



Standard Guide for Evaluating Non-Contacting Optical Strain Measurement Systems¹

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1. Scope

1.1 The purpose of this document is to assist potential users in understanding the issues related to the accuracy of non-contacting strain measurement systems and to provide a common framework for quantitative comparison of optical systems. The output from a non-contacting optical strain and deformation measurement system is generally divided into optical data and image analysis data. Optical data contains information related to specimen strains and the image analysis process converts the encoded optical information into strain data. The enclosed document describes potential sources of error in the strain data and describes general methods for quantifying the error and estimating the accuracy of the measurements when applying non-contacting methods to the study of events for which the optical integration time is much smaller than the inverse of the maximum temporal frequency in the encoded data (that is, events that can be regarded as static during the integration time). A brief application of the approach, along with specific examples defining the various terms, is given in the Appendix.

2. Referenced Documents

2.1 ASTM Standards:

- E 8 Test Methods for Tension Testing of Metallic Materials²
- E 83 Practice for Verification and Classification of Extensometers²
- E 251 Test Methods for Performance Characteristic of Bonded Resistance Strain Gages²
- E 399 Test Method for Plane Strain Fracture Toughness of Metals²
- E 1823 Terminology Relating to Fatigue and Fracture Testing²

3. Terminology

3.1 Definitions of Terms Specific to This Standard:

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² Annual Book of ASTM Standards, Vol 03.01.

3.1.1 *accuracy*—quantitative relationship of the measurements to the value obtained by standard measurement techniques

3.1.2 *basic data*—data obtained directly by the measurement system. For optical, non-contacting methods, a two-dimensional array of image intensity data is generally the basic data.

3.1.3 *coherent illumination*—light source where the difference in phase is solely a function of optical path differences; interference is a direct consequence.

3.1.4 *decoded data*—measurement information related to the displacement or displacement gradient field.

3.1.5 *decoded data bandwidth*—spatial frequency range of the information after decoding of the optical data.

3.1.6 *derived data*—data obtained through processing of the basic data. Typically, this is displacement field data.

3.1.7 *dynamic range*—the range of physical parameter values for which measurements can be acquired with the measurement system.

3.1.8 *illumination wavelength*—wavelength of illumination, λ .

3.1.9 *incoherent illumination*—light source with random variations in optical path differences; constructive or destructive interference of waves is not possible.

3.1.10 *maximum temporal frequency of encoded data*—reciprocal of the shortest event time contained in the encoded data (for example, time variations in displacement field).

3.1.11 *measurement noise*—variations in the measurements that are not related to actual changes in the physical property being measured. May be quantified by statistical properties such as standard deviation.

3.1.12 *measurement resolution*—smallest change in the physical property that can be reliably measured.

3.1.13 *numerical aperture, (N.A.)*—non-dimensional measure of diffraction-limitation for imaging system; $N.A. = D/f$ for a simple lens system, where D is lens diameter and f is lens focal length.

3.1.14 *optical data*—recorded images of specimen, containing encoded information related to the displacement or displacement gradient field, or both.