TECHNICAL ISO/TR

First edition
2011-12-15

Non-destructive testing — Methods for absolute calibration of acoustic emission transducers by the reciprocity technique

Essais non destructifs — Méthodes d'étalonnage absolu des capteurs d'émission acoustique par la technique de réciprocité

Reference number
ISO/TR 13115:2011(E)

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Published in Switzerland

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Foreword

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ISO/TR 13115 was prepared by Technical Committee ISO/TC 135, *Non-destructive testing*, Subcommittee SC 9, *Acoustic emission testing*.

Introduction

A standard method for primary calibration of acoustic emission transducers, ISO 12713:1998[1], introduced the seismic surface pulse method for Rayleigh surface wave calibration, wherein the breaking of a glass capillary is employed for the sound source and a standard capacitive transducer is used for the measurement of dynamic displacements of the surface. In ISO 12714:1999[2], on secondary calibration of acoustic emission sensors, a transducer which has been calibrated by the seismic surface pulse method is employed for comparison of reception sensitivity.

This Technical Report describes the methods for calibrating absolute sensitivity of acoustic emission transducers, both to Rayleigh surface waves and longitudinal waves, by means of a reciprocity technique. Since reciprocity parameters have been derived, absolute sensitivity can be determined by purely electrical measurements without the use of mechanical sound sources or reference transducers.

Procedures of the seismic surface pulse method and reciprocity technique differ from each other; however, there is a common theoretical basis in the two calibration methods. For the seismic surface pulse method, theoretical surface displacements were calculated on the basis of Lamb's theory (Reference [7]). For the reciprocity calibration, reciprocity parameters for the Rayleigh wave calibration were also derived from Lamb's theory. As for the Rayleigh surface wave calibration, a round robin experiment was carried out in a collaborative effort between the USA and Japan, and it was ascertained that absolute sensitivities as obtained by either method agreed well.

The aim of both methods is the same, namely, to establish uniformity of acoustic emission testing, to form a basis for data correlation, and to provide for the interpretation of results obtained by different laboratories at different times.

This Technical Report describes methods for three-transducer calibration, two-transducer calibration, and impulse response calibration, respectively. In three-transducer calibration, three acoustic emission transducers of the same kind, which are reversible transducers, are prepared to configure three independent pairs of transmitting and receiving transducers on a solid transfer medium. Transmission signal current and reception signal voltage are measured on each pair as a function of frequency, and frequency responses of amplitude of absolute sensitivity both to the Rayleigh surface waves and longitudinal waves are determined on each transducer. Once three-transducer calibration has been carried out, an optional transducer, which is not necessarily a reversible transducer, can be calibrated by a relatively simple procedure by using the calibrated transducer as a reference of transmission or reception. In two-transducer calibration, frequency responses of amplitude of absolute reception sensitivity are determined on an optional transducer by using one acoustic emission transducer, the transmission responses of which have been calibrated by the three-transducer calibration. In addition, by means of three-transducer calibration, impulse responses of each acoustic emission transducer can also be determined. In the impulse response calibration, frequency responses of phase angle, in addition to amplitude, of absolute sensitivity are measured by three-transducer calibration on the basis of complex reciprocity parameters, and impulse responses are determined through inverse Fourier transform of the frequency responses of amplitude and phase.