

- **Retrievability** - “*Ability to retrieve (remove) waste packages at different stages of the DGR life*”
- **Reversibility** - *A broader meaning: Decision-making process adopted during the Project life; it involves decisions like: “Pursuing, Modifying, Retrieving”.*

June 28, 2006 – Nuclear Waste Management Act :

- Deep **Reversible** Geological Repository (aka DGR or Cigéo) is the reference solution for HLW & IL-LLW Elimination;
- DGR Reversibility cannot be less than 100 years.

“Reversibility Conditions” :

- Andra first issued its “Statement of opinion” used as a basis for discussion with the French Parliament (OPECST),
- In 2016, Andra issued its first “Retrievability Option” File (DORéC) for discussion with the Nuclear Authority (ASN) and its TSO (IRSN).

Need for tangible Retrievability Demonstrations :

- Practical trials of prototypes;
- Integration of solutions in the Cigéo design;
- Planning of Retrieval tests during the Cigéo “Pilot Phase”.

Question: is Reversibility likely? **Answer:** very much so !
This is why a Pilot Phase is planned in Cigéo.
Question: is Retrievability likely ? **Answer:** not so much... but at the end political decisions will prevail on all other considerations!
SO BE PREPARED AND WORK ON IT!

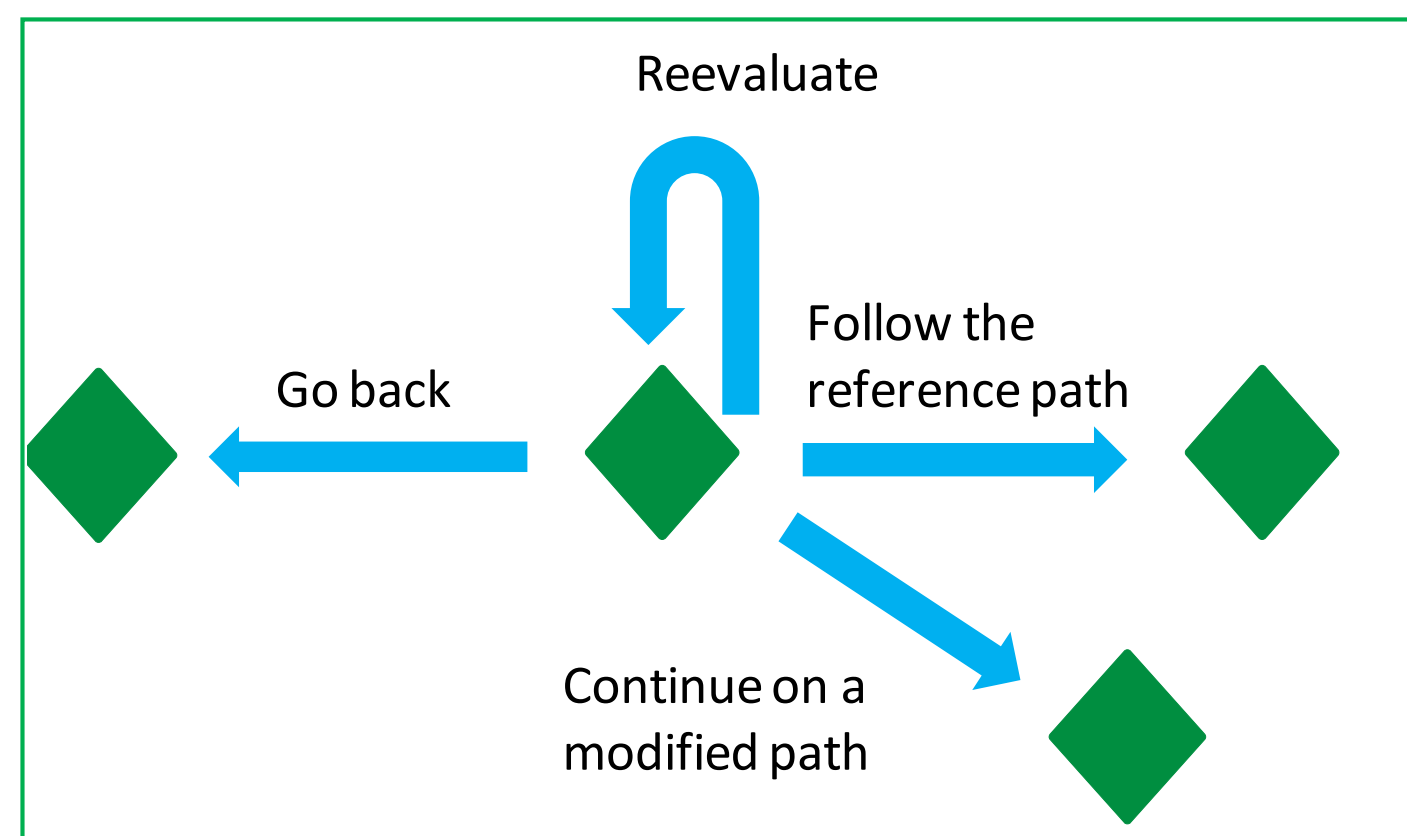
Retrievability in Cigéo Design

- Work on phenomenology:
 - ✓ What is the state of the disposal cell / of the package at time of retrieval?
- Work on cell design and package design:
 - ✓ Cell structure must resist rock creeping over 150 years,
 - ✓ Minimize effects of corrosion,
 - ✓ Optimize operational conditions (ventilation, flushing).

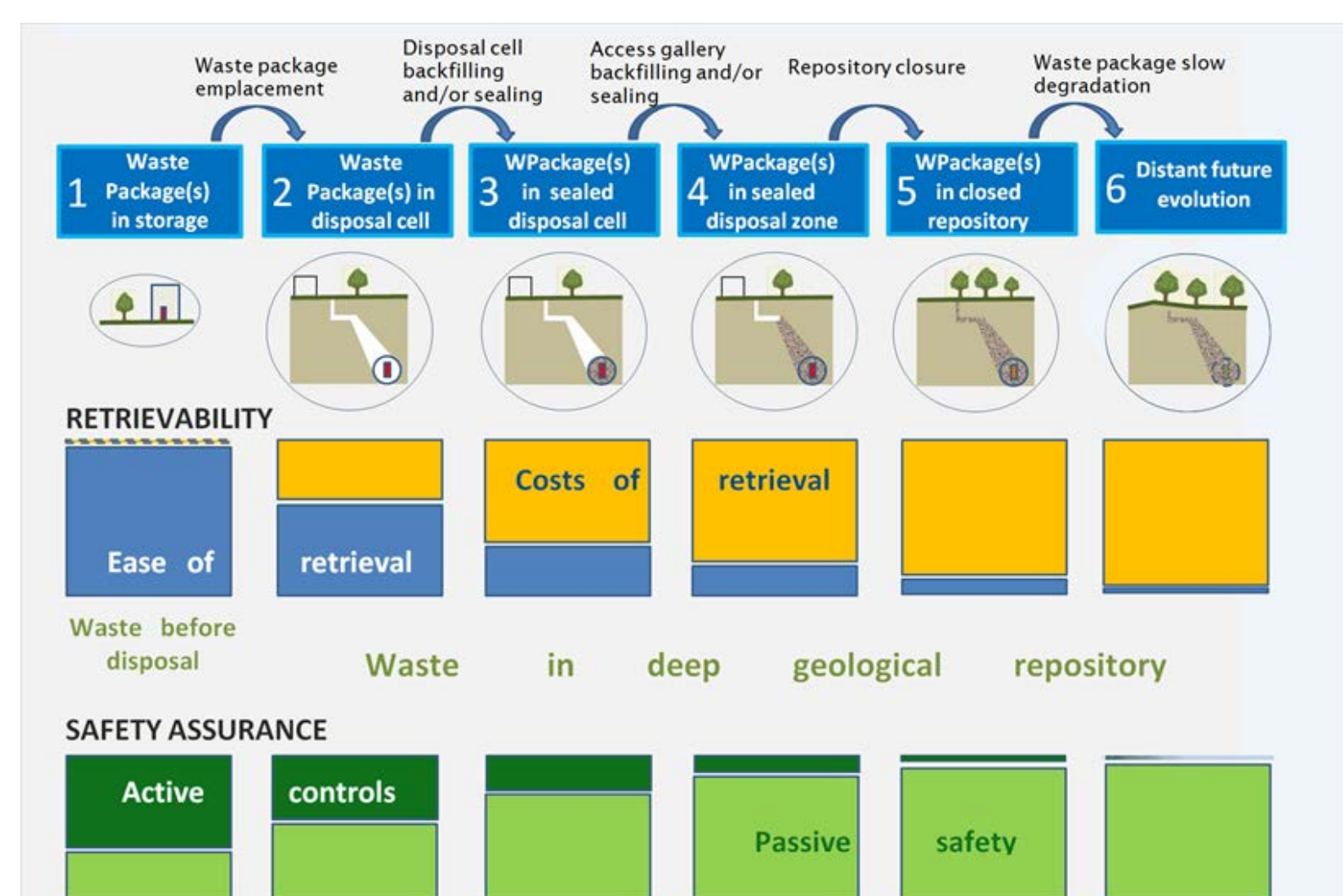
Tests of Industrial Prototypes

- Develop monitoring tools:
 - ✓ Robust sensors and data transmission devices.
- Develop mechanical systems for retrieval:
 - ✓ Inspection Robots;
 - ✓ Retrieval Robots.

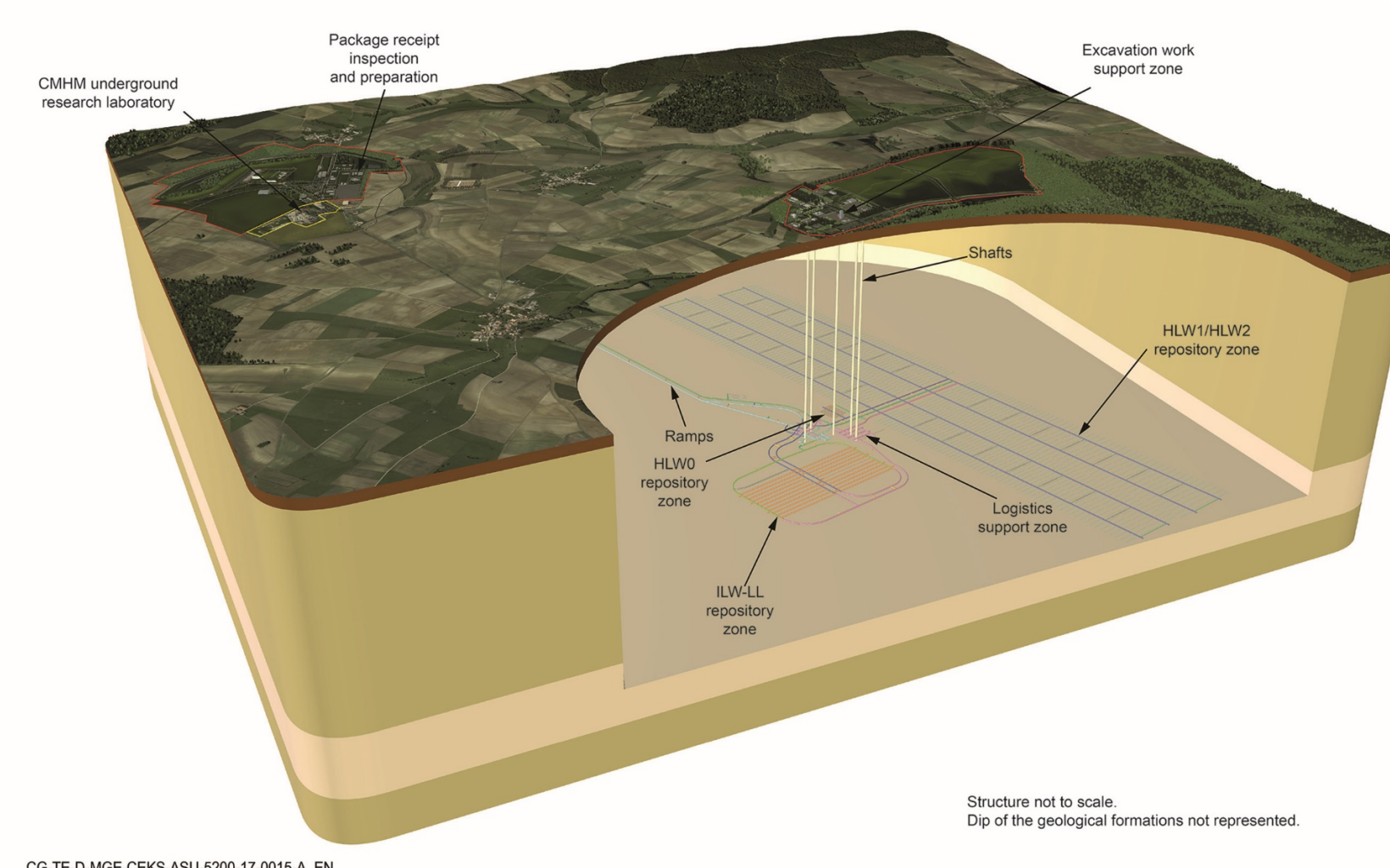
Reversibility Options for Cigéo during its life time



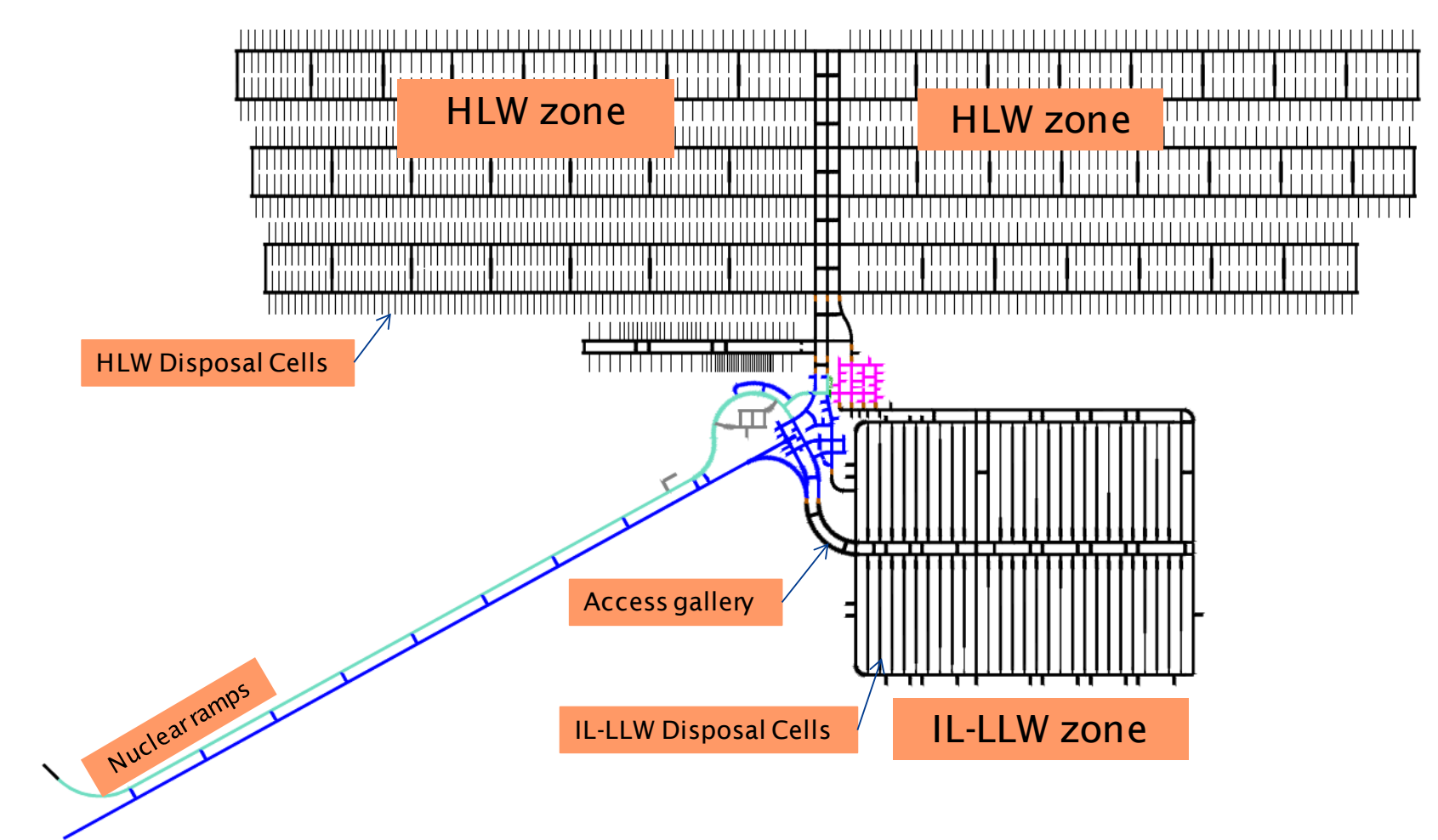
Retrievability Scale as defined by OECD/NEA



OVERVIEW OF CIGEO FACILITIES



CIGEO UNDERGROUND FACILITIES



The Retrieval Test Objectives & Milestones

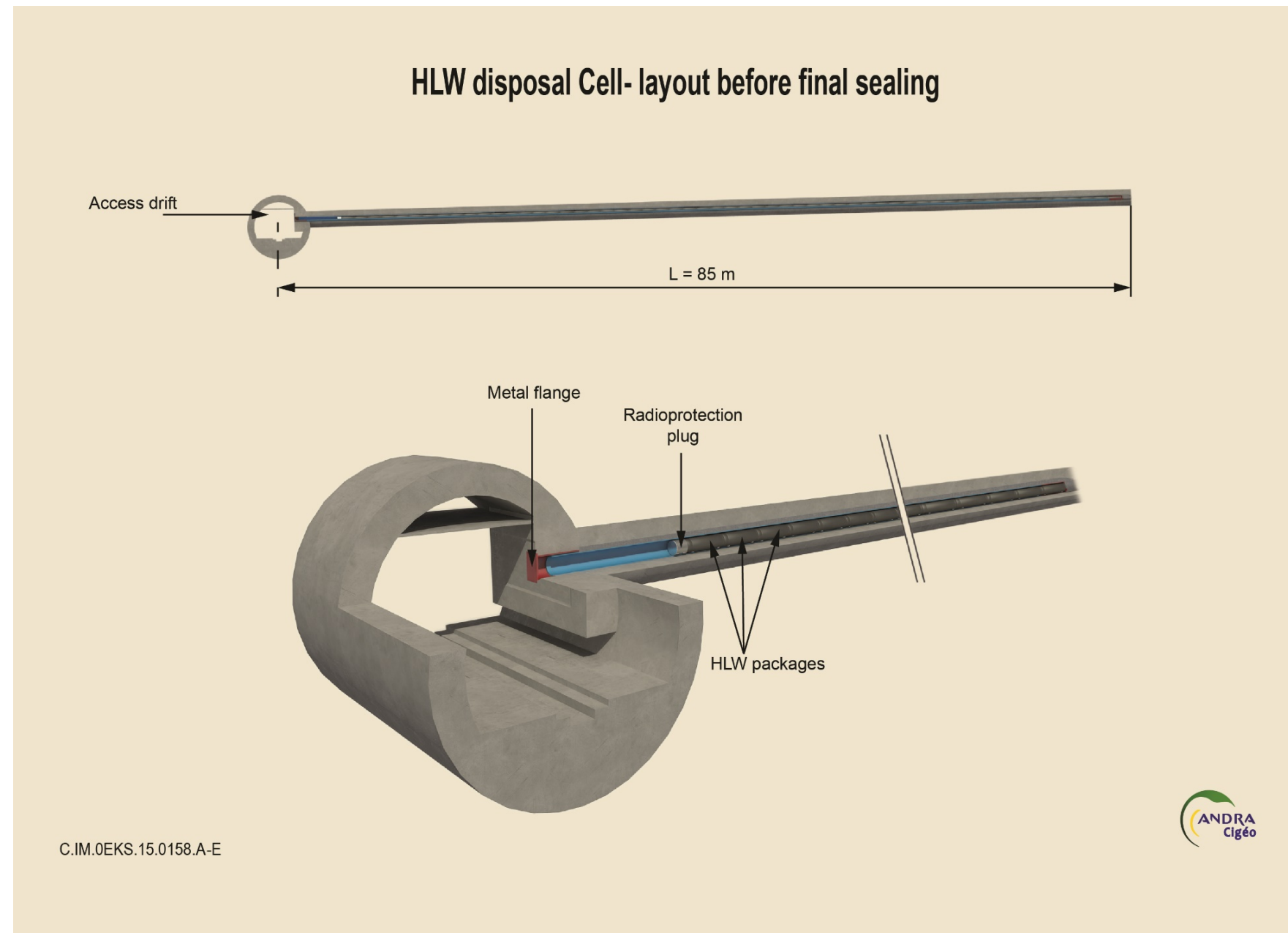
Test bench created for a retrieval test campaign in 2014-2015:

- Devices installed to provide heat and humidity:
 - ✓ Temperature maintained at 90°C inside the steel liner;
 - ✓ Salt spray (generating a flow of condensed water running on the liner bottom intrados);
 - ✓ Creation of corrosion products on steel casing intrados and container wall;
- Environmental conditions created considered as a very penalizing situation:
 - ✓ In the real underground environment the thermal peak should be reached after some 10 years;
 - ✓ While water inlet peak may be somehow deferred in time by comparison to the one created on the test bench;
- Need to address the technical difficulties for Retrieval Robot:
 - ✓ Temperature tough on Robot actuators (change from electric to pneumatic);
 - ✓ Robot moving forward in rust not easy (change trolley from hard rubber to steel for better grip);
 - ✓ When coming back: Robot and container are scrapping rust (build-up): identification of risk of jamming radioprotection doors.

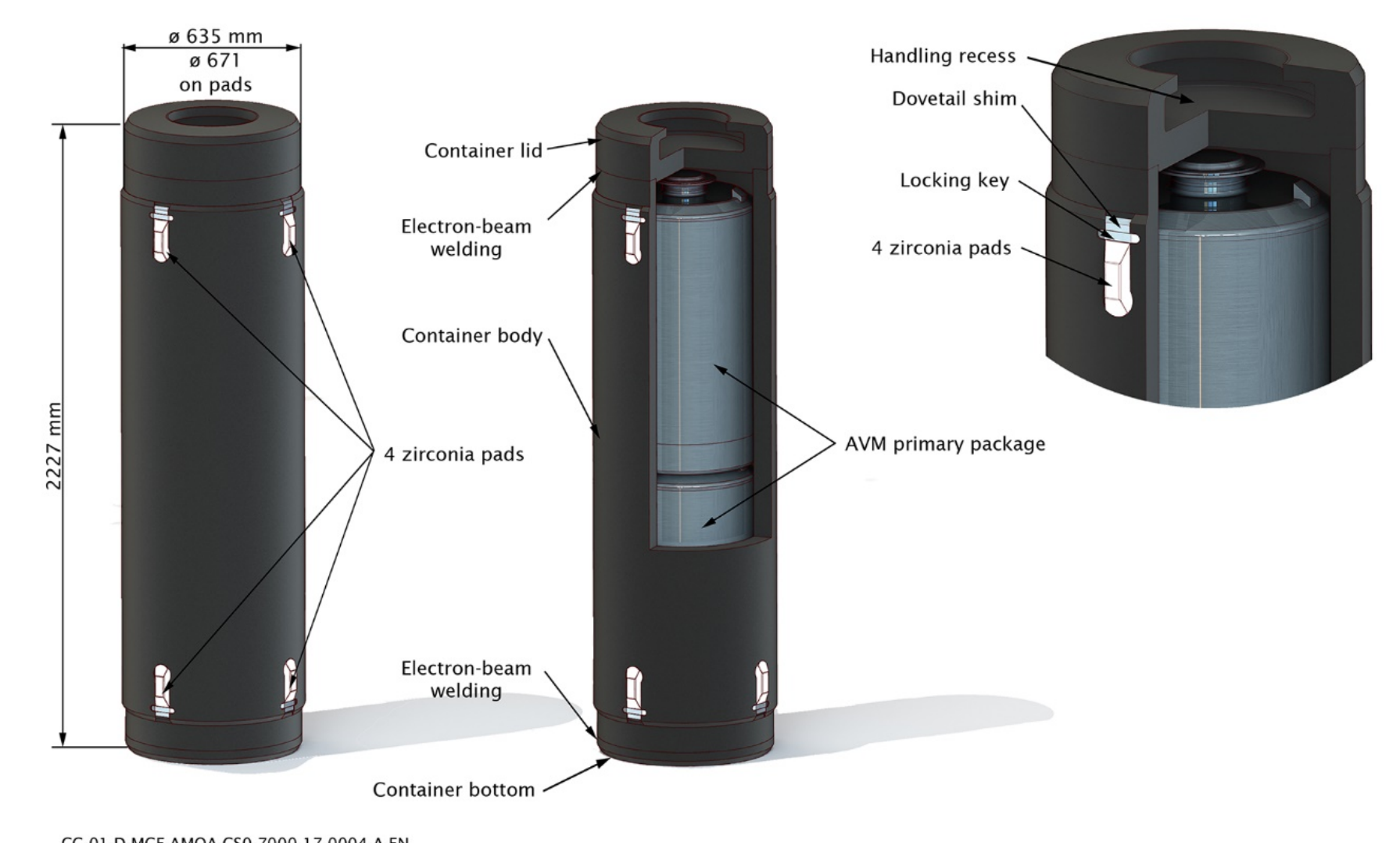
Need to develop another robot to scrap rust on casing and collect it in 2016 -2017:

- Design, fabrication and test of a cleaning robot in 2016,
- Integration of specific fixtures on the Pushing Robot as designed for the Cigéo HLW emplacement-retrieval process (2017).

The disposal container is emplaced inside a steel cased horizontal borehole (the disposal cell) by a “pushing robot”



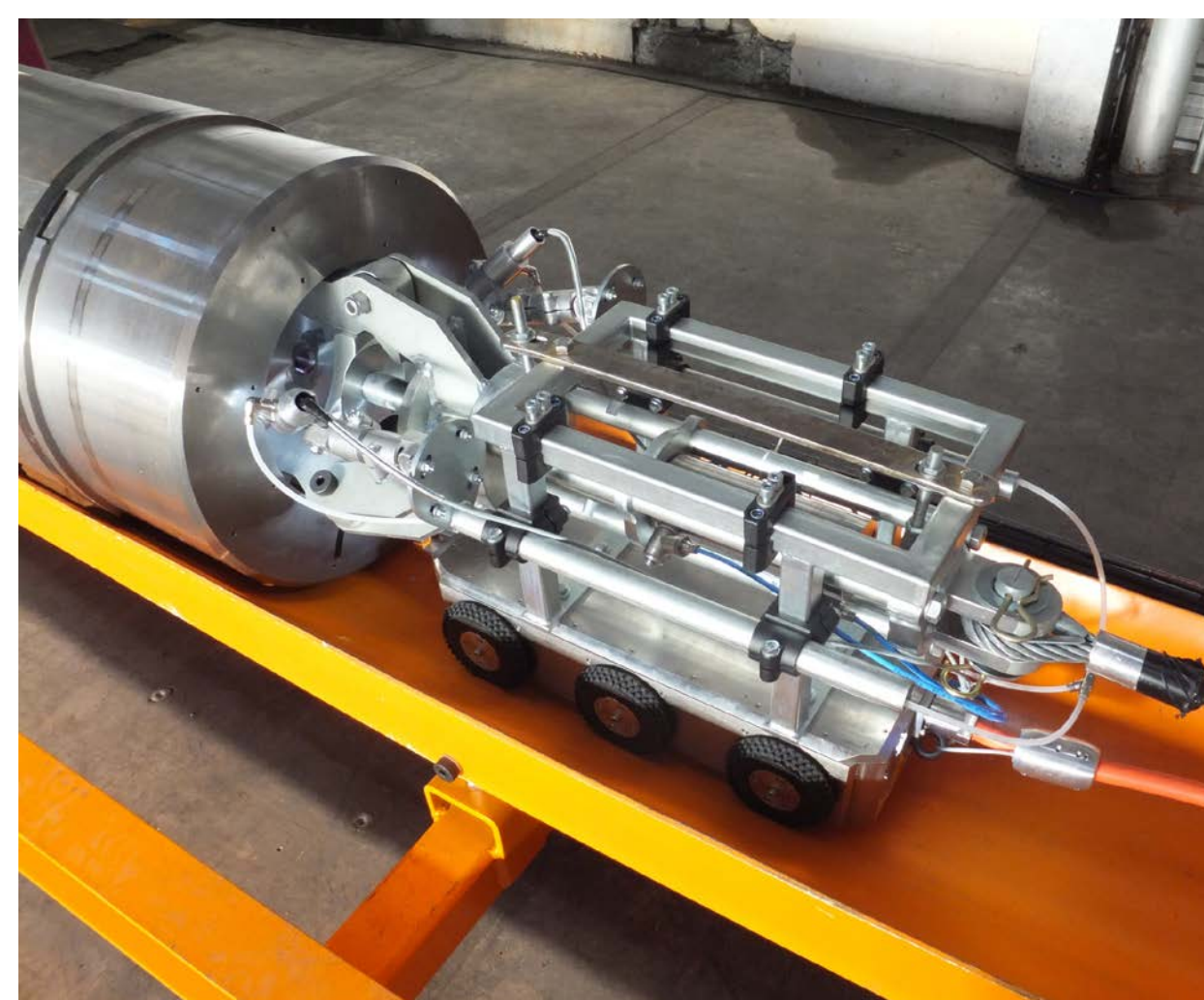
The vitrified (HL) primary waste package (from COGEMA) is encapsulated in a steel overpack (60mm thick), forming the disposal container.



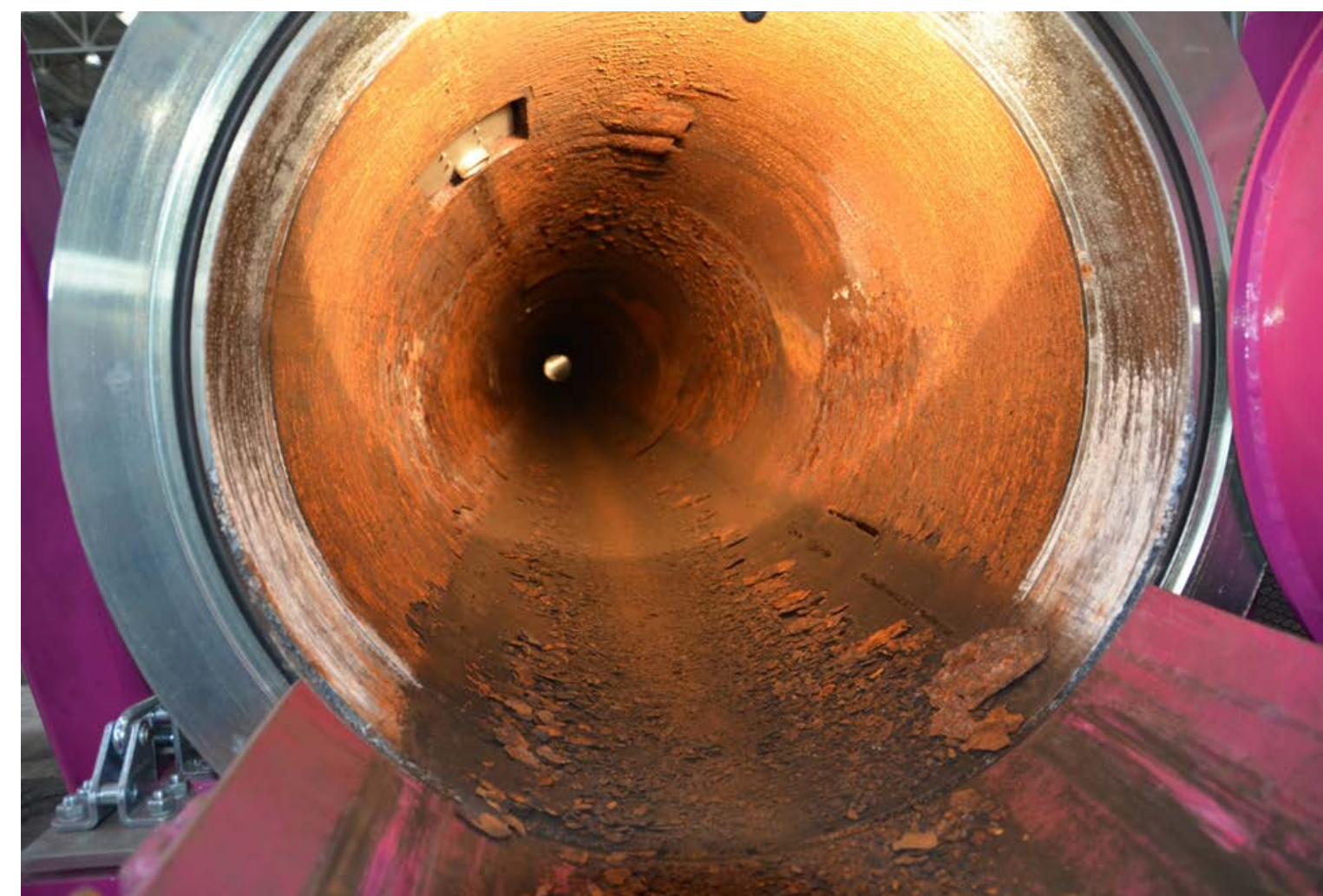
Overall view of test bench with heating and saltwater spraying systems



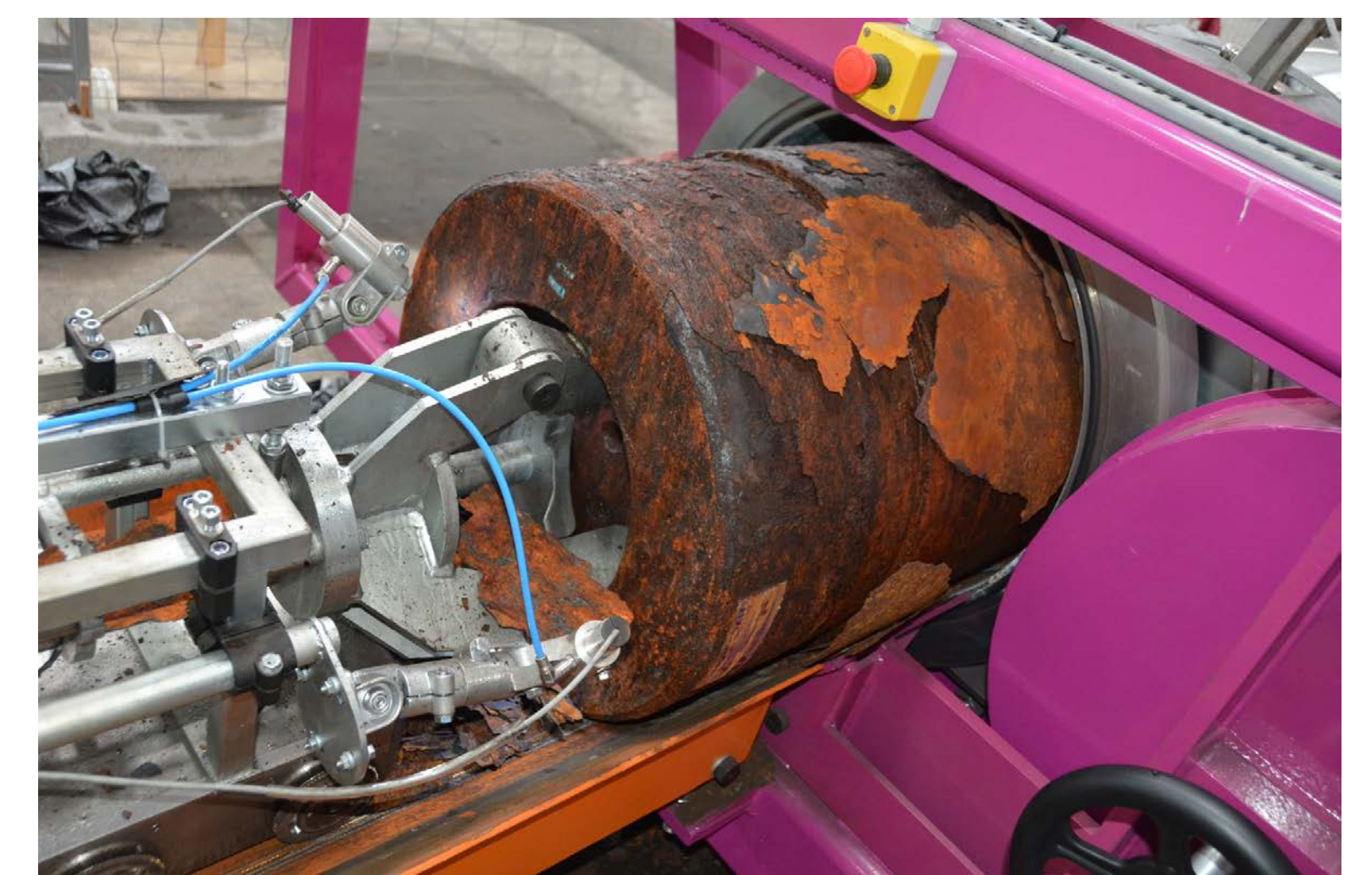
The disposal container is removed by a pulling robot (before heating and corrosion phases)



Corrosion inside the casing, following activation by heat and saltwater spraying



The disposal container is removed from the disposal cell with a significant corrosion product build up



Overall view of cleaning robot



Cleaning robot at work



Collection of corrosion flakes in dedicated box



- Capacity to remove a waste package out of a disposal cell in severe environmental conditions is proven ,
- Considerable work remaining to pass from prototypes to industrial systems :
 - ✓ Monitoring devices;
 - ✓ Inspection robots;
 - ✓ Cell atmosphere control system & purging;
 - ✓ Retrieval tests in real conditions.