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

National foreword

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**Non-destructive testing - Methods for absolute calibration of
acoustic emission transducers by the reciprocity technique
(ISO/TR 13115:2011)**

Essais non destructifs - Méthodes d'étalonnage absolu des
capteurs d'émission acoustique par la technique de
réciprocité (ISO/TR 13115:2011)

Zerstörungsfreie Prüfung - Methode zur Absolutkalibrierung
von Schallemissionswandlern durch Reziproktechnik
(ISO/TR 13115:2011)

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Foreword

This document (CEN ISO/TR 13115:2011) has been prepared by Technical Committee ISO/TC 135 "Non-destructive testing" in collaboration with Technical Committee CEN/TC 138 "Non-destructive testing" the secretariat of which is held by AFNOR.

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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.

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

1 Scope

This Technical Report describes the method of three-transducer calibration for calibrating frequency responses of absolute sensitivity by means of a reciprocity technique using three reversible acoustic emission transducers of the same kind, the method of two-transducer calibration for calibrating frequency responses of reception sensitivity of an optional acoustic emission transducer by using one acoustic emission transducer, the transmission responses of which have been calibrated by three-transducer calibration, the method for impulse response calibration for calibrating impulse responses of absolute sensitivity through inverse Fourier transform of the frequency responses measured by the three-transducer calibration, and the method for representing the calibration results.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 12716:2001, *Non-destructive testing — Acoustic emission inspection — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12716 and the following apply.

3.1

reciprocity technique

calibration method on three reversible acoustic emission transducers of the same kind, wherein transducers are arranged on a solid transfer medium so that they configure three independent pairs of transmitting and receiving transducers, and absolute sensitivity is determined only by electrical measurements of transmission current and reception voltage on each pair

3.2

reversible transducer

transducer which can be used both for transmission and reception

3.3

absolute sensitivity

quantity of reception voltage sensitivity or transmission current response of an acoustic emission transducer

3.4

reception voltage sensitivity

ratio of the open-circuit output voltage of an acoustic emission transducer used for reception to the vertical component of displacement velocity at the position where the transducer is to be placed

3.5

transmission current response

ratio of the vertical component of displacement velocity at the index point to the input current of an acoustic emission transducer used for transmission

3.6

index point

position on the surface of the transfer medium, which is located at the specified distance in the specified direction from the acoustic emission transducer used for transmission, and used as the reference of transmission response

3.7

reciprocity parameter

ratio of reception sensitivity to transmission response of an acoustic emission transducer which is a reversible transducer

3.8

transfer medium

solid block on the surfaces of which transducers are placed in the calibration so that they configure a pair of transmitting and receiving transducers of the Rayleigh surface waves or longitudinal waves

3.9

calibration signal

electrical voltage signal which is applied to the transmitting transducer in the calibration

3.10

tone burst signal

calibration signal consisting of sinusoidal waves with a specified frequency and a specified period modulated so that the envelope forms one squared cosine

3.11

calibration frequency

frequency of sinusoidal waves of which a tone burst signal consists

3.12

squared-cosine signal

calibration signal which trigonometrically increases from zero to a maximum and decreases to zero during a specified period

3.13

Hanning window

cosine-type time window with a specified period, which is used for Fourier transform of transmission and reception signals measured in the impulse response calibration

3.14

Rayleigh wave calibration

calibration by which sensitivity to Rayleigh surface waves is determined by using Rayleigh waves for transmission and reception

3.15

longitudinal wave calibration

calibration by which axial sensitivity to longitudinal waves is determined by using longitudinal waves for transmission and reception

3.16

three-transducer calibration

calibration by a reciprocity technique, wherein frequency responses of amplitude of reception voltage sensitivity and/or transmission current response are determined on each of the three acoustic emission transducers