ENCIO project: overview, status up-date and planned fireside corrosion tests

Enel – Engineering and Research Division

VGB/IEA Workshop
Advanced USC coal-fired power plants
19-20 September 2012
Vienna, Austria

ENCIO: overview

What is?

European **N**etwork for **C**omponent **I**ntegration and **O**ptimization

ENCIO is an **European project** aiming at **qualifying** materials, components, manufacturing processes, as well as erection and repair concepts, as follow-up of **COMTES700** activities and by means of erecting and operating a new **Test Facility**.

encio
European Network for Component Integration and Optimisation

ENCIO PARTNERSHIP

Leading partners

CS TT

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HITACHI
Inspire the Next

VGB POWERTECH

Generators

✓ **CEZ, EDF, EnBW, ENEL, E.ON., Eskom, EVN, STEAG, GDF Suez, GKM, RWE, Vattenfall**

Suppliers

✓ **HORA, Sandvik, Sempell, Siemens, Sumitomo, V&M, ThyssenKrupp VDM, VoestAlpine**

EU-Funded project (RFCS)

✓ **The ENCIO project has been approved to receive funding from the European Community's Research Fund for Coal and Steel (RFCS) under grant agreement n° RFCP-CT-2011-00003**

Research Fund for Coal & Steel

www.encio.eu

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Host Plant

Enel's power station
"Andrea Palladio"
Fusina (Venice)

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ENCIO: process and demonstration program

STEAM PROCESS

Steam is taken from existing boiler (Host Plant) at 540°C

Steam is additionally superheated up to 705°C by additional SH bundles installed into the furnace

Additionally superheated steam is sent to experimental components

Experimental components are installed in 4 Test Loops

Pipe repair concept TEST LOOP 1	**Take advantage of additional investigations carried out in COMTES700 and in ENCIO to get optimized WPS. Prior to start any weld testing basic investigations have been done to characterize the aged material.**
Lifetime monitoring TEST LOOP 2	**The creep behavior of alloy 617B is monitored by running tests under respective load and temperature, as well as by using a thin wall piece designed for ~30000 h (measuring and monitoring of the creep online).**
HIP Process TEST LOOP 2	**Interesting for T-pieces, valve bodies and turbine parts. Already commercial, but has been never used for pressure parts and not applied to alloy 617B or alloy 625. Potential for cost reduction.**
617 OCC / 263 HR6W TEST LOOP 3	**Explore possible improvement in weldability of 617 by means of improved melting processes to reduce the amount of impurities within the ingot. 263 promising for hot corrosion and flexible operation.**
Turbine cast material TEST LOOP 4	**Need to prove thick walled welds in the range of the real pipe dimensions of a demonstration plant with material combination alloy 617 OCC - alloy 625 cast. The material combinations alloy 617 OCC/alloy 625 is not tested in COMTES700 (real dimensions).**
Erection concept	**Orbital narrow gap TIG welding for new material as well as for aged material is applied.**

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Erection sequence and general schedule

Sections of the Test Facility

BOP, components external to the boiler furnace (excl. TL)	Components internal to the boiler furnace	Experimental components (test loops)

	Item	Delivery	Erection sequence
1	✓ BOP, main steam line, including valves	by April 2013	To be erected prior to add. SH
2	✓ Headers and heating surfaces	end of April 2013	To be erected during the boiler maint. overhaul
3	✓ Test Loops	Apr-Aug 2013	Flexible after item (1) and (2)

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Main facts

- ✓ TSF installed - tie-ins installed end of Aug. 2012
- ✓ all time critical orders already put in place
- ✓ test loop 1: material available, trial welds started
- ✓ test loop 2: per-investigation trials accomplished and pipe manufacturing started
- ✓ test loop 3: pipe and weld manufacturing started. NDE started. Pipe cut and sampling started (PMA, WPQR, R&D purposes)
- ✓ test loop 4: material manufacturing

End of erection scheduled end of August 2013

Commissioning planned to start on September 2013

Experimental operation to be started by end 2013

tie-in installation

HR6W pipe – experimental component

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Rationale for additional corrosion tests

Risk analysis was carried out on components considered as key for reliability, including additional SH bundles

Critical issues	Actions taken
Litterature data are spread and rather applicable to the relevant material (617B), combustion environment and operating temp. at the same time	A) the max tube schedule was selected
Refuse Derived Fuel (RDF) is burnt toghether with coal	B) on-site corrosion tests were scheduled with respect to relevant materials, design conditions and environment

RDF may affect the SO_2/SO_3 ratio; also, RDF may activate other corrosion mechanisms. This leads to increased uncertainties

Additional opportunity taken: alloy 263 is additionally tested toghether with alloy 617B (which is the selected SH tube material)

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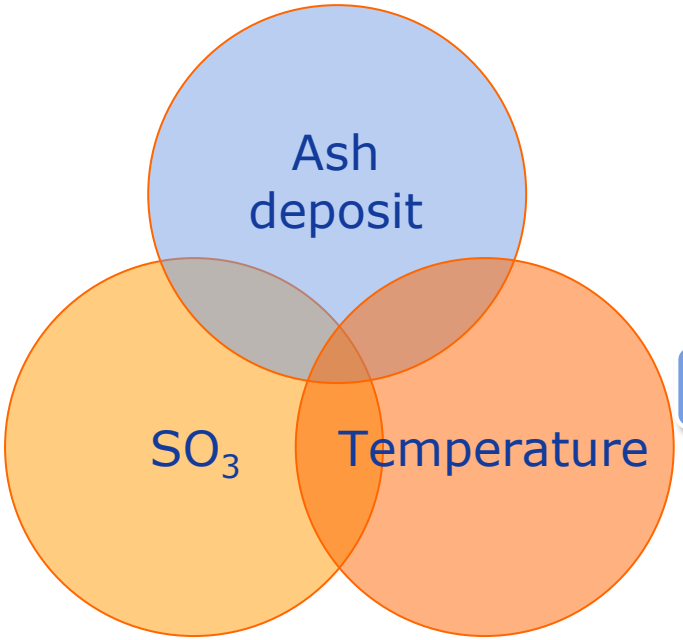
Why do we need experimental data?

hot corrosion: definition

Deposit-induced corrosion of metals and alloys, occurring in a hot oxidizing gaseous environment



Corrosion mech. are affected by

- ✓ exposure time
- ✓ temperature
- ✓ physical state of deposit (liquid/solid)
- ✓ chemical composition of deposit
- ✓ surrounding gas composition
- ✓ alloy chemical composition

factors affecting fundamental phenomana of hot corrosion

Other factors which may affect

- ✓ microstructure, gas velocity, cyclic vs. isothermal conditions, dust load, geometry

factors indirectly affecting corrosion behaviour

Source: F. Pettit, Hot Corrosion of Metals and Alloys, Oxid Met (2011) 76:1-21, doi 10.1007/s11085-011-9254-6

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Hot corrosion mechanisms – short summary

Mechanisms

Propagation via:

- ✓ basic fluxing
- ✓ acid fluxing
- ✓ sulphidation

In the temperature range of interest (650÷750°C), hot corrosion is supposed to occur via gas-phase induced acid fluxing or sulphidation

Presence of Mo in the alloy contributes to increase the total metal waste:

- ✓ deposits become acid due to the incorporation of **Mo oxide**
- ✓ NiO and Cr_2O_3 dissolve where MoO_3 activity is high

Relevant Hot Corrosion type

Type II hot corrosion:

- ✓ 650°C-750°C, typically
- ✓ Sulfate deposits (e.g. Na_2SO_4)
- ✓ SO_3

$$Mo + 3/2\ O_2 \rightarrow MoO_3$$
$$MoO_3 + Na_2SO_4 \rightarrow Na_2MoO_4 + SO_3$$
$$Cr_2O_3 + 3MoO_3\ (\text{in } Na_2SO_4) \rightarrow 2Cr^{3+} + 3MoO_4^{2-}$$
$$3NiO + 3MoO_3\ (\text{in } Na_2SO_4) \rightarrow 3Ni^{2+} + 3MoO_4^{2}$$

In **boilers** it's important to consider the presence of S and Cl, Sulphur both in gases (SO3) and ashes (Na2SO4 – K2SO4)

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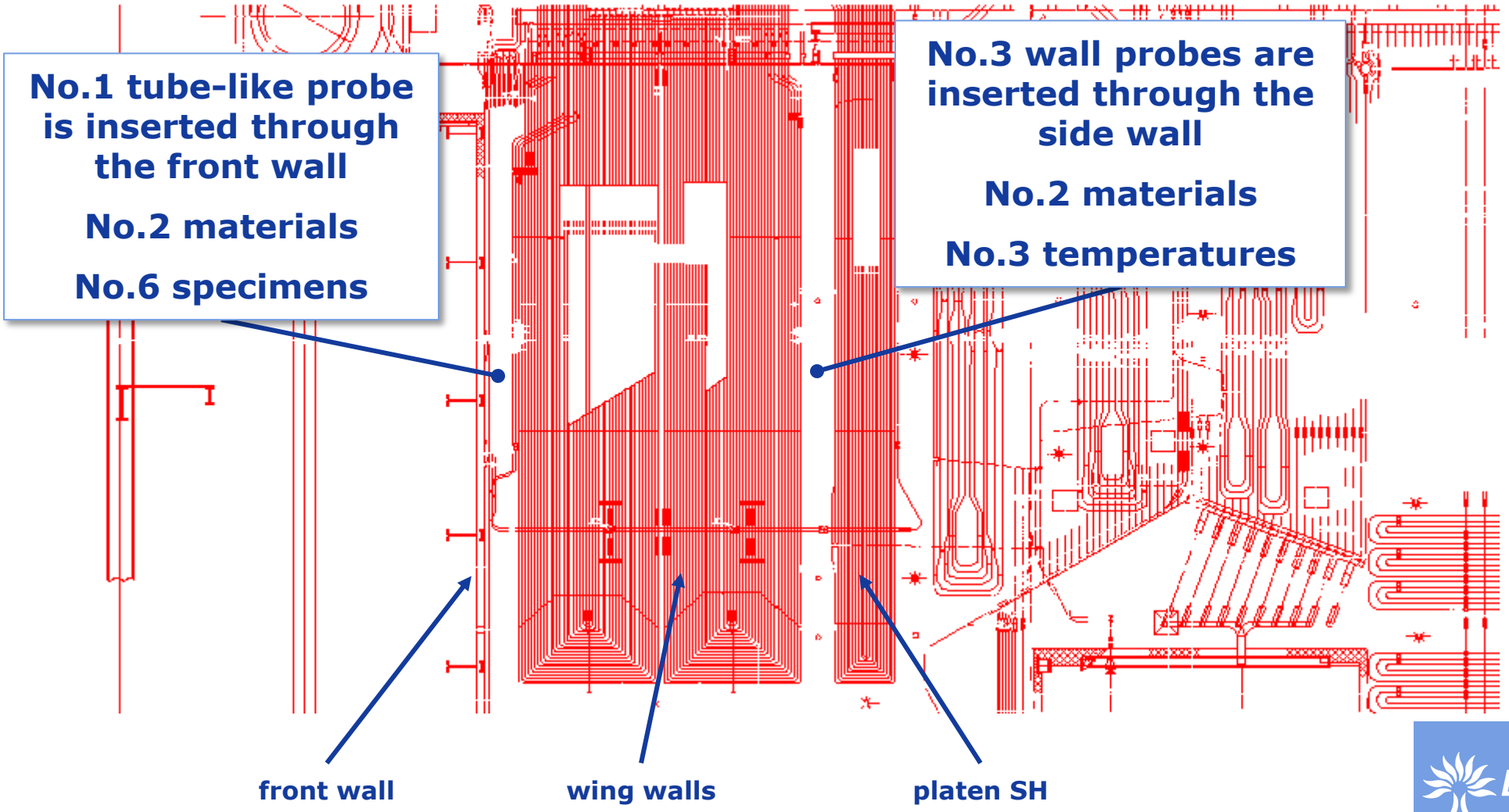
Positioning of probes into the furnace



Tube-like corrosion probe - commissioning

Experimental activity started early Sept. 2012

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Selected temperatures for corrosion tests

	Alloy 617B			Alloy 263		
	650°C	700°C	750°C	650°C	700°C	750°C
Tube-like probe		X			X	
Wall probe 1	X			X		
Wall probe 2		X			X	
Wall probe 3			X			X

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Tube-like corrosion probe - specimens

Selected materials

No.10 pieces, No.2 materials:

- ✓ Alloy 617B
- ✓ Alloy 263

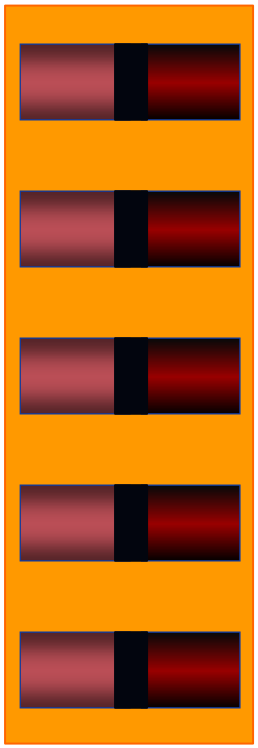
Components manufactured

No.5 welded joints:

- ✓ OD 38 mm x WT 8,8 mm
  70 mm long each

Welding technology

- ✓ Submerged Arc Welding
- ✓ Filler material: 617B



5 welded joints

Devoted to destructive testing before exposure (time=0 characterization)

Devoted to destructive testing after exposure

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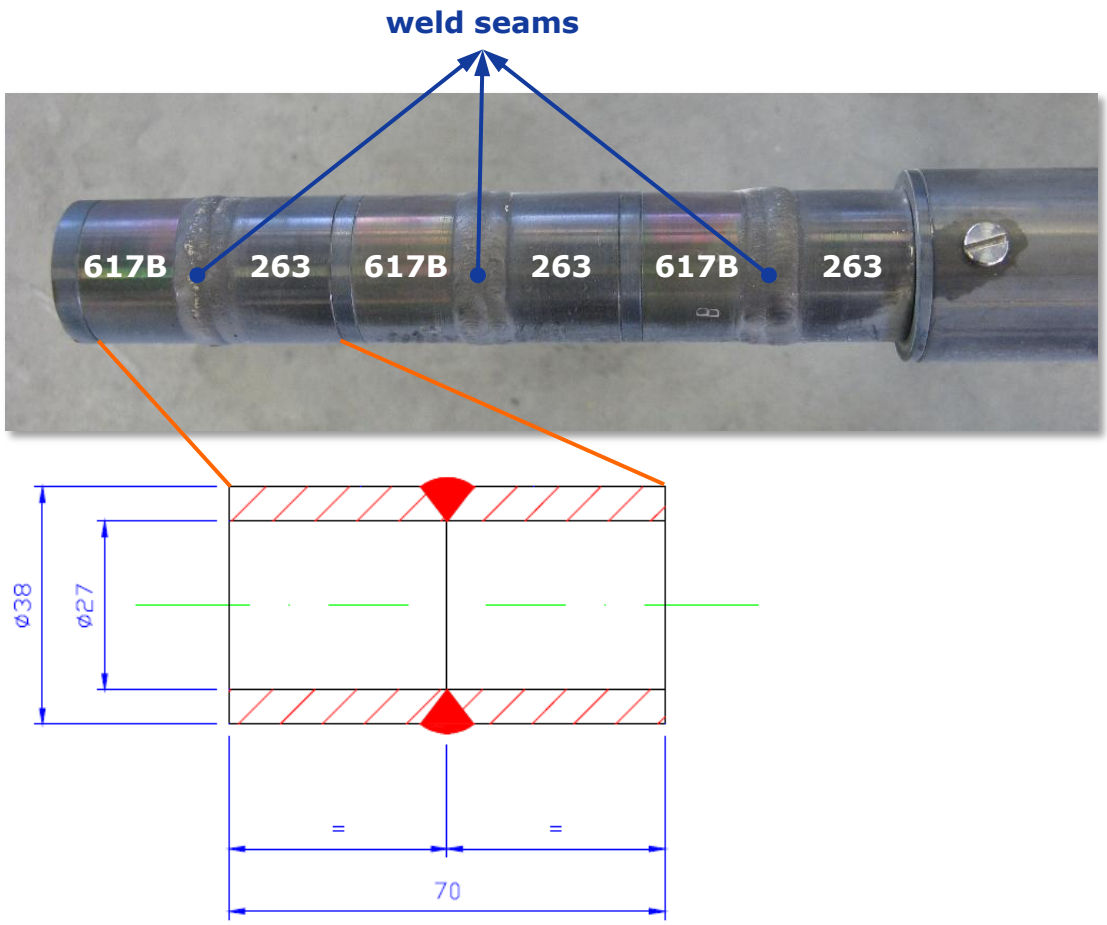
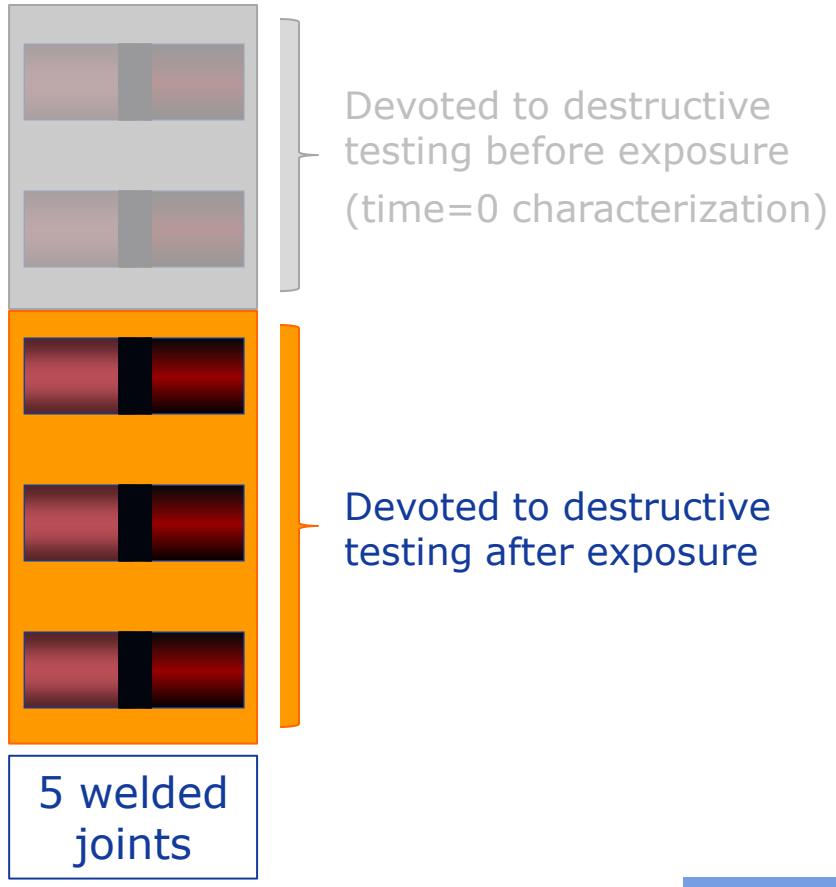
Tube-like corrosion probe - specimens





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Investigations

Analysis	Target
Metallurgical/metallographic tests (LOM, SEM, EDS)	Determination of the type of corrosion
Hardness measurement	Microstructural/precipitate evolution on bulk material
Thickness measurement	Determination of the corrosion rate

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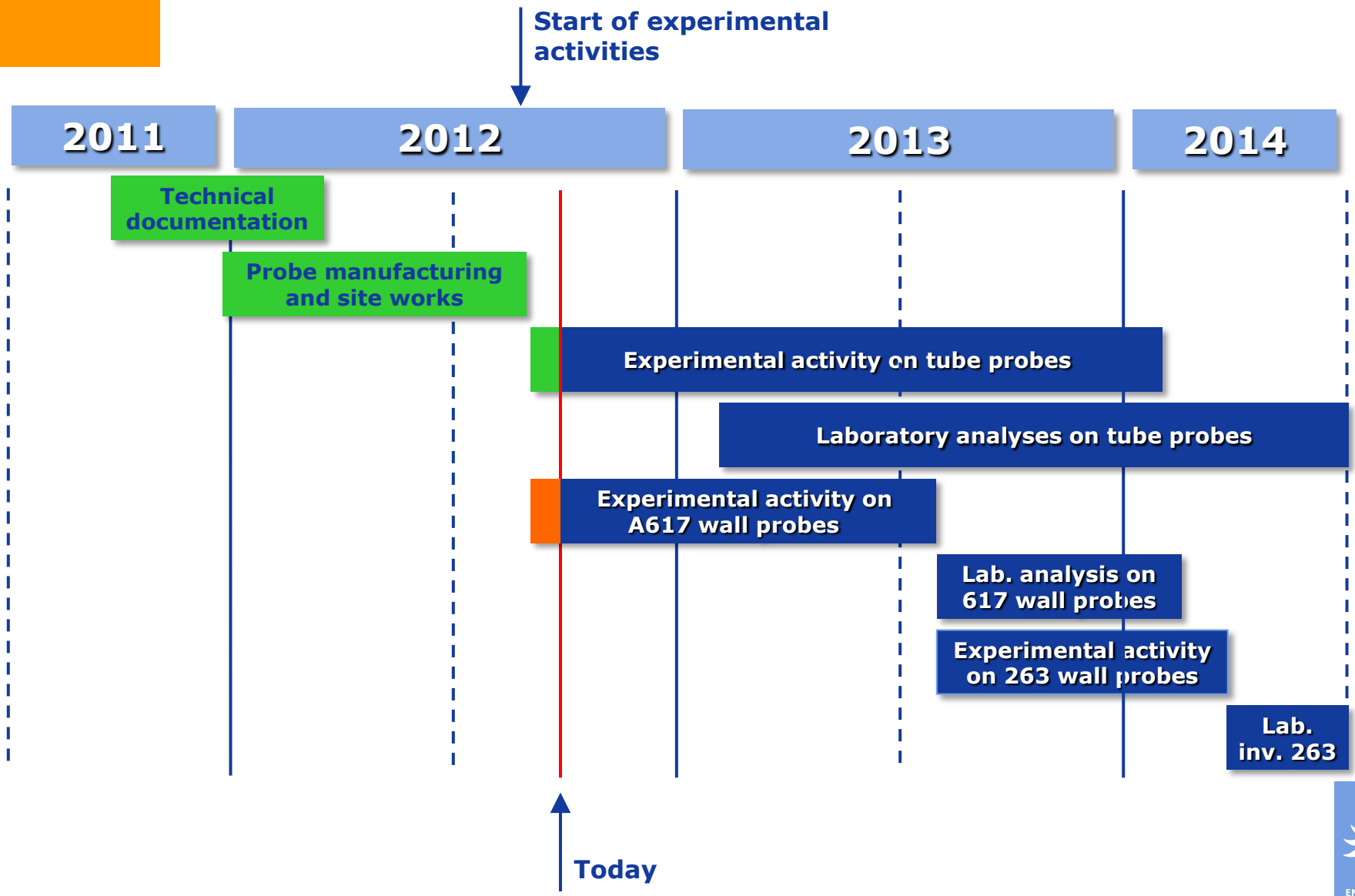
Time schedule



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Thank you for your kind attention