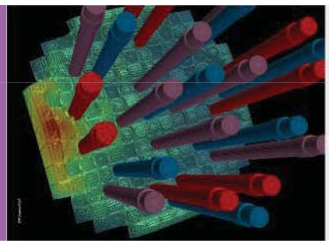

FISA 2022
30 May - 3 June 2022
Lyon, France

Increase of Nuclear Installations Safety by Better Understanding of Materials Performance and New Testing Techniques Development

MEACTOS, INCEFA-SCALE AND FRACTESUS H2020 Projects

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Project has received funding from the Euratom research and training programme 2014-2018 under grant agreement no. 755151.

Project has received funding from the Euratom research and training program 2014-2018 under grant agreement No 945300.

Project has received funding from the Euratom research and training programme 2020-2024 under grant agreement No 900014.

Motivation

Research to better understand the phenomena influencing materials and components performance is important for **increasing the safety of Generation II and III nuclear plant**.

Main research path of **MEACTOS** (2017-2022), **INCEFA-SCALE** (2020-2025) and **FRACTESUS** (2020-2024) H2020 projects:

- Better understating of phenomena related with **fracture** and **fatigue** of materials used to build reactor components (**environmental effect, surface effect, scaling effect**)
- Development of **new testing techniques** that allow to precisely determine mechanical properties with relatively small amount of material needed (**optimization of material usage** in surveillance programs, **scaling from laboratory to real size components**, **new specimen designs**)

Increase of nuclear installations safety (Generation II and III reactors)

Better understanding of phenomena influencing materials and components performance

Development/validation of material testing techniques

Environmental and surface effect

New testing techniques

MEACTOS (2017-2022)

Mitigating Environmentally-Assisted Cracking Through Optimisation of Surface Condition

Main aim: Improvement the safety and reliability of Generation II and III nuclear power plants by improving the resistance of critical locations, including welds, to **environmentally-assisted cracking (EAC)** through the application of optimized surface machining and improved surface treatment

Database of testing results

INCEFA-SCALE (2020-2025)

INcreasing safety in NPPs by Covering gaps in Environmental Fatigue Assessment – focusing on gaps between laboratory data and component SCALE

Main aim: Advance the ability to predict lifetimes of Nuclear Plant components when subjected to **Environmental / Fatigue** loading

Scale effect

FRACTESUS (2020-2024)

Fracture mechanics testing of irradiated RPV steels by means of sub-sized specimens

Main aim: To demonstrate the **applicability of miniaturized compact tension specimens (MCT) in fracture toughness testing** (master curve determination) of the reactor pressure vessel steels hot cell conditions

MEACTOS

Project has received funding from the Euratom research and training programme 2014-2018 under grant agreement no. 755151.

General information

Mitigating Environmentally-Assisted Cracking Through Optimisation of Surface Condition

This project receives funding from the Euratom research and training programme 2014-2018 in the topic NFRP-01: Continually improving safety and reliability of Generation II and III reactors; Grant Agreement Nº. 755151.

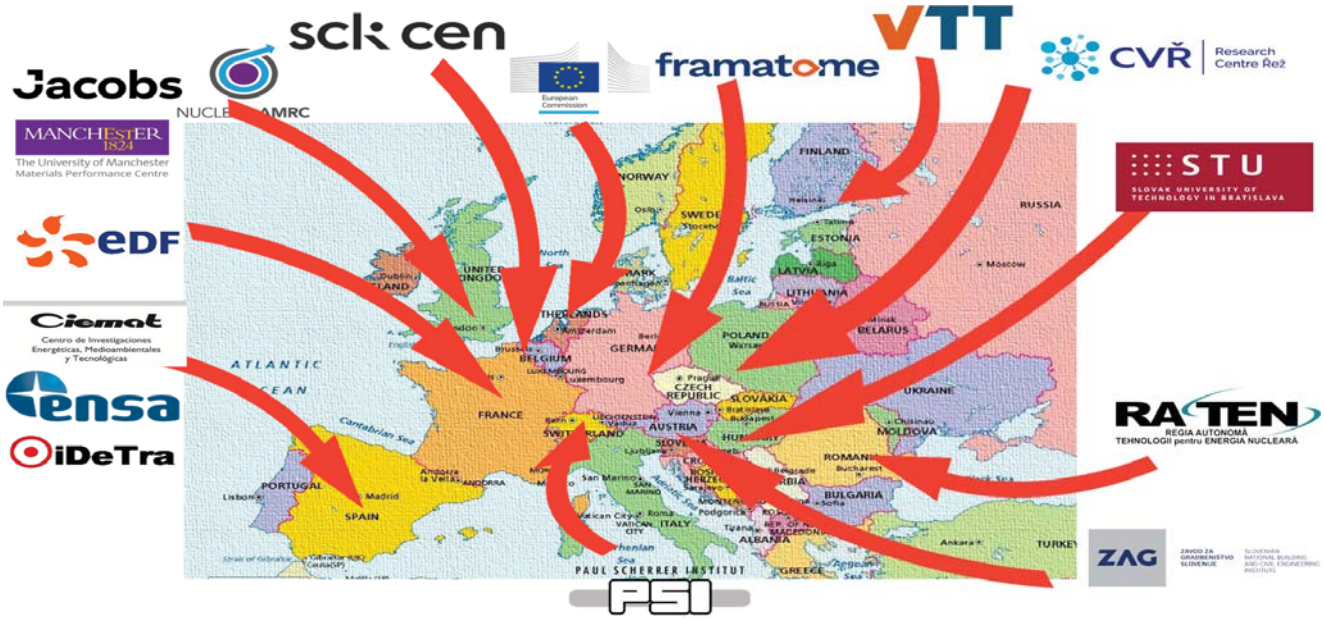
- Start date: 01/09/2017
- End date: 27/02/2022
- 16 partners

The goal of the MEACTOS project is to improve the safety and reliability of Generation II and III nuclear power plants (NPPs) by improving the resistance of critical locations, including welds, to environmentally-assisted cracking (EAC) through the application of optimized surface machining and improved surface treatments.

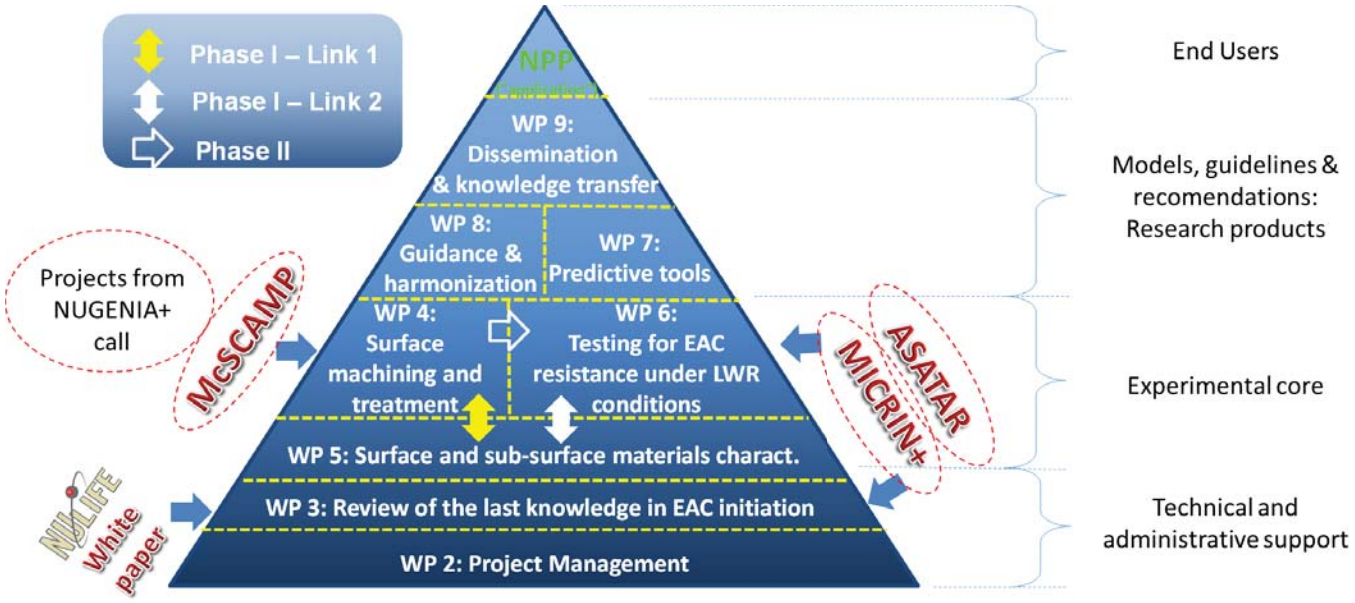
Project website: https://meactos.eu/

Partners

15 laboratories from different European countries



Work package structure



Workflow

SOTA Workshop	Fabrication of coupons	Machining specimens	Test campaign	Results collection	Fit models	Final Workshop
Choice of materials and conditions to be tested during the project	• A182 by weld overlay on carbon steel plate • 316L Cold Worked Up to a 15% of thickness reduction by rolling	• Flat tapered specimens for task 6.1 • Flat tapered and other geometries for task 6.2 **Side A: Machined** **Side B: Manually Polished**	Task 6.1 • 3 strain rates Task 6.2 • Constant load **Environments** • **PWR** • **BWR** • **SCWR**	Task 6.1 • Stress threshold for crack initiation Task 6.2 • Time to initiation	3 models • EngInit (SCK-CEN) • ACETMA (CVR) • Local (EDF) parametrized with tests results	Harmonization guidelines

Main results

- Despite the scatter, **the trend** of the observed results seems to indicate that for the **A 182** advanced machining slightly improves the resistance to the initiation of cracks , compared to traditional machining and to the reference surface (manually polished).
  - **Resistance of surface to EAC**: **Advanced machining > Traditional machining > Polished**
- For **316L** and for the applied cold work level (around 14%) there is no clear benefit in the applied surface treatments. However, this material is itself very resistant, so the initial degree of cold work applied may not have been sufficient to increase the susceptibility to EAC.
- **All machining processes** used have produced **ultrafine-grained layers (UFG)** or different thickness in both materials. At least for A 182 this UFG layer seems to correlate with the enhanced EAC resistance.
- Since critical stress data from standard and advanced surfaces show only little difference it can be further concluded, that **advanced surface machining methods have nearly the same impact on EAC initiation behaviour than standard methods, i.e. they are not inferior**. In combination with benefits like higher cutting speed and less pollution by lubricants, **advanced surface machining methods are therefore a promising alternative to standard procedures**.
- **Advanced surface machining methods** can be used for future applications or if standard methods cannot be used **(e.g. repair robots for pipes)**.
- The resistance to EAC of **the layer treated by peening techniques** strongly depends on the quality of the resulting surface.

INCEFAscale
Horizon 2020

Project has received funding from the Euratom research and training program 2014-2018 under grant agreement No 945300.

General information

INcreasing safety in NPPs by Covering gaps in Environmental Fatigue Assessment – focusing on gaps between laboratory data and component

- Start date: 01/10/2020
- End date: 30/09/2025
- 18 partners (2 associate partners being engaged through non-disclosure agreements)

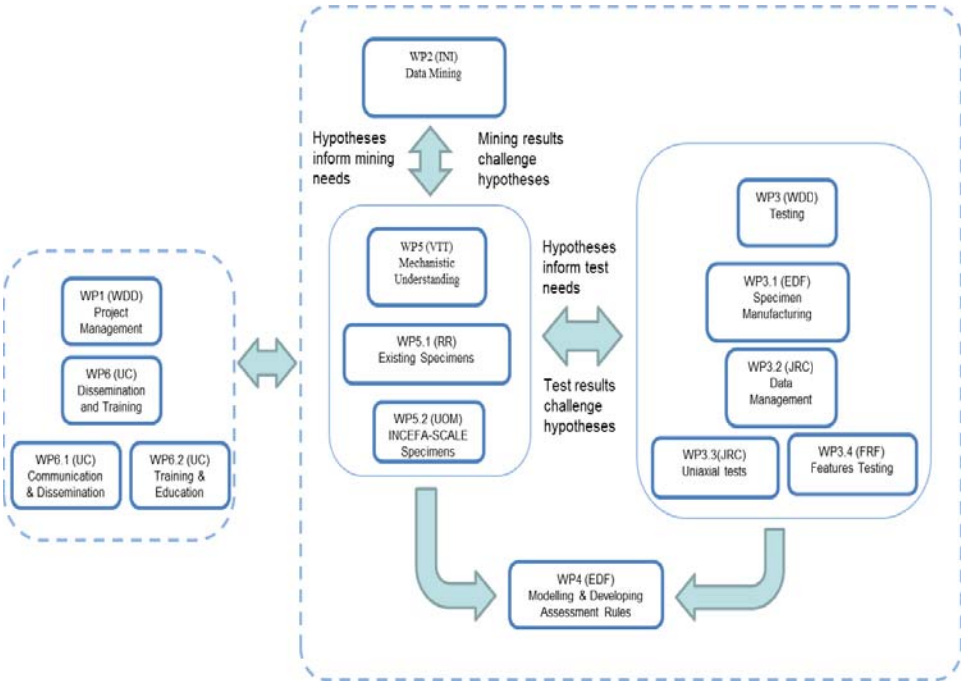
Primary focus: developing mechanistic understanding of EAF to permit extrapolation of lab data up to component scale

Project website: https://incefascale.unican.es/

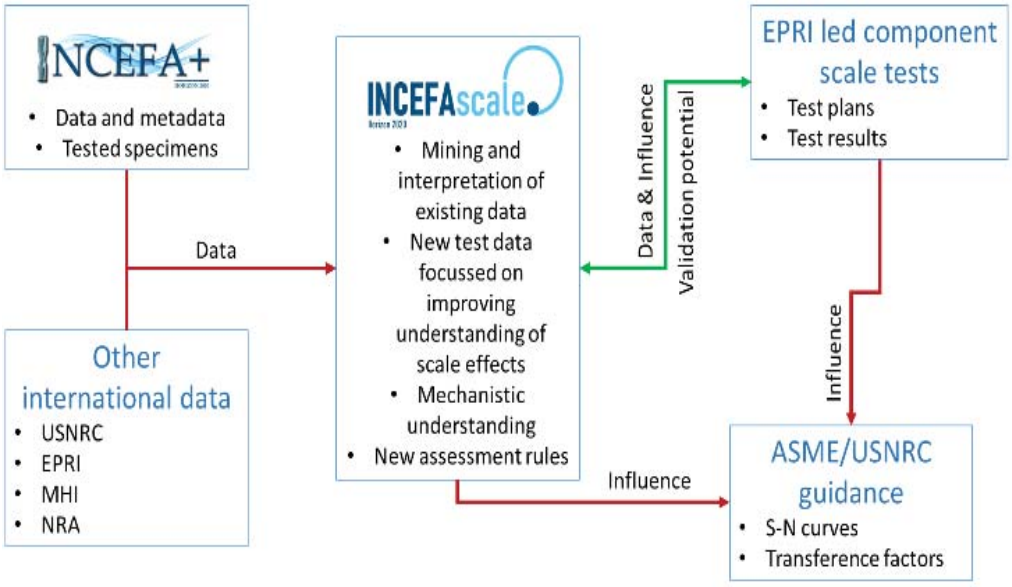
Partners

UK NED KOR FRA ESP SWI FIN CZ LIT GER USA

Work Package structure



Workflow/external relationship



Highlights

- A collaboration with EPRI, through a non-disclosure agreement (NDA) (under development), has been agreed.
- WP2 has completed the development of a software application that will facilitate datamining activities using the information stored in MatDB.
- An upcoming International Fatigue Database Agreement will make significant additional data available for examination from external collaborators.
- INCEFA-SCALE will target conservatisms in the treatment of Variable Amplitude loading of current design codes.
- Three working hypotheses were identified for the first year of testing to be expanded on as the project progresses:
  - The negative effects of mean stress on fatigue life are relatively less damaging at higher temperatures and are conservatively accounted for in current design codes.
  - In PWR environments, the effects of hardening on fatigue life should not be treated as additional to effects of environment.
  - In PWR environments, negative effects from hardening, environment and surface roughness are not multiplicative.
- WP3 uniaxial testing has commenced and features testing defined with support from the recently established Expert Panel and Data Management Committee.
- WP4 modelling and assessment has kicked off and defined the aims and scope for the work package.
- WP5 characterisation continues to progress and support the INCEFA-SCALE aims.
  - A round robin for striation counting has reached completion and issued a common method for calculating striation spacing.
  - The WP team is now in the process of engaging with the consortium on analysing pre-test specimens.
- The project dissemination channels have been set up consists of a public website (https://incefascale.unican.es), ResearchGate, Twitter and LinkedIn presences.

FRACTESUS

Project has received funding from the Euratom research and training programme 2020-2024 under grant agreement No 900014.

General information

FRACTure mechanics TEsting of irradiated RPV steels by means of SUb-sized Specimens (FRACTESUS)

Project within EURATOM Work Programme 2019-2020 in the section NFRP-04: Innovation for Generation II and III reactors:

- Start date: 01/10/2020
- End date: 30/09/2024
- 21 partners from Europe, Japan and Canada

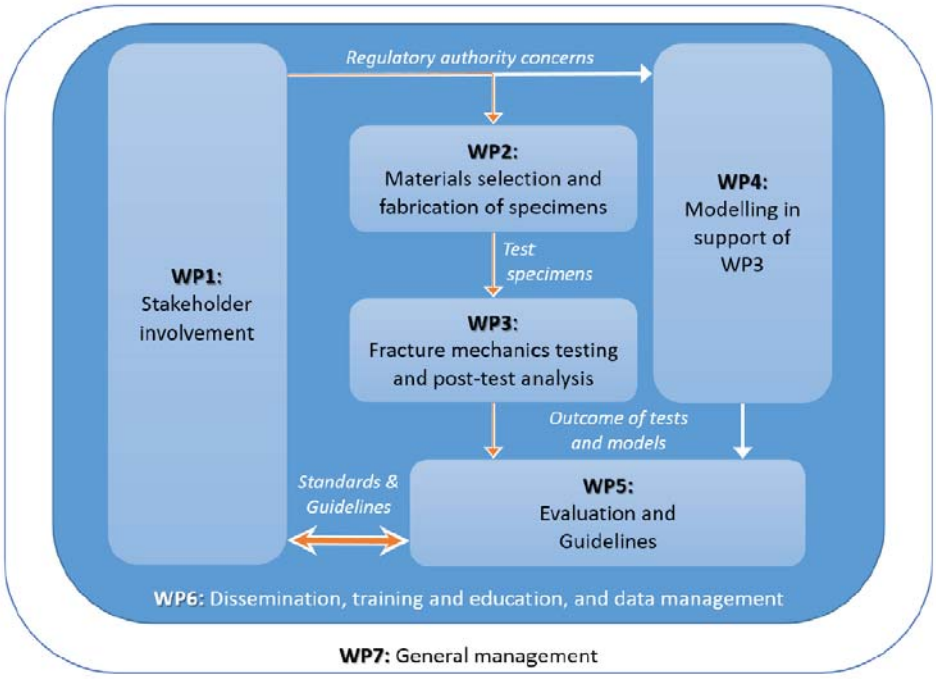
Main aim: to demonstrate the applicability of miniaturized compact tension specimens in fracture toughness testing (master curve determination) of the reactor pressure vessel steels under hot cell conditions.

Project website: https://fractesus-h2020.eu/

Partners

21 partners from 14 countries

Work package structure



With support of:

- Scientific Advisory Committee
- End User Group
- Standardization Committee

General workflow

Analyze of current standards and selection of **RPV materials** with **various** T_{41J},...

- Database of results available
- Materials are available in sufficient amount

FT testing

Comparison to large specimens (FEM supported)

The same results

Guidelines and dissemination

Validation of MC(T) approach

Approval by the Authorities

Usage by NPP Operators

Correction method (including changes in standard if needed)

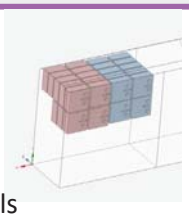
Investigation on the reason/importance/trend... (FEM supported)

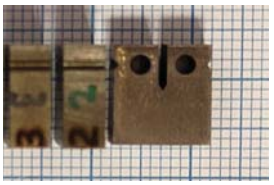
Different results

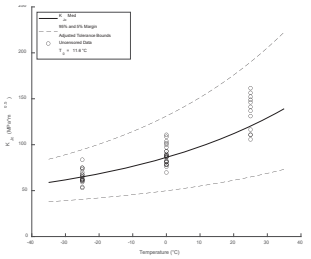
- Discrepancy of results
- Validity problems

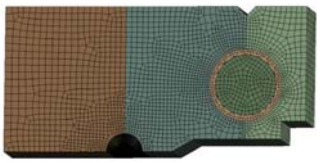
Current status

- Current standards overview was done
- Material selection process is finalized
  - Main requirements
    - Wide spectrum of properties typical for rector pressure vessel materials
    - Results from larger specimen testing available
    - Availability for testing by multiple partner (round robin)
- Selected unirradiated materials were distributed to partners to be tested in round robins
- Preparation of irradiated material is started
- First fracture toughness tests on unirradiated materials are done
- First results from round robin on numerical modelling are available









Summary

- Three presented here H2020 projects aim to increase the safety of nuclear reactors
- The output of multidirectional research activities is important to assure a longer and more reliable service of currently operated nuclear power plants, and will be also taken into account during new facilities design
- The results delivered in all three projects will have influence on providing electric power in safe and sustainable way that will meet still growing demand of modern European and worldwide societies

THANK YOU FOR YOUR ATTENTION

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