INNUMAT WORKSHOP

16-17 November 2023

CEN/WS TOUGHSTEEL

Fracture toughness evaluation methodologies applied to AHSS sheets

Javier LÓPEZ-QUILES (UNE)

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ToughSteel project

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TOUGHSTEEL

Fracture toughness as a tool to address cracking problems in forming and in-service performance of AHSS

ToughSteel project

Overview

Dissemination and valorisation of fracture toughness as a material property to rationalise crack-related problems in Advanced High Strength Steels.

- European project funded by the Research Fund for Coal and Steel (RFCS) within the Horizon 2020 programme of the European Union.
- 2 years duration, from 1/07/2021 to 30/06/2023
- 8 partners from 4 different European countries
- Coordinated by Eurecat, RTO
- Grant agreement ID: 101034036

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ToughSteel project

Consortium

- 8 partners (2 universities, 1 research institution, 1 end user, 3 steel associations and 1 standardisation body)

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ToughSteel project

Objectives

Enhancing the value and increasing stakeholder awareness of Fracture Toughness benefits

- To **promote and transfer the know-how** acquired about the use of fracture toughness as a tool to address cracking problems in forming and in-service performance of AHSS.
- Contributing to improve the **efficiency and competitiveness** of sheet metal forming processes involving high-strength steels:
  - prevention of production loses
  - reduction of production costs and time-to-market for sheet products

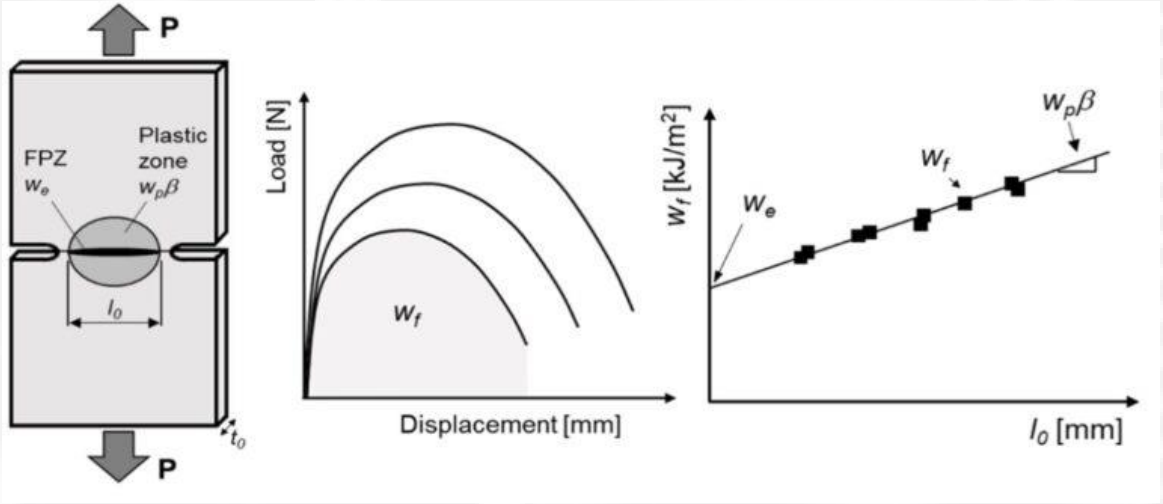
Pia Nordlander / www.jernkontoret.se

ToughSteel project

Novel methodologies to evaluate fracture toughness

An alternative simpler and faster experimental approach to satisfy the growing need of knowing the fracture properties of thin metallic sheets

- Fracture toughness is defined as the energy spent in the creation of two surfaces at the crack tip that give rise to crack propagation.
- The **Essential Work of Fracture (EWF)** methodology, offer a simpler solution for measuring the fracture toughness of thin metal sheets.
- The EWF methodology has shown to be **suitable** to readily measure the fracture toughness of high-strength sheet materials. Their results can be used to understand their cracking behaviour during forming or in crash situations.



Schematic representation of the experimental procedure for the EWF determination

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Activities

1 Literature review

Collection, organisation and analysis of fracture toughness data measurements from previous and ongoing RFCS projects and open literature.

2 Fracture toughness database

Creation of a database of fracture toughness of AHSS and steel sheets data with detailed information about material, test methodology, test conditions, among others.

3 User guidelines

Industrial guidelines to describe methodologies of fracture toughness evaluations in sheet metals, based on the research done in previous RFCS projects.

4 “Problems solving” Open Call

To enrol 3 to 5 industrial companies as case studies to show how fracture toughness can be used to understand and solve crack-related problems.

5 Training workshops & webinars

Academic and industrial events to introduce the methodology, receive feedback and facilitate an open discussion.

6 Standardisation activities

Identification of standards and presentation of the EWF to relevant standardisation committees to reinforce market acceptance and industrial take-up.

7 White paper

Publication summarising the results and case-studies of the open call to disseminate fracture toughness concept, benefits and applications.

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Expected impacts

ToughSteel is bound to help the scientific and academic community

- **Material selection**
  Improving material selection in cold sheet metal forming and future optimisation of AHSS microstructures.
- **Performance prediction**
  Predict part performance and prevent production losses to the sheet metal forming industries.
- **Crashworthiness assessment**
  Assess crashworthiness of AHSS for structural components.
- **Reduce time to market**
  Improve the accuracy of model process manufacturing and part performance and, thereby, shorten the part design phase.

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Why standardisation?

To **disseminate** the project findings and results

To facilitate the **acceptance and implementation** by the market of the knowledge gained

No existing standards concerning fracture toughness for thin metal sheets or AHSS

Interest in assuring the **reliability and quality** of the test procedures and results, and thus providing confidence to users

DECISION TO DEVELOP STANDARDS

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Creation of the CEN Workshop

Proposal

Standardisation principles

Openness and transparency

CEN/WS Proposal Form document (For CEN)

- Proposer and participants
- Title and justification
- Scope
- Related TCs and standards
- Secretariat
- Financing

CEN/WS Project Plan document (Public)

- Proposer and participants
- Title and justification
- Scope
- Related TCs and standards
- **Work programme**
- Chair and secretariat **responsibilities**
- **Communication** strategy

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Creation of the CEN Workshop

Proposal

[CEN/CENELEC Website]

CEN CENELEC

EUROPEAN STANDARDIZATION | GET INVOLVED | AREAS OF WORK | NEWS AND EVENTS

Draft CWAs on a test method and guidelines on advanced high strength steel sheets

Mining and Metals | Workshop | CEN

The main objective of the CEN/WS 'Fracture toughness evaluation methodologies applied to advanced high strength steel sheets' is to provide guidelines describing different methodologies, informing about their suitability, and to provide recommendations that can be applied by the manufacturers during the planning, design, and operational phases of the manufacture of AHSS sheets.

The CEN/WS is developing two draft CWAs:

- CWA "Test method for the determination of a cracking resistance index for advanced high strength steel sheets", which describes a single-specimen testing procedure for the evaluation of a cracking resistance index (CRI) for *AHSS* sheets with thicknesses between 0,5 mm and 3,0 mm;
- CWA "Guidelines for the evaluation of the plane stress fracture toughness of advanced high strength steel sheets in the frame of fracture mechanics", which provides information of interest about the fracture toughness evaluation of thin high strength metal sheets and its implication on sheet metal formability and crashworthiness.

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Creation of the CEN Workshop

Proposal

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The CEN/WS will develop two CEN Workshop Agreements (CWA):

- The first planned CWA will describe the existing methodologies for fracture toughness evaluation in metal sheets. It will compile relevant findings from research developed in previous and ongoing RFCS projects and academic research. It will also provide recommendations to be applied during the planning, design, and operational phases of the manufacture of AHSS sheets and components, as well as successful industrial case studies.
- The second planned CWA will describe a new testing procedure to estimate the crack propagation resistance of AHSS sheets using a Cracking Resistance Index (CRI) based on fracture mechanics. The procedure provides a fast and simple method that can be implemented as a routine procedure for in-plant quality control and material selection and/or acceptance.

TAGS: Workshop | CWA | Steel

The kick-off meeting will be held on 26 October 2022, from 9:00 to 12:00 CET as hybrid meeting. People interested to participate in the kick-off meeting can follow the instructions detailed in the agenda.

All interested parties are invited to **submit comments on the draft Project Plan** using the commenting form below, to the Workshop secretary, Mr. Javier Lopez-Quiles Pastor (**jlopezquiles@une.org**), **by 16 October 2022**.

Download the documents:

- Draft Project Plan
- Agenda of the kick-off meeting
- Commenting form

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Creation of the CEN Workshop

Kick-Off meeting

- 2022-10-26 Hybrid format
- 8 attending organisations (6 continued as CEN/WS participants)
- Relevant content:
  - Presentation of the CEN/WS and **ToughSteel results**
  - Adoption of the **Project Plan**, including CWAs to be developed

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Project Plan

Proposer	Fundació Eurecat
Secretariat	Spanish Association for Standardistion (UNE)
Participants	Université Catholique de Louvain, CIEMAT, OCAS NV, APERAM
Title	**Fracture toughness evaluation methodologies applied to advanced high strength steel sheets**
Objectives and scope	To address crack-related issues in AHSS sheets in response to the industry growing need of knowing the fracture properties of this material. To provide guidelines (CWAs) describing the different methodologies for the evaluation of fracture toughness, informing about their suitability, and to provide recommendations that can be applied by the manufacturers during the planning, design, and operational phases of the manufacture of AHSS sheets.

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Project Plan

Work programme	• **CWA#1 Existing methodologies on fracture toughness evaluation in metal sheets** • **CWA#2 Test method to estimate the crack propagation resistance of AHSS**
Related TCs and standards	• CEN/TC 459/SC 1 Test methods for steel (other than chemical analysis) • ISO/TC 164/SC 4 Fatigue, fracture and toughness testing • CEN/WS FORMPLANET “Innovative testing in support of the sheet metal forming industry” • CWA 17793:2021 Test method for determination of the essential work of fracture of thin ductile metallic sheets • ISO 26843:2015 Metallic materials — Measurement of fracture toughness at impact loading rates using precracked Charpy-type test pieces • ISO 12135:2021 Metallic materials — Unified method of test for the determination of quasistatic fracture toughness • ISO 22889:2013 Metallic materials — Method of test for the determination of resistance to stable crack extension using specimens of low constraint • ASTM E1820-21 Standard Test Method for Measurement of Fracture Toughness • ASTM E2472-12 Test to Determine Resistance of metal to Stable Crack Extension

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Organisation of the works

ToughSteel Deliverable D2.1

User guideline

Eurecat's research on cracking resistance

Adaptation

CWA #1

"Guidelines for the evaluation of the fracture properties of AHSS in the frame of fracture mechanics"

CWA #2

"Test method for the determination of a Cracking Resistance Index (CRI) in AHSS sheets"

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Organisation of the works

WORK TYPE	TASK	RESPONSIBLE
MAIN WORK	▪ Adaptation of existing documents ▪ Editorial review and editing ▪ Publication	EURECAT UNE CEN
SUPPORTING WORK	▪ Review and comment CWA drafts when circulated ▪ Take part in approval decisions	Université Catholique de Louvain, CIEMAT, OCAS NV, APERAM

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Drafting organization

Table 1: Workshop schedule (preliminary)

CEN/CENELEC Workshop	M01 JUN 22	M02 JUL 22	M03 SEP 22	M04 OCT 22	M05 NOV 22	M06 DEC 22	M07 JAN 23	M08 FEB 23	M09 MAR 23	M10 APR 23
Initiation										
1. Proposal form submission and TC response										
2. Project plan development										
3. Open commenting period on draft project plan (mandatory)										
Operation										
4. Kick-off meeting										
5. CWAs development										
6. Open commenting period on draft CWA(s) (optional)										
7. CWAs finalised and approved by Workshop participants										
Publication										
8. CWAs publication										
Dissemination (see 7)										
Milestones				K		V			V A	P D

KoM

Finished drafts/ Comments

Final approval

K	Kick-off
M	Workshop meeting
V	Virtual Workshop meeting
A	Adoption of CWA
P	Publication of CWAs
D	Online distribution of CWAs

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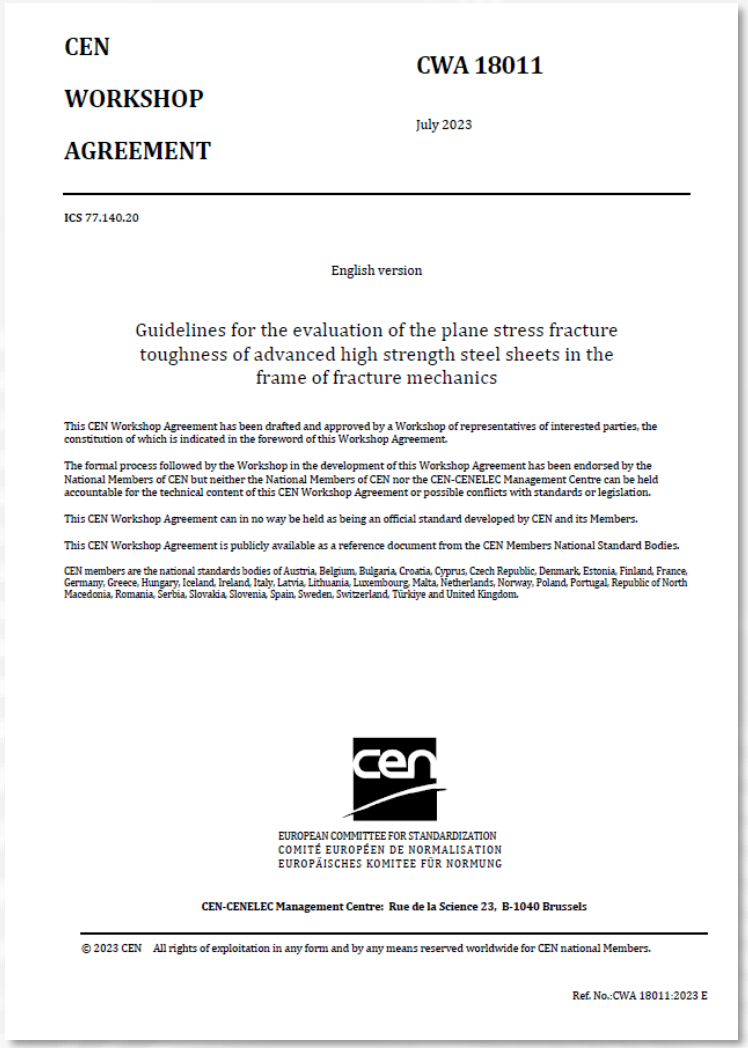
Published CWAs



CEN

WORKSHOP

AGREEMENT

CWA 18011

July 2023

ICS 77.140.20

English version

Guidelines for the evaluation of the plane stress fracture toughness of advanced high strength steel sheets in the frame of fracture mechanics

This CEN Workshop Agreement has been drafted and approved by a Workshop of representatives of interested parties, the constitution of which is indicated in the foreword of this Workshop Agreement.

The formal process followed by the Workshop in the development of this Workshop Agreement has been endorsed by the National Members of CEN but neither the National Members of CEN nor the CEN-CENELEC Management Centre can be held accountable for the technical content of this CEN Workshop Agreement or possible conflicts with standards or legislation.

This CEN Workshop Agreement can in no way be held as being an official standard developed by CEN and its Members.

This CEN Workshop Agreement is publicly available as a reference document from the CEN Members National Standard Bodies.

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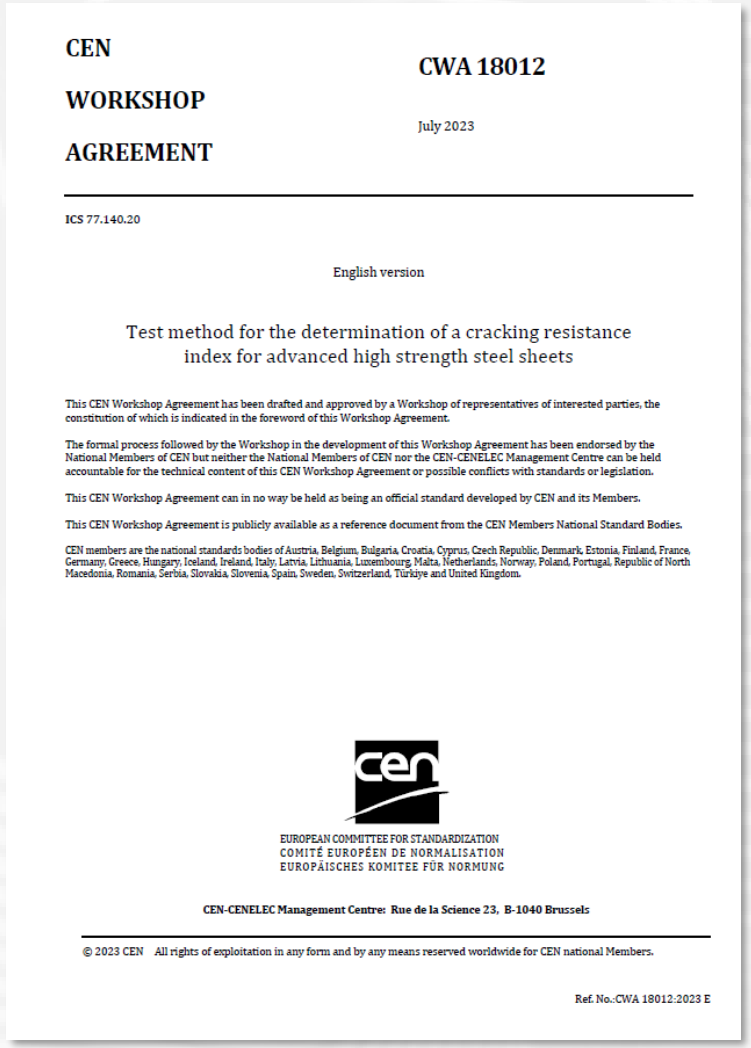
CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

Ref. No.:CWA 18011:2023 E



CEN

WORKSHOP

AGREEMENT

CWA 18012

July 2023

ICS 77.140.20

English version

Test method for the determination of a cracking resistance index for advanced high strength steel sheets

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Ref. No.:CWA 18012:2023 E

Standardisation principle

Consensus

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Published CWAs

CWA 18011:2023

Guidelines for the evaluation of the fracture properties of AHSS in the frame of fracture mechanics

SCOPE

This document provides a guideline to describe the different fracture toughness testing methodologies for thin ductile metal sheets, informing about their suitability, and providing recommendations that can be applied by the manufacturers during the planning, design, and operational phases of the manufacture of AHSS sheets.

CWA 18012:2023

Test method for the determination of a Cracking Resistance Index (CRI) in AHSS sheets

SCOPE

This document provides a test method for the determination of a Cracking Resistance Index (CRI) to classify the crack propagation resistance of advanced high strength steel sheets.

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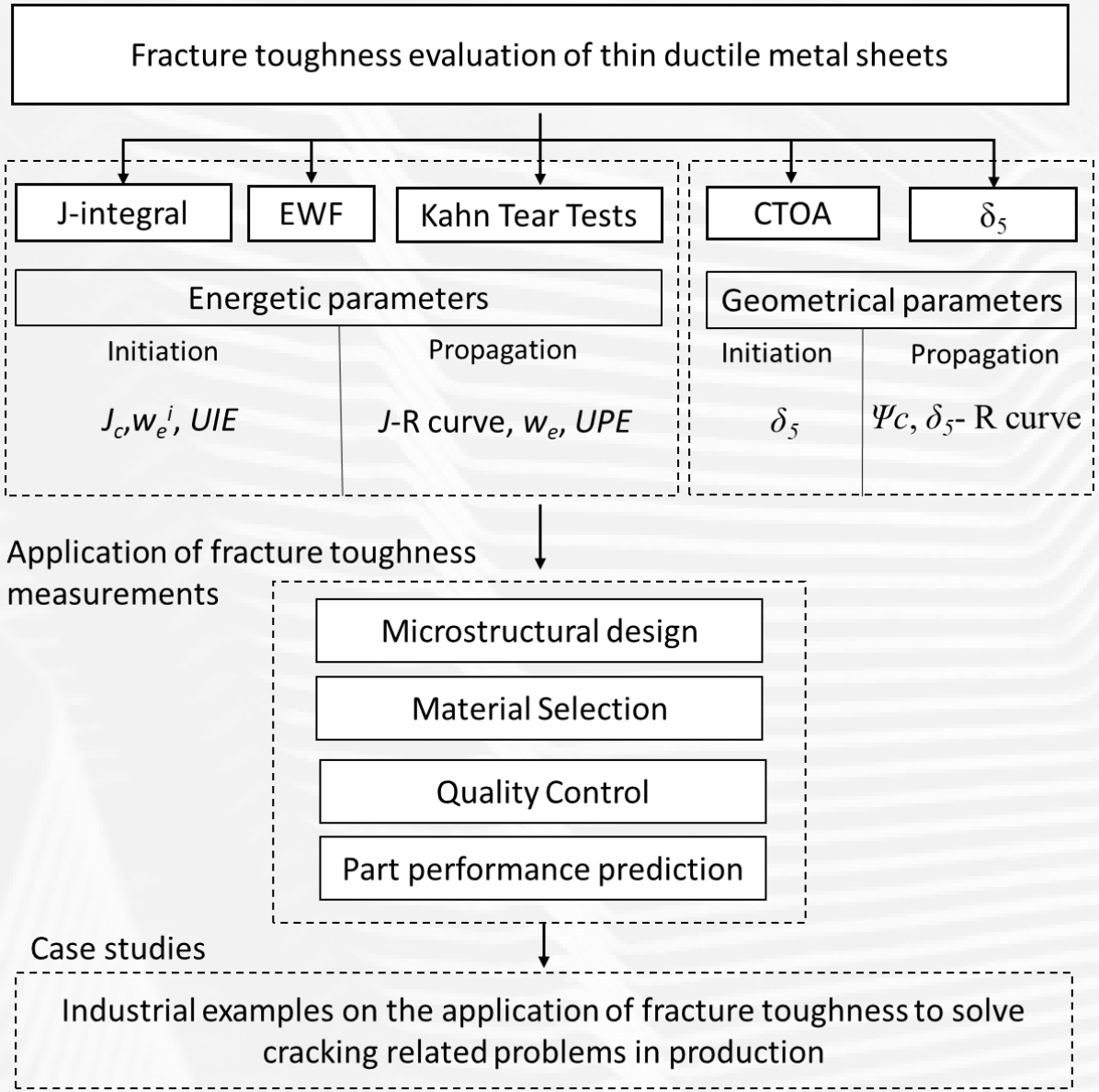
Published CWAs

CWA 18011:2023

Guidelines for the evaluation of the fracture properties of AHSS in the frame of fracture mechanics

- Measurement of the fracture toughness
- Standard methods: ASTM E1820, ASTM E2472, ISO 22889, ISO12135
- Essential Work of Fracture (EWF) methodology



[Download the CWA]

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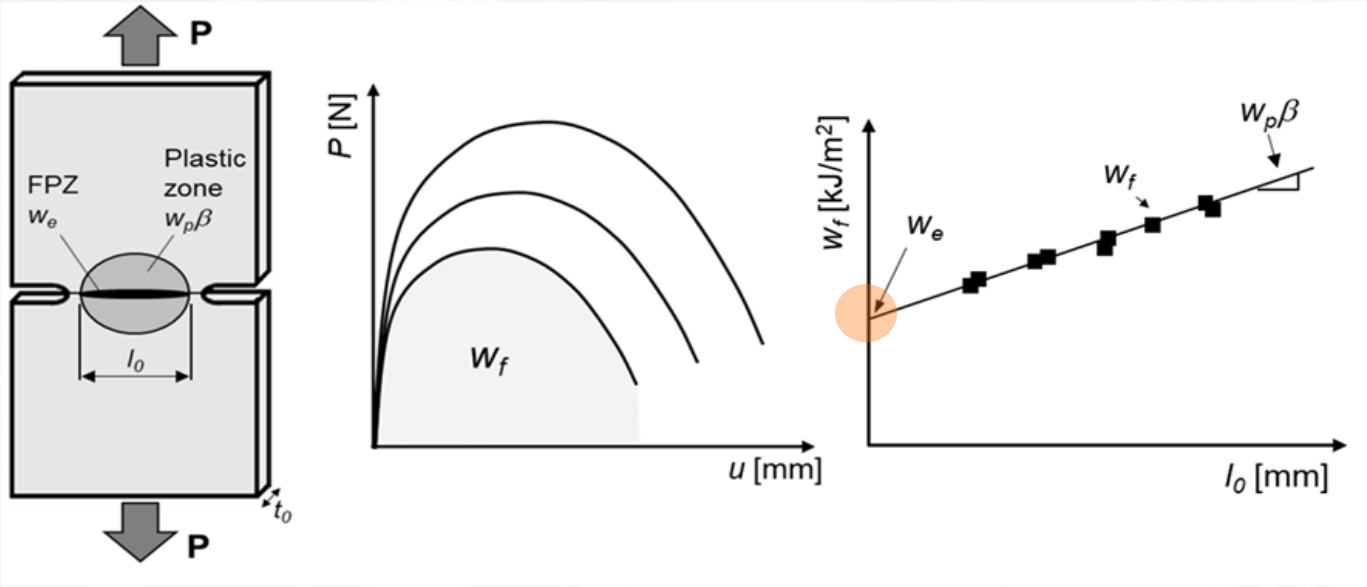
Published CWAs

CWA 18012:2023

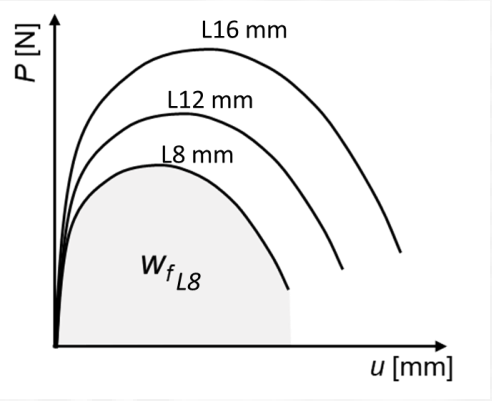
Test method for the determination of a Cracking Resistance Index (CRI) in AHSS sheets

Essential Work of Fracture



w_e: crack propagation resistance → Indicator of fracture performance

Cracking Resistance Index (CRI)



$$CRI\ [\%] = \frac{W_{fL8}}{UTS \cdot TE \cdot t_0 \cdot l_0^2}\ x\ 100$$

W_{fL8}: Fracture energy for a ligament length of 8 mm

UTS: Ultimate Tensile Strength

TE: Total Elongation

t_0: Specimen thickness

l_0: Ligament length

CRI [%]	Cracking resistance level
>50	High
25-50	Medium
<25	Low

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Download the CWA

Thank you very much for your attention!

Javier LÓPEZ-QUILES
Spanish Association for Standardisation - UNE
jlopezquiles@une.org

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