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Australian Standard[®]

**METHODS FOR THE
CALIBRATION AND
GRADING OF
EXTENSOMETERS**

The following scientific, industrial and governmental organizations and departments were officially represented on the committee entrusted with the preparation of this standard:

Aluminium Development Council
Associated Chambers of Manufactures of Australia
Australian Institute of Metals
Bureau of Steel Manufacturers of Australia
Department of Manufacturing Industry
Materials Research Laboratories—Department of Defence
Metal Trades Industry Association of Australia
National Association of Testing Authorities
National Measurement Laboratory
Railways of Australia Committee
Society of Automotive Engineers—Australasia
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STANDARDS AUSTRALIA

RECONFIRMATION

OF

AS 1545—1976

Methods for the calibration and grading of extensometers

RECONFIRMATION NOTICE

Technical Committee MT-009 has reviewed the content of this publication and in accordance with Standards Australia procedures for reconfirmation, it has been determined that the publication is still valid and does not require change.

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Approved for reconfirmation in accordance with Standards Australia procedures for reconfirmation on 20 March 2017.

The following are represented on Technical Committee MT-009:

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Australian Industry Group
Australian Steel Institute
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Galvanizers Association of Australia
Galvanizing Association of New Zealand
New Zealand Metal Roofing Manufacturers

NOTES

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PREFACE

This standard was prepared by the Association's Committee on Mechanical Testing of Metals, under the direction of the Metals Standards Board, to apply to extensometers used in the testing of metals but it may be used, where appropriate, for extensometers associated with tests on other materials.

The widespread use of extensometers of various types has necessitated the preparation of this standard, which describes methods and procedures for the calibration of these instruments, establishes the requirements for calibrating devices, and grades the extensometers in terms of gauge length, readability, repeatability and accuracy of indicated extension.

The standard has been based on BS 3846.* Significant modifications, however, include the omission of the method of calibration by means of elastic devices and the omission of the requirements for Grade A extensometers. Grades B to F still correspond respectively to Grades B to F in BS 3846 in regard to accuracy and repeatability of indicated extension. The requirements for gauge length and readability of indicated extension have been modified and special requirements for multirange extensometers have been included.

The standard unifies methods for calibrating extensometers at room temperature. It is intended for use by calibrating authorities and also by committees responsible for the preparation or revision of standards covering methods of mechanical testing in which the measurement of strain is required.

This standard requires reference to the following standards:

AS 1457	Gauge Blocks and Accessories (Metric Units)
AS B80	Dial Gauges for Linear Measurement
AS B140	Micrometer Heads

* BS 3846, Methods for the Calibration and Grading of Extensometers for Testing of Metals.

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STANDARDS ASSOCIATION OF AUSTRALIA

Australian Standard

METHODS FOR THE CALIBRATION AND GRADING
OF EXTENSOMETERS

SECTION 1. SCOPE AND GENERAL

1.1 SCOPE. This standard deals with the calibration at room temperature and grading of extensometers used in tension and compression testing. (See Appendix A regarding the use of extensometers at other than room temperature.) It defines the terms used and describes the standard method of calibration; the requirements for calibrating devices are stated. Extensometers are graded in terms of repeatability of gauge length, and readability, repeatability and accuracy of indicated extension.

Instructions for the issue of reports of calibration are included together with recommendations on certain constructional features of extensometers and the use of calibrating equipment.

1.2 DEFINITIONS. For the purpose of this standard the following definitions apply:

1.2.1 Extensometer—a device used for determining extension and hence strain. It comprises an extension sensing element and a readout system.

NOTES:

1. The readout may be in units of length or in strain, or in arbitrary units.
2. See also definition of indicated extension.
3. An extensometer may measure on one side or on opposite sides of a test piece. Where the latter type does not average the readings, it is hereinafter referred to as a 'dual extensometer'.

1.2.2 Extensometer gauge length—the initial length at room temperature used for the measurement of extension.

NOTES:

1. The extensometer gauge length is hereinafter referred to as the 'gauge length'.
2. Distinction is made between nominal and assigned values of extensometer gauge length (refer to Clause 2.3).

1.2.3 Repeatability of gauge length—the difference between the highest and lowest values obtained when repeated measurements of the gauge length are made.

1.2.4 Displacement—a change in length brought about by the calibrating device and as measured by that device.

1.2.5 Indicated extension—the change in length as measured by the extensometer.

NOTE: If, at the commencement of a set of readings, the initial reading of an extensometer is not zero, the indicated extension is the difference between the reading obtained and the initial reading at the beginning of that set.

1.2.6 Readability of indicated extension—the smallest value of extension that can be estimated with assurance from the readout system of the extensometer.

1.2.7 Repeatability of indicated extension—the difference between the highest and lowest values of indicated extension at the same displacement during repeated sets of calibration readings.

Alternatively, the repeatability of indicated extension is the difference between the highest and lowest values of displacement when an extensometer is repeatedly set to the same reading.

1.2.8 Calibration for indicated extension—determination of the relation between indicated extension and displacement.

1.2.9 Error of indicated extension—the value obtained by subtracting the displacement from the indicated extension.

1.2.10 Accuracy of indicated extension—the degree of closeness of indicated extension to displacement at any one value of displacement, derived from the arithmetic mean of the errors obtained at that displacement during repeated sets of observations.

1.2.11 Positive extension—extension either increasing or decreasing in which the measured length is greater than the gauge length.

1.2.12 Negative extension—extension either increasing or decreasing in which the measured length is less than the gauge length.

1.2.13 Increasing extension—extension in which the measured length increases.

1.2.14 Decreasing extension—extension in which the measured length decreases.

1.2.15 Strain—the extension per unit length.

1.2.16 Magnification factor—the factor derived from the results of calibration by which the readings of an extensometer, indicating in arbitrary units, are multiplied to obtain the displacement. (See Clause 2.4.)

1.2.17 Nominal range—the limits of extension within which an extensometer is designed to operate.

1.2.18 Grade—a category into which an extensometer is placed by virtue of the specified limits of repeatability of gauge length, and readability, repeatability and accuracy of indicated extension with which it is found to comply.

1.2.19 Grading range—the limits of extension within which an extensometer has been demonstrated to comply with grading requirements.

1.2.20 Calibrating authority—any approved person or organization qualified and equipped to perform the tests set out in Section 3.

1.3 PRINCIPLE OF CALIBRATION. Calibration involves the assessment of readability of indicated extension, the measurement of the gauge length, and calibration for indicated extension. Calibration for indicated extension consists of applying displacements to the extensometer and using suitable apparatus for measuring these displacements to the appropriate degree of accuracy. The errors in the extensometer are determined by comparing the indicated extensions with the displacements.

SECTION 2. GRADING OF EXTENSOMETERS

2.1 GENERAL. This standard provides for five grades of extensometers, designated B, C, D, E and F.

Extensometers shall be graded according to the following properties:

- (i) Repeatability of gauge length.
- (ii) Readability of indicated extension.
- (iii) Repeatability of indicated extension.
- (iv) Accuracy of indicated extension.

The final grading of the extensometer shall be the lowest grading assigned to any of these four properties. An extensometer may be allocated more than one grading applicable to different parts of its range of calibration or when used in different ways, such as, for example, at a different gauge length or at a different magnification; provided, however, that, for any set of conditions, no higher grading may be given for any strain value than is given for a higher strain value.

2.2 REQUIREMENTS FOR GRADING. Limitations of accuracy at low strains have been taken into account in forming the basis of grading. The requirements for accuracy are governed by the following general expression:

$$Y = Mx + C$$

where

- Y = the maximum permissible error expressed as strain
- M = the proportional error
- x = the value of strain being measured
- C = a constant.

A suitable constant and coefficient have been chosen for each grade and the following expressions apply:

$$\begin{aligned} Y_B &= 0.004x + 20 \times 10^{-6} \\ Y_C &= 0.008x + 40 \times 10^{-6} \\ Y_D &= 0.020x + 100 \times 10^{-6} \\ Y_E &= 0.040x + 200 \times 10^{-6} \\ Y_F &= 0.080x + 400 \times 10^{-6} \end{aligned}$$

The requirements for the grading of extensometers, based on the above, are given in Table 1. An example of the application of Table 1, for an extensometer having a gauge length of 25 mm, is shown in Table 2.

2.3 GAUGE LENGTH TO BE USED DURING CALIBRATION AND WHEN TESTING MATERIALS. The value of the gauge length used for calibration of the extensometer, and for tests performed with the extensometer, herein referred to as the 'assigned gauge length', shall be a convenient value chosen such that no

measured value of the gauge length differs from the chosen value by more than ± 0.3 percent for Grade B, ± 0.5 percent for Grade C and ± 1.0 percent for Grades D, E and F. Thus for example in the case of a Grade D, E or F extensometer, the assigned gauge length must be between 0.99 times the highest measured value and 1.01 times the lowest measured value. Where possible the assigned gauge length should be the nominal gauge length.

2.4 MAGNIFICATION FACTOR. With certain types of extensometers, it is possible to reduce progressive errors by adjusting the magnification. Adjustments may only be carried out during an exploratory set of readings. However, the report of calibration shall supply sufficient information to enable the extensometer to be used at the same magnification at which it was calibrated, e.g. —

- (a) with optical extensometers, where it may be advantageous to use a scale distance which differs from the theoretical value or from the value used during the previous calibration, the actual scale distance used during calibration shall be given in the report;
- (b) where a device is used to adjust the magnification of the extensometer for use, details of this unit, its operation and settings shall be reported.

If extensometers are not graduated directly in units of extension, the factor to be applied shall be determined from the readings obtained during calibration (see Clause 3.6).

2.5 ASSESSMENT OF CALIBRATION. Compliance of an extensometer with the grading requirements of Table 1 shall be determined according to Clause 3.6 on the basis of the calibration results obtained.

TABLE 1
GRADING REQUIREMENTS FOR EXTENSOMETERS

Property	Maximum permissible value				
	Grade				
	B	C	D	E	F
Repeatability of gauge length, expressed as length per unit gauge length	0.006	0.01	0.02	0.02	0.02
Readability of indicated extension, expressed as strain	$0.4Y_B$	$0.4Y_C$	$0.4Y_D$	$0.4Y_E$	$0.4Y_F$
Repeatability of indicated extension, expressed as strain	$0.6Y_B$	$0.6Y_C$	$0.6Y_D$	$0.6Y_E$	$0.6Y_F$
Accuracy of indicated extension, expressed as strain	$\pm Y_B$	$\pm Y_C$	$\pm Y_D$	$\pm Y_E$	$\pm Y_F$

TABLE 2
EXAMPLES OF GRADING REQUIREMENTS FOR 25 mm
GAUGE LENGTH EXTENSOMETERS

Property	Maximum permissible value, μm				
	Grade				
	B	C	D	E	F
Repeatability of gauge length	150	250	500	500	500
Readability of indicated extension at—					
zero strain	0.20	0.40	1.0	2.0	4.0
0.001 strain	0.24	0.48	1.2	2.4	4.8
0.005 strain	0.40	0.80	2.0	4.0	8.0
0.010 strain	0.60	1.2	3.0	6.0	12
0.020 strain	1.0	2.0	5.0	10	20
Repeatability of indicated extension at—					
zero strain	0.30	0.60	1.5	3.0	6.0
0.001 strain	0.36	0.72	1.8	3.6	7.2
0.005 strain	0.60	1.2	3.0	6.0	12
0.010 strain	0.90	1.8	4.5	9.0	18
0.020 strain	1.5	3.0	7.5	15	30
Accuracy of indicated extension at—					
zero strain	± 0.50	± 1.0	± 2.5	± 5.0	± 10
0.001 strain	± 0.60	± 1.2	± 3.0	± 6.0	± 12
0.005 strain	± 1.0	± 2.0	± 5.0	± 10	± 20
0.010 strain	± 1.5	± 3.0	± 7.5	± 15	± 30
0.020 strain	± 2.5	± 5.0	± 12	± 25	± 50

NOTES:

1. After calculation according to the expressions given in Clause 2.2, the values in Table 2 have been rounded to the second significant figure. The Calibrating authority should use discretion in applying these values to an extensometer being calibrated.
2. More comprehensive tables of grading requirements covering extensometers of nominal gauge lengths 25, 50, 100 and 200 mm are given in Appendix C.

Application of this standard is not restricted to the values shown in these tables. If the assigned gauge length differs from 25, 50, 100 or 200 mm, the grading requirements should be calculated from the expressions given in Clause 2.2.