BRITISH STANDARD

BS 7935-2:2004

Constant amplitude force calibration —

Part 2: Calibration of the calibration device instrumentation to be used for the dynamic calibration of non-resonant uniaxial dynamic testing systems — Method

ICS 29.040

Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee ISE/NFE/4, Mechanical testing of materials, upon which the following bodies were represented:

GAMBICA Association Ltd.

Network Rail

Society of British Aerospace Companies Ltd.

United Kingdom Accreditation Service

University College London

National Physical Laboratory

Copper Development Association

Railway Industry Association

British Non-Ferrous Metals Federation

UK Steel Association

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 September 2004

Amendments issued since publication

Amd. No.	Date	Comments

The following BSI references relate to the work on this British Standard:
Committee reference ISE/NFE/4
Draft for comment 04/19981143 DC

ISBN 0 580 44479 1

Contents

Foreword

This part of BS 7935 has been published under the authority of Technical Committee ISE/NFE/4. It describes a method for performing the DC and AC calibration of calibration device instrumentation used in BS 7935-1.

BS 7935-1 describes a method for determining the relationship between the true force range applied to a test-piece subject to constant amplitude uniaxial sinusoidal loading and the force range indicated by the testing system.

This British Standard describes methods of performing the DC and AC calibration of calibration device instrumentation used in BS 7935-1. References to this standard should indicate that the methods used are in accordance with BS 7935-2.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 6, an inside back cover and a back cover.

The BS I copyright notice displayed in this document indicates when the document was last issued.

Introduction

In a dynamic test, the true force experienced by the test-piece might differ significantly from the force indicated by the testing system. This error results from inertia force acting on the loadcell and any errors in the electronics of the dynamic force indicating system. Inertia forces equate to the grip mass (interposed between the loadcell and test-piece) multiplied by its local acceleration. Inertia forces depend on:

a) the amplitude of motion;

b) the frequency;

c) the grip mass;

d) the compliance of the test-piece;

e) the configuration of the testing system e.g. frame compliance and type of mounting.

BS 7935-1 describes two methods of measuring dynamic force errors on uniaxial test machines. Both of these methods requires that the calibration device instrumentation be calibrated in accordance with BS 7935-2.

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 part of BS 7935 defines the calibration procedure for the calibration device instrumentation. The method for the analysis of the results is also described, leading to a range of frequencies over which the instrumentation is valid for use with BS 7935-1.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 7935-1*, Constant amplitude dynamic force calibration — Part 1: Calibration and verification of non-resonant uniaxial dynamic testing systems — Method.*

3 Terms and definitions

For the purposes of this part of BS 7935, the following terms and definitions apply.

3.1
calibration device
replica test-piece or proving device

3.2
calibration device instrumentation
conditioning electronics and display used in conjunction with calibration device

3.3
dynamic reference standard
instrumentation providing traceable ±2 mV/V excitation voltage for calibration device instrumentation

4 Principle

Generate a set of DC voltages using a dynamic reference standard. Determine the difference between the values displayed on the calibration device instrumentation and the nominal values generated by the dynamic reference standard.

Similarly, generate a set of AC waveforms using the dynamic reference standard in the range from DC to the maximum test frequency with varying amplitudes and offsets. The peak and trough values displayed on the calibration device instrumentation are compared with the nominal values generated by the dynamic reference standard.

To simulate laboratory conditions, the AC calibration is repeated with a known amount of harmonic distortion to ensure the instrumentation is capable of measuring such peak and trough values correctly.

5 Apparatus

5.1 *Calibration device instrumentation*, supplies a DC excitation voltage (V_E) to the calibration device, reads the output voltage from the calibration device, and digitally displays the ratio of this voltage to the excitation voltage (in mV/V). Where the calibration device output voltage is varying in a sinusoidal manner (due to a dynamic force being applied to the device), the instrumentation shall display the peak and trough values of this mV/V ratio. The resolution of the calibration device instrumentation shall not be greater than 0.000 1 mV/V.

5.2 *Dynamic reference standard*, enables the amplitude and frequency of the output waveform, and the DC offset value, to be independently set, for the nominal specified impedances. In addition, it enables a specified amount of harmonic distortion to be added to the waveform to allow the performance of the calibration device instrumentation under non-ideal conditions to be determined.

The uncertainty in the peak and trough voltages generated by the dynamic reference standard shall not exceed 0.2 % of the range (i.e. peak voltage – trough voltage). In the DC case, the uncertainty of the generated voltage shall not exceed 0.000 002 VE (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 uncertainty of 20 μV at specified impedances).

6 General requirements

6.1 General

The dynamic reference standard shall have certified traceability to national and international standards of measurement.

6.2 Temperature

The calibration of the calibration device instrumentation shall be performed at a temperature in the range of 18 to 28 °C and the actual temperature reported.

7 Calibration procedure

7.1 DC calibration of the instrumentation

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

Generate a set of nine DC voltages, ranging from $-0.002\ V_E$ to $+0.002\ V_E$, in steps of $0.000\ 5\ V_E$ using the dynamic reference standard. Record the voltage ratio values displayed on the instrumentation at each voltage.

Repeat the process to generate two sets of readings.

7.2 AC calibration of the instrumentation

Energize and connect both the calibration device instrumentation and the dynamic reference standard for a period of not less than 30 minutes prior to AC calibration.

Generate a set of seven AC waveforms, in accordance with Table 1 and as shown in Figure 1 using the dynamic reference standard. Vary the frequency over the range of interest and at a minimum of three discrete frequencies, record the peak and trough voltage ratio values displayed on the instrumentation for each waveform.

Table 1 — AC 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

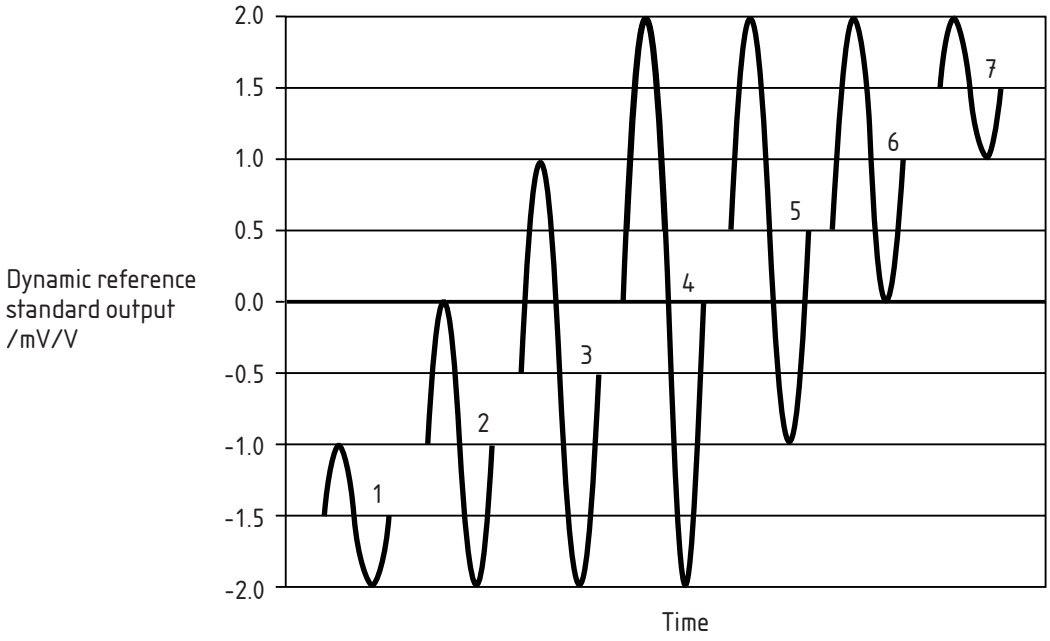

Figure 1 — AC calibration waveform

Repeat the AC calibration specified above but with a fixed amount of total harmonic distortion of 0.125 % ± 0.01 % added to the generated waveforms (see Annex A).

Repeat the process to generate two sets of readings.

7.3 Multiple impedance calibrations

Repeat **7.1** and **7.2** for each value of impedance where more than one impedance needs to be calibrated.

8 Calculation of results

8.1 General

For each impedance, for which the instrumentation is being calibrated, calculate the results as specified in **8.2** and **8.3**.

8.2 DC calibration results

The DC calibration results for each of the nine applied DC voltages (see **7.1**), shall be determined by calculating the difference between the values displayed on the calibration device instrumentation and the nominal value generated by the dynamic reference standard, for each of the three readings.

If any single difference exceeds a value of 0.01 mV/V, the instrumentation shall be deemed to have failed its DC calibration.

8.3 AC calibration results

The AC calibration results for each of the waveforms applied (see **7.2**) shall be determined by calculating at each discrete frequency, the differences between the peak values and trough values displayed on the calibration device instrumentation and the respective nominal values generated by the dynamic reference standard. These differences shall be expressed as a percentage of the waveform amplitude. For each waveform, the range shall be determined as frequencies within which none of these differences exceeds a value of 0.5 %.

The AC calibration shall be deemed to be valid from DC up to the maximum frequency at which all seven waveforms fall within the 0.5 % limit.

9 Calibration report

9.1 General

The calibration report shall state, at a minimum, the information given in **9.2** and **9.3**.

9.2 General information

The report shall state details of the following:

a) the instrumentation, including the manufacturer, model number, serial number and the identifiers;

b) the dynamic reference standard, including the manufacturer and serial number (see **5.2**);

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

d) the impedance(s) for which the calibration device instrumentation has been calibrated;

e) the ambient temperature at the time of the test (see **6.2**);

f) the name of the organisation that carried out the calibration;

g) the date of calibration (see **9.3**);

h) reference to this standard, i.e. BS 7935-2:2004.

9.3 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.

9.4 Re-calibration

For the purposes of this standard, the maximum period of validity of the report shall not exceed 12 months.

Annex A
Calibration frequency content

The use of Total Harmonic Distortion to specify the distortion is well known however not as specific as time series data. The plots illustrated in Figure A.1, Figure A.2, Figure A.3 and Figure A.4 give examples of both the wave shape and the frequency content which should be replicated for each calibration.

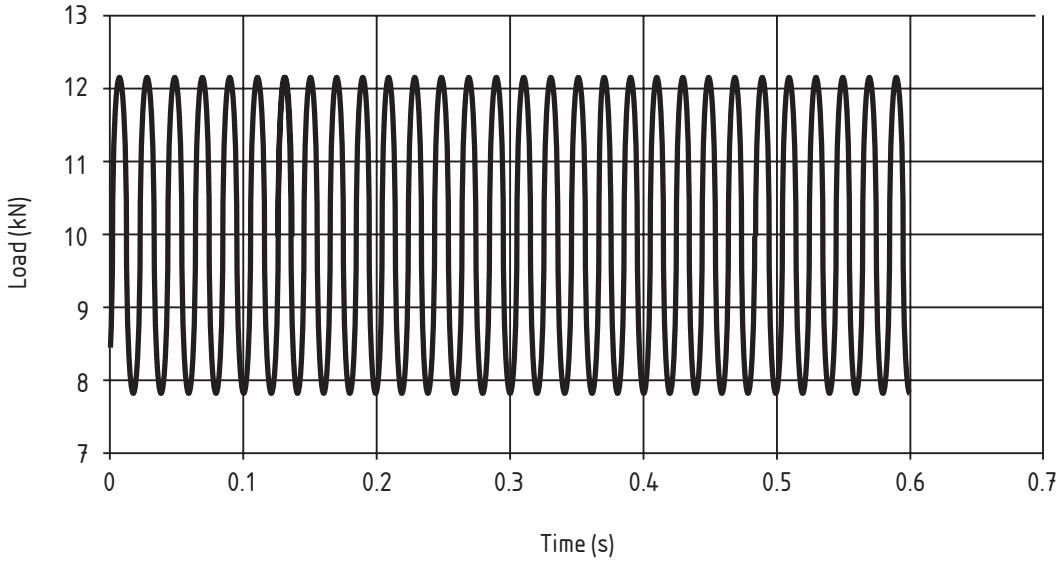

Figure A.1 — Example of 59 Hz load sinewave (measured signal)

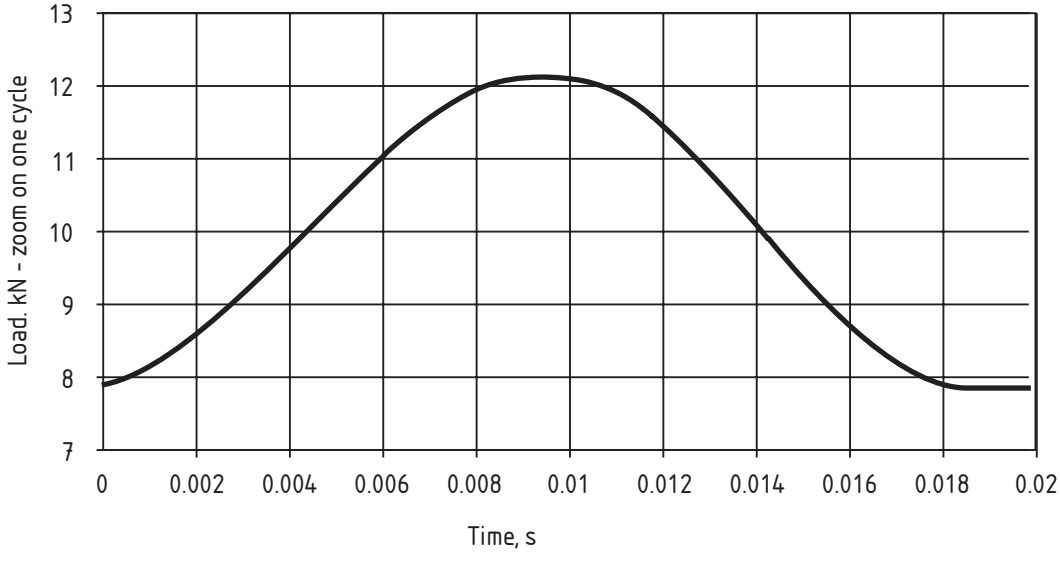

Figure A.2 — Example of single cycle of 50 Hz load sinewave (measured signal)

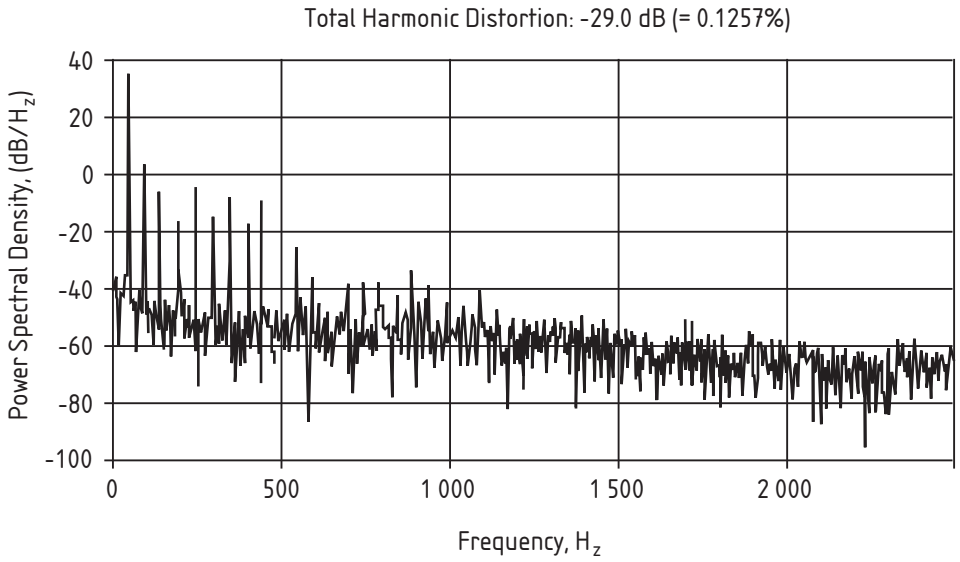

Figure A.3 — Power spectral density of signal shown in Figure A.1 over the range DC to 2.5 KHz

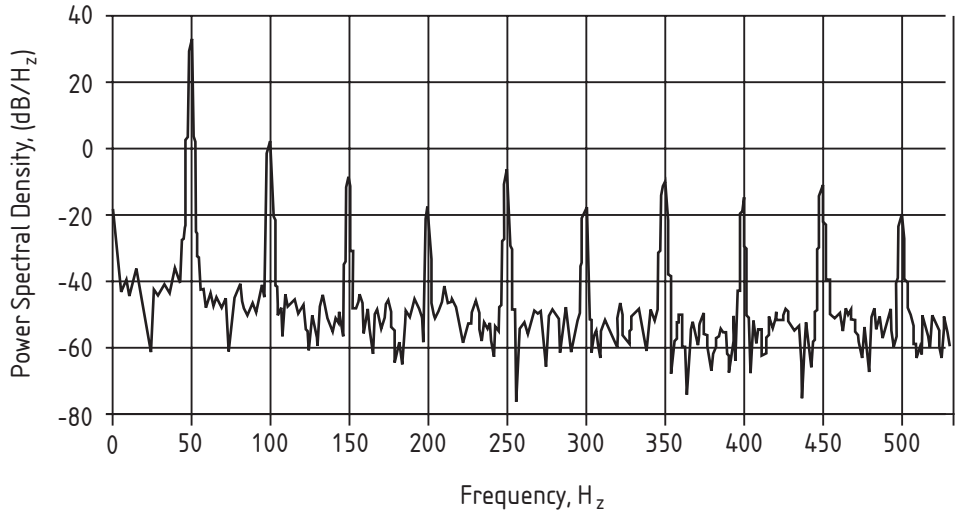

Figure A.4 — Power spectral density of signal shown in Figure A.1 over the range DC to 500 Hz

blank

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: +44 (0)20 8996 9000. Fax: +44 (0)20 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: +44 (0)20 8996 9001. Fax: +44 (0)20 8996 7001. Email: orders@bsi-global.com. Standards are also available from the BSI website at http://www.bsi-global.com.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: +44 (0)20 8996 7111. Fax: +44 (0)20 8996 7048. Email: info@bsi-global.com.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: +44 (0)20 8996 7002. Fax: +44 (0)20 8996 7001. Email: membership@bsi-global.com.

Information regarding online access to British Standards via British Standards Online can be found at http://www.bsi-global.com/bsonline.

Further information about BSI is available on the BSI website at http://www.bsi-global.com.

Copyright

BSI
389 Chiswick High Road
London
W4 4AL