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Non-destructive testing — Acoustic emission testing — Specific methodology and general evaluation criteria for testing of fibre-reinforced polymers

Essai non destructif — Essai de l'émission acoustique — Méthodologie spécifique et critères d'évaluation générale d'essai des polymères renforcés de fibre

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Contents

Page

Foreword ... **iv**
Introduction ... **v**
1 Scope ... **1**
2 Normative references ... **1**
3 Terms and definitions ... **2**
4 Personnel qualification ... **3**
5 Acoustic emission sources and acoustic behaviour ... **3**
5.1 Acoustic emission source mechanisms ... 3
5.2 Wave propagation and attenuation characterization ... 3
5.3 Test temperature ... 4
5.4 Source location ... 4
5.5 Analysis of acoustic emission from fibre-reinforced polymers ... 5
6 Instrumentation and monitoring guidelines ... **5**
6.1 Instrumentation ... 5
6.2 Sensors ... 6
6.3 Sensor location and spacing ... 6
6.4 Sensor coupling and mounting ... 6
6.5 Detection and evaluation threshold ... 6
6.6 Application of load ... 7
6.7 Graphs for real-time monitoring ... 7
7 Specific methodology ... **7**
7.1 Size of component ... 7
7.2 Testing of specimens ... 8
7.3 Testing of components and structures ... 8
7.3.1 Preliminary information ... 8
7.3.2 Test preparation ... 8
7.3.3 Load profiles ... 9
7.3.4 Written test procedure ... 11
7.3.5 Evaluation criteria ... 12
7.3.6 Stop criteria ... 15
7.3.7 Health monitoring ... 16
8 Interpretation of acoustic emission test results/source mechanisms ... **16**
9 Report ... **16**
Bibliography ... **18**

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 135, *Non-destructive testing*, Subcommittee SC 9, *Acoustic emission testing.*

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Introduction

The increasing use of fibre-reinforced polymer (FRP) materials in structural (e.g. aerospace, automotive, civil engineering) and infrastructural applications (e.g. gas cylinders, storage tanks, pipelines) requires respective developments in the field of non-destructive testing.

Because of its sensitivity to the typical damage mechanisms in FRP, acoustic emission testing (AT) is uniquely suited as a test method for this class of materials.

It is already being used for load test monitoring (increasing test safety) and for proof-testing, periodic testing and periodic or continuous, real-time monitoring (health monitoring) of pressure vessels, storage tanks, and other safety-relevant FRP structures.

Acoustic emission testing shows potential where established non-destructive test methods (e.g. ultrasonic testing or water-jacket tests) are not applicable (e.g. thick carbon-fibre reinforced gas cylinders used for the storage and transport of compressed natural gas (CNG), gaseous hydrogen).

The general principles outlined in EN 13554 apply to all classes of materials but this International Standard emphasizes applications to metallic components (see EN 13554:2011, Clause 6).

However, the properties of FRP relevant to AT testing are distinctly different from those of metals.

FRP structures are inherently non-homogeneous and show a certain degree of anisotropic behaviour, depending on fibre orientation and stacking sequence of plies, respectively.

Material composition and properties, and geometry affect wave propagation, e.g. mode, velocity, dispersion, and attenuation, and hence the AT signals recorded by the sensors.

Composites with a distinct viscoelastic polymer matrix (e.g. thermoplastics) possess a comparatively high acoustic wave attenuation which is dependent on wave propagation parallel or perpendicular to the direction of fibre orientation, plate wave mode, frequency, and temperature-dependent relaxation behaviour.

Therefore, successful AT of FRP materials, components, and structures requires a specific methodology (e.g. storage of complete waveforms, specific sensors and sensor arrays, specific threshold settings, suitable loading patterns, improved data analysis), different from that applied to metals.

There are recent developments in acoustic emission testing, e.g. modal AT (wave and wave mode analysis in time and frequency domain) and pattern recognition analysis.

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Non-destructive testing — Acoustic emission testing — Specific methodology and general evaluation criteria for testing of fibre-reinforced polymers

1 Scope

This International Standard describes the general principles of acoustic emission testing (AT) of materials, components, and structures made of fibre-reinforced polymers (FRP) with the aim of

— materials characterization,

— proof testing and manufacturing quality control,

— retesting and in-service testing, and

— health monitoring.

This International Standard has been designed to describe specific methodology to assess the integrity of fibre-reinforced polymers (FRP), components, or structures or to identify critical zones of high damage accumulation or damage growth under load (e.g. suitable instrumentation, typical sensor arrangements, and location procedures).

It also describes available, generally applicable evaluation criteria for AT of FRP and outlines procedures for establishing such evaluation criteria in case they are lacking.

This International Standard also presents formats for the presentation of acoustic emission test data that allows the application of qualitative evaluation criteria, both online during testing and by post-test analysis, and that simplify comparison of acoustic emission test results obtained from different test sites and organizations.

NOTE The structural significance of the acoustic emission cannot in all cases definitely be assessed based on AT evaluation criteria only but can require further testing and assessment (e.g. with other non-destructive test methods or fracture mechanics calculations).

2 Normative references

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

ISO 9712:2012, *Non-destructive testing — Qualification and certification of NDT personnel*

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

ISO/IEC 17025:2005, *General requirements for the competence of testing and calibration laboratories*

EN 13477-1:2001, *Non-destructive testing — Acoustic emission — Equipment characterisation — Part 1: Equipment description*

EN 13477-2:2010, *Non-destructive testing — Acoustic emission — Equipment characterisation — Part 2: Verification of operating characteristics*

EN 14584, *Non-destructive testing — Acoustic emission — Examination of metallic pressure equipment during proof testing — Planar location of AE sources*

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