

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

## EESTI STANDARDI EESSÕNA

## NATIONAL FOREWORD

Käesolev Eesti standard EVS-EN 15857:2010 sisaldab Euroopa standardi EN 15857:2010 ingliskeelset teksti.

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ICS 19.100

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English Version

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

Essais non destructifs - Émission acoustique - Essai des polymères renforcés par des fibres - Méthodologie spécifique et critères d'évaluation généraux

Zerstörungsfreie Prüfung - Schallemissionsprüfung - Prüfung von faserverstärkten Polymeren - Spezifische Vorgehensweise und allgemeine Bewertungskriterien

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## Foreword

This document (EN 15857:2010) has been prepared by Technical Committee CEN/TC 138 “Non-destructive testing”, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2010, and conflicting national standards shall be withdrawn at the latest by July 2010.

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## Introduction

The increasing use of fibre-reinforced polymer materials (FRP) in structural (e.g. aerospace, automotive, civil engineering) and infra structural 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, AE testing 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 inspection and periodic or continuous, real-time monitoring (health monitoring) of pressure vessels, storage tanks and other safety-relevant FRP structures.

AE testing shows potential where established non-destructive test methods (e.g. ultrasonic 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, etc.).

The general principles outlined in EN 13554 apply (as stated) to all classes of materials but the document in fact emphasises applications to metal components (see Clause 6 "Applications of the acoustic emission method").

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

FRP structures are inherently inhomogeneous 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 AE 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 direction of fibre orientation, plate-wave mode, frequency and temperature dependent relaxation behaviour.

Therefore, successful AE testing 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, etc.), different from that applied to metals.

Most evaluation criteria for AE tests on FRP components and structures to date are either empirical (derived from comparative tests on a limited number of specimens) or else classified (proprietary, unpublished data banks).

The time and effort to establish qualified evaluation criteria for specific AE test applications may be too costly to make it worthwhile.

Generally applicable evaluation criteria for a class of materials – FRP – will help to pave the way for the development of new applications.

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

In particular, feature extraction and pattern recognition techniques seem promising for achieving, among others, improved source location and damage mechanism discrimination in materials that show complex wave propagation behaviour and signals originating from multiple mechanisms acting simultaneously, such as FRP.

## 1 Scope

This European Standard describes the general principles of acoustic emission (AE) testing of materials, components and structures made of FRP with the aim of:

- materials characterisation;
- proof testing/manufacturing quality control;
- retesting/in-service inspection;
- health monitoring.

When AE testing is used to assess the integrity of FRP materials, components or structures or identify critical zones of high damage accumulation or damage growth under load this standard further describes the specific methodology (e.g. suitable instrumentation, typical sensor arrangements, location procedures, etc.).

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

**NOTE** The structural significance of the AE may not in all cases definitely be assessed based on AE evaluation criteria only but may require further inspection and assessment (e.g. with other non-destructive test methods or fracture mechanics calculations).

This standard also recommends formats for the presentation of AE test data that allow the application of qualitative and quantitative evaluation criteria, both on-line during testing and by post test analysis, and that simplify comparison of AE test results obtained from different test sites and organisations.

## 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.

EN 473, *Non-destructive testing — Qualification and certification of NDT personnel — General principles*

EN 1330-1:1998, *Non destructive testing — Terminology — Part 1: List of general terms*

EN 1330-2:1998, *Non-destructive testing — Terminology — Part 2: Terms common to the non-destructive testing methods*

EN 1330-9:2009, *Non-destructive testing — Terminology — Part 9: Terms used in acoustic emission testing*

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

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

EN 13554, *Non-destructive testing — Acoustic emission — General principles*

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

EN 15495, *Non-destructive testing — Acoustic emission — Examination of metallic pressure equipment during proof testing — Zone location of AE sources*