# International Standard ISO 5436

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION●МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ●ORGANISATION INTERNATIONALE DE NORMALISATION

## Calibration specimens — Stylus instruments — Types, calibration and use of specimens

*Échantillons d'étalonnage — Instruments à palpeur — Type, étalonnage et emploi des échantillons*

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## Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.



International Standard ISO 5436 was prepared by Technical Committee ISO/TC 57, *Metrology and properties of surfaces*.

# Calibration specimens — Stylus instruments — Types, calibration and use of specimens

## 1 Scope and field of application

This International Standard specifies the characteristics of specimens for the calibration of stylus instruments (see ISO 1880 and ISO 3274) and the annexes give information regarding their calibration and application to the calibration and adjustment in laboratories, standards rooms and workshops.

## 2 References

ISO 468, *Surface roughness — Parameters, their values and general rules for specifying requirements.*

ISO 1878, *Classification of instruments and devices for measurement and evaluation of the geometrical parameters of surface finish.*

ISO 1879, *Instruments for the measurement of surface roughness by the profile method — Vocabulary.*

ISO 1880, *Instruments for the measurement of surface roughness by the profile method — Contact (stylus) instruments of progressive profile transformation — Profile recording instruments.*

ISO 3274, *Instruments for the measurement of surface roughness by the profile method — Contact (stylus) instruments of consecutive profile transformation — Contact profile meters, system M.*

## 3 Definitions

For the purposes of this International Standard, the definitions given in ISO 468, ISO 1878, ISO 1879 and ISO 3274, and the following apply.

**standard instrument calibration specimen**: A specimen having accurately determined standardized characteristics for testing or establishing one or more features of the performance of an instrument.

## 4 Types and purposes of instrument calibration specimens

The calibration of the existing wide range of instruments in all modes of operation calls for more than one type of calibration specimen.

Each calibrated specimen may have a limited range of application according to its own characteristics and those of the instrument to be calibrated. The validity of the calibration of an instrument will be dependent on the correct association of these characteristics.

To cover the range of requirements, four types of specimens are described, each of which may have a number of variants. Their principal applications are specified in 4.1 to 4.4 and dimensions and tolerances in 7.1 to 7.4.

### 4.1 Type A



These specimens are for checking the vertical magnification of profile recording instruments having displacement sensitive pick-ups.

#### 4.1.1 Type A1

These specimens have a wide calibrated groove with a flat bottom, or a number of separated grooves of equal or increasing depth, each groove being wide enough to be insensitive to the shape or condition of the stylus tip.

#### 4.1.2 Type A2

These specimens are similar to type A1, except that the grooves have rounded bottoms of sufficient radius to be insensitive to the shape or condition of the stylus tip.

### 4.2 Type B

These specimens are primarily for checking the condition of the stylus tip.

#### 4.2.1 Type B1

These specimens have a narrow groove or a number of separated grooves proportioned to be increasingly sensitive to the dimensions of the stylus. They are intended for use with instruments having displacement sensitive pick-ups.

#### 4.2.2 Type B2

These specimens have two grids of nominally equal $R_a$ values, one being sensitive and the other insensitive to the dimensions of the stylus tip. These grids are used comparatively for checking the stylus tips of parameter instruments having motion-sensitive pick-ups, the ratio of the $R_a$ values being taken as the criterion.

### 4.3 Type C

These specimens are primarily intended for checking parameter meters.

They have a grid of repetitive grooves of simple shape (either sinusoidal, triangular or arcuate) which have relatively low harmonic amplitudes. They are used primarily for calibrating parameter meters, but they may also be used for checking horizontal magnification if the spacing of the grooves is held within limits acceptable for this purpose.

An essential requirement of type C calibration specimens is that standardized specimens of differing waveform are nevertheless compatible, in the sense that they will all lead to the same state of instrument calibration or verification, provided they are used correctly.

The declared parameter values issued with each specimen refer to a smooth straight datum and filtered profiles derived from the trace according to ISO 3274. Although the wider grooves are generally insensitive to the dimensions of the stylus tip, sensitivity in this respect may become appreciable for the narrowest grooves; and for this reason the parameter values shall be declared with reference to the stylus tip.

#### 4.3.1 Use for skidless instruments

Each specimen will calibrate a skidless instrument (one which traces the profile with respect to a smooth straight datum) with respect to the particular crest spacing of that specimen.

The purpose of the series of specimens is to enable the transmission characteristic to be checked for a number of spacings and amplitudes.

#### 4.3.2 Use for skid-type instruments

The use of type C specimens for calibrating skid-type instruments is restricted to those for which the generally indeterminate rise and fall of the skid(s) over the crests makes an insignificant contribution to the calibration. This is best assured by using a specimen having the shortest crest spacing permitted by the stylus, as shown in annex B, and this is the general practice.

### 4.4 Type D

These specimens are for overall check of meter calibration.

They have irregular profiles (for example as obtained by grinding) in the direction of traverse, but they have the convenience of an approximately constant cross-section along their lengths.

The specimens simulate workpieces containing a wide range of crest spacings, but reduce the number of traverses needed to give a good average value. They provide, for reassurance, a final overall check on calibration.

The accuracy obtainable by averaging a few random traverses will generally be less than type C specimens, but may be sufficient for workshop purposes. Higher accuracy can be obtained by averaging a statistically determined number of appropriately positioned traverses.[1)]

## 5 Materials

The material used shall be hard enough to ensure adequate life in relation to cost. Its surface shall be smooth and flat enough not to affect the evaluation of the grooves. Glass or quartz or materials harder than 750 HV are favoured.

## 6 Size of specimen



The operative area shall be large enough to provide for the total length of traverse required for all intended determinations.

One or more than one kind of specimen may be provided on a single block. So as to ensure the best possible economic conditions, overall dimensions of specimens are not given.



## 7 Mechanical requirements

It should be noted that, in the tables which follow, the nominal values carry a wide tolerance, and that these values should not be used as the basis of instrument calibration (see clause 9, notes 1 and 2).

### 7.1 Type A

#### 7.1.1 Type A1: Wide grooves with flat bottoms

(see figure 1 and table 1)

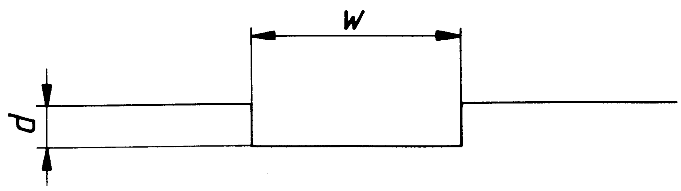


**Figure 1 — Type A1 groove**

1) To form the subject of a future International Standard.

**Table 1 — Nominal values of depth and width for type A1**

Values in micrometres

| | | | | | | |
|---|---|---|---|---|---|---|
| **Depth,** *d* | 0,3 | 1,0 | 3,0 | 10 | 30 | 100 |
| **Width,** *w* | 100 | 100 | 200 | 200 | 500 | 500 |

If a skid is used, it shall not cross a groove at the same time that the stylus crosses the groove being measured.

For tolerances, see table 2.

**Table 2 — Tolerances for types A1 and A2**

| Nominal value | Tolerance on nominal value | Uncertainty of measurement in calibrated mean depth | | Standard deviation from the calibrated mean |
|---|---|---|---|---|
| µm | % | % | (µm) | % |
| 0,3 | ± 20 | ± 3 | (± 0,01) | 3 |
| 1 | ± 15 | ± 2 | (± 0,02) | 2 |
| 3 | ± 10 | ± 2 | (± 0,06) | 2 |
| 10 | ± 10 | ± 2 | (± 0,2) | 2 |
| 30 | ± 10 | ± 2 | (± 0,6) | 2 |
| 100 | ± 10 | ± 2 | (± 2) | 2 |



**7.1.2 Type A2: Wide grooves with rounded bottoms** (see figure 2 and table 3)

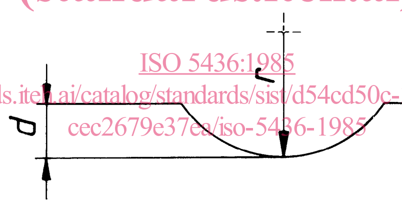


**Figure 2 — Type A2 groove**

**Table 3 — Nominal values of depth and radius for type A2**

| | | | | | |
|---|---|---|---|---|---|
| **Depth,** *d*, (µm) | 1,0 | 3,0 | 10 | 30 | 100 |
| **Radius,** *r*, (mm) | 1,5 | 1,5 | 1,5 | 0,75 | 0,75 |

If a skid is used, it shall not cross the groove at the same time that the stylus crosses the groove being measured.

For tolerances, see table 2.

**7.1.3** The basis of assessment for types A1 and A2 is given in 8.1; requirements regarding statements of mean values are given in clause 9; guidance on calibration is given in clauses A.1 and A.2; guidance on use is given in clauses B.1 and B.2.

## 7.2 Type B grooves for checking stylus tips

### 7.2.1 Type B1

Development of specimens having single narrow grooves is proceeding, but is not yet sufficiently advanced to permit standardization.

### 7.2.2 Type B2

These specimens have two grids formed on a common base.

#### 7.2.2.1 **Sensitive grid** (see figure 3)

Isosceles triangular grooves with sharp peaks and valleys, for testing 10 µm radius tips.

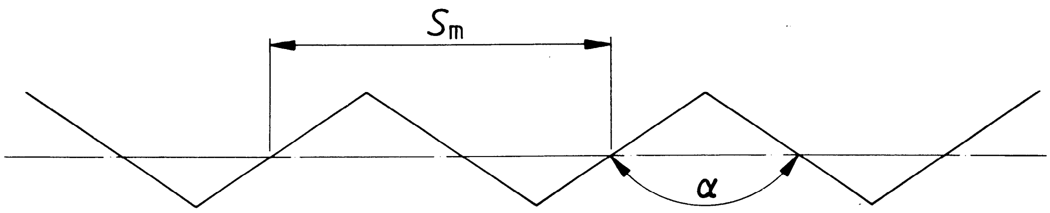


**Figure 3 — Type B2 grooves (sensitive grid)**

For 10 µm radius tips :

— $\alpha$ = 150°

— $R_a$ = 0,5 µm ± 5 %

$S_m$ shall be determined by $\alpha$ and $R_a$, and will thus have the mid-limit value of 15 µm.

For tolerances, see table 4.

#### 7.2.2.2 **Insensitive grid** (see figure 4)

Sinusoidal or arcuate grooves, proportioned to make $R_a$ substantially independent of the stylus tip.




**Figure 4 — Type B2 grooves (insensitive grid)**

For 10 µm radius tips :

— $R_a$ = 0,5 µm ± 5 %

— $S_m$ = 0,25 mm

For tolerances, see table 4.

NOTES

1 Grooves for tips with a radius of less than 10 µm (if such are practical) have still to be developed.

2 For convenience, one or more type C grids may be added for general calibration of $R_a$. Such grids shall be clearly distinguished from the type B2 pair.

**7.2.3** The basis of assessment for type B2 is given in 8.2, tolerances are given in 7.2.2 and table 4, and the method of use is described in B.4.

**Table 4 — Tolerances for type B2 sensitive and insensitive grids**

| Nominal value | | Tolerance on nominal value |
|---|---|---|
| for sensitive grids | for insensitive grids | % |
| $\alpha$ = 150°<br>$R_a$ = 0,5 µm<br>$S_m$ = 15 µm | $R_a$ = 0,5 µm<br>$S_m$ = 0,25 mm | ± 5 |
| Ratio of mean $R_a$ values | | ± 2 |

### 7.3 Type C

The nominal values given in 7.3.1, 7.3.2 and 7.3.4 are values which assume negligible attenuation by the stylus or filter.

#### 7.3.1 Type C1: Grooves having a sine wave profile (see figure 5 and table 5)

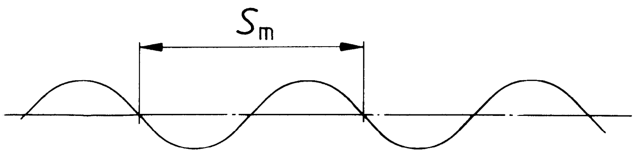


**Figure 5 — Type C1 grooves**

**Table 5 — Nominal values of $R_a$ for type C1**

| Mean spacing of profile irregularities, $S_m$, mm | | | |
|---|---|---|---|
| 0,08 | 0,25 | 0,8 | 2,5 |
| $R_a$, µm | | | |
| 0,1<br>0,3<br>1<br>3 | 0,3<br>1<br>3<br>10 | 1<br>3<br>10<br>30 | 3<br>10<br>30<br>— |



For tolerances, see table 6.

**Table 6 — Tolerances for types C1 to C4**

| Nominal value of $R_a$ | Tolerance on nominal value | Uncertainty of measurement of stated mean value of $R_a$ | Standard deviation from mean value |
|---|---|---|---|
| µm | % | % | % |
| 0,1 | ± 25 | ± 3 | 3 |
| 0,3 | ± 20 | ± 2 | 2 |
| 1 | ± 15 | ± 2 | 2 |
| 3 | ± 10 | ± 2 | 2 |
| 10 | ± 10 | ± 2 | 2 |
| 30 | ± 10 | ± 2 | 2 |

NOTE — The sine wave provides an ideal reference for calibrating a frequency-dependent instrument because the perfect sine wave, having no harmonics, is not changed in shape by a wave filter and accords directly with the transmission characteristics defined in ISO 3274.

#### 7.3.2 Type C2: Grooves having an isosceles triangular profile (see figure 6 and table 7)

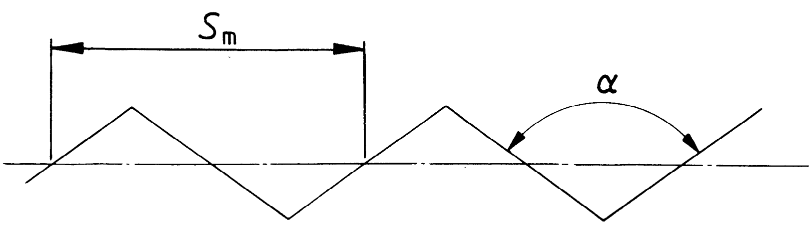


**Figure 6 — Type C2 grooves**

**Table 7 — Nominal values of $R_a$ and $\alpha$ for type C2**

| Mean spacing of profile irregularities, $S_m$, mm | | | | $\alpha^\circ$ |
|---|---|---|---|---|
| 0,08 | 0,25 | 0,8 | 2,5 | |
| $R_a$, µm | | | | |
| 0,1 | 0,3 | 1,0 | 3 | 178,9 |
| 0,3 | 1,0 | 3 | 10 | 176,4 |
| 1,0 | 3 | 10 | 30 | 168,6 |
| 3 | 10 | 30 | — | 144,5 |

For tolerances, see table 6.

### 7.3.3 Type C3: Simulated sine wave grooves (see figure 7)

These are simulated sine waves, which include triangular profiles with rounded or truncated peaks and valleys, the total r.m.s. harmonic content of which shall not exceed 10 % of the r.m.s. value of the fundamental.

For tolerances, see table 6.

**Figure 7 — Type C3 grooves**



NOTE — Specimens of this kind have often been provided by instrument manufacturers for calibrating their own instruments, but without commitment regarding the further use of the specimens.

### 7.3.4 Type C4: Grooves having an arcuate profile (see figure 8 and table 8)



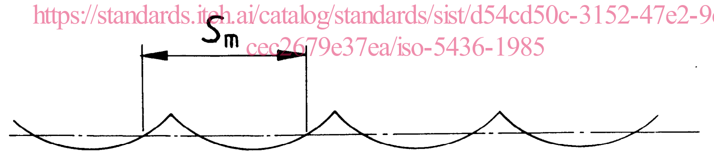


**Figure 8 — Type C4 grooves**

**Table 8 — Nominal unfiltered values of $R_a$ for type C4**

| Mean spacing of profile irregularities, $S_m$, mm | |
|---|---|
| 0,25 | 0,8 |
| $R_a$, µm | |
| 0,2 | 3,2 |
| 3,2 | 6,3 |
| 6,3 | 12,5 |
| 12,5 | 25 |

For tolerances, see table 6.

## 7.4 Type D: Unidirectional irregular profiles (see figure 9)

These have an irregular ground profile which is repeated every 4 mm in the longitudinal direction of the specimen. Normal to the measuring direction of the specimens, the production grooves on the measuring area have a constant profile form.

The nominal filtered values, $R_a$, of the specimens, in micrometres, are

0,15; 0,5; 1,5 (cut-off value 0,8 mm)

For tolerances, see table 9.

**Table 9 — Tolerances for type D**

| Nominal value $R_a$ | Tolerance on nominal value | Uncertainty of measurement of stated mean value of $R_a$ [1)] | Standard deviation from mean value |
|---|---|---|---|
| µm | % | % | % |
| 0,15 | ± 30 | ± 5 | 4 |
| 0,5 | ± 20 | ± 3 | 3 |
| 1,5 | ± 15 | ± 3 | 3 |

1) From 12 evenly distributed readings.

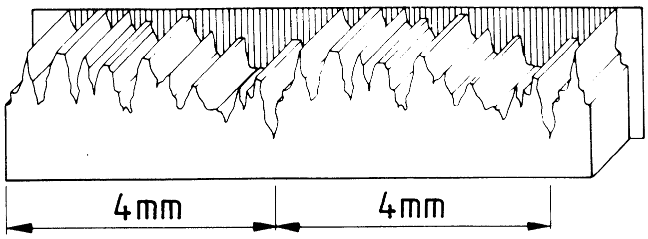


**Figure 9 — Type D grooves** (profile repetition at 4 mm intervals)

**7.5** The basis of assessment for types C and D is given in 8.3. Guidance on calibration is dealt with in clause A.3, while clauses B.3 to B.6 refer to use and other relevant matters.



## 8 Basis of assessment of calibrated values

### 8.1 Type A

#### 8.1.1 Type A1

A continuous straight mean line equal in length to three times the width of the groove is drawn over the groove to represent the upper level of the surface and another to represent the lower level, both lines extending symmetrically about the centre of the groove (see figure 10).

To avoid the influence of any rounding of the corners, the upper surface on each side of the groove is to be ignored for a length equal to one-third of the width of the groove. The surface at the bottom of the groove is assessed only over the central third of its width. The portions to be used for assessment purposes are therefore those shown at A, B and C in figure 10.

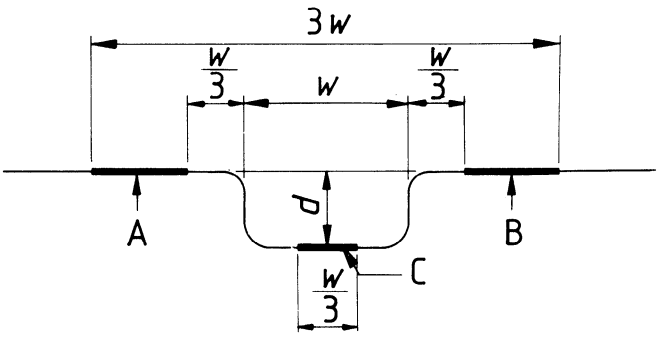


**Figure 10 — Assessment of calibrated values for type A1**

The depth $d$ of the groove shall be assessed perpendicularly from the upper mean line to the mid-point of the lower mean line.

NOTE — The depth $d$ as defined here will be equal to the mean of the portion C below the upper mean line.

A significant number, not less than five, of evenly distributed traces shall be taken.

#### 8.1.2 Type A2

A mean line representing the upper level is drawn over the groove as described for type A1. The depth shall be assessed from the upper mean line to the lowest point of the groove.

A significant number, not less than five, of evenly distributed traces shall be taken.

### 8.2 Type B2

The ratio of the mean $R_a$ of the sensitive grid and the mean $R_a$ of the insensitive grid shall be calibrated using a substantially sharp tip (< 2 µm nominal radius) and a standard two C-R[1)] filter having 0,25 mm cut-off according to ISO 3274. (See clause B.4.)

Not less than 18 evenly distributed traces shall be taken on each grid, all instrument adjustments remaining constant throughout the determination.

### 8.3 Types C1 to C4, and D

The profile shall be traced by one or more specified stylus tips with respect to a straight datum, and an $R_a$ value shall be determined, by measurement or computation, after modification of

1) "C" stands for "capacitive", "R" for "resistive".

the traced profile by each of the standard two C-R filters defined in ISO 3274 for which the evaluation length is less than that of the grid, the filter being designated by its cut-off (the wavelength for which it gives 75 % transmission).

A significant number, not less than 12, of evenly distributed traces shall be taken.

If the profile is traced by a 2 µm tip, values for other tips may be derived by computation, this fact being stated.

## 9 Marking

After each specimen has been individually calibrated, it shall be accompanied by the following statements as and where applicable:

a) type(s) of specimen;

b) the nominal value(s);

c) the effective radius of the stylus tip(s) to which each calibrated value applies;

d) details of calibration:

1) for types A1 and A2, the calibrated mean value of depth of the groove, the standard deviation from the mean, and the number of evenly distributed observations taken;

2) for type B2, the calibrated ratio of the mean $R_a$ value of the sensitive grid to that of the insensitive grid for a sharp tip (of not more than 2 µm nominal radius);

3) for types C and D, the calibrated mean value of $R_a$ for each tip used and for each two C-R transmission characteristic (defined by its 75 % transmission cut-off) for which the specimen may be used, the standard deviation from each mean, and the number of observations taken;

e) the permitted uncertainty in the calibrated mean value, as given in tables 2, 4, 6, and 9;

f) any other reference conditions to which each calibration applies, for example the basis of digital evaluation (ordinate discretization, vertical quantization), and whether the values declared refer to direct measurement or are derived therefrom.

NOTES

1 The nominal value is used only as an aid to identification. It carries a large tolerance as a concession to problems of economic manufacture. The difference between the nominal value and the calibrated value does not constitute an error.

2 The calibrated mean value is the value to be used for calibrating instruments. It is the measured mean value of the appointed number and distribution of traces taken across the operative portion of the specimen, corrected for any predetermined errors in the calibrating equipment, as far as these are known. (See annex C.)

Some degree of uncertainty in the calibrated mean value is permitted to allow for the possibility of residual errors in the calibrating equipment which are unknown and for which correction cannot be made.

3 The stated standard deviation is the standard deviation of the measured values corrected where possible for the estimated standard deviation of the calibrating equipment.



In principle, estimation of the random error of the instrument in the selected mode of use can be made by traversing a specimen a number of times over precisely the same track. To ensure that wear of the track does not occur and progressively alter its value, it is generally acceptable to use several closely adjacent tracks and assume they are identical. For example five tracks spaced 0,1 mm apart may each be traversed five times.

As far as possible the required information specified here shall be marked on each specimen; but, if there is insufficient space, the values may be stated separately and uniquely identified with the specimen, for example by means of a serial number.

# Annex A

# Calibration of instrument calibration specimens

## A.1 General procedure for type A specimens

A stylus instrument having displacement-sensitive pick-up, or an optical interferometer can be used.

The interferometric results are directly traceable to the wavelength of light, but are generally limited to the shallower grooves unless the instrument is built to allow for optical desensitization. The surface may have to be metallized to ensure adequate reflectivity, and the quality of the fringes may limit the attainable accuracy.

The stylus method is indirectly traceable to the wavelength of light, but it can cover the whole range of specimens without difficulty.

In theory, a very small divergence between the two methods is possible. There may be differences in the mechanical and optical properties of the upper and lower surfaces, and while the stylus method measures normal cross-sections, the optical method generally measures oblique cross-sections which assume uniformity within the length of the groove occupied by the obliquity. In practice, such effects are generally negligible.

## A.2 Procedure for type A specimens using a stylus instrument



The vertical magnification of the instrument is first calibrated. For this purpose a step, as nearly as possible equal in size to that of the specimen, may be formed by two gauge blocks wrung down on an optical flat. The instrument is then used as a comparator to compare the specimen step with that of the gauge block. In this way residual errors in the instrument tend to cancel out. For highest accuracy, at least five equally spaced traverses should be taken along the marked length of the groove, and a corresponding number across the gauge block step.



The adjacent sides of the gauge blocks used are preferably manufactured so that the corners are sharp enough to produce a clearly defined step on the profile graph, as shown in figure 11.

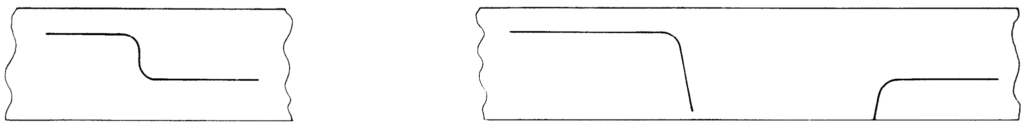

**Figure 11 — Profile graphs**

A number of gauge blocks can be wrung down to provide a series of steps, as shown in figure 12, attention being paid to the flatness, smoothness and parallelism of the surfaces. The steps can be calibrated directly by interferometry.

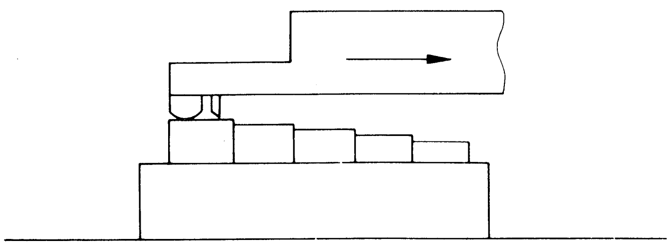

**Figure 12 — Gauge blocks providing a series of steps**

Gauge block steps over 2 µm can be used directly, but for smaller displacements the calibration error of the gauge block step itself may represent an excessively large proportion of the step height. Small displacements down to 0,2 µm can be produced by scaling down larger gauge block steps with an accurate reducing lever. Reductions of 10 or 20 times are used.