CONTENTS

Foreword		iv
Committee Roster		v
Correspondence With the B89 Committee		vi
1	**Scope**	1
2	**Definitions**	1
3	**System Performance Evaluation: General Considerations**	5
4	**Test Procedure — Laser Interferometer Comparison Test**	7
5	**Verifying Test Performance, Estimating Bias in the Test, and Uncertainty of Results**	16
6	**Measurement Evaluation**	19
7	**References**	22
Figure		
2-1	Schematic Illustration of the Abbe Offset	2
Tables		
4.2-1	Recommended Target Positions	8
4.7.2-1	Sensitivity Coefficients Associated With LDE	12
4.8-1	Wavelength Corrections (Parts in 10^6) for Low Humidity Air (25% RH)	13
4.8-2	Wavelength Corrections (Parts in 10^6) for Medium Humidity Air (50% RH)	13
4.8-3	Wavelength Corrections (Parts in 10^6) for High Humidity Air (75% RH)	14
4.8-4	Combinations of Environmental Conditions	14
Forms		
4.10-1	Reporting Results for Intercomparison Test	17
4.10-2	Reporting Results for Sensor Calibration	17
4.10-3	Reporting Overall Result	17
6-1	Sample Uncertainty Budget: Errors Predictable by Manufacturer	20
6-2	Sample Uncertainty Budget: Combining Manufacturer's Reported Uncertainty With Additional Sources of Error for a Metrology Laboratory	21
Nonmandatory Appendices		
A	Uncertainty Budget for Interferometric Length Measurements	25
B	Methods for Comparing Two Interferometer Systems	33
C	Performing Accurate Linear Measurements With a Laser Interferometer System — Best Procedures and Practices	41
D	Retesting of Interferometer Systems	49
E	AC Interferometers Versus DC Interferometers	50
F	Suggestions for Testing the Master Interferometer and Estimating Uncertainty	51

FOREWORD

Laser interferometry has become the preferred way to measure machine tool and coordinate measuring machine (CMM) linear displacement accuracy. Laser interferometers are also used as the main incremental radius-measuring devices in other dimensional measuring systems, such as laser trackers. The laser interferometer is preferred because of its versatility, portability, robustness, high bandwidth, and high accuracy, and because the laser frequency can be measured with a high degree of accuracy relative to a He–Ne iodine stabilized laser, which, for all practical purposes, may be considered to be an intrinsic length standard. The vacuum laser wavelength, the basic unit of measure, is a direct function of this frequency. Commercial instruments based on laser interferometry offer an extremely high degree of measurement accuracy to the user.

This Standard is written to help users evaluate the accuracy of laser interferometer systems. A folded common path test is included to permit users to functionally compare systems for accuracy, even if the laser systems use different wavelengths or measurement techniques. A measurement uncertainty table is included to allow users to evaluate a measurement or compare competing laser systems. A Nonmandatory Appendix covering best practices gives the user guidance in the proper application of laser systems to practical incremental distance measurement.

This Standard was approved by the American National Standards Institute on July 15, 2011.

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Dimensional Metrology

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The Committee welcomes proposals for revisions to this Standard. Such proposals should be as specific as possible, citing the paragraph number(s), the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent documentation.

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Subject:	Cite the applicable paragraph number(s) and the topic of the inquiry.
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PERFORMANCE EVALUATION OF DISPLACEMENT-MEASURING LASER INTERFEROMETERS

1 SCOPE

This Standard establishes requirements and methods for the specification, evaluation, setup, and use of laser interferometers. This Standard will explicitly discuss only single-pass optics and a single axis of linear displacement measurement.

The Standard is currently limited to ionized gas laser interferometer systems. Only single-color lasers will be considered in this edition of the Standard. Single color will include both homodyne systems and heterodyne systems (see Nonmandatory Appendix E) where all operating frequencies lie within a Doppler-broadened frequency band associated with one specific atomic transition or Zeeman multiplet. Diode laser systems, chirp systems, and two-color interferometers may be included in future editions of this Standard. It should be noted that the folded common path comparison technique of this Standard could be used to compare any of the above systems to a standard He–Ne laser interferometer.

Testing of laser interferometers as described in this Standard has bearing on a number of other standards, such as ASME B89.4.19, ASME B5.54, ASME B5.57, ISO 230-1, ISO 230-2, ISO 230-3, and ISO 230-6 (see references [1–7] in section 7).

2 DEFINITIONS

This section contains brief definitions of the majority of technical terms used in this Standard. Omissions should be reported to ASME. In this section, some definitions have been taken from the International Vocabulary of Metrology (VIM) [8], others are taken from the Guide to the Expression of Uncertainty in Measurement (GUM) [9], and some are taken from ASME B89 or ASME B5 standards as indicated. References to all of these standards are given in section 7.

Abbe offset: the instantaneous value of the perpendicular distance between the displacement-measuring system of a machine (scales) and the measurement line where the displacement in that coordinate is being measured. A schematic illustration of this concept is shown in Fig. 2-1.

Abbe offset error: the measurement error resulting from angular motion of a movable component and an Abbe offset between the scales measuring the motion of that component and the measurement line (see Fig. 2-1).

accuracy [8]: the closeness of agreement between a measured quantity value and a true quantity value of a measurand. See reference [8] for a detailed discussion.

air dead path: distance imbalance between the interferometer reference and measurement arms when the laser system readout is set to zero. If the refractive index of the air within the interferometer changes during the measurement, there will be a measurement error unless the laser system includes a dead path correction capability.

air turbulence: regions of varying refraction in air, usually caused by thermal gradients. Air turbulence is a common source of fluctuations in the reading of an interferometer. This weakens the signal and, if severe enough, interrupts the measurement.

back-to-back test: a test for comparing the performance of two laser systems arranged in a back-to-back configuration, as defined in Nonmandatory Appendix B.

beamsplitter: optical component in an interferometer that divides the light beam into reference and measurement beams. In most interferometer designs, the beamsplitter is also used to recombine the reference and measurement beams on their return so that interference fringes may be detected or observed.

calibration [8]: an operation that, under specified conditions, first establishes a relationship between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties, then uses this information to establish a relation for obtaining a measurement result from an indication. See reference [8] for a detailed discussion.

chirp system: a laser system employing a swept laser frequency to determine absolute distance.

coefficient of thermal expansion [10]: the rate of change of length of a body with respect to temperature.

common optics test: a test for comparing the performance of two laser systems where both lasers share a single set of external optics, as defined in Nonmandatory Appendix B.

compensated back-to-back test: a test for comparing the performance of two laser systems arranged in a special back-to-back configuration that compensates for