THE PLINIUS PLATFORM FOR «SEVERE ACCIDENTS»

The name PLINIUS is derived from Pliny the Younger, a writer from ancient Rome and author of the first scientific description of a volcanic eruption. PLINIUS (PLatform for Improvement in Nuclear Industry and Utility Safety) is an experimental platform dedicated to studying the behavior of corium[1] in the various situations that may be encountered during a severe accident. The tests carried out use high-temperature technologies (3000K) and high-frequency electromagnetic fields (400 kW, 80 to 300 Hz) to conduct experiments on experimental loads based on depleted uranium oxides. These tests are designed to reproduce as closely as possible the actual behavior of the corium in the reactor.

The PLINIUS facility is a Nuclear Facility Classified for the Protection of the Environment (ICPE[2]).

→ Concrete test section from the VULCANO facility

→ PLINIUS

Widely open to international markets, PLINIUS contributes to:

- **improving the design of reactors to make them more resistant to severe accidents, by:**
  - taking into account the corium-coolant interaction (steam explosion);
  - qualifying the mitigation measures (dispersion, spreading, cooling);
  - developing and qualifying scientific calculation tools.
- **safety demonstrations (in response to the requirements of the nuclear safety authorities):**
  - for the current nuclear infrastructure: extension of the operating life of a PWR[3] (a mandatory inspection required every ten years for 900 MW reactors);
  - for new reactor models as was the case for the EPR[4].
- **the maintenance and development of relative expertise:**
  - the management of a severe accident;
  - the diagnosis of the state of an accidented reactor (characteristics, location of the corium).
- **the clean-up and dismantling of the Fukushima site (corium retrieval).**

[1] **Corium** is the term given to the material resulting from the melting of elements that make up the reactor core. Among others, there are oxide phases from nuclear fuel (UO_2, ZrO_2...) or even concrete (SiO_2, CaO) and metal phases from structural elements, fuel assemblies and the vessel (Fe, Cr, Ni, Zr...).

[2] Facility Classified for the Protection of the Environment.

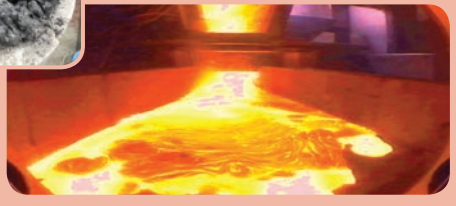
[3] Pressurized Water Reactor.

[4] European Pressurized Reactor or Evolutionary Power Reactor.

VULCANO: Corium - Material Interaction

VULCANO is a test facility dedicated to the study of the interaction of corium with different solid substrates including concrete. The experimental section is adapted to the objective of the tests: spreading on retrievalable material, corium-concrete interaction. It allows researchers to melt 100 kg of corium, either by means of a strongly exothermic oxidation-reduction reaction or by means of electromagnetic induction heating. It is instrumented with thermocouples to measure the progression of the corium in or on the interacting material. The simulation of the heat decay is carried out by means of electromagnetic induction heating. The goal of the VULCANO tests is to improve our understanding of the mechanisms of interaction between corium and materials, to test technological solutions relating to corium spreading and corium-concrete interaction management, and also to develop and qualify codes for calculating corium-concrete interaction and corium spreading.

→ VULCANO Section after a test



→ Experiment on VULCANO aimed at studying corium spreading on a concrete surface

VITI: The properties of corium

VITI (VIscosity Temperature Facility) is a facility designed to study the high-temperature physico-chemical properties of corium and steels (viscosity, surface tension, density), the interaction between corium and various materials and the liquidus and solidus temperatures of high melting point materials. VITI uses a few grams of prototypical corium (1 - 100g). Corium melting is carried out by indirect inductive heating, via a graphite or tungsten susceptor (thermal radiation heating).

→ Installing a test component on VITI

KROTOS: Corium - Water Interaction

The KROTOS device studies the interaction between corium and water. In a severe accident situation, it could lead to a steam explosion with the potential consequence of damaging the reactor building containment. The KROTOS experimental facility consists of a resistive furnace that can heat up to 8 kg of corium at temperatures up to 3000K. As the melting temperature of the mixture is reached, the crucible is «released». It then falls from a height of several meters through a transfer tube and releases the corium that flows into the water-filled test section in the form of a jet. Visualization and characterization are achieved through the use of highly specific instrumentation (fast camera, thermocouples, force sensors, pressure sensors, level probe, mass spectrometer) and an X-ray system that is unique in the world. The objectives are to improve understanding of the phenomena by finely characterizing the premixing phase, modeling the formation of the debris bed and finally by analyzing the mechanisms of the steam explosion and capitalizing on lessons learned from the tests in the dedicated numerical simulation code.

→ Upper part (Heating)

→ Lower part (test section filled with water)

MERELEVA: recooling of the corium

MERELAVA (Mitigation for Ex-vessel REtention of LAVA) is an experimental device dedicated to the study of corium cooling by top reflooding. The purpose of this device is to obtain 80 kg of in situ prototypical corium using a thermal reaction to simulate the decay heat of the real corium by inductive heating, to inject water into the corium and to measure the steam flow generated in order to determine the heat flow extracted from the corium.

→MERELEVA Test Section

Photos credits: CEA - G. Lesénéchal/CEA • Design: PUBLICOM • March 2019

CEA Cadarache • 13108 Saint-Paul-lèz-Durance
+33 (0)4 42 25 33 60 (visites) • +33 (0)4 42 25 70 00 (standard)
www.cad.cea.fr