ASME B89.1.2M–1991

Calibration of Gage Blocks by Contact Comparison Methods (Through 20 in. and 500 mm)

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

AN AMERICAN NATIONAL STANDARD

Calibration of Gage Blocks by Contact Comparison Methods

(Through 20 in. and 500 mm)

ASME B89.1.2M–1991

The American Society of Mechanical Engineers

345 East 47th Street, New York, N.Y. 10017

Date of Issuance: November 30, 1991

This Standard will be revised when the Society approves the issuance of a new edition. There will be no addenda or written interpretations of the requirements of this Standard issued to this edition. The next edition of this Standard is scheduled for publication in 1994.

FOREWORD

(This Foreword is not part of ASME B89.1.2M-1991)

ASME Standards Committee B89 on Dimensional Metrology, under procedures approved by the American National Standards Institute, has the responsibility of preparing standards which encompass the inspection and the means of measuring characteristics of various geometrical parameters such as diameter, length, flatness, parallelism, concentricity, taper, and squareness.

Comments and suggestions for improvement of this Standard are welcomed. They should be addressed to:

ASME
Standardization Dept. (M/S 8E)
United Engineering Center
345 East 47th Street
New York, NY 10017

This edition was approved as an American National Standard by ANSI on July 22, 1991.

ASME STANDARDS COMMITTEE B89
DIMENSIONAL METROLOGY

(The following is the roster of the Committee at the time of approval of this Standard.)

OFFICERS

B. R. Taylor, *Chairman*
F. G. Parsons, *Vice-Chairman*
P. D. Stumpf, *Secretary*

COMMITTEE PERSONNEL

A. M. Bratkovich, National Machine Tool Builders Assoc., McLean, Virginia
J. B. Bryan, Bryan Associates, Pleasanton, California
A. K. Chitayat, Anorad Corp., Hauppauge, New York
W. E. Drews, Rank Precision Industries, Inc., Des Plaines, Illinois
C. B. Erickson, Sterling Die Operation, West Hartford, Connecticut
M. F. A. Fadl, Consultant, Providence, Rhode Island
R. D. Farley, Lincoln Gage Co., Warren, Michigan
M. B. Grant, Cummins Engine Co., Columbus, Indiana
R. B. Hook, Metcon, Coventry, Rhode Island
F. L. Jones, USATSG, Redstone Arsenal, Alabama
A. A. Lindberg, Moore Special Tool Co., Inc., Bridgeport, Connecticut
E. G. Loewen, Milton Roy Co., Rochester, New York
T. Mukaihata, Hughes Aircraft Co., El Segundo, California
D. Pieczulewski, A. G. Davis Gage and Engine Co., Hazel Park, Michigan
L. K. Reddig, AGMC/MLDA, Newark, Ohio
E. L. Watelet, Consultant, Warwick, Rhode Island
W. A. Watts, Glastonbury Gage, Glastonbury, Connecticut
J. H. Worthen, Consultant, Durham, New Hampshire
R. B. Zipin, Eli Whitney Metrology Lab, Dayton, Ohio

PERSONNEL OF SUBCOMMITTEE 1 — LENGTH

E. L. Watelet, *Chairman,* Warwick, Rhode Island
A. K. Chitayat, Anorad Corp., Hauppauge, New York
E. G. Loewen, Milton Roy Co., Rochester, New York

PERSONNEL OF WORKING GROUP 1.2 — MEASUREMENT OF GAGE BLOCKS BY COMPARISON METHODS

G. B. Webber, *Chairman,* L. S. Starrett Co., Westlake, Ohio
G. G. Erickson, Sterling Die Operation, West Hartford, Connecticut
D. D. Friedel, L. S. Starrett Co., Westlake, Ohio

CONTENTS

Tables

CALIBRATION OF GAGE BLOCKS BY CONTACT COMPARISON METHODS (THROUGH 20 IN. AND 500 MM)

1 SCOPE

This Standard covers procedures to establish unified practice in calibration laboratories for measuring gage blocks up to 20 in. (500 mm) in length (size) by contact comparison methods. It does not cover interferometric comparison methods.

2 OBJECTIVE

To establish an American standard for laboratory calibration of gage blocks by contact type comparison for tolerance Grade 3 (formerly A and B), Grade 2 (formerly A+), and Grade 1 (formerly AA), as defined in Federal Specifications GGG-G-15C, and ANSI/ASME B89.1.9M, when such calibration is traceable to NBS calibrated master blocks.

This Standard provides procedures for measuring the length and parallelism of used gage blocks required for recalibration and for measuring the length and parallelism of new gage blocks requiring certification.

Procedures for determination of flatness, surface texture, and wringing quality are provided, to be used only for new gage blocks or for used gage blocks when specified.

3 UNITS OF MEASURE

3.1 Inch Unit of Length

The inch unit of length equals exactly 25.4 millimeters (mm) in the Metric System.

3.2 Microinch Unit

One microinch equals one millionth (0.000001) of an inch.

3.3 Metric Equivalents

The metric equivalents used parenthetically after inch values in this Standard are not necessarily exact conversions, but are the most convenient or rounded off values.

3.4 Micrometer Unit

The metric unit representing one millionth (1/1,000,000) of a meter was formerly expressed as one "micron," and identified symbolically by the Greek letter μ (mu). It has been replaced by the name "micrometer" and identified by the symbol μm. For reasons of clarity the word "micrometer" is always spelled out in this Standard. One microinch equals 0.0254 micrometer.

4 ENVIRONMENT

4.1 Cleanliness

Cleanliness must be maintained in the immediate vicinity of the measurement being performed. The critical surfaces of the master gage block, the gage block being calibrated, and the measuring equipment must be clean and free of foreign matter and dust particles.

4.2 Temperature

The international standard temperature, at which the actual length of a gage equals its nominal length, is 68°F (20°C). The actual temperature of test gage block, reference gage block, and instrument, must be known if accurate and reliable calibrations are to be achieved.

The calibration accuracy may suffer when the ambient temperature departs from standard, by an amount depending on the temperature difference and its rate of change, the length of the gage blocks, the materials of which they are made, and the accuracy of the coefficients of thermal expansion used in making corrections.

Conditions will be improved by thermal shielding of the measuring station, the use of a soaking plate, and the knowledge of the exact temperature of the test block and reference block as determined by temperature measuring devices.

It follows that, in order to achieve the level of accuracy required for the calibration of gage blocks, the deviation of the environmental ambient temperature from the standard must be held to a minimum. A suggested maximum is ± 0.5°F (0.25°C) or less. For a complete analysis of the subject, refer to ANSI B89.6.2-1973, Temperature and Humidity Environment for Dimensional Measurement.

4.3 Humidity

It is recommended that the relative humidity in the measuring environment shall not exceed 45%. Humidity significantly beyond that value may cause problems with rusting of iron and steel surfaces, and cause personnel discomfort.

4.4 Vibration

Excessive mechanical vibration in the measurement laboratory may seriously affect the accuracy required for gage block measurement by causing instability at the point of measurement and at the readout. Vibration should be minimized by locating the laboratory away from vibration sources and by using insulating mountings for measuring equipment. An ideal solution, used by some laboratories, is to support all measuring equipment on a massive floating subfloor isolated from the surrounding structure, the building foundation and the work floor.

5 GAGE BLOCK GEOMETRY

5.1 Shape

Gage blocks are made in three cross sectional shapes: rectangular, square and round, with and without holes (see Fig. 1).

5.2 Reference Points

The reference point is a point located in the plane of each gaging surface. The top reference point is located for each shape in relation to the size marking as shown in Fig. 1. The bottom reference point is the mirror image of the top reference point.

5.3 Gage Block Length

The mechanical length of a gage block, for the tolerance grades 1, 2, and 3 is the length perpendicular to one gaging surface and between the two reference points. The length is obtained by comparison to a reference gage block at 68°F (20°C). When the test block and reference are of different materials, corrections must be made for differential deformation, and for differential thermal expansion when the temperature of the blocks differ from standard. (Refer to B1 and B2.)

5.4 Parallelism

The parallelism of the gaging surfaces is the greatest difference in length obtained from scanning the gaging surfaces with mechanical contacts (see para. 8.6.)

5.5 Flatness

The flatness of a gaging surface is the distance between two theoretical parallel planes with minimum separation which envelop the gaging surface.

6 MEASURING INSTRUMENT

6.1 Design

The measuring instrument shall consist of a comparator and readout specifically designed to measure the length of a gage block between the top and bottom reference points by comparison with a reference gage block, and shall meet the requirements stated in paras. 6.2 and 6.3, over its full range.

The instrument may consist of one of, but not limited to, the following:

(*a*) Type A. A comparator with dual opposed matched upper and lower gage heads, platen and readout. The readout indicates the differential of the movements of the upper and lower gage head contacts. The platen is used to support the gage blocks being measured and is not a reference.

(*b*) Type B. A comparator with a single lower gage head, adjustable upper reference contact, platen and readout. The measuring system floats with respect to a fixed platen which supports the gage blocks and is not a reference.

(*c*) Type C. A comparator with a single upper gage head and a lower platen having a flat, serrated, or dual track configuration. The platen is the lower reference. (Refer to para. A5.)

6.2 Functional Requirements

6.2.1 Alignments

It is not the intent of this Standard to specify the necessary alignments and geometry of the components involved in the measuring instrument, since these factors are inherent in the accuracy attainable. The manufac-

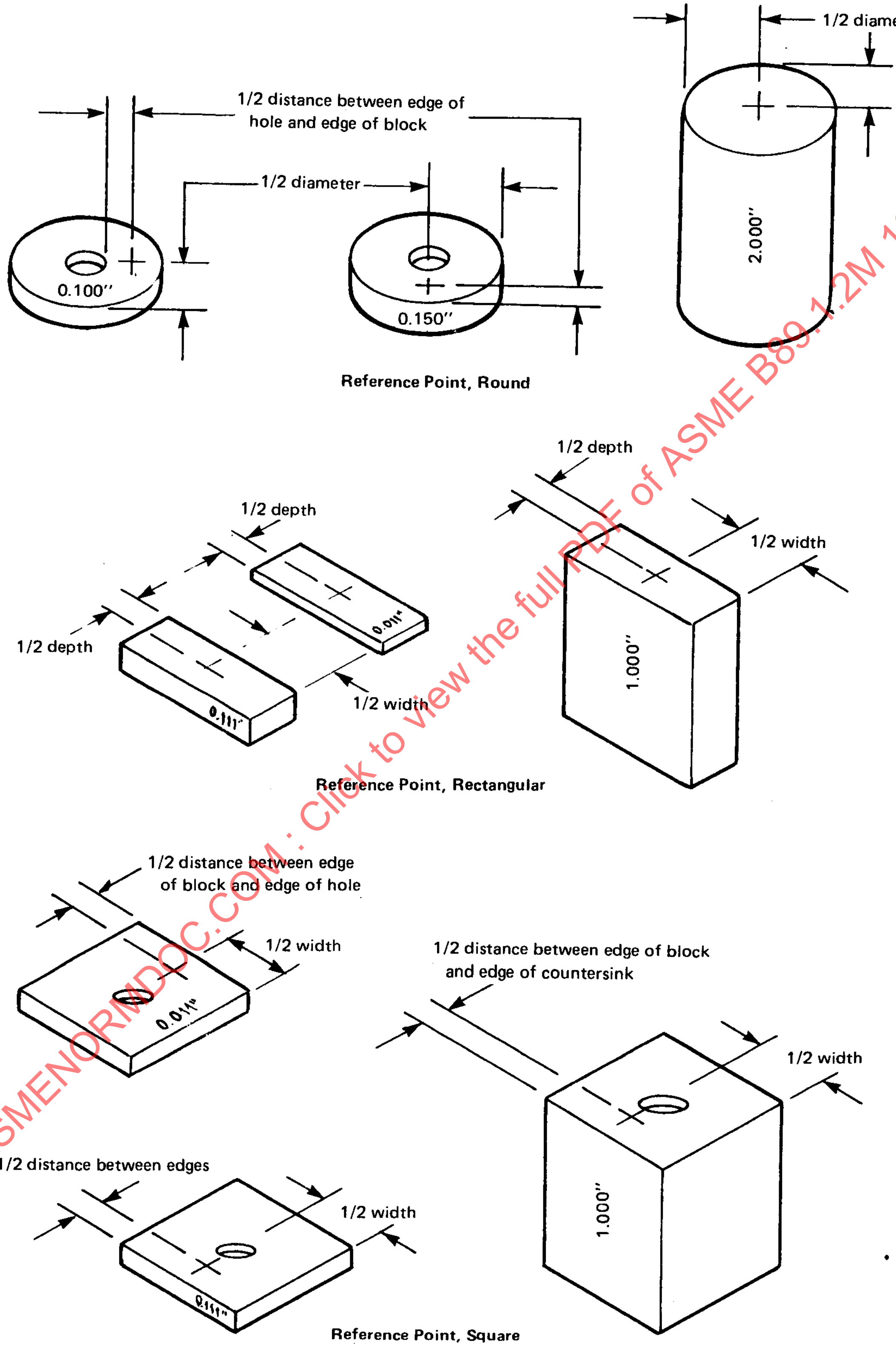

FIG. 1 GAGE BLOCK REFERENCE POINTS

turer or a certified laboratory must warrant that the instrument will meet the accuracy, linearity, and precision required in para. 6.3, over its full range.

6.2.2 Contact Tip Material

The gaging contact tips and reference contact tips, where applicable, shall be made of diamond.

6.2.3 Contact Tip Geometry

The contact shall have a spherical shape. The spherical radius of the tip may vary from one instrument to another and is not specified in this Standard since its value is not critical in the calibration procedure when reference and test gage blocks are made of the same material.

However, when the reference and test blocks are made of different materials, the contact tip radii must be known in order to compute the correction factor to be applied to the test block reading to compensate for the differential penetration of the contact tips in the different materials. (Refer to para. 8.1 and B1.)

6.2.4 Measuring Force

The upper gage head contact, or upper reference contact, (Type A or B, para. 6.1), as applicable, shall exert a force of 3 to 4 oz. (0.8 to 1.1 newtons).

The lower gage head contact shall exert a force of 1 to 2 oz. (0.28 to 0.56 newtons).

The upper gage head contact or upper reference contact force must always exceed the lower gage head contact force to assure that thin lightweight blocks will seat on the platen.

A single head (Type C, para. 6.1) suggested force is 2 oz. (0.56 newtons).

6.2.5 Platen

The platen shall be flat and smooth over its entire area but not sufficiently smooth to cause gage blocks to wring to its surface. It should be made of a material that will withstand wear and maintain flatness and stability over long periods of time.

6.2.6 Readout

The comparator shall be provided with either an analog readout (scale and pointer) or a digital readout, each having a high amplification range, and one or more lower amplification ranges with corresponding longer ranges of indication for convenience in set-up and for calibrating long gage blocks having larger deviations from nominal length. The instrument shall have means for adjusting the reading.

An analog readout shall have a discrimination (smallest marked division) of one microinch (0.02 micrometer) or less, and an amplification of 60000 or higher at the high range. At this amplification the user can set or read the scale to one quarter of a division, 0.25 microinch (0.005 micrometer).

A digital readout shall have a resolution of 0.1 microinch (0.002 micrometer). This higher resolution is required in this case to allow a resolution in setting or reading comparable to that of an analog readout with a discrimination of one microinch. The standard specification for digital readout systems allows an uncertainty of plus or minus one least count. A digital readout with a one microinch least count could therefore have an uncertainty in setting or reading of ±1 microinch which is unsatisfactory.

6.3 Performance Requirements

The measuring instrument shall meet the following tolerances:

Stability. Under laboratory calibrating conditions with a gage in measuring position the reading shall remain constant for at least 5 minutes.

Precision. The precision (repeatability) shall be within .5 microinch (0.012 micrometer) at highest amplification over the full range.

Accuracy and Linearity. The accuracy and linearity shall be within 1% of full scale at highest amplification over the full range.

The instrument should be calibrated periodically. It is not the intent of this Standard to specify procedures for verifying the above tolerances. For suggested methods refer to Appendix D, Measuring Instrument.

7 PREPARATION OF GAGE BLOCKS

7.1 Cleaning

All gage blocks shall be washed in a nonchlorinated, acid free, water free solvent and wiped clean with lint free cloth or tissue. (See para. A1.)

7.2 Deburring

This operation applies only in the calibration of used gage blocks. All blocks shall be examined visually for nicks, burrs, and scratches. Such defects shall be removed with the use of flat Granite or white Arkansas stones for steel blocks. Silicon carbide or sintered aluminum oxide stones are used for chromium carbide and tungsten carbide blocks. After deburring, the blocks should be recleaned and placed in a clean shielded tray in the temperature controlled atmosphere and left for at least 12 hrs. Thereafter, all handling shall be done with insulated handling devices. (See para. A2)

8 PROCEDURES FOR MEASUREMENT OF LENGTH AND PARALLELISM

These procedures apply to both used and new gage blocks.

8.1 Reference Gage Blocks

The reference gage blocks used in the comparison calibration procedure shall be tolerance grade 0.5 or 1, calibrated and traceable to the National Bureau of Standards (see para. A4). If possible, the reference blocks shall be made of the same material as the test blocks to reduce the possibility of error resulting from differential deformation and differential thermal expansion. If not, applicable corrections can be determined using formulas (refer to paras. B1 and B2) or slide charts available from manufacturers of gage blocks.

All possible precautions must be observed to protect the reference gage blocks against corrosion, scratches, burring, and other sources of damage. Steel blocks should be wiped clean with a soft clean chamois or lint free cloth and protected with rust preventative after use.

8.2 Use of Soaking Plate

A soaking plate (heat sink) shall be provided adjacent to the measuring instrument, to be used for temperature equalization of the reference and corresponding test blocks. It shall be made of anodized aluminum, magnesium, copper, or other suitable material having a high thermal conductivity factor and a smooth, ground surface. It should be at least 1½ in. (38 mm) thick with an area sufficient to accommodate the largest gage block set and masters.

The reference and test blocks shall be placed on the soaking plate with their largest area in contact. When the reference and test blocks are made of the same materials, slight differences from the standard temperature will not affect the accuracy of measurement, provided that both blocks are at the same temperature. It is important, therefore, to assure that the length of soaking time is sufficient for temperature equalization.

However, if reference and test blocks are made of different materials and their temperature is different from standard, a correction must be applied to the test block reading to compensate for differential thermal expansion between reference and test block (see para. B2). In this case the actual mean temperature of the soaking plate must be known, and temperature equalization of the blocks assured. Contact type temperature sensors with a certified accuracy of 0.5°F (0.25°C) or less should be used to monitor the soaking plate temperature.

For gage blocks in sizes up to 0.950 in. (24.50 mm) the soaking time may be determined experimentally and used thereafter. The procedure to minimize overall measuring time will depend on the number and sizes of blocks being measured. Generally, by measuring blocks in sequence from thinner to longer, the overlapping soaking time will minimize the overall time and permit continuous measurement.

For blocks in sizes of 1 in. (25 mm), 2 in. (50 mm), 3 in. (75 mm), and 4 in. (100 mm), temperature equalization between reference and test block becomes more critical.

For blocks in sizes from 5 in. (125 mm) through 20 in. (500 mm) the critical importance of the temperature and temperature gradient of both reference and test block requires that special attention be taken. Shielding of the comparator will minimize the possibility of errors due to drafts and other factors (see para. A3). Insulation, such as reflective foil, placed over the sides of reference and test block will minimize external influences of thermal radiation. Overnight soaking plate equalization is recommended.

8.3 Handling of Gage Blocks

During the calibration procedure the reference and test blocks shall be moved from the soaking plate to the measuring instrument with insulated handling devices. Before placing the blocks on the instrument platen, dust particles shall be removed from the gaging surfaces and platen, with a clean, soft, camel hair brush.

Plastic templates, or forceps, are used to slide the gage blocks between the measuring contact points. Some instruments are provided with a mechanical slide for this purpose.

8.4 Setting the Comparator

Details of set-up adjustments and use of the comparator will depend on the particular type used. The manufacturer's instructions should be followed.

The reference gage block is slid between the comparator contacts with the tips located at the reference points (see Fig. 1) and the comparator adjusted until the readout shows an active reading (analog or digital).

The length of a reference gage block is usually not equal to its nominal value and has a plus or minus deviation value assigned to it. There are at least two methods to compensate for this deviation in setting the comparator.

(*a*) The comparator readout is set away from zero by an amount equal to the deviation value, either plus or minus as the case may be. The size of the test block will be the direct indication of the readout.

(*b*) The comparator readout is set to zero and the deviation value applied by adding it algebraically to the final averaged reading of the test block. Some computerized systems may be programmed to eliminate the need to set the readout to a specific reading.

At least three separate readings should be taken on the reference block at the reference points to assure repeatability. The block is then moved away from measuring points.

8.5 Measuring Length

The test block shall be moved between the measuring points for at least three consecutive readings taken at the reference points designated in Fig. 1 for the applicable style of block. The final reported deviation from nominal size shall be the average of the three readings. The reference should be rechecked to assure that the setting did not change.

8.5.1 Corrections to Length Readings

When the reference gage block and the test block are made of different materials a differential deformation correction must be applied to the test block reading (see para. B1).

If, under those conditions, the temperature of the reference and test block differs from 68°F (20°C), a further correction must be made for differential thermal expansion (see para. B2).

8.6 Measuring Parallelism

The parallelism is the greatest difference in length between the gaging surfaces, excluding 0.020 in. (0.5 mm) at the edges of the faces. Using forceps, or a plastic template, the test block is introduced between the measuring contacts and the gaging surfaces scanned. Readings are taken on rectangular style gage blocks in two directions; across the depth and along the width, and midway between the edges. Readings are taken on square style gage blocks along the width, midway between the hole or edge of the countersink, and the edge of the gage on each of four sides excluding 0.020 in. (0.05 mm) at the edges of the faces.

This procedure does not preclude the checking of parallelism by optical interference methods.

The results of the measurement of parallelism are reported as the difference between maximum and minimum readings and should be within tolerances specified in Table C3.

9 FLATNESS, SURFACE TEXTURE, AND WRINGING QUALITY

Normal calibration of used gage blocks by metrology laboratories covers only the reporting of gage length deviation from nominal size and parallelism. The following procedures for determination of flatness, surface texture, and wringing quality are done only for acceptance testing of new gage blocks or when, and as specified for, used gage blocks.

Before performing each of the following tests, each gage block and optical flat (when used) shall be washed with a nonchlorinated solvent and wiped clean with a lint free cloth or tissue.

9.1 Flatness

The flatness deviations of the gaging surfaces of blocks over 0.100 in. (2.5 mm) in length shall be measured with a reference grade optical flat using the "air wedge" method (Fig. 2) in monochromatic light. The optical flat is brought into contact with one edge of the block gaging surface and lowered into contact with the surface without pressure. The maximum deviation from straightness of the light bands, expressed in microinches (micrometers) as an estimated fraction of the band spacing, excluding a width of 0.02 in. (0.5 mm) at the four edges, shall not exceed the values shown in Table C3 for the tolerance grade of blocks being tested. A convenient value of 12 microinches (0.3 micrometer) may be used for light band spacing.

The above test should be repeated from an adjacent edge to provide readings in two directions 90 deg. apart. Blocks failing to meet the flatness tolerance shall be reported.

Gage blocks under 0.100 in. (2.5 mm) in length may not be precisely flat in their free state. Tolerance grade 1 blocks shall be measured for flatness by wringing to the optical flat, in which case no trace of color should appear. For tolerance grades 2 and 3 blocks, the test for parallelism is considered sufficient.

This test will also indicate when burrs or raised edges are present which will show up as colored spots or sharp changes in band continuity. Gage blocks having burrs or raised edges exceeding 1 microinch (0.03 micrometer) shall be reported.

A Fizeau Jig or plano-interferometer can also be used eliminating physical contact with the gage block.

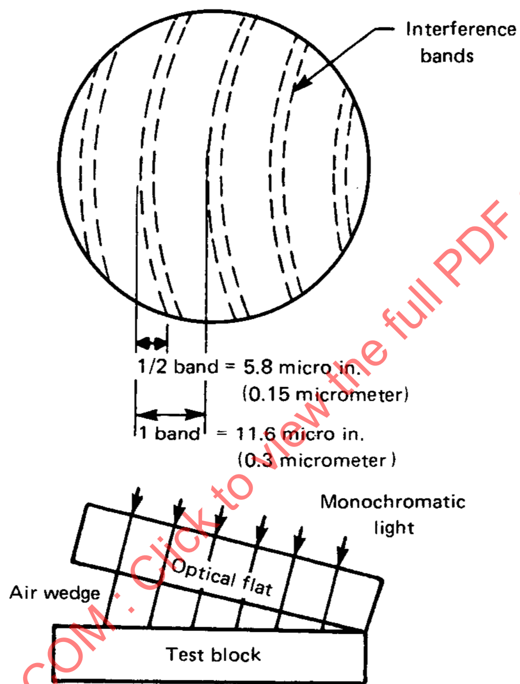

FIG. 2 FLATNESS TEST

TABLE 1 ALLOWABLE MEASUREMENT UNCERTAINTY

		Tolerance Grade								
		0.5		1		2		3		
Nominal Size		Length	Flatness Parallelism	Length	Flatness Parallelism	Length	Flatness Parallelism	Length	Parallelism	Flatness
in.	mm	± Values in microinches (micrometers)								
4 or less	100 or less	1 (0.03)	1 (0.03)	2 (0.050)	1 (0.03)	3 (0.080)	1 (0.03)	4 (0.10)	2 (0.050)	1 (0.03)
over 4 thru 8	over 100–200	. . .	. . .	3 (0.08)	1 (0.03)	6 (0.150)	1 (0.03)	8 (0.20)	2 (0.050)	1 (0.03)
over 8 thru 12	over 200–300	. . .	. . .	4 (0.100)	1 (0.03)	8 (0.200)	1 (0.03)	10 (0.25)	2 (0.050)	1 (0.03)
over 12 thru 20	over 300–500	. . .	. . .	5 (0.13)	1 (0.03)	10 (0.250)	1 (0.03)	12 (0.30)	2 (0.050)	1 (0.03)

GENERAL NOTE:
This Standard does not cover the calibration of tolerance grade 0.5 gage blocks which are laboratory grade master gage blocks. The uncertainty values shown are for information only.

9.2 Surface Texture

All gage blocks supplied shall be arranged in an array on a tray and the gaging surfaces examined. Those appearing to have the rougher surface texture shall have their gaging surface texture measured for arithmetical average roughness height (Ra) with a calibrated tracer type surface roughness analyzer or for predominant peak to valley height (Ry) from a chart produced from a surface roughness analyzer. The results shall meet the surface texture tolerances shown in Table C3 for the tolerance grade blocks being tested. ANSI/ASME B46.1-1985 may be consulted for reference information.

9.3 Wringing Quality

The test for wringing quality shall be done only when specified. The gaging surfaces of the gage block shall be wetted with a thin film of rust inhibiting wringing agent applied with a clean lint free cloth or tissue. The surfaces shall then be wiped clean. A clean dry reference grade optical flat shall be slid into contact with the gaging surface using a twisting motion and light pressure. No color or trace of film shall appear through the clear optical flat over the entire wrung gaging surface for tolerance grade 1 and 2 gage blocks. Tolerance grade 3 gage blocks shall have not less than 80% of colorless wringing area. Blocks failing to meet these wringing requirements shall be reported.

10 ACCURACY OF CALIBRATIONS

10.1 Process Measurement Uncertainty

The accuracy of the calibration of tested gage blocks will depend on the measurement uncertainty of the process which produced the calibrations. The uncertainty is a value expressed in ± microinches (micrometers) due to the summation of random and systematic errors inherent in the particular measuring process. It will vary with the tolerance grade and size of gage blocks. Random errors include such factors as errors in measurement appropriately adjusted to account for multiple measurements or the statistical design used and the effects of day to day components of variation. Systematic errors include such factors as the uncertainty of reference standards, errors in the comparator process due to environmental or other factors, and uncertainties in the determination of contact tip penetration.

Sources of error may be known but their magnitudes usually are not known. The determination of values of measurement uncertainty for each particular measuring process requires a scientific study, the details of which are beyond the scope of this Standard. Dimensional metrology laboratories requiring scientific proof of process uncertainty values and statistical control can obtain assistance from the National Bureau of Standards in establishing a measurement assurance program giving such proof.

A statement of process uncertainty shall be reported for each of the following size groups, for the tolerance grade involved: 4 in. (100 mm) and smaller; 5 in. (125 mm) through 20 in. (500 mm) on a per inch (25 mm) basis.

Gage blocks that are worn or damaged beyond parallelism, flatness, and surface finish specifications shown in Table C3 are not expected to provide accuracies within the process uncertainties.

10.2 Tolerance or Acceptance Testing of Gage Blocks

This is a measuring procedure for determining the conformance of gage blocks to tolerances specified in Tables C1, C2, and C3. Due to measurement uncertainty, disagreement between facilities may occur in borderline cases. Table 1 lists allowable measurement uncertainty for the various tolerance grades and sizes. It was established to reduce disagreement when a difference in measurement occurring between facilities does not exceed the applicable allowance value listed. However, before accepting or rejecting a new gage block, the applicable process uncertainty described in para. 10.1 is added to the upper and lower tolerance values listed in Tables C1, C2, and C3. The process uncertainty value should not exceed the applicable value shown in Table 1. When the process uncertainty value exceeds the value in Table 1, the tolerance value in Tables C1, C2, or C3 is reduced by an amount equal to the difference between the process uncertainty and the applicable value of Table 1, to assure that gage blocks reported as acceptable are actually within tolerance. This procedure unavoidably may cause the rejection of borderline blocks that are actually within tolerance.

11 CERTIFICATE OF CALIBRATION

A report of calibrations shall be provided containing the following information:

(*a*) the name of the calibration facility;
(*b*) date the calibrations were performed;
(*c*) certificate number or facility test number;
(*d*) nominal size of each gage block;
(*e*) deviation from nominal size for each gage block in microinches for the inch system or micrometers for the metric system;
(*f*) deviation from allowable tolerance in parallelism;
(*g*) deviation from allowable tolerance in flatness (not applicable to used gage blocks unless requested);
(*h*) certify that surface texture requirements are met (not applicable to used gage blocks);
(*i*) brand, style, grade, and set serial number, if applicable;
(*j*) individual block indentification numbers, if applicable (see Note);
(*k*) statement of material (see Note);
(*l*) statement of temperature at which calibration was performed;
(*m*) statement of traceability of calibration to N.B.S., including N.B.S. test number and date (see para. A1.4);
(*n*) statement of process uncertainties for sizes 4 in. (100 mm) and under and for 5 in. (125 mm) through 20 in. (500 mm) on a per inch (25 mm) basis;
(*o*) signature of calibration technician.

NOTE: Gage block sets in grades 1 and 2 of mixed materials should be so noted. Code symbol indentification shall be CC for chrome carbide, TC for tungsten carbide, and none for steel.

APPENDIX A
GENERAL

(This Appendix is not part of ASME B89.1.2M-1991, and is included for information purposes only.)

A1 Cleaning Gage Blocks

Ethyl alcohol, freon or solvents may be used as washing agents. However, the complete removal of protective film from steel gage blocks, resulting from use of such agents, encourages corrosion. Extreme caution should be exercised in handling the gage blocks.

A2 Deburring Stones

Aluminum oxide stones used for deburring chromium and tungsten carbide gage blocks may be provided with serrations, allowing shearing action and voids for undesirable particles, thus reducing the danger of scratching the gaging surfaces.

A3 Comparator Housing for Long Block Calibration

The possibility of external heat sources, drafts, temperature gradients etc., affecting the actual temperatures and temperature equalization of reference and test block in long gage block calibration, is critical. These effects may be reduced by housing the comparator in an insulated, open-faced enclosure, lined inside and out with reflective foil.

The front of the enclosure should be fitted with a removable transparent plastic shield with suitable openings for adjusting the comparator and moving the gage blocks.

A cape made of insulating material, with reflective coating, may be worn by the operator to minimize the effects of body heat.

A4 Statement of Traceability

The statement of traceability verifies that the reference gage blocks used have been directly or indirectly compared with standards that have been calibrated by the National Bureau of Standards. Such statements should include the N.B.S. test number and date. The statement of traceability is normally considered current on an annual basis, although exceptions may be made by the responsible quality assurance authority involved, based on available records of proven stability, and wear resistance, combined with limited frequency of use.

A5 Type C Comparator

The mechanical length of a gage block for tolerance grades 1, 2, and 3 is defined as the length perpendicular to one gaging surface and between the upper and lower reference points. Refer to para. 5.2 and 5.3. Paragraph 6.1 calls for a comparator designed to measure the length between the reference points. Instrument type C, however, measures between the upper reference point and the lower gaging surface of a gage block. In this case the level of correlation with comparators A and B may vary slightly.

APPENDIX B
CALIBRATION CORRECTIONS

(This Appendix is not part of ASME B89.1.2M-1991, and is included for information purposes only.)

B1 Differential Deformation

Deformation is the amount of elastic penetration of the measuring and reference contact points into the material of the gage block. When the reference and test blocks are made of the same material, the amount of penetration is the same for both and the measured length difference will be correct.

However, when the reference and test blocks are made of different materials, the amounts of penetration in each material will be different. This difference, known as differential deformation, must be determined and applied as a correction to the comparison reading of the test block.

Deformation of the measuring and reference contact tips, specified in this Standard as made of diamond, will be the same in different gage block materials within negligible amounts and may be ignored.

The amount of deformation depends on the spherical radii of the measuring and reference contact tips, the measuring forces of the contact tips, and the material of the gage block being measured.

Since the first two factors may vary from one instrument to another, the deformation values for the different materials should be determined using values that apply to the specific comparator being used in the calibration procedure.

Deformation values may be determined from the following nomographs, obtained from the National Bureau of Standards publication NBS Technical Note 962. These nomographs are valid only for gaging contact tips and reference tips made of diamond having nearly perfect spherical shapes, and for gage block gaging surfaces that meet the surface texture tolerances shown in Table C3 for the class of gage blocks being measured. Nomographs in inch/ounce and metric systems are shown for the common gage block materials, 52100 steel hardened to Rockwell C 65, Tungsten Carbide, and Chromium Carbide. (See Figs. B1.1–B1.6)

To determine the axial deformation for a given material, adjust a straight edge on the nomograph so that it intersects the outer scales at the value of ball (tip) radius and at the value of applied force (tip force). The value of deformation is the point at which the straight edge intersects the center (deformation) scale.

The deformation correction to be applied to the reading of the test block is the algebraic difference between the deformation of the test block and that of the reference block or

$$C_d = d_x - d_r \quad (1)$$

where
C_d = deformation correction
d_x = deformation of test block
d_r = deformation of reference block

The corrected length of the test block for a single probe comparator at 68°F (20°C) is

$$L_x = L_r + (x - r) + C_d \quad (2)$$

where
L_x = corrected length of the test block
L_r = calibrated length of the reference block
x = comparator reading of the test block
r = comparator reading of the reference block

For a dual probe comparator or one with a single probe and a reference contact point, deformation will occur at each contact point and must be determined separately and summed. In these cases the corrected length of the test block is

$$L_x = L_r + (x - r) + Cd_1 + Cd_2 \quad (3)$$

Where subscripts 1 and 2 refer to the upper and lower contact points respectively.

B2 Differential Linear Thermal Expansion

When the reference and test blocks are made of different materials and the equalized temperature of both is other than 68°F (20°C), the two blocks will expand or contract by different amounts. This difference will result in an erroneous reading of the test block in comparison with the reference, and requires that an additional correction be applied to the reading.

The linear thermal expansion of a gage block is

$$E = C_e L(t - t_s) \tag{4}$$

where

E = expressed in microinches or micrometers as applicable

C_e = coefficient of thermal expansion for the material involved, in microinches or micrometers as applicable

L = nominal length of the block, in. or m, as applicable

t = equalized temperature of the block in °F or °C as applicable

t_s = standard temperature 68°F or 20°C as applicable.

The differential thermal expansion is

$$E_d = E_r - E_t \tag{5}$$

where

E_t = expansion of the test block

E_r = expansion of the reference block

E_d is the correction to be added algebraically to equation (2) or (3) as applicable.

The coefficients of linear thermal expansion for different gage block materials are approximately as shown in Table B2.1.

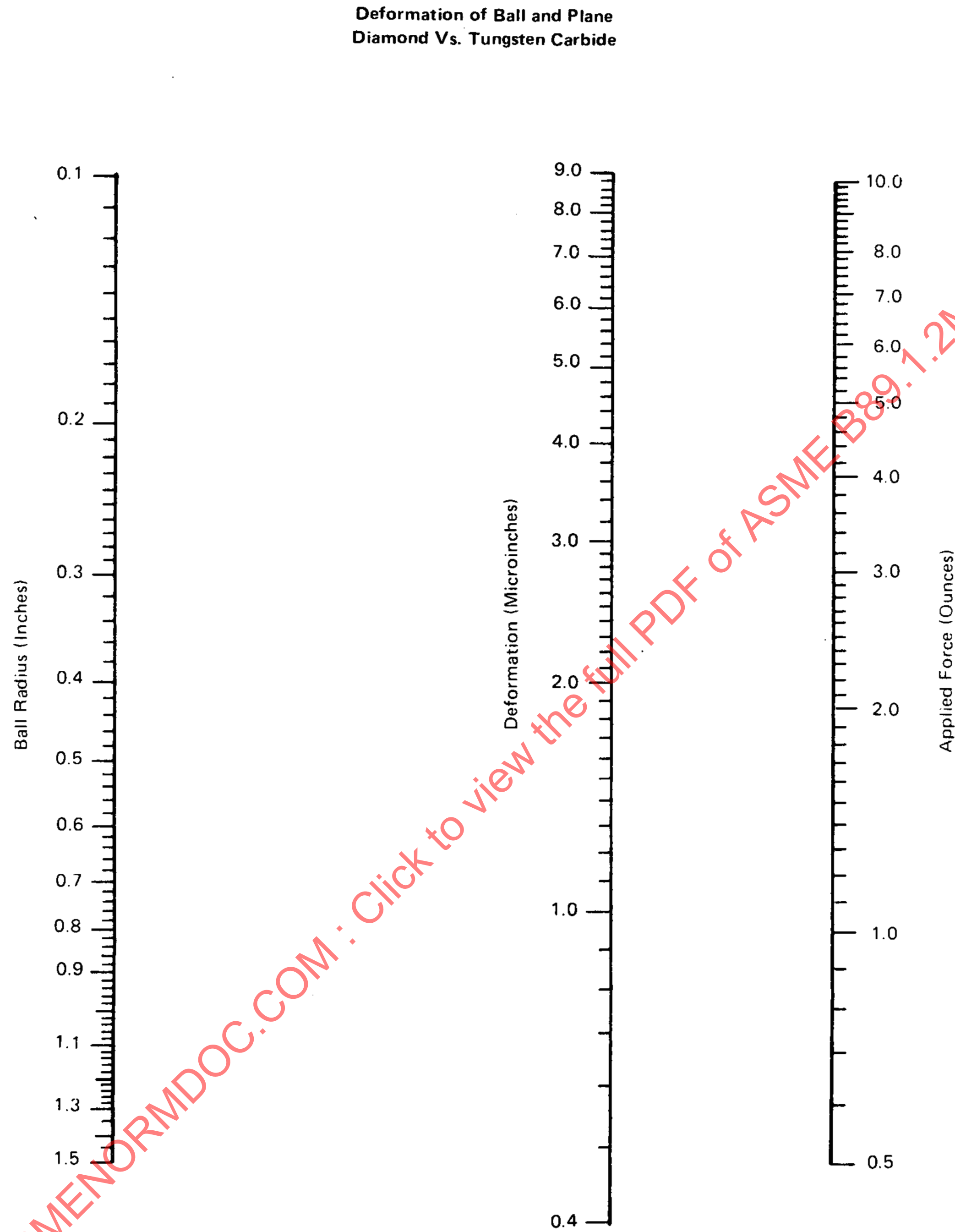

FIG. B1.1 DEFORMATION OF BALL AND PLANE — DIAMOND VS. TUNGSTEN CARBIDE

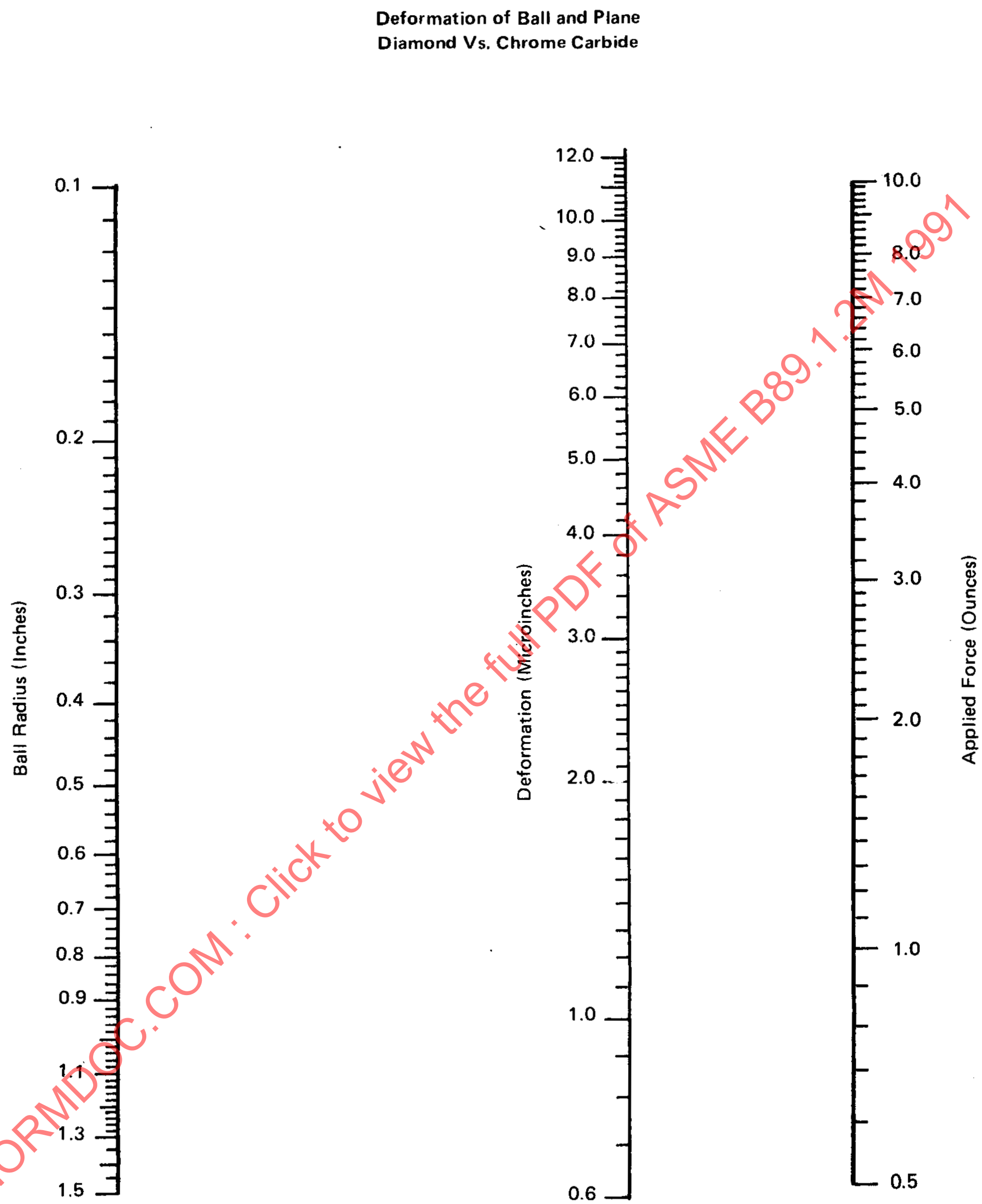

FIG. B1.2 DEFORMATION OF BALL AND PLANE — DIAMOND VS. CHROME CARBIDE

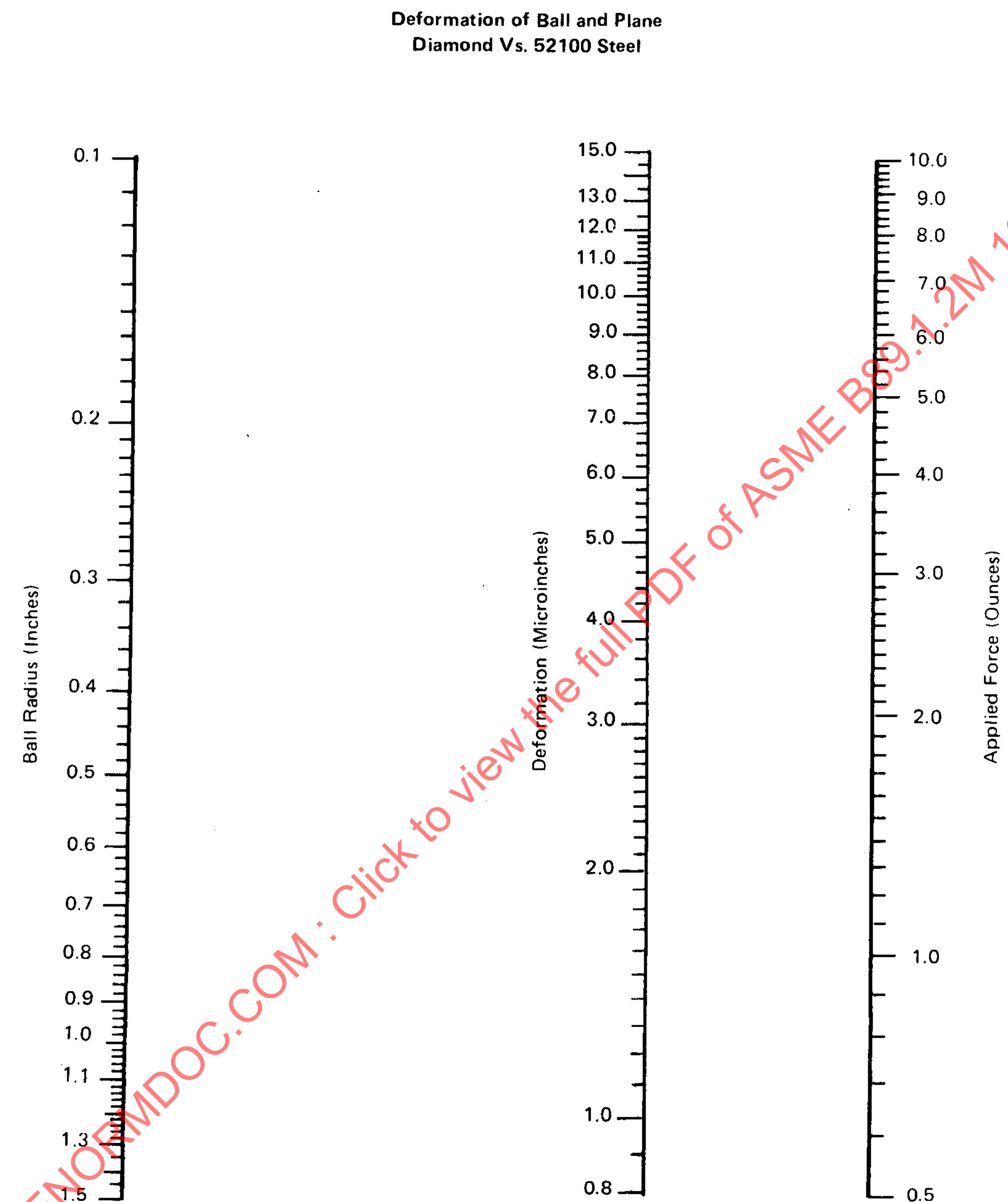

FIG. B1.3 DEFORMATION OF BALL AND PLANE — DIAMOND VS. 52100 STEEL

Deformation of Ball and Plane
Diamond Vs. 52100 Steel

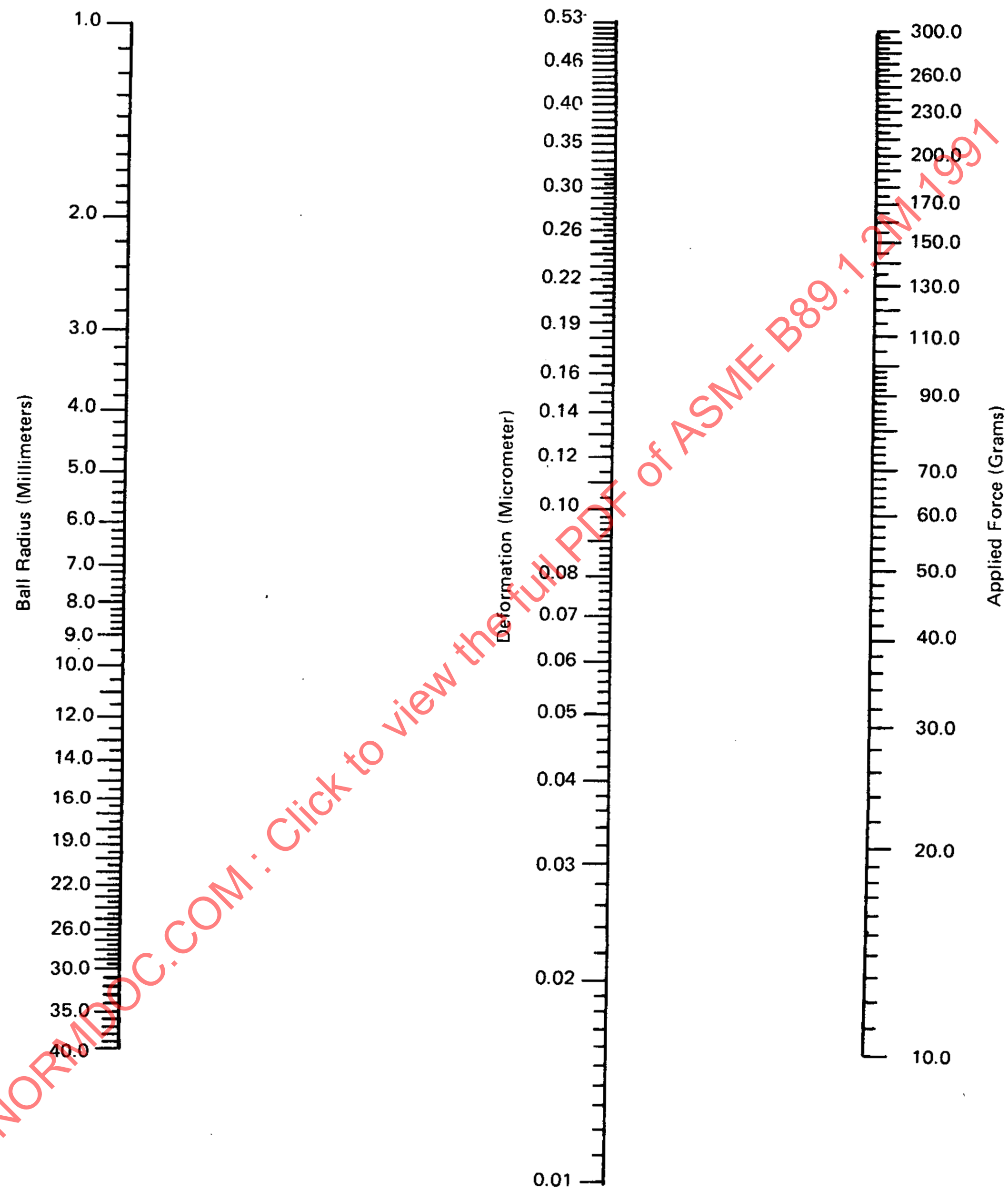

FIG. B1.4 DEFORMATION OF BALL AND PLANE — DIAMOND VS. 52100 STEEL

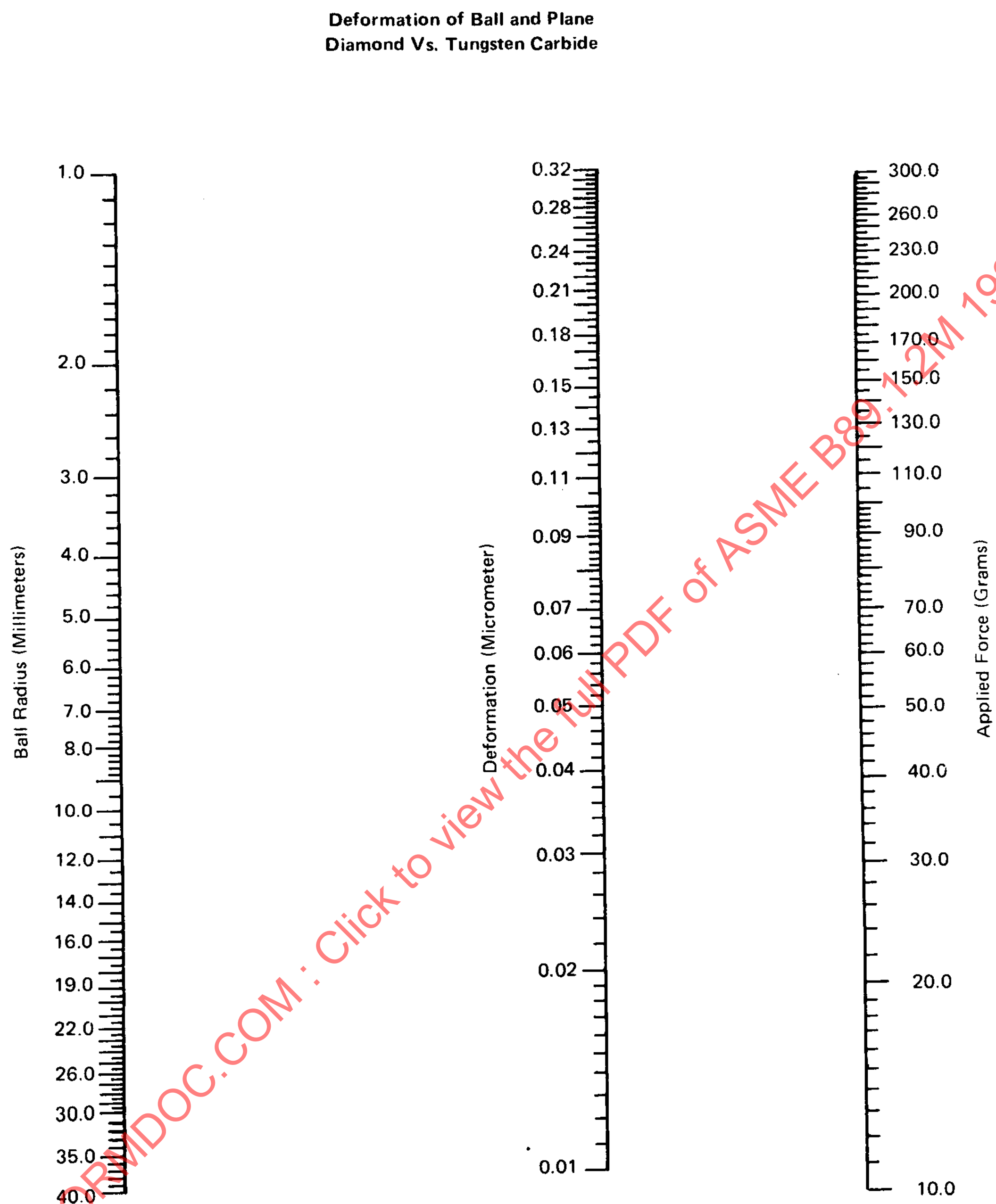

FIG. B1.5 DEFORMATION OF BALL AND PLANE — DIAMOND VS. TUNGSTEN CARBIDE

Deformation of Ball and Plane
Diamond Vs. Chrome Carbide

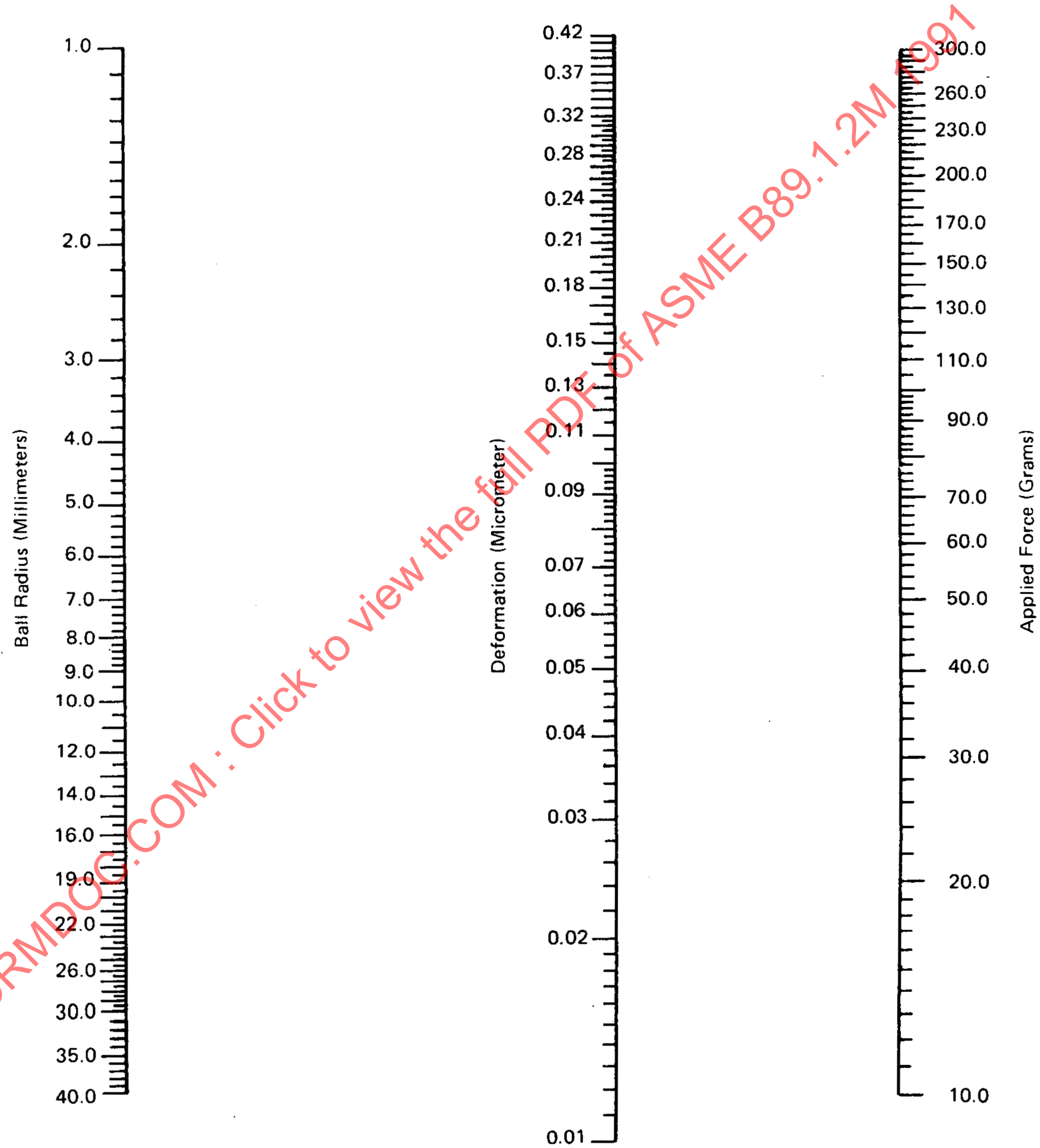

FIG. B1.6 DEFORMATION OF BALL AND PLANE — DIAMOND VS. CHROME CARBIDE

TABLE B2.1 COEFFICIENTS OF LINEAR THERMAL EXPANSION

Gage block material	Microinches/inch °F (Micrometers/meter °F)	Microinches/inch °F (Micrometers/meter °F)
Chromium carbide	4.7 $^{+.2}_{-.7}$	8.5 $^{+.3}_{-1.3}$
Steel	6.4 $^{+.2}_{-.4}$	11.5 $^{+.4}_{-.8}$
Tungsten carbide	3.6	6.5