INTERNATIONAL STANDARD

ISO 4965-2

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Metallic materials — Dynamic force calibration for uniaxial fatigue testing —

Part 2: Dynamic calibration device (DCD) instrumentation

Matériaux métalliques — Étalonnage de la force dynamique uniaxiale pour les essais de fatigue —

Partie 2: Instrumentation pour équipement d'étalonnage dynamique

Reference number
ISO 4965-2:2012(E)

Contents

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 4965-2 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 5, *Fatigue testing*.

This first edition of ISO 4965-2, together with ISO 4965-1, cancels and replaces ISO 4965:1979, which has been technically revised.

ISO 4965 consists of the following parts, under the general title *Metallic material — Dynamic force calibration for uniaxial fatigue testing*:

— *Part 1: Testing systems*

— *Part 2: Dynamic calibration device (DCD) instrumentation*

Introduction

In a dynamic test, the force experienced by the test-piece may differ significantly from the intended force indicated by the testing system. The dynamic errors result from inertial forces acting on the force transducer and any dynamic errors in the electronics of the force indicating system. Inertial forces equate to the grip mass (interposed between the force transducer and the test-piece) multiplied by its local acceleration, and therefore depend on

a) the amplitude of motion,

b) the frequency of motion, and

c) the grip mass.

The amplitude of motion will, in turn, depend on the applied force and the mechanical configuration of the testing system, including the compliances of the load train, the test-piece, the reaction frame, and the base mounting.

ISO 4965-1 describes two methods of determining the testing system's performance. Both of these methods require that the DCD instrumentation has previously been calibrated in accordance with this part of ISO 4965.

Metallic materials — Dynamic force calibration for uniaxial fatigue testing —

Part 2:
Dynamic calibration device (DCD) instrumentation

1 Scope

In order to perform a dynamic calibration of a uniaxial testing system, it is necessary to measure the forces experienced by the test-piece to known levels of accuracy – this measurement is made by a dynamic calibration device (DCD) in place of the test-piece and the calibration method is described in ISO 4965-1. This part of ISO 4965 defines the calibration procedure for the DCD's instrumentation. The method for the analysis of the results is also described, leading to a range of testing frequencies over which the instrumentation is valid for use with DCDs in accordance with ISO 4965-1.

2 Terms, definitions, and symbols

For the purposes of this document, the following terms, definitions, and symbols apply.

2.1
DCD
dynamic calibration device
replica test-piece or proving device

2.2
DCD energising voltage
V_E
DC voltage used to energise the DCD's strain gauge bridge

NOTE The DCD energising voltage is expressed in volts.

2.3
DCD instrumentation
instrumentation used in conjunction with DCD, including strain gauge bridge output conditioning electronics and display

NOTE The DCD instrumentation may also supply the DCD energising voltage – it could then display the DCD output as an mV/V ratio.

2.4
dynamic voltage reference standard
instrument capable of generating specific sinusoidal voltage waveforms (with magnitudes proportional to either actual or nominal DCD energising voltages) and DC voltages

NOTE 1 The dynamic voltage reference standard may be two separate pieces of equipment, one generating the DC voltages and the other generating the sinusoidal waveforms.

NOTE 2 See References [1], [2], and [3].

2.5
peak voltage value
maximum value of voltage contained within a generated or measured sinusoidal waveform

2.6
valley voltage value
minimum value of voltage contained within a generated or measured sinusoidal waveform

3 Principle

Generate a set of DC voltages using a dynamic voltage reference standard. Determine the difference between the values displayed by the DCD instrumentation and the values generated by the dynamic voltage reference standard.

Similarly, generate a set of sinusoidal waveforms using the dynamic voltage reference standard in the range from DC to the maximum test frequency, with varying amplitudes and offsets. Compare the peak and valley voltage values displayed on the DCD instrumentation with the values generated by the dynamic voltage reference standard.

To simulate laboratory conditions, repeat the sinusoidal calibration with a known amount of harmonic distortion to ensure that the DCD instrumentation is capable of measuring such peak and valley voltage values correctly.

4 General requirements

4.1 Temperature

The calibration of the DCD instrumentation shall be performed at a temperature in the range from 18 °C to 28 °C, with the actual temperature being reported.

4.2 DCD instrumentation

The DCD instrumentation reads and displays the output of the DCD. When the DCD's DC energising voltage (V_E) is also supplied by the DCD instrumentation, this output will be an mV/V value – when it is supplied from an external source, the output will simply be an mV value (which can be converted to an mV/V value via division by the externally-supplied energising voltage). When the DCD output is varying in a sinusoidal manner (due to a dynamic force being applied to it), the instrumentation shall display the peak and valley values of this output. The resolution of the DCD instrumentation shall not be greater than 0,000 1 mV/V (equivalent to 0,000 1 V_E mV).

4.3 Dynamic voltage reference standard

The dynamic voltage reference standard generates DC voltage levels and sinusoidal voltage waveforms (specified in terms of amplitude, frequency, and DC offset), traceable to voltage standards within given uncertainties. In addition, it enables a specified amount of harmonic distortion to be added to the waveform to allow the performance of the DCD instrumentation to be determined under non-ideal conditions.

The expanded uncertainty (at a level of confidence of approximately 95 %) in the peak and valley voltages generated by the dynamic voltage reference standard shall not exceed 0,2 % of the voltage range (i.e. peak voltage – valley voltage). In the DC case, the expanded uncertainty (at a level of confidence of approximately 95 %) of the generated voltage shall not exceed 2 V_E µV (e.g. for an excitation voltage of 10 V, the reference standard shall be capable of generating differential DC voltages in the range from –20 mV to +20 mV, with an expanded uncertainty of 20 µV).

The difference between the output impedance of the dynamic voltage reference standard and the output impedance of any DCD to be used with the DCD instrumentation in ISO 4965-1 shall be less than 0,05 % of the DCD instrumentation's minimum input impedance throughout its calibrated frequency range.

NOTE The DCD instrumentation's input impedance is likely to decrease with increasing frequency, and a mismatch between its input impedance and the output impedance of the system it is connected to will lead to errors – this is why it is important that the minimum input impedance value be used. For example, for DCD instrumentation with a minimum input impedance of 100 kΩ, to be used with DCDs with an output impedance of 350 Ω, the output impedance of the dynamic voltage reference standard would need to lie between 300 Ω and 400 Ω.

The dynamic voltage reference standard shall have certified traceability to national electrical standards of measurement.

5 Calibration procedure

5.1 DC calibration

Energise and connect both the DCD instrumentation and the dynamic voltage reference standard for a period of not less than 30 minutes prior to DC calibration.

Use the dynamic voltage reference standard to generate a set of nine DC voltages over the calibration range. As an example, for a calibration range from –2 mV/V to +2 mV/V and an energising voltage of 10 V, voltages from –20 mV to +20 mV in steps of 5 mV shall be used. Record the DCD instrumentation output at each voltage. Repeat the process twice to generate three sets of readings. When the DCD instrumentation supplies the DCD energising voltage, the DC voltage value shall be based on the actual generated voltage. When the DCD energising voltage is to be supplied from an external source, the DC voltage value shall be calculated from its nominal value.

5.2 Sinusoidal calibration

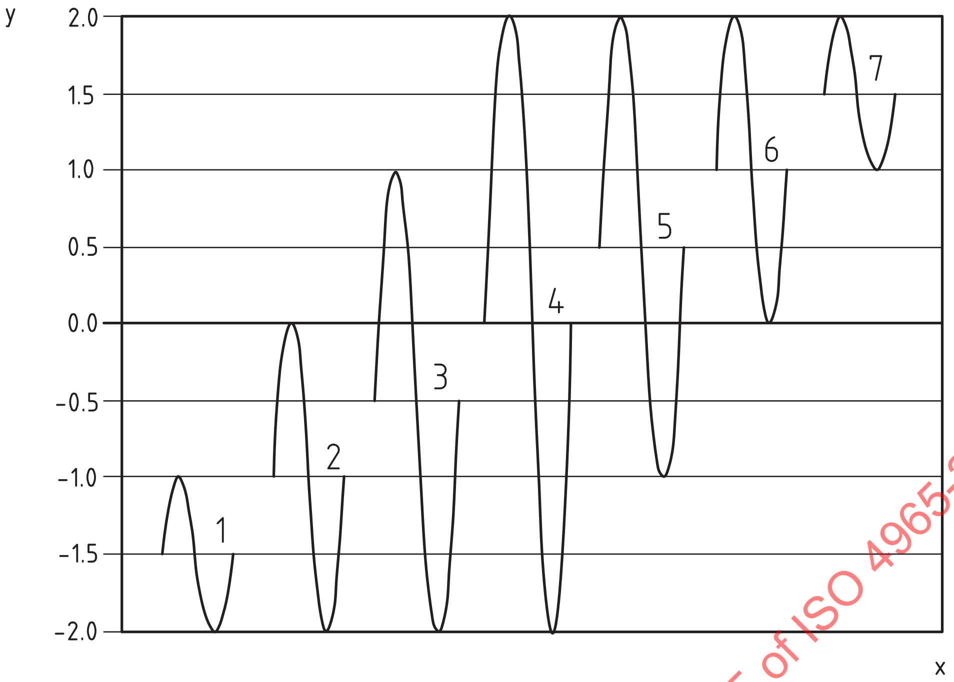
Energise and connect both the DCD instrumentation and the dynamic voltage reference standard for a period of not less than 30 minutes prior to sinusoidal calibration.

Use the dynamic voltage reference standard to generate a set of seven sinusoidal waveforms, in accordance with Table 1, and as shown in Figure 1. When the DCD instrumentation supplies the DCD energising voltage, the amplitude and DC offset of the waveforms shall be based on the actual generated voltage. When the DCD energising voltage is to be supplied from an external source, the waveform amplitude and DC offset shall be calculated from its nominal value.

For each waveform, vary the frequency over the range of interest and, at a minimum of three discrete frequencies, record the peak and valley DCD instrumentation output values.

Table 1 — Sinusoidal calibration waveforms

Waveform	DC Offset	Amplitude
1	-1,5 mV/V	0,5 mV/V
2	-1,0 mV/V	1,0 mV/V
3	-0,5 mV/V	1,5 mV/V
4	0,0 mV/V	2,0 mV/V
5	+0,5 mV/V	1,5 mV/V
6	+1,0 mV/V	1,0 mV/V
7	+1,5 mV/V	0,5 mV/V



Key

x time

y dynamic reference standard output, in mV/V

Figure 1 — Sinusoidal calibration waveforms

Repeat the sinusoidal calibration specified above but with a fixed amount of total harmonic distortion of 0,125 % ± 0,010 % added to the generated waveforms (see Annex A).

Repeat the process to generate two sets of readings.

6 Calculation of results

Calculate the results as specified in 6.1 to 6.2.

6.1 DC calibration results

The DC calibration results for each of the nine applied DC voltages (see 5.1) shall be determined by calculating the difference between the values displayed on the DCD instrumentation and the value generated by the dynamic voltage reference standard, for each of the three readings.

If any single difference exceeds a value of 0,01 mV/V (equivalent to 0,01 V_E mV), the instrumentation shall be deemed to have failed its DC calibration.

6.2 Sinusoidal calibration results

For each of the waveforms applied (see 5.2), the sinusoidal calibration results shall be determined by calculating, at each discrete frequency:

— the difference between the peak value displayed on the DCD instrumentation and the peak value generated by the dynamic voltage reference standard;

— the difference between the valley value displayed on the DCD instrumentation and the valley value generated by the dynamic voltage reference standard.

These differences shall both be expressed as a percentage of the waveform amplitude. For each waveform, the valid frequency range is defined as that range of frequencies within which neither of these two differences exceeds a value of 0,5 %.

The sinusoidal calibration shall be deemed to be valid from DC up to the maximum frequency at which the results from all seven waveforms still fall within this 0,5 % limit.

7 Calibration report

The calibration report shall state, as a minimum, the information given in 7.1 and 7.2.

7.1 General information

The report shall include the following information:

a) the DCD instrumentation, including the manufacturer, model number, serial number, the settings used (including, if applicable, energising voltage), and any other identifiers;

b) the dynamic voltage reference standard, including the manufacturer and serial number (see 4.3);

c) the range of frequencies over which the calibration was performed;

d) if applicable, the nominal value of the energising voltage;

e) the output impedance for which the DCD instrumentation has been calibrated;

f) the maximum and minimum temperatures at the time of the calibration (see 4.1);

g) the name of the organization that carried out the calibration;

h) the date of calibration (see 7.3);

i) a reference to this part of ISO 4965, i.e. ISO 4965-2.

7.2 Results of calibration

The report shall state the results of the calibration as follows:

a) a table of all the measurements taken and details of the frequency range over which they are valid;

b) any observations, notes, or recommendations concerning the dynamic calibration.

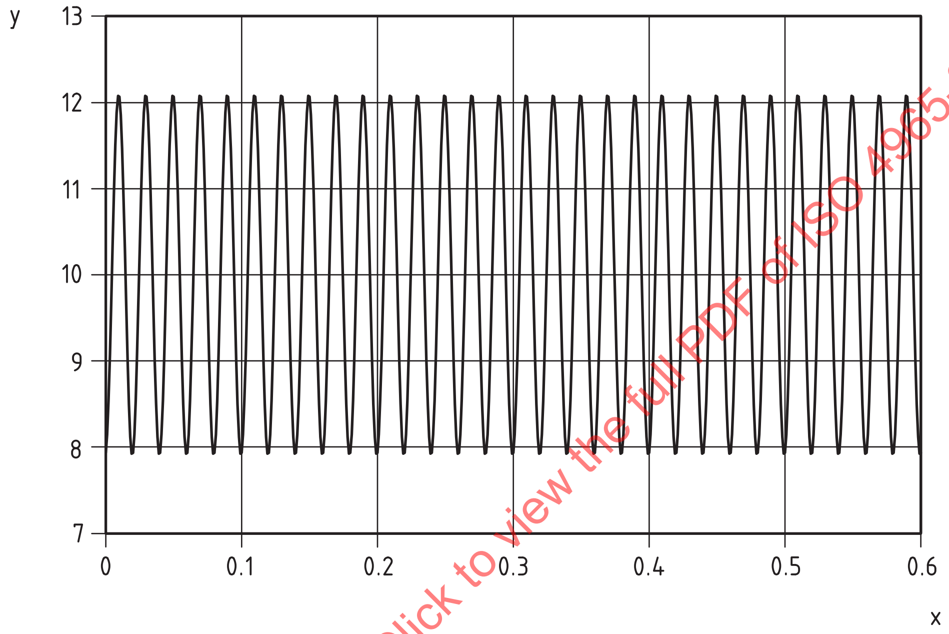
7.3 Re-calibration

For the purposes of this part of ISO 4965, the maximum period of validity of the report should not exceed 26 months.

Annex A
(informative)

Calibration frequency content

The use of Total Harmonic Distortion (THD) to specify the distortion is well-known but, however, not as specific as time series data. The plots in Figures A.1 to A.4 show examples of both the wave shape and the frequency content that should be replicated for each calibration.



Key

x time, in seconds

y force, in kN

Figure A.1 — Example of a 50 Hz force sine wave (measured signal)