BRITISH STANDARD

BS 1610 :
Part 3 : 1990

Materials testing machines and force verification equipment

Part 3. Specification for the grading of the forces applied by deadweight and lever creep testing machines

Machines d'essais des matériaux et équipements de contrôle des contraintes Partie 3. Classification des charges exercées par les machines d'essai de fluage à poids morts et à levier — Spécifications

Werkstoffprüfmaschinen und Kraftmeßgeräte Teil 3. Klasseneinteilung nach Prüfkraftbereichen von Zeitstandprüfmaschinen mit Kraftübertragung durch Hebelwirkung

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Committees responsible for this British Standard

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Electricity Association

This British Standard, having been prepared under the direction of the Iron and Steel and the Non-ferrous Metals Standards Policy Committee, was published under the authority of the Board of BSI and comes into effect on 31 January 1991

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Contents

Foreword

This Part of BS 1610 has been prepared under the direction of the Iron and Steel Standards Policy Committee and the Non-ferrous Metals Standards Policy Committee.

Part 1 of BS 1610 specifies requirements for the grading of the forces applied by a materials testing machine and the method of verification. Part 2 of BS 1610 specifies requirements for the grading of force verification equipment and the method of calibration of proving devices. It has been found that a new Part of BS 1610 is required as Parts 1 and 2 do not adequately cover requirements for creep testing. This Part of BS 1610 specifies requirements for the grading of the forces applied by deadweight and lever creep testing machines and describes the method of verification.

Cognizance has been taken of discussions in the International Organization for Standardization (ISO) and the International Organization for Legal Metrology (OIML). A numerical system of grading is specified which relates to that being adopted internationally and is also conceptually similar to the system for testing machines specified in Parts 1 and 2 of BS 1610. For each grade of the verification equipment, the numerical value of repeatability has been defined as five times better than that required for the corresponding grade of the test machine.

Some parameters adopted in this Part of BS 1610 differ slightly from international views because they have been chosen as a result of national experience and to maintain conformity with a wide range of commercial interests.

This Part of BS 1610 does not restrict the type of equipment used for verification but, by reference to Part 2 of BS 1610, requires that calibration forces be traceable to national standards held at the National Physical Laboratory, either directly or indirectly through a hierarchical chain such as that provided by a calibration laboratory accredited by the National Measurement Accreditation Service (NAMAS). Traceability to national standards of other countries is acceptable, provided these standards are recognized by NPL.

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

Section 1. General

1.1 Scope

This Part of BS 1610 specifies requirements for the grading of the forces applied by deadweight and lever creep testing machines, and describes the method of verification.

NOTE. The titles of the publications referred to in this standard are listed on the inside back cover.

1.2 Definitions

For the purposes of this Part of BS 1610 the following definitions apply.

1.2.1 creep testing machine

A machine used for applying a constant or changing load to a test specimen for an extended period of time, usually at an elevated temperature for the purposes of creep, creep rupture or stress-relaxation testing.

NOTE. Details of creep testing procedures are given in BS 3500.

1.2.2 SI unit of force

The force that, when applied to a mass of 1 kg, gives the mass an acceleration of 1 m/s^2, i.e. the newton (N).

1.2.3 force-measuring system

A system for measuring force by means of an analogue or digital display or a chart recorder.

NOTE. Each form of display and each range in a multi-range machine is an independent force-measuring system.

1.2.4 loading mode

The direction of an increasing force, either tensile or compressive.

1.2.5 repeatability

The greatest difference between the true forces corresponding to repeated applications of the indicated force.

1.2.6 error

The error is the indicated force minus the mean true force, corresponding to repeated applications of the indicated force.

1.2.7 resolution

The smallest increment of force that may be applied to a testpiece.

NOTE. Methods for determining the resolution of the various categories of machine are given in **3.2.1** to **3.2.3**.

1.2.8 lower limit of verification

The lowest specified force on a given measurement range to which a creep testing machine can be verified.

1.2.9 verification equipment

Equipment consisting of proving devices, verification masses and proving levers (see BS 1610 : Part 2).

1.2.10 proving device

A device that determines force by the measurement of the elastic deflection of a loaded member.

1.2.11 deflection

A value obtained by subtracting the reading of the deflection-measuring indicator of the proving device at zero force from the reading with a force applied.

1.2.12 lever ratio

The multiplication factor, R, determined during calibration over a range of forces, relating the magnitude of the masses applied to the scale pan to the force measured in the specimen loading train.

1.2.13 verification masses

A set of masses reserved for calibration purposes only.

1.2.14 working masses

The masses used to apply a load to a test specimen during creep testing.

Section 2. Grading of creep testing machines

2.1 General

Uniaxial creep testing machines shall be graded in accordance with the maximum permissible values given in table 1 for the repeatability and error of the forces specified in **2.2** and **2.3**, when verified in accordance with section 3.

NOTE. A creep machine may normally be regarded as a single range materials testing machine.

Table 1. Grading of deadweight and lever creep testing machines

Grade of machine	Maximum permissible repeatability of forces as percentage of nominal force	Maximum permissible error of forces as percentage of nominal force[1)]
	%	%
0.5	0.5	± 0.5
1.0	1.0	± 1.0
2.0	2.0	± 2.0

[1)] In the case of a reverification carried out using verification masses, the maximum permissible error of force, expressed as a percentage of the nominal force for the various grades given in table 1, is the algebraic sum of the error plus the tolerance error of the working masses.
If dedicated masses are used for the machine reverification, the masses are effectively an integral part of the machine and thus no separate allowance need be made for the tolerance of the dedicated masses.

2.2 Lever creep testing machines

At least five approximately equispaced consecutive forces, from the maximum to be verified downwards, shall not exceed the values given in table 1 for a specific grade.

The grading shall cease to apply below the minimum force that complies with these requirements.

It is possible for a range to be given more than one grading, but for each such grading, all forces from the maximum downwards shall be considered. Thus a more exacting grade shall not be introduced to cover some intermediate part of the range.

2.3 Deadweight creep testing machines

Each range shall be graded as described in **2.2**. Machines with guides below the testpiece, which could introduce friction effects, shall be calibrated using a proving device. The verifier shall be satisfied that the axis of loading is through the longitudinal axis of the testpiece, see **3.4**.

NOTE. Normally the grading will be determined by the accuracy of the masses and of the mass of the load suspension system below the testpiece.

2.4 Certificate of grading

When a creep testing machine has been graded and verified in accordance with this Part of BS 1610, the verifier shall issue a certificate stating the following:

(a) the identity and location of the creep testing machine and the date of verification;

(b) the grade, mode and range of forces on each force-measuring system verified;

(c) where appropriate, any force-measuring systems that were not verified;

(d) the average lever ratio for each force measuring system;

(e) the resolution of the testing machine (see **3.2**);

(f) the method of verification used (see **3.5**) and the identity, grading and date of the certificate of grading of the verification equipment used;

(g) the average temperature of the verification equipment at the time of verification;

(h) if verification masses are employed, details of the method, the date of their reverification and identity of any equipment used together with details of its certified traceable route to the national primary standards;

(i) details of the certified verification route to the national primary standards used to verify the working masses.

2.5 Frequency of reverification

2.5.1 Lever machines

A creep testing machine shall be reverified annually if it is used for short term tests, the number of which exceeds 20 tests per annum. Machines used for long term tests shall be reverified after 20 tests or an interval of 3 years whichever is the shorter, unless a long term test is in progress. In the case of multi-testpiece string machines of the type having more than one load train within a single furnace, the entire machine shall be reverified at an interval of not more than 3 years unless a long term test is in progress. The individual load trains shall be reverified after 20 tests or after 3 years, whichever is the shorter.

NOTE. Careful management of testing schedules will need to be applied in order to minimize the down time of some of the load trains pending the availability of the entire machine for reverification. Long term tests should not be set up on the various levers with continually overlapping fracture lifetimes thereby extending the reverification period.

Machines shall also be reverified prior to carrying out a test if the estimated test life exceeds 3 years from the last verification. Any machine shall also be reverified if it has been dismantled for moving or subject to major repair or adjustment.

2.5.2 Machines with load measuring devices

Machines incorporating a load measuring device as the primary means of measuring the force shall be reverified in accordance with BS 1610 : Part 1. The reverification shall be annual except where machines are used for long term tests. These shall be reverified after 20 tests or an interval of 3 years whichever is the shortest, unless a long term test is in progress.

In the case of multi-testpiece string machines of the type having more than one load train within a single furnace, the entire machine shall be reverified at an interval of not more than 3 years unless a long term test is in progress. The individual load trains shall be reverified after 20 tests or after 3 years, whichever is the shorter.

Machines shall also be reverified prior to carrying out a test if the estimated test life exceeds 3 years from the last verification.

Any machine shall also be reverified if it has been dismantled for moving or subject to major repair or adjustment.

Section 3. Method of verification

3.1 General

The forces applied by creep testing machines shall be verified according to the procedure described in **3.5** so as to permit a determination of grading for repeatability and error of force. To ensure that the grading is consistent with the resolution of the force indication, a lower limit of verification shall be determined.

NOTE. Figure 1 illustrates tensile creep machine loading systems.

3.2 Resolution

3.2.1 Overslung lever creep testing machines

The resolution shall be determined by a precalibration procedure under nominally zero force to ascertain the smallest force applied to the testpiece necessary to cause a freely balanced lever to move a predetermined amount. The loading train shall either be disconnected above the specimen fixing or removed, whichever is most practical, and the lever balanced in the normal horizontal position as specified in **3.4.3**. The amount the lever moves shall be determined either by monitoring the displacement of the loading train at the testpiece attachment position, ensuring that movement of at least 1 mm is attained by the addition of small masses on the scale pan; or by monitoring the angular movement of the primary lever, ensuring that an angular rotation of at least 1° is attained by the addition of small masses on the scale pan.

The resolution shall also be determined at nominally half load and full load conditions corresponding to the maximum of the force scale being verified utilizing the force proving device mounted in the loading train.

NOTE 1. The resolution is the magnitude of the smallest mass, multiplied by the nominal lever ratio, added or removed from the scale pan which causes an indicated change in the force indicator of the proving device. The resolution of the machine cannot be better than the resolution of the proving device as specified in **3.2** of BS 1610 : Part 2 : 1985.

The resolution of the creep machine shall be taken as being the largest of the three values so determined. The resolution shall be expressed in International System (SI) units of force.

NOTE 2. The angular movement of the primary lever may be monitored using a graduated spirit level.

NOTE 3. Overslung loading systems are shown in (a), (b) and (c) of figure 1.

3.2.2 Underslung lever and deadweight creep testing machines

The resolution of underslung lever and deadweight creep testing machines shall be determined with the use of a force proving device mounted in the loading train in place of a specimen.

NOTE 1. The resolution is taken as being the magnitude of the smallest mass multiplied by the nominal lever ratio added or removed from the scale pan which causes a detectable change in the force indicator on the proving device, at half and full loads as specified in **3.2.1**.

NOTE 2. Underslung lever and deadweight loading systems are shown in (d), (e) and (f) of figure 1.

3.2.3 Jockey weight scale creep testing machines

Where the force is applied by the position of a moving jockey weight on a lever, the resolution shall be the force applied to the testpiece equivalent to the smallest recordable movement of the weight detectable on the proving device or the resolution as defined in **3.2.1.1** of BS 1610 : Part 1 : 1985, whichever is the greater. The graduated jockey weight position scale shall comply with **3.2.1.1** of BS 1610 : Part 1 : 1985.

NOTE 1. Jockey weight loading systems are shown in (b) and (e) of figure 1.

NOTE 2. Widths of graduations and pointer should be in accordance with BS 3693.

3.3 Verification

3.3.1 General

Verification shall be carried out for each force-measuring system and in each loading mode for which a grade is sought.

3.3.2 Lower limit of verification

Verification shall not be performed below the lower limit F_v on any force-measuring system determined as follows:

$$F_v = ar$$

where

a has the following values:

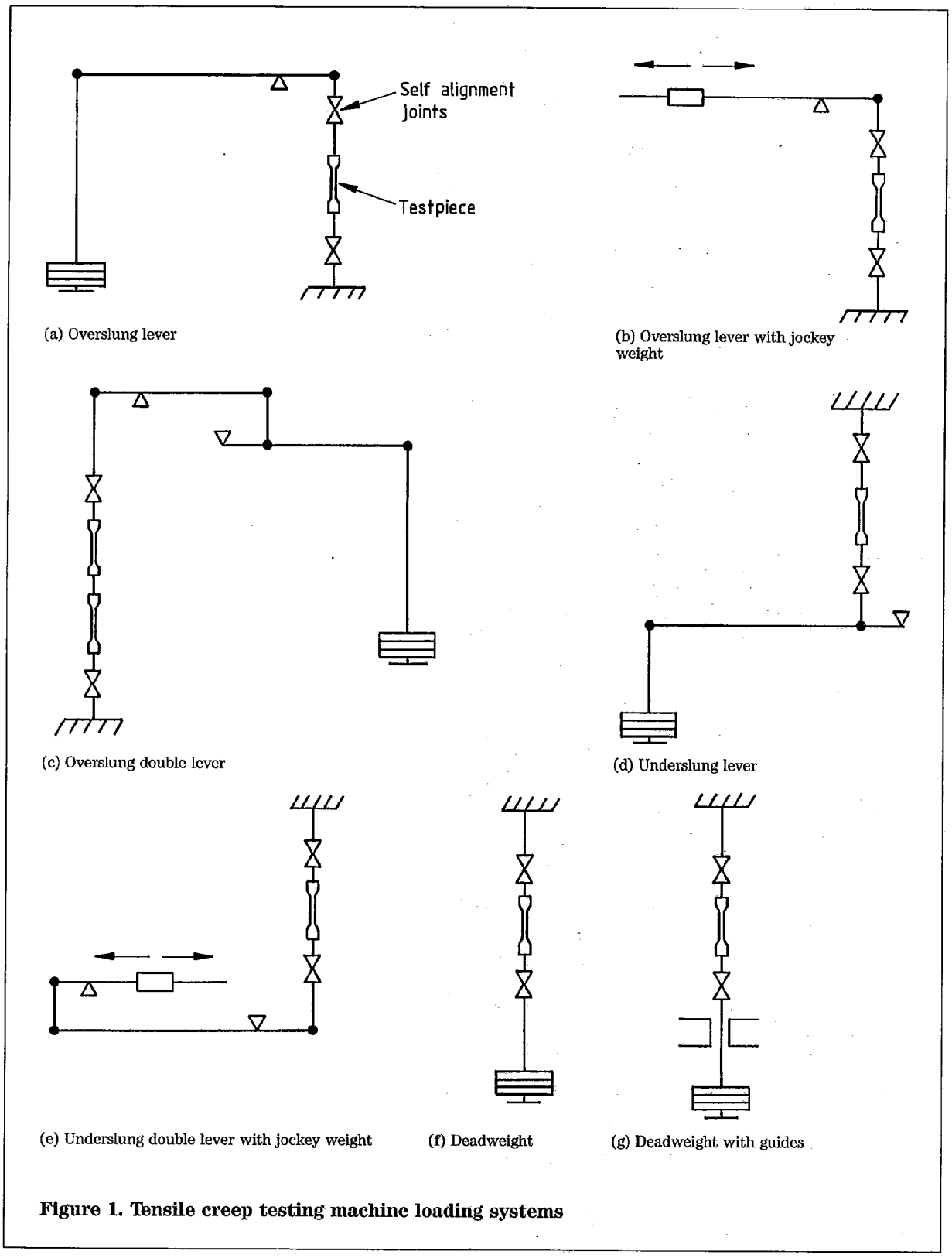
400 for grade 0.5 machines;

200 for grade 1.0 machines;

100 for grade 2.0 machines;

r is the resolution determined in accordance with **3.2**.

NOTE. The lower limit of verification of the machine may be less than the operating range of the equivalent grade force proving device used to determine the resolution at the half and full load conditions. Thus if it is desired to verify the testing machine down to its lower limit of verification it will probably necessitate the use of two proving devices, one to verify the top end of the range of the machine, and a smaller capacity providing device to verify the lower end of the range.



(a) Overslung lever

(b) Overslung lever with jockey weight

(c) Overslung double lever

(d) Underslung lever

(e) Underslung double lever with jockey weight

(f) Deadweight

(g) Deadweight with guides

Figure 1. Tensile creep testing machine loading systems

3.3.3 Verification equipment

3.3.3.1 *General*

Proving devices shall be in accordance with BS 1610 : Part 2. The grade of the verification equipment shall be equal or superior to the grade determined for the creep testing machine.

3.3.3.2 *Verification masses*

Each mass shall be individually marked and shall have a known accuracy of better than ± 0.05 %, with certified traceability to the national measurement system. Recalibration of the masses shall be carried out every 5 years or immediately subsequent to suffering any damage or adjustment. Verification masses shall comply with **2.2** of BS 1610 : Part 2 : 1985.

3.3.3.3 *Working masses*

Working masses shall be one of the following categories.

(a) Masses used to specify the load applied to the specimen, which shall be suitably marked to indicate compliance with the specified accuracy and reverification period. Masses of greater than 1 kg shall have an accuracy better than or equal to ± 0.1 % with certified traceability to the primary national standard. Masses smaller than 1 kg shall be accurate to within ± 0.25 % of the nominal value. All masses shall be reverified within periods not exceeding 5 years, or imediately subsequent to suffering any damage or adjustment, or immediately prior to use for any long term estimated to last more than 5 years.

NOTE. Specimen test loads should consist of the smallest number of individual masses practicable.

(b) Masses dedicated for use with a specific creep machine which are marked with the machine identification and which are used with the machine during its calibration.

For machines verified using dedicated masses for which traceability is not held, the grading shall apply only for forces corresponding to the exact combination of masses used during verification. The verification shall not be regarded as being valid at intermediate forces.

For machines used with dedicated masses for repetitive material release testing, e.g. 100 h rupture tests, the combination of masses used to apply the required force shall be used to apply one of the force levels during verification.

(c) Masses which are used to make up a desired test load which are collectively weighed to an accuracy of better than ± 0.1 % prior to the creep test, using a calibrated balance having traceability back to the primary national standard.

3.4 Preliminary procedure

3.4.1 Condition

Verification shall not commence unless the creep testing machine is in good working order, and the base of the machine has been levelled to ensure that the line of action of force runs through the centres of knife edges or ball seatings of the force train.

3.4.2 Alignment

Mount the verification equipment in the machine so that the forces are applied along the loading axis of the machine. Mount the tension proving devices in the machine so that the self-alignment devices used are included at each end of the loading train. For correct alignment of a proving device in a compression mode, the contact between the machine force train and the proving device shall be via a spherical seating.

NOTE. This may be achieved by means of a soft-steel loading pad placed on the domed boss of the proving device or, where the upper boss is plane, by means of a spherical seating unit placed on the boss or by using the spherically-seated platen of the machine loading directly on to the device.

3.4.3 Balancing the lever

3.4.3.1 *General*

The loading train shall be balanced to achieve a zero loading reading on the verification equipment when the force proving device is mounted in the loading train in place of the specimen. In some machines it is not possible to fully balance the lever, in which case the minimum force that is applied to the test piece with no masses on the scale pan shall be recorded on the test certificate and the value taken into account when calculating the force applied to the test piece when undertaking a creep test.

NOTE. The precise method of balancing is dependant upon the design of the machine.

3.4.3.2 *Overslung lever*

The force verification device shall be hung in the loading train in place of the test specimen, with the lower loading bar disconnected immediately below the proving device. The lever shall then be balanced by movement of the adjustment weight normally attached to the machine, or by the addition of an extra balancing weight. The force indicator of the verification device shall be set to zero where practicable before connecting the lower loading bar, otherwise it can be set to zero after connecting the lower loading bar and balancing the lever.

NOTE 1. It should be remembered that the lever will need to be rebalanced before commencing creep testing.

If it is impractical to balance the lever in order to achieve nominally zero force on the test piece the minimum force applied to the test piece shall be measured by the force proving device and the value recorded on the certificate.

NOTE 2. Overslung lever loading systems are shown in (a), (b) and (c) of figure 1.

3.4.3.3 *Levers which cannot be balanced at zero force*

Force shall be recorded on the certificate and will constitute the lower limit of verification if it is greater than the value calculated in accordance with **3.3.2**.

NOTE 1. Because of the geometrical design of underslung lever machines it is seldom possible to balance out the mass of the lower loading bars, lever and scale pan. It is therefore necessary to zero the verification device with the lower loading bar disconnected, and then merely to note the force applied when the loading train is reconnected and the system adjusted to bring the lever to the normal operating position with no masses placed on the scale pan.

NOTE 2. Levers which cannot be balanced at zero force are shown in (c), (d) and (e) of figure 1.

3.4.4 Temperature compensation

Allow sufficient time for the verification equipment to attain a stable temperature. Record the temperature at the beginning and end of the application of each series of forces. Where necessary, apply temperature corrections to the deflections of proving devices using the equations given in **A.3** of BS 1610 : Part 1 : 1985.

3.4.5 Machine conditioning

Exercise the materials testing machine and verification equipment at least once between zero force and the maximum force to be measured. Then reset the machine's force indicator to zero if the machine is fitted with such a device.

NOTE. This task could be carried out using a jack under the scale pan.

3.5 Verification procedure

3.5.1 Selection of masses

The machine shall be verified using verification masses (see **1.2.13** and **3.3.3.2**) or dedicated working masses are used (see **1.2.14** and **3.3.3.3**).

3.5.2 Selection of test forces

Apply a series of at least five approximately equispaced forces upwards from 20 % of the scale maximum or the lower limit of verification, whichever is greater.

When required, apply additional forces below 20 % of the scale maximum down to the lower limit of verification (see **3.3.2**). Apply one additional force for each 5 ± 1 % of the scale to be verified, working downwards from the 20 % point.

NOTE. The scale maximum is the upper limit of verification; it may be the maximum capacity of the machine, or it may be some lower value stated by the customer.

3.5.3 Application of test forces

For each range, apply the series of forces in ascending order and repeat each series to give three series of such forces.

NOTE 1. The indicator on the force proving device may be reset to zero before commencing the second or third series of readings.

Undertake two of the series of readings with the loading system as close as possible to the mid point of the normal operating range. Record the third series with the loading system at the maximum excursion of its operating range that it is possible to encounter during creep testing.

NOTE 2. On an overslung lever or a single underslung lever creep machine this requirement implies that two series of readings are taken with the lever in the horizontal position, at which point the lever ratio is at its maximum value, whilst the third is with the lever at the lowest position.

3.6 Calculation of results

Tabulate the multiplication factor corresponding to the lever ratio at each nominal force.

At each nominal force, calculate the repeatability and error from the results of all the applications of forces and express these as a percentage of the nominal force.

Publication(s) referred to

BS 1610	Materials testing machines and force verification equipment Part 1 Specification for the grading of the forces applied by materials testing machines Part 2 Specification for the grading of equipment used for the verification of the forces applied by materials testing machines
BS 3500	Methods for creep and rupture testing of metals
BS 3693	Recommendations for the design of scales and indexes on analogue indicating instruments

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