

THE NEW CABRI WATER LOOP

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Holiday Inn

Gaithersburg, MD

➤ THE NEW CABRI WATER LOOP

- ✓ Description
- ✓ Safety options and design

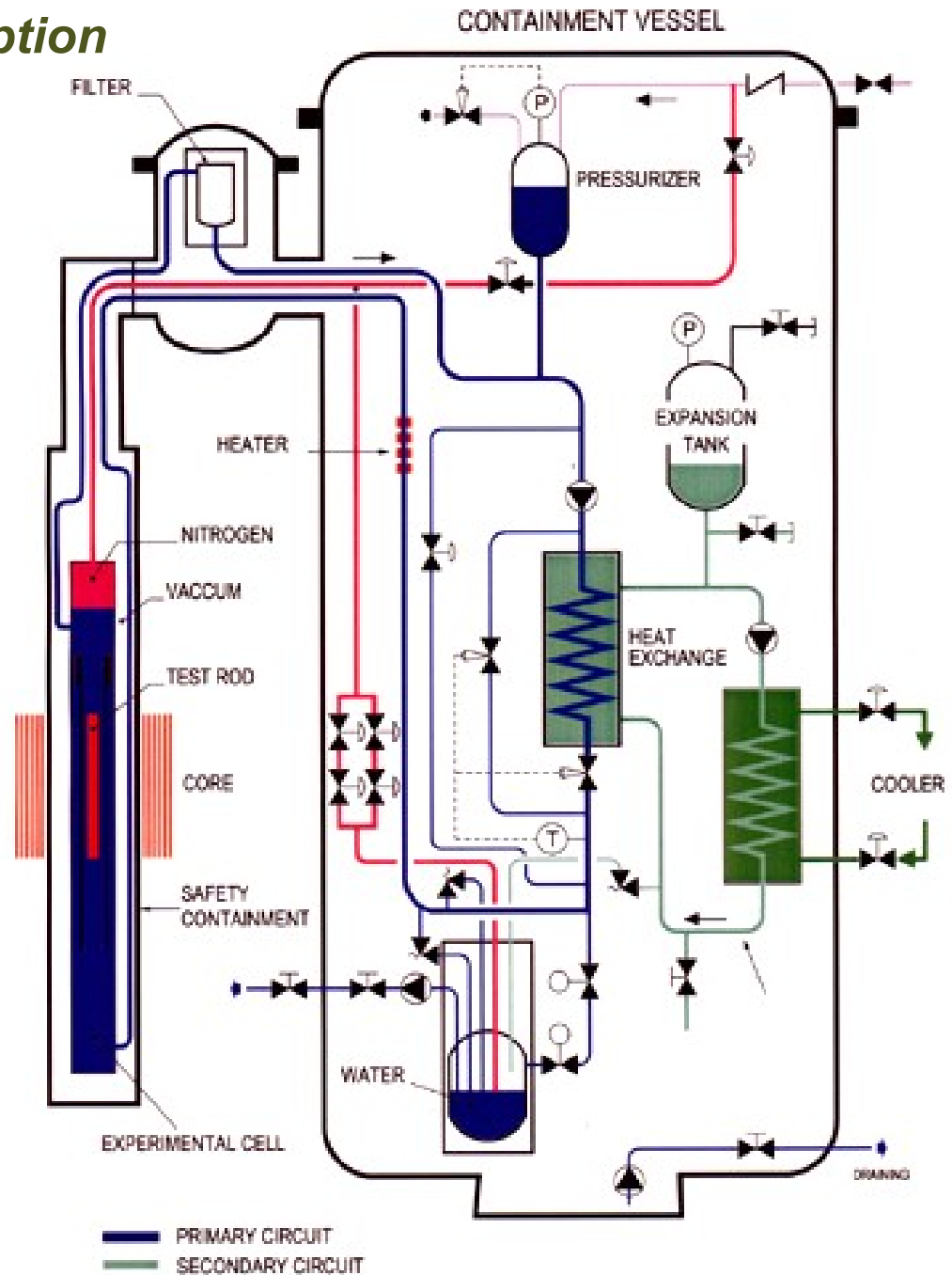
➤ THE ZIRCALOY EXPERIMENTAL CELL

- ✓ Description
- ✓ Zircaloy characterization
- ✓ Zircaloy / Stainless steel junction
- ✓ Ultrasonic control equipment

Cabri water loop - Description

The main components are :

- In core experimental cell
 - ✓ Water pressure vessel
 - ✓ Safety tube
- Primary circuit
 - ✓ Primary pump
 - ✓ Pressurizer
 - ✓ Heat Exchanger
 - ✓ Heater
- Filter
- Draining Tank
- Secondary loop and cooling loop
- Containment vessel
- Auxiliary circuits



Nominal operating conditions in the experimental cell :

- ✓ Pressure : 155 bars
- ✓ Temperature : up to 300°C
- ✓ Flow rate : from 1 to 6 m³/h

➤ The maximum power extracted by the cooling loop is 75 kW

Main safety options :

➤ The loop is composed of two barriers :

- ✓ First barrier : the primary loop (up to double blocking valves on each connections).
- ✓ Second barrier : Safety tube (for in core part), main containment vessel, piping double containment.

➤ Each components have been displayed in safety classes. And with each safety classes was associated a equivalent level of the RCC-M (design and construction code for the loop)

➤ The third barrier is ensured by the reactor building and its associated ventilation.

➤ Primary circuit :

- ✓ Design pressure : 190 bars
- ✓ Design temperature : 355°C
- ✓ MHPE seismic conditions : maintain of tightness
- ✓ SSE seismic conditions : non rupture
- ✓ A pressure wave due to fuel/water interaction is also one of the design conditions.

➤ Main containment vessel :

- ✓ Design pressure : 8 bars
- ✓ Design temperature : 130°C
- ✓ MHPE and SSE seismic conditions : maintain of tightness

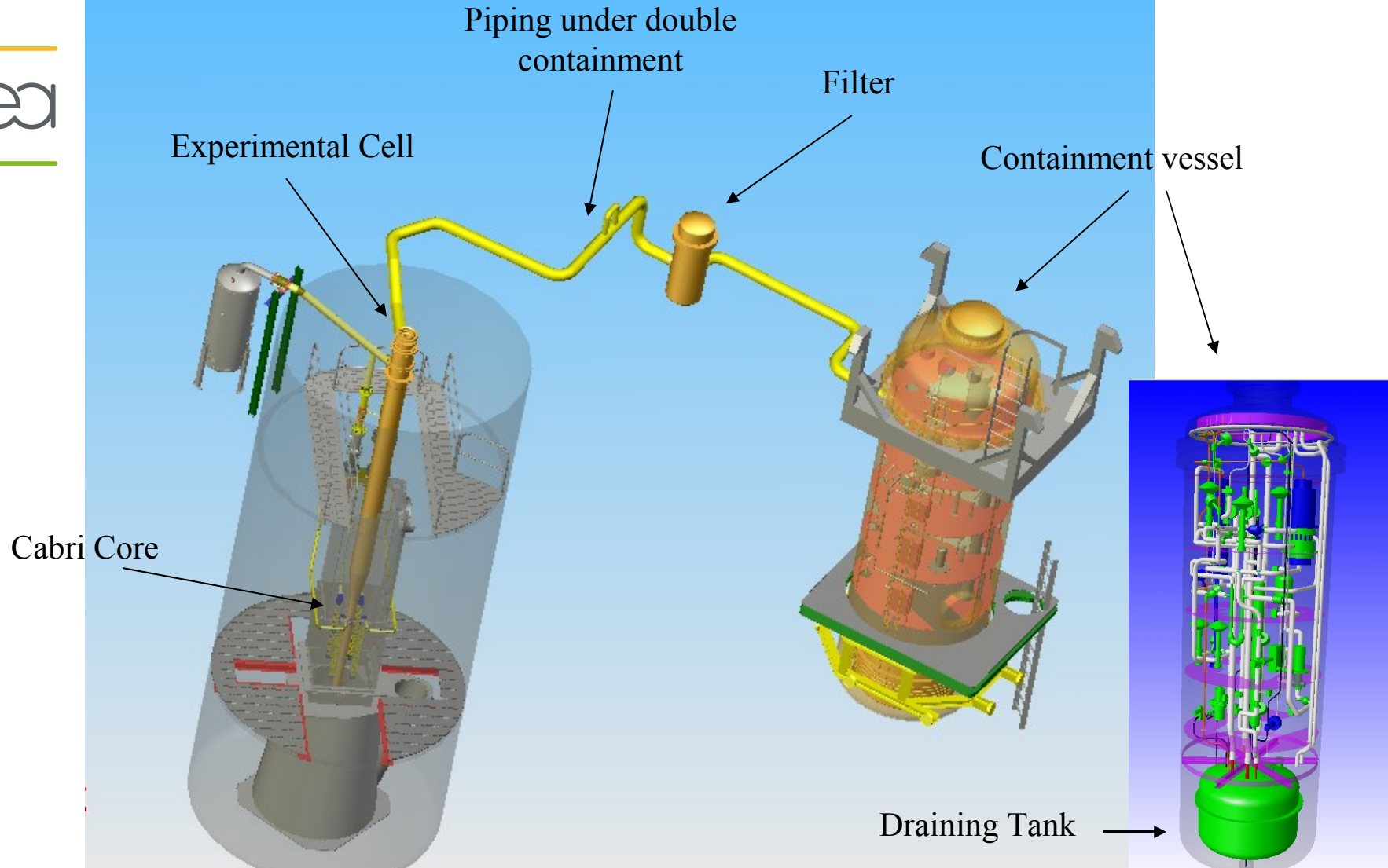
➤ Safety tube :

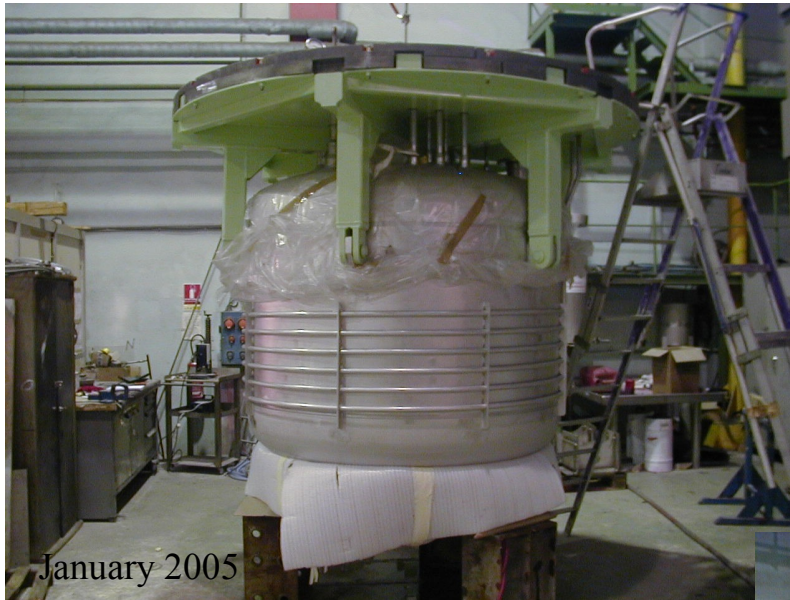
- ✓ Design pressure : 4 bars
- ✓ Design temperature : 130°C
- ✓ MHPE and SSE seismic conditions : maintain of tightness
- ✓ Aggressions like guillotine break of the primary cell or whippings of pipings are also design conditions.

MHPE = Maximum Historically Probable Earthquake

SSE = Safe Shutdown Earthquake

Cabri water loop - Description





Draining tank during the hydraulic test.

- 3.1 m³
- Design : 10 bars / 100°C

Main containment vessel

- Diameter : 2,6m
- High : 9 m
- Design : 8 bars / 130 °C

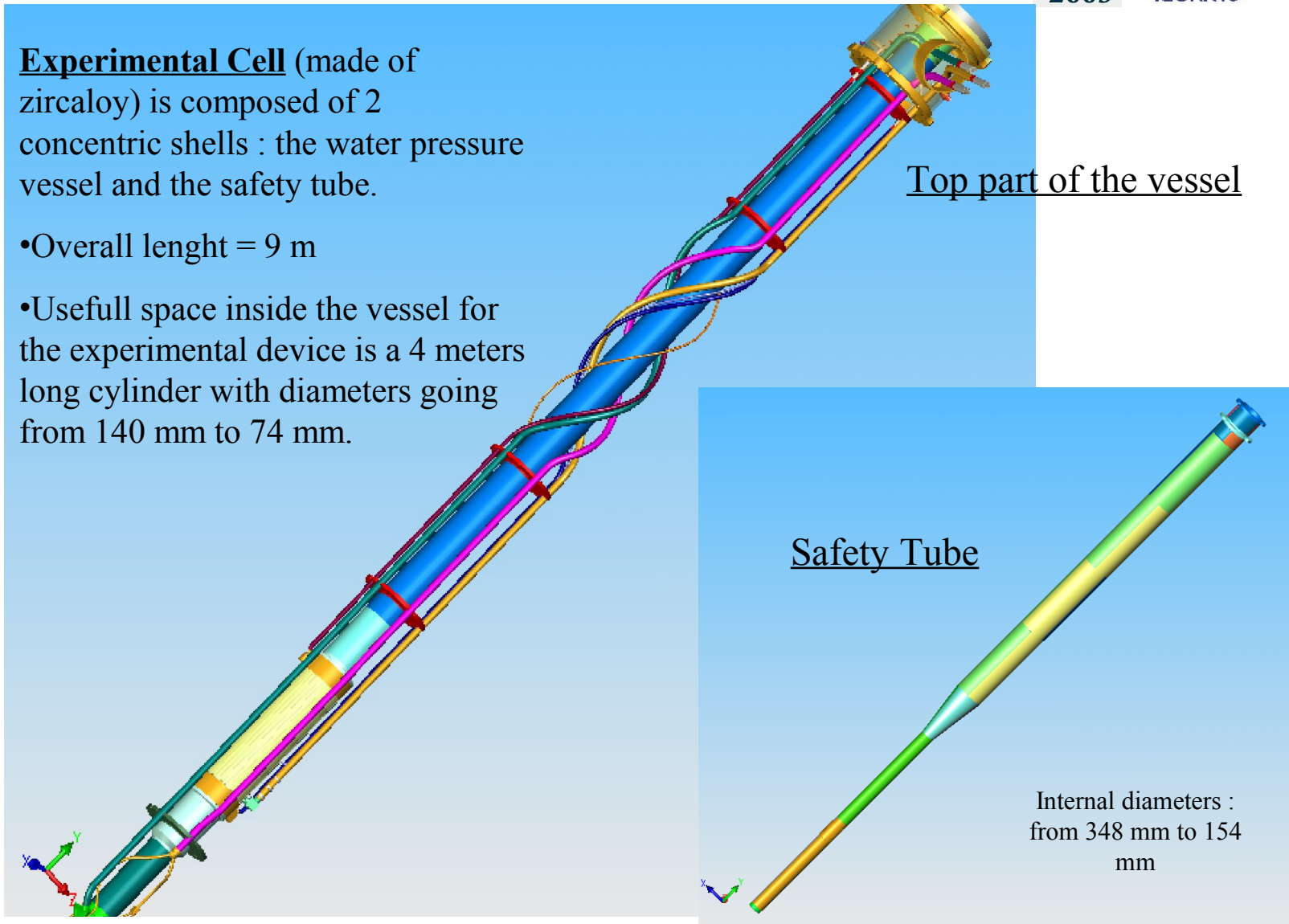


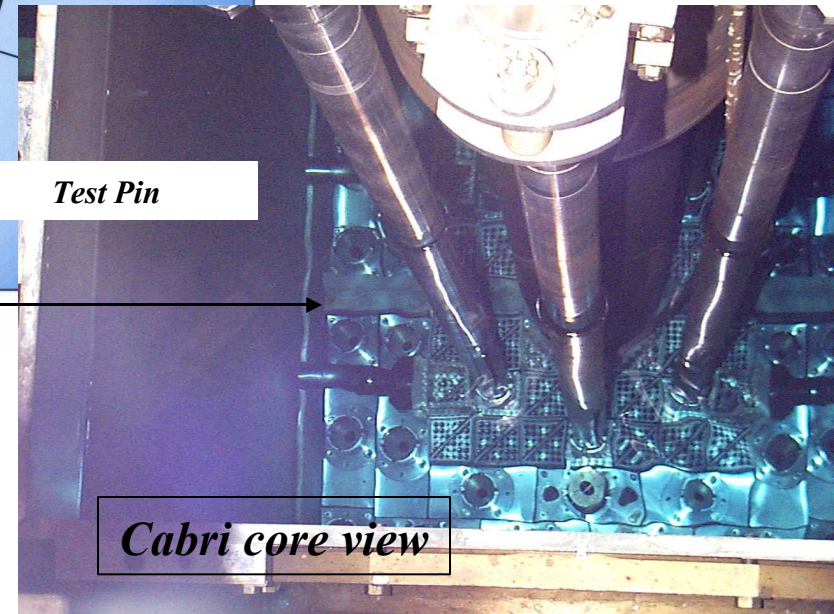
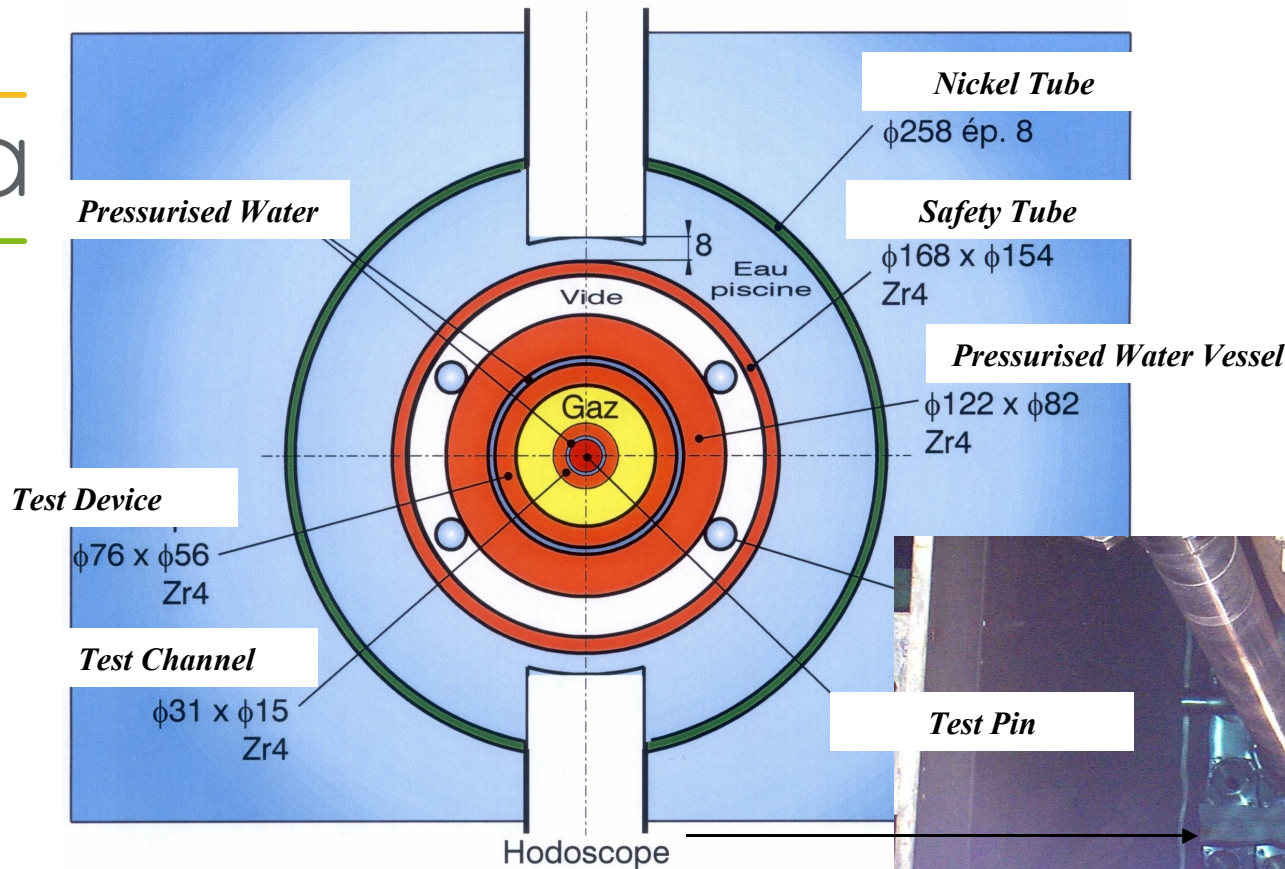




Experimental Cell (made of zircaloy) is composed of 2 concentric shells : the water pressure vessel and the safety tube.

- Overall length = 9 m
- Usefull space inside the vessel for the experimental device is a 4 meters long cylinder with diameters going from 140 mm to 74 mm.





The first design conditions (200 bars / 500 °C) led to the need of a specific casting for Cabri.

➤ Specific Cabri Casting

- ✓ High oxygen %
- ✓ High tin %
- ✓ Special heat treatment

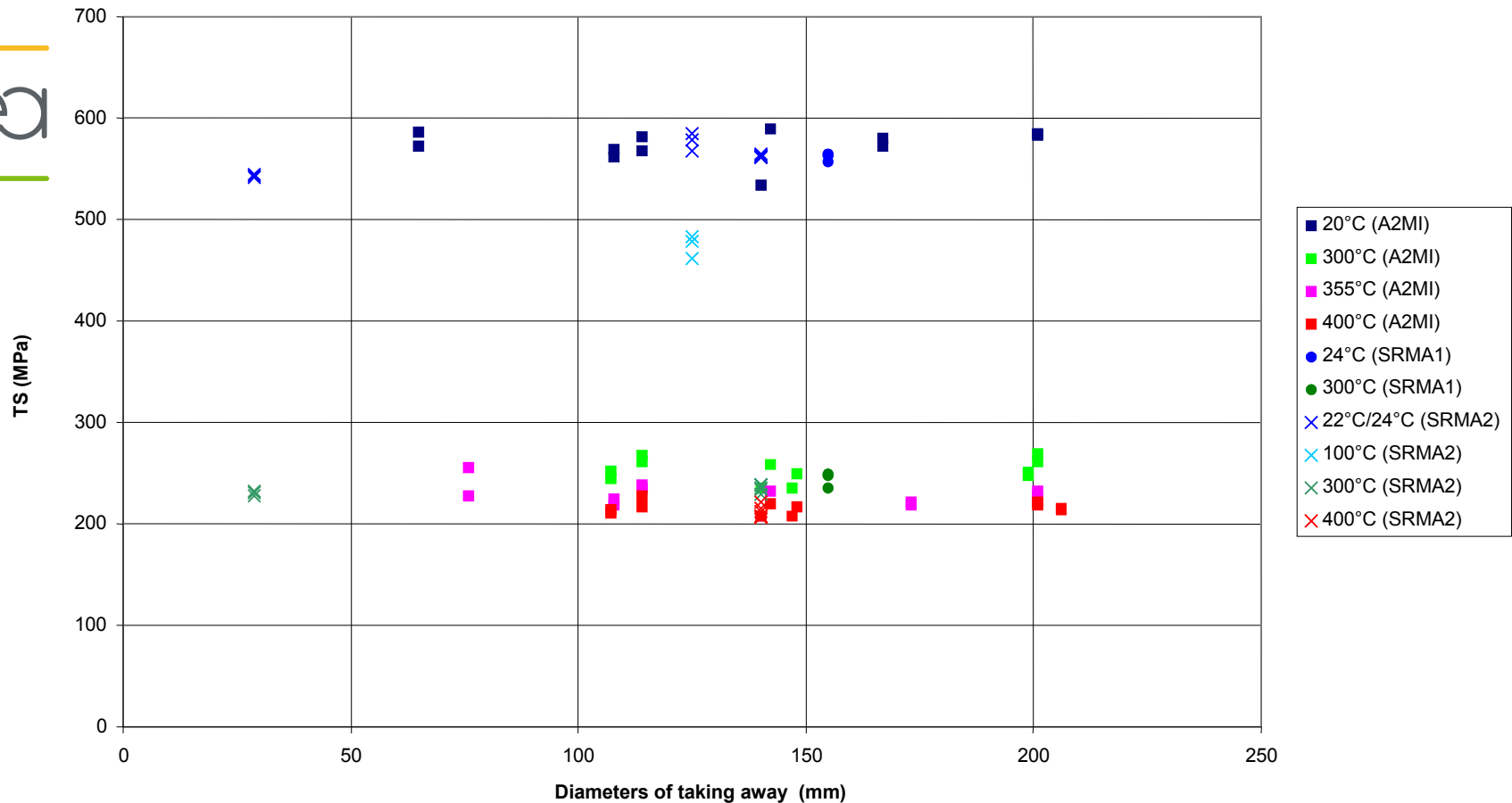
➤ The objectives :

- ✓ Increase mechanical characteristic and creep resistance.
- ✓ Obtain homogeneous material

➤ Characterisation objectives (on base metal and welds) :

- ✓ Determine allowables stresses values
- ✓ Validate toughness values
- ✓ Shows good homogeneity
- ✓ Justify unimportant creep curve
- ✓ Supplement data on creep at 400°C

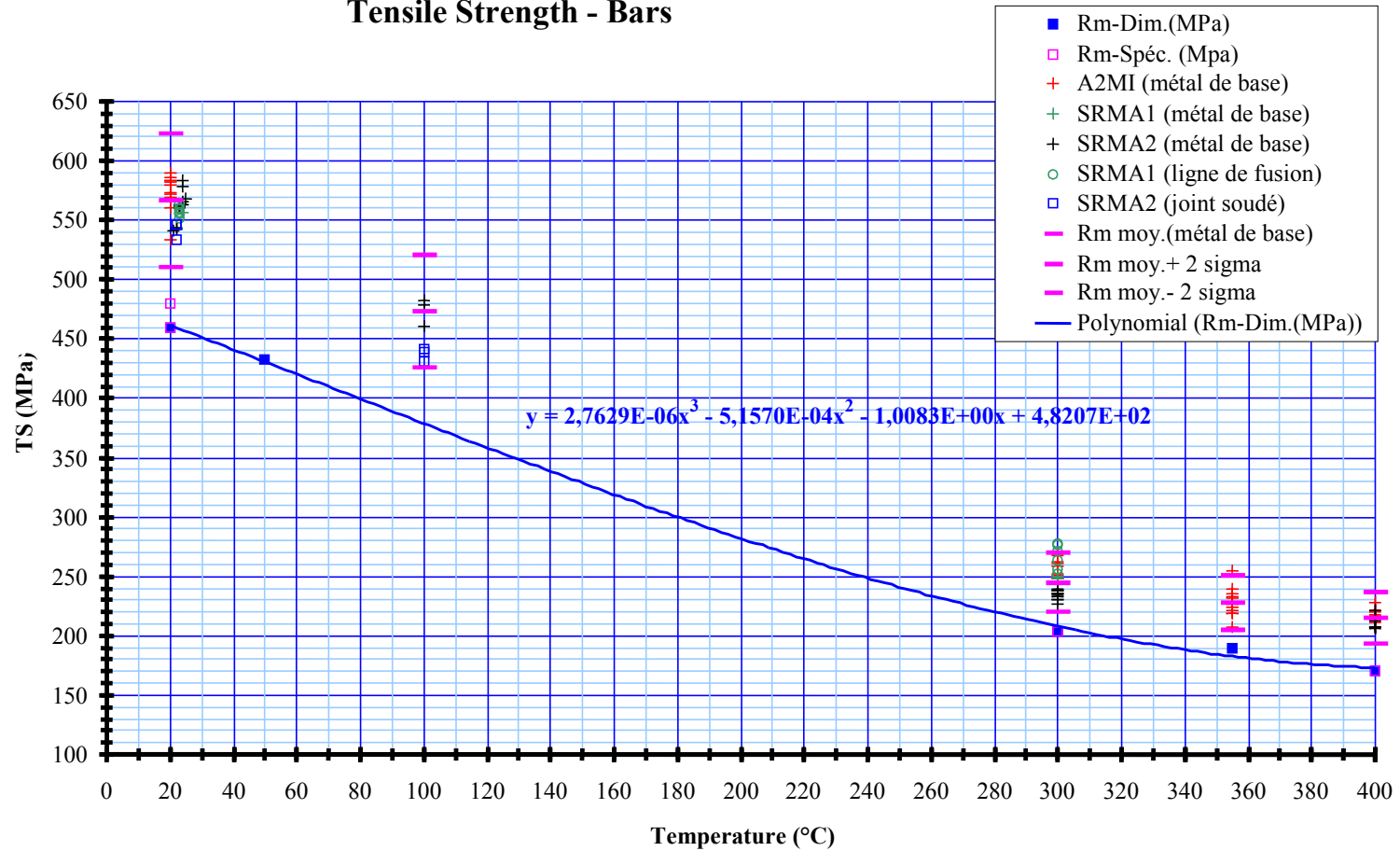
Tensile Strength



Results (YS, TS, E) for the bars show good homogeneity between the various bars, in the thickness of the rounds and in their length.



Tensile Strength - Bars



No deteriorations by the welding process of the tensile properties of the base metal.



Summary of the toughness test results on the beta treated bars (base metal, fusion line, welded joint) - Average of measurements

Temperature (°C)	Toughness base metal		Toughness fusion line		Toughness welded joint
	J (kJ/m ²)	K _{JC} (MPa.m ^{1/2})	J (kJ/m ²)	K _{JC} (MPa.m ^{1/2})	
20	46	72	56	79	In readiness
100	78	90	—	—	«
150	61	80	70	86	«
300	85	90	114	105	«

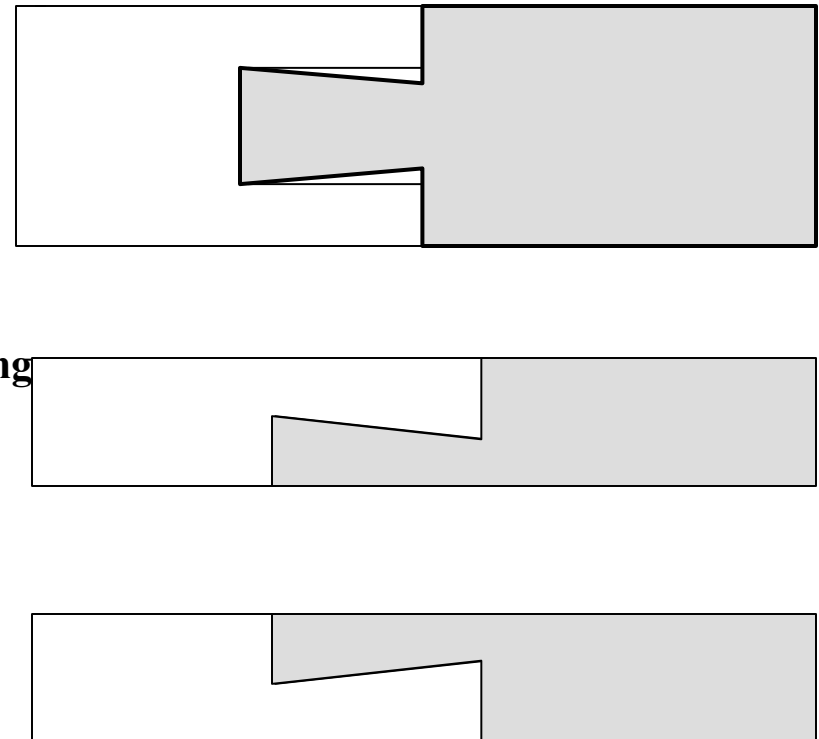
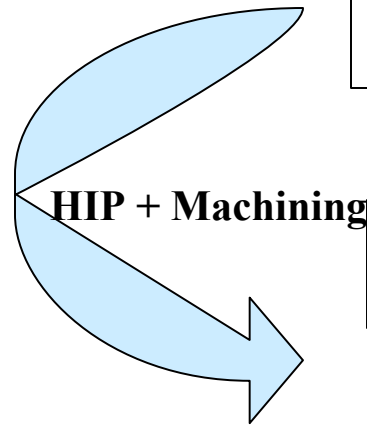
All the results cover the minimum values used in fracture mechanics calculations :
(50 MPa.m^{1/2} or 35 kJ/m²)

Combination of 2 process :

- Mechanical fixing by 2 cones
- Connection by welding-diffusion

Satisfactory first results :

- Tensile strenght values in temperatures are only slightly lower then zircaloy base metal.
- Ruptures occur in the zircaloy.



➤ Specification requirements :

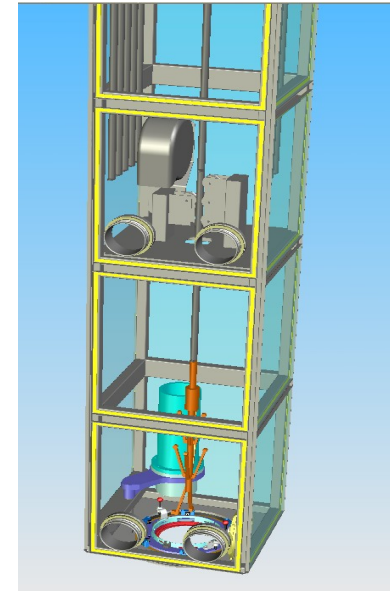
- ✓ an accuracy of 0.1 mm to the measures of diameters and thickness
- ✓ a detection, characterization and positioning of minimal defect in internal or external skin of : length = 5mm, width = 0.3mm and 0.5 mm depth,
- ✓ the possibility of inspecting all the weldings of the cell and the globality of the part being in regard of Cabri core reactor.

➤ Two ultrasonics methods :

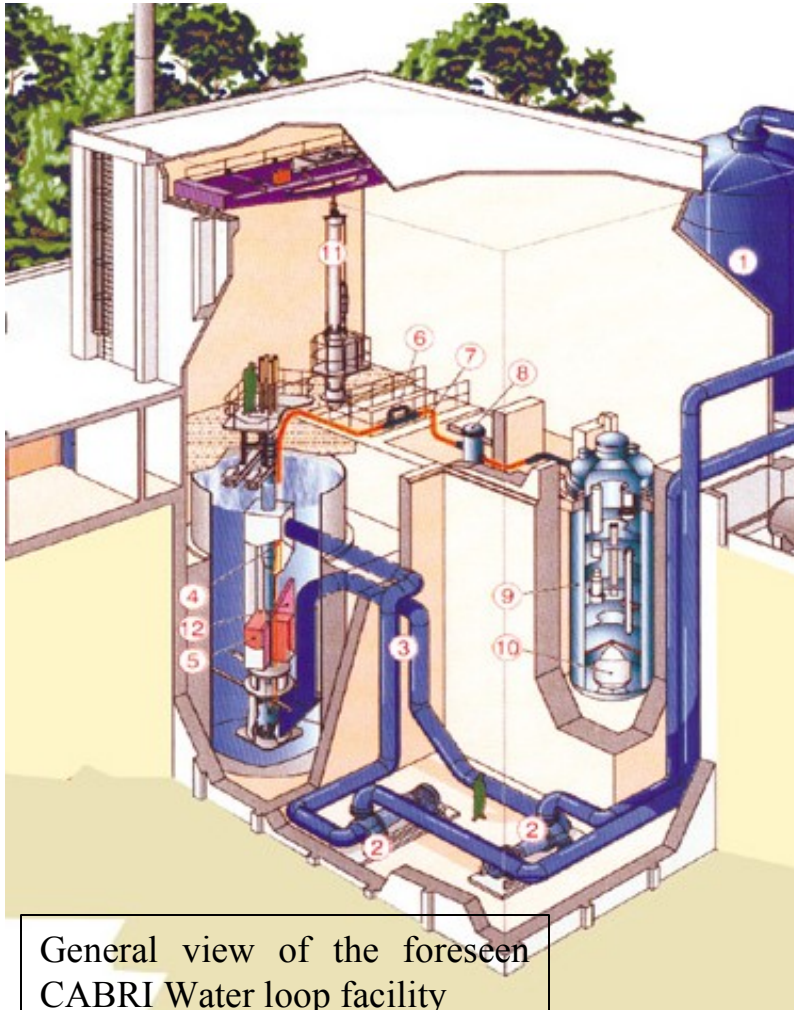
- ✓ Pulsate echos -> for measurements (diameters and thickness)
- ✓ TOFD (Time Of Flight Diffraction) -> for research and defect characterization.

➤ Technical Challenge :

- ✓ Need to control 7 different diameters (from 145 mm to 71mm) displayed on 9 meters height, without any risk of wedging.



Gloves box



General view of the foreseen CABRI Water loop facility

Implementation of the new loop is on his way. Manufacturing and works on site are going on by now.

Most of the challenges have been faced and the facility should be available for the commissioning scheduled in the beginning of 2007.