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Test method for the evaluation of the adhesive properties of fibre reinforced polymer composite joints

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Foreword

This CEN Workshop Agreement (CWA 17896:2022)has been developed in accordance with the CEN-CENELEC Guide 29 “CEN/CENELEC Workshop Agreements – A rapid prototyping to standardization” and with the relevant provisions of CEN/CENELEC Internal Regulations - Part 2. It was approved by a Workshop of representatives of interested parties on 2022-04-06, the constitution of which was supported by CEN following the public call for participation made on 2021-07-26. However, this CEN Workshop Agreement does not necessarily include all relevant stakeholders.

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Introduction

Advanced fibre reinforced polymer composites, due to their lightweight, are used in aeronautics, aerospace, automotive, and naval activities (e.g., aircraft fuselage, wind turbines, gears, chassis, etc.). Skin-stiffened or “stringer run-outs” structures are used mostly in aerospace and are very sensitive to local damages. Usually, the stringer tends to debond from the skin, and then the delamination may further propagate in the skin. The mechanical characterization of these specimens is both time-consuming and material intensive.

This document describes a modified test method used in a European project to characterize delamination at the tip of the flange and to understand ‘stringer run-out’ experienced in the manufacture of composite large panel, typically greater than 0,5 m in any in-plane direction. The method employed a simplified joint configuration via a lap-strap geometry. The results of the work showed that the simplified lap-strap specimens showed the same damage mechanisms as the stringer run-out.

Firstly, the lap debonds from the strap and then the delamination may further propagate interplay in the strap. It should be mentioned that failure in the lap -strap geometry is manifested in a mixed-mode. At the early stages of the test, the adhesive layer between lap and strap fails in mode II, followed by mode I failure at higher stress levels. This test method could also be used to evaluate the healing or repair efficiency at self-healing or repairable composites or their knockdown effect (see 5.6).

Non-destructive Evaluation (NDE) techniques, for example Acoustic Emission, can be optionally applied to the Lap Strap specimen with the mechanical testing. NDE techniques include Electrical Resistance Change Method (ERCM) and Acoustic Emission (AE). These techniques could provide information about the failure of the geometry and, additionally, information about the damage that was induced before failure. They are strongly suggested in cases of poor mechanical properties of the adhesive.

1 Scope

This document provides a test method for the determination of the adhesive properties in joints of continuous fibre reinforced polymer matrix composite structures using the Lap Strap specimen.

The evaluation includes the optional concurrent use of the non-destructive technique of the Electrical Resistance Change Method (ERCM) and/or Acoustic Emission (AE) for the monitoring of the debonding of the lap from the strap optionally. The ERCM NDE technique has a limited application only on carbon fibre composites due to the inherent electrical conductivity of the carbon fibres.

This test applies to composites manufactured with continuous carbon fibres (woven or unidirectional) and thermoset or thermoplastic matrices, with quasi-isotropic lamination. This methodology can be used on repairable or self-healing composites in order to estimate the repair or healing efficiency respectively.

Safety aspects about manufacturing and mechanical testing of the composites are excluded.

2 Normative references

There are no normative references in this document.

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms, definitions, symbols and abbreviated terms apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
non-destructive evaluation
NDE
process or procedure for determining the quality or characteristics of a material, part or assembly without permanently altering the subject or its properties

[SOURCE: ISO 21648:2008, 2.1.29]

3.1.2
on-line monitoring
any inspection activity carried out concurrent with the mechanical testing

3.1.3
knockdown effect
the change of the initial mechanical properties of a composite material after the incorporation of a self-healing or a self-repairing system

3.1.4
balanced laminate
continuous fibre-reinforced laminate that each +θ° (angle) lamina is balanced by a -θ° (angle) lamina in regard to a reference axis