ΔH Test Lab

EPERC - 1 April, 2019 Roma, Italy

UNIVERSITÀ DELLA CALABRIA
DIPARTIMENTO DI FISICA

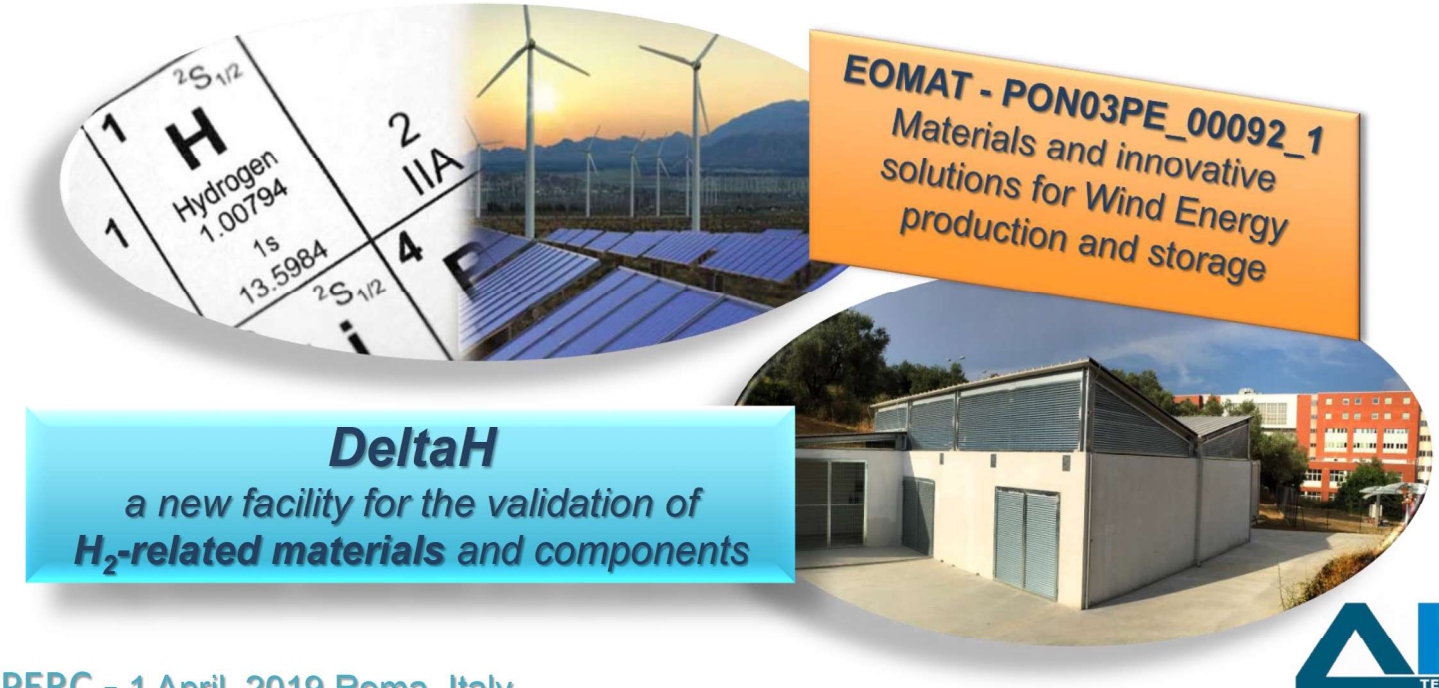
OVERVIEW

- Introduction
- DeltaH
  - Map
  - H2 supply & Compression
- Labs
  - Small Scale
  - Full scale
  - Solid state H_2 Storage Systems
- DeltaH Local Network
- Conclusions

UNIVERSITÀ DELLA CALABRIA
DIPARTIMENTO DI FISICA

INTRODUCTION

The DeltaH test lab has been built in the frame of EOMAT project with the collaboration between Rina Consulting - Centro Sviluppo Materiali S.p.A. (CSM) and University of Calabria.



DeltaH

a new facility for the validation of
***H_2-related materials** and components*

EPERC - 1 April, 2019 Roma, Italy

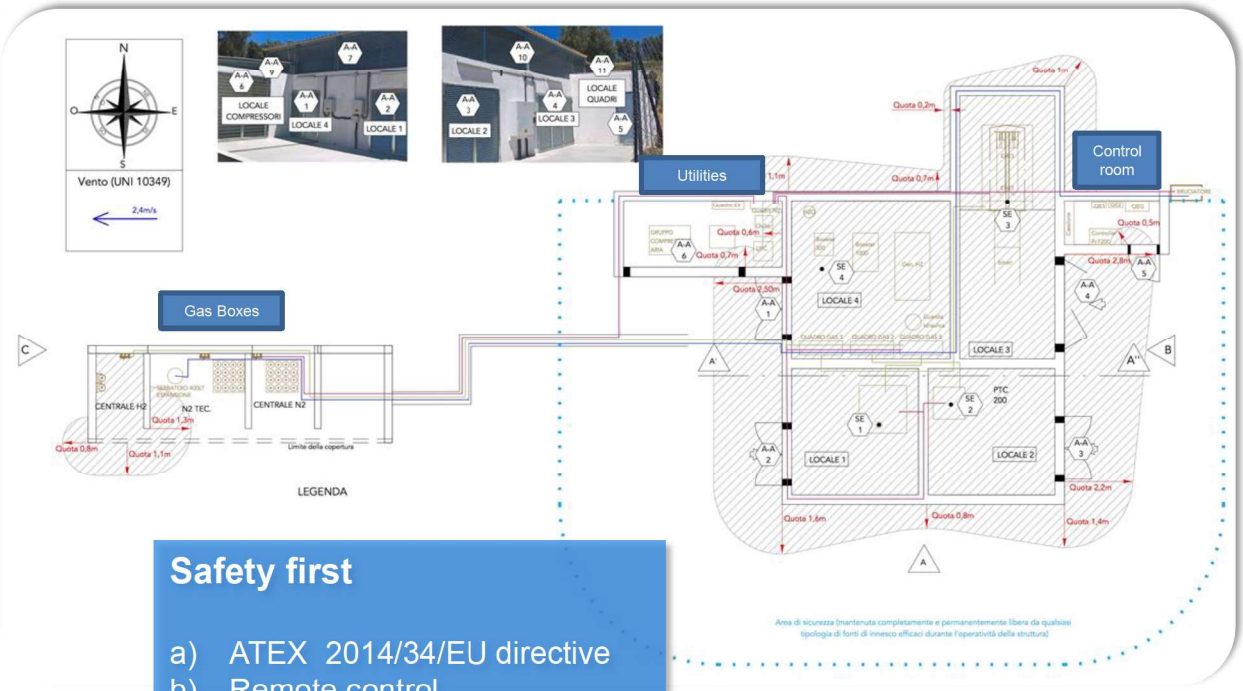
ΔH TEST LAB

UNIVERSITÀ DELLA CALABRIA
DIPARTIMENTO DI FISICA

DeltaH Map

A new building hosting

1. Solid state H_2 Storage Systems
2. In-situ Mechanical Tests
3. Full-size High Pressure Tanks and Components
4. Hydrogen Production and Compression



Safety first

a) ATEX 2014/34/EU directive
b) Remote control
c) Fully automated procedures
d) Common P&I
e) Shared safety infrastructure

TEST LAB

LABS

EPERC - 1 April, 2019 Roma, Italy

UNIVERSITÀ DELLA CALABRIA
DIPARTIMENTO DI FISICA

LABS

The research activities and services of the DeltaH Lab are devoted to the development, testing and validation of materials for the H2 storage, transportation and distribution.

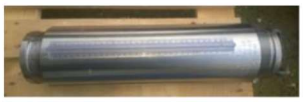
The test capabilities of the laboratory are currently three:

- mechanical tests on materials for tanks and piping (Small Scale);
- tests on components for the compressed hydrogen storage (up to 1000 bar) for stationary and mobile applications (Full Scale);
- tests on H2 sorption in solid nanomaterials (HPcT).

Test on materials
(Small Scale)

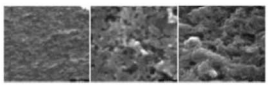
200÷1000 bar

Test on components
(Full scale)



100÷1000 bar

Test on **nano-materials**
(Hpct)



0-300 bar

TEST LAB

UNIVERSITÀ DELLA CALABRIA
DIPARTIMENTO DI FISICA

LABS: Small Scale

Small scale – Characterizations of materials for cylinders, vessel and tubes

Main Features of the vessel

- Volume: 1 l;
- Temperature: -10 °C ÷ 150 °C;
- Pressure: 0 ÷ 1000 bar;

Main Features of the traction machine:

- Gas composition: ultrapure H2 and mixtures;
- Temperature: -10 °C ÷ 150 °C;
- Pressure: 0 ÷ 1000 bar;
- Types of materials testeds: metallic and composite materials;
- Load Cell: 100kN;
- **Velocity: 10 -6[s-1];**
- Frequency: <5Hz.

TEST LAB

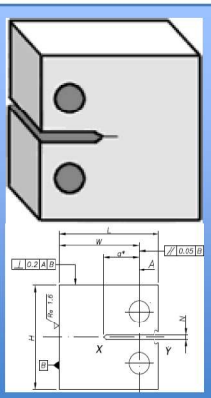
UNIVERSITÀ DELLA CALABRIA
DIPARTIMENTO DI FISICA

Small Scale: Tests and specimens

Different tests can be performed on different specimens to evaluate some mechanical features:

- Slow Strain Rate Tests;
- Notched tensile specimen tests (σ_s, k_t);
- Evaluation of threshold stress-intensity factor (K_{TH});
- Evaluation of the effect of H2 for crack propagation by fatigue approach (da/dn versus ΔK).
- Evalutation of cracks progress by the technique of potential drop (ACPD)

Specimen according to NACE TM0198-2011



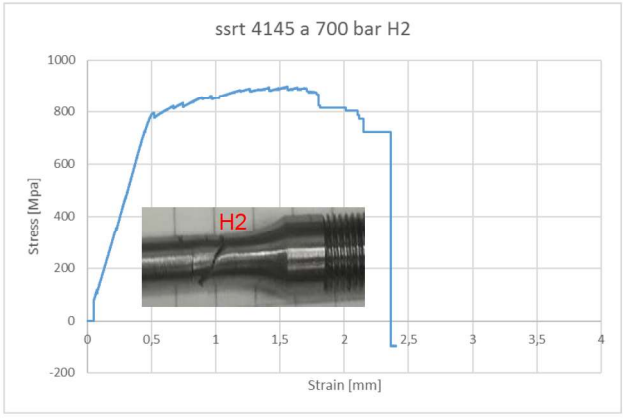
Types of sample	Geometry (mm)
a) cylindrical	L= 70
b) C.T.	L=31,25±0,25 - H=30±0,25
others	

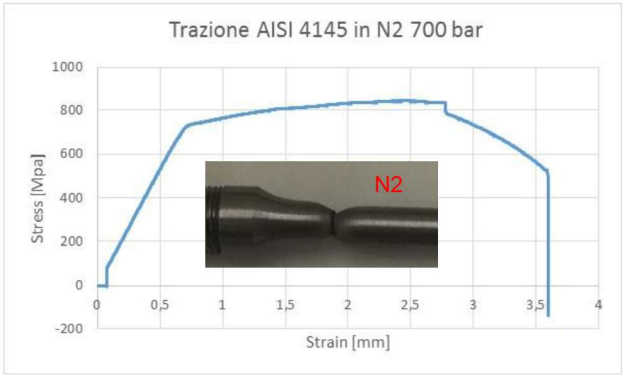
FIRST TESTS to verify the H2 effect on AISI 4145 steel

UNIVERSITÀ DELLA CALABRIA
DIPARTIMENTO DI FISICA

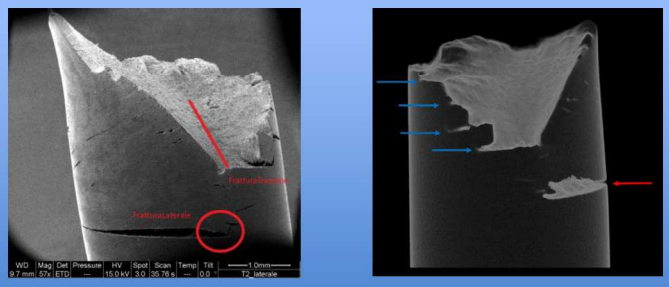
Small Scale: SSR Tests

Material	Low alloy steel
Testing Rate	10 $^{-6}$ [s^{-1}]
Gas used	100% N2 (Test 1) 100% H2 (Test 2)
Testing Pressure	700 bar





SAMPLE CHACTERIZATION



Left) SEM image and Right) µ-Ct image of fracture area of SSRT sample with evidenced secondary crack due to hydrogen embrittlement

TEST LAB

UNIVERSITÀ DELLA CALABRIA
DIPARTIMENTO DI FISICA

LABS: Full scale

Full scale testing is based on compression and decompression cycles of component (e.g. tubes, cylinders) dedicated to the storage and distribution of H2.

Main Features :

- Max operating pressure: 200÷1000 bar;
- N° of cycles: 0÷∞;
- Volume of component under test: 1÷ 15 L;
- Internal volume of the components under testing can be reduced by filler bar to reduce as much as possible the overall volume of H2 and so enhance the testing frequence;
- Ratio Pmax/Pmin: 5÷10;
- Gas composition: ultrapure H2 and gas mixture;
- Testing of cylinders with selected defects;
- Possibility to control compression rate and time of permanence at high/low pressure;
- Control of Temperature;
- The time of cycle for cylinder with a volume 1L, Pmax=500 bar is 3 minute.
- Type of materials testing: metallic and composite

TEST LAB

UNIVERSITÀ DELLA CALABRIA
DIPARTIMENTO DI FISICA

LABS: Full scale testing- safety

RINA

For safety reasons the testing component is confined in an autoclave inertized in nitrogen at P= 0,5 bar. It performs two main functions:

- The protection from possible splinters that can originate from the breaking of the components
- The realization of an inert nitrogen atmosphere around the components in order to prevent the formation of explosive Air/H2 mixture in case of rupture of the component under testing.

Main feature :

- Length: 3 m;
- Volume: 2500l;
- Max working pressure: 10 bar;
- Volume: 2500 litres;
- Automated control system

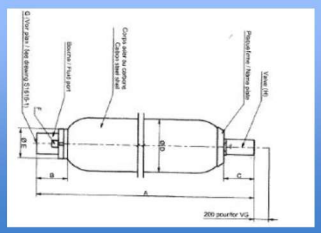
ΔH TEST LAB

UNIVERSITÀ DELLA CALABRIA
DIPARTIMENTO DI FISICA

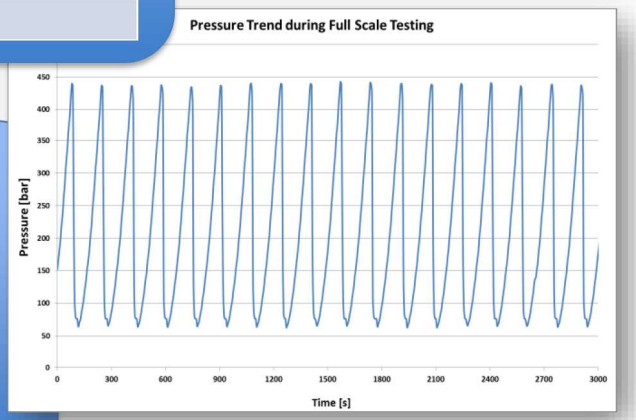
Full Scale: Test

Fatigue test was performed on AISI 4145 steel tank subjected to 3500 pressure cycles between a minimum P_{min} and a maximum P_{max}.

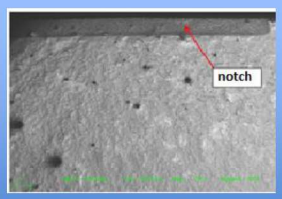
SAMPLE and TEST CONDITION



Material	Low alloy steel
Vessel nominal pressure	450 bar
Gas used	100% H2
P_{max} in full scale cycle	440 bar
P_{min} in full scale cycle	65 bar
N° of cycles performed	3500
Defects	1,0 mm and 1,5 mm notches obtained by electro erosion
cycle duration	3 minutes



SAMPLE CHACTERIZATION



Left) image of the fracture surface and Right) SEM image of fracture zone of the fatigue test in H2

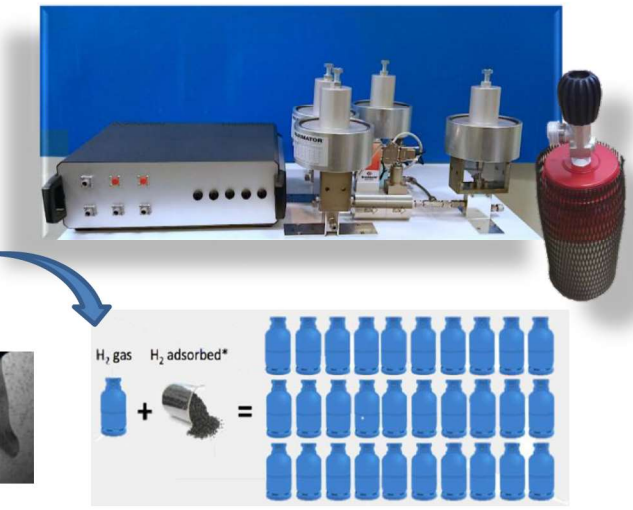
TEST LAB

UNIVERSITÀ DELLA CALABRIA
DIPARTIMENTO DI FISICA

LABS: Solid state H_2 Storage Systems

HPcT: High Pressure Sievert-type apparatus

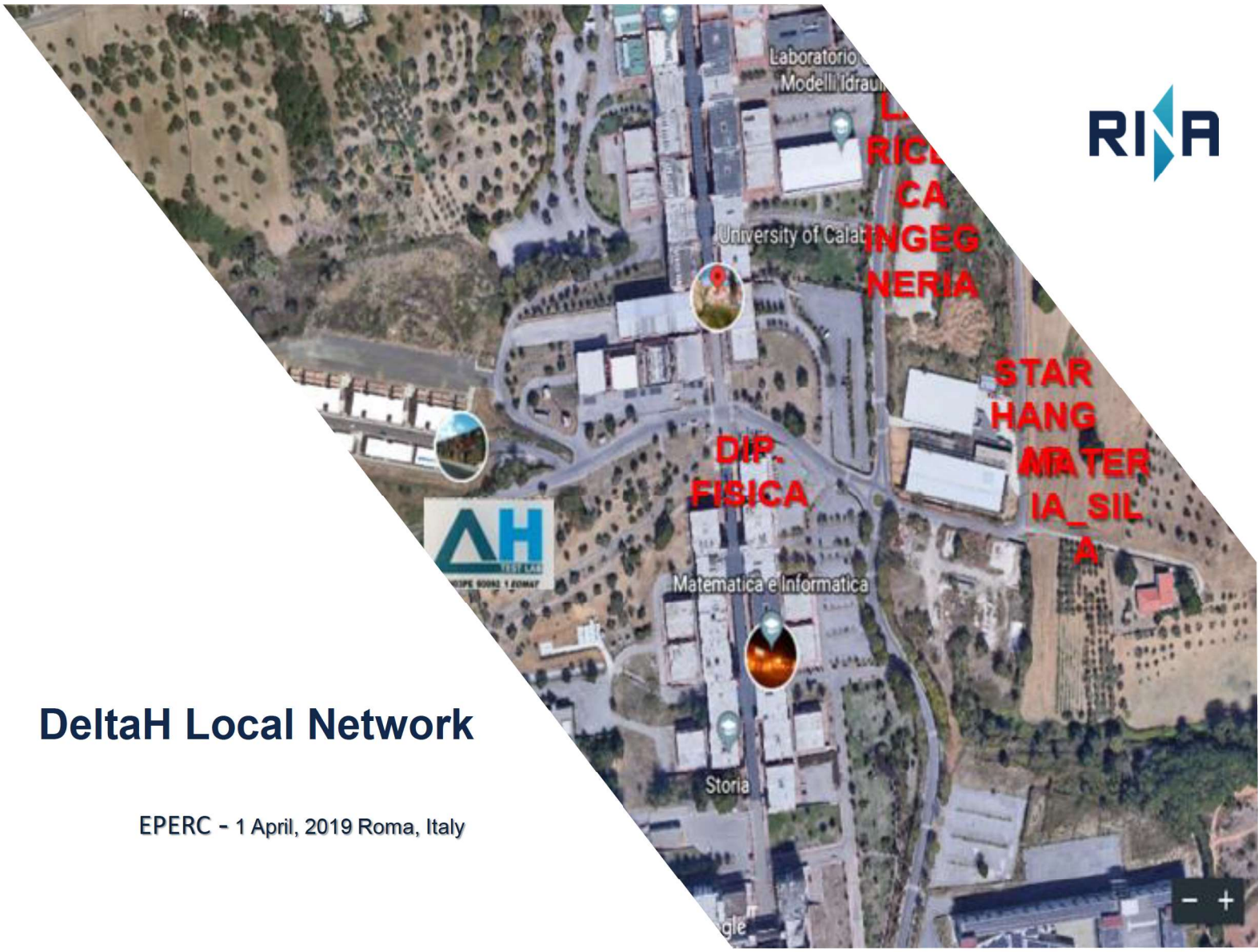
The apparatus allowing the adsorption/desorption tests on kg-scale amounts of sorbent materials at pressures up to 250 bar and controlled temperatures ranging in a wide range (RT ± 40 K).



Main Features:

- 1-10 litres tank;
- 10^{-2} bar up to 300 bar;
- 2-100 Nlitre/min flux;
- -20-100 °C temperature range;
- Gas composition: H2 and mixture
- Type of materials testing:
  Activeted carbon, zeolites, polymer, mof, metal hydrides

TEST LAB



DeltaH Local Network

EPERC - 1 April, 2019 Roma, Italy

UNIVERSITÀ DELLA CALABRIA
DIPARTIMENTO DI FISICA

DeltaH Position

The laboratory is located in the Techonological Pole of the University of Calabria :

- Physics Department *Surface Science lab*
  - **Microscopic techniques:**
    - Atomic force microscopy AFM/STM
    - SEM microscopy
  - **Spectroscopic techniques:**
    - XPS
    - AES
  - **Gas/surface**
    - Porosimetry
    - Gas Adsorption

- Mechanical Engineering Department
- STAR_Lab- *µTomo beamline:* Hard X-ray Microtomography

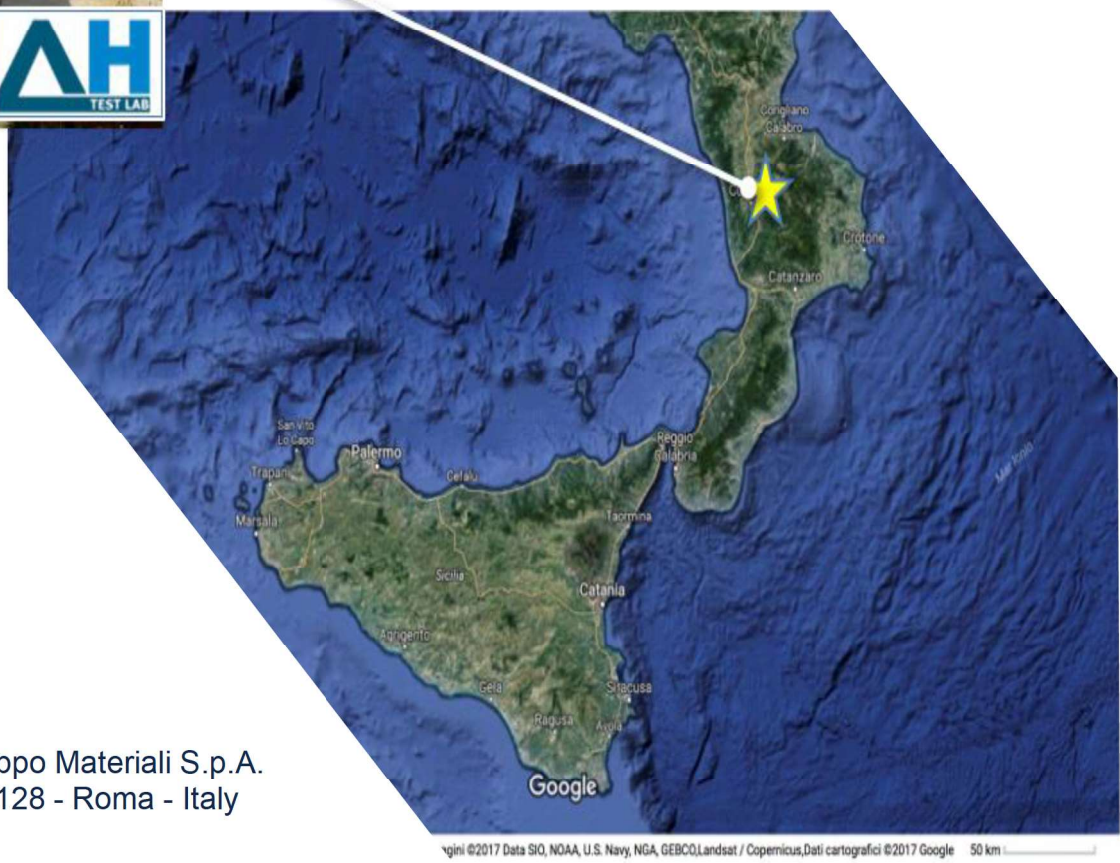
TEST LAB

UNIVERSITÀ DELLA CALABRIA
DIPARTIMENTO DI FISICA

Conclusions

EPERC - 1 April, 2019 Roma, Italy

TEST LAB



THANKS FOR YOUR ATTENTION

RINA Consulting – Centro Sviluppo Materiali S.p.A.
Via di Castel Romano, 100 - 00128 - Roma - Italy