATION RECORD OF ZERO DRIFT**

Book number_____
Page____________

Load cell owner_____; Manufacturer_____; Type & specification_____; Production number_____;
Driving voltage________V, DC, _________Hz, AC; Preheat_________min, Variation_________V

Time	Output (mV, μV)	Temperature (°)	Humidity (%)	Atmospheric pressure (kPa)	Time	Output (mV, μV)	Temperature (°)	Humidity (%)	Atmospheric pressure (kPa)	Remark

Indicating meter_____; Driving load source_____; Zero drift Z_d_____%FS/___h; Temperature____°; Humidity_____%;
Atmospheric pressure_____kPa

Calibrator________, Checker________, Date____________