PHEBUS FACILITY: TWO YEARS OF MODIFICATION AND COMMISSIONING BETWEEN TWO FP TESTS

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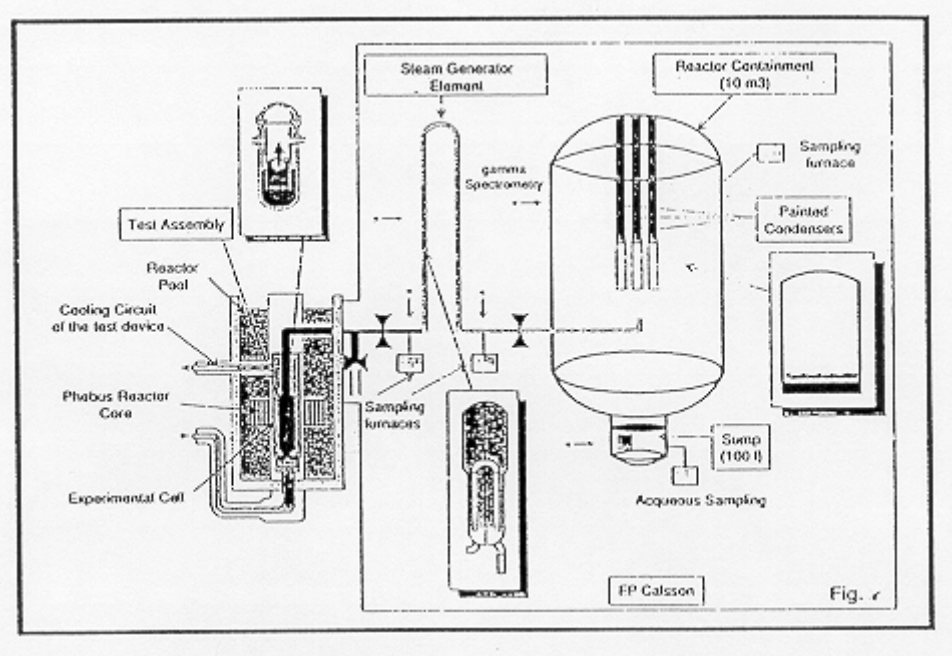
The requirement for improving data of reactor severe accident phenomenology decided IPSN in partnership with European Commission, Electricité de France, USA (NRC), Canada (COG), Japan (NUPEC and JAERI), South Korea (KAERI) and Switzerland (HSK and PSI) to launch an integral experimental programme on the PHEBUS facility.

The experiments allow the study at a scale of 1/5000 of both the degradation of fuel (less than 10 kg) and the behaviour of fission products in a representative reactor circuit and containment under severe accident conditions.

The facility located at Cadarache consists of two main sections (see Fig. 1):

- the reactor itself, a <<pool type reactor>> with a power of 40 megawatts, used to supply the neutron flux heating the test fuel,
- the experimental circuits, consisting of three main parts: the in pile section containing the test assembly (part A), a portion of the circuit simulating the primary circuit up to the breach (part B), a vessel representing the reactor containment building (part C). These two last items of equipment are displayed in a vessel, the <<caisson>>, which constitutes the first barrier of containment.



The degradation phase lasts approximately 5 hours. The on line measurements are going on during four days, then:

- sampling equipment is recovered,
- experimental circuits are decontamined (part A and B), and dismantled (part B),
- the caisson is decontaminated and then opened for rebuilding the experimental circuits and its instrumentation,
- commissioning tests of the circuits and reactor are conducted before the next experiment.

The inventory of active products in the test fuel is of about 200,000 curies. The 60,000 curies which migrated through the circuits (fission products, fuel aerosols) with partial deposit decays down to 500 curies after 4 weeks with about half in the containment vessel.

These operations which last for over two years for each test give to the teams of IPSN the opportunity of developing process and equipment taking into account the safety, security and scientific constraints. This is particularly pertinent for the following actions occurring in a particular hostile environment in the caisson.

1) Sample recovery

The challenge of this operation from a scientific point of view is triple:

- a high quality gamma-spectrometry of the deposit in the samples which constitutes for the fission product the reference for all the other laboratories involved in similar or different process (chemistry),
- the quick recovery of some samples in order to measure the amount of short lives products, particularly the iodine,
- the minimisation of the sample content perturbation during the handling operations.

These constraints added to safety ones and to the minimisation, as far as possible, of the caisson contamination induced the development of remote handling devices and video systems allowing:

- simultaneous separation of the sample from the main experimental circuit and the reconstitution of its tightness,
- the cover of a large zone inside the caisson despite numerous equipment inside,
- the transfer of the samples to a hot cell for gamma spectrometry measurement.

2) Circuit decontamination

The decontamination of the experimental circuits has not only the objective to reduce the activity of the not consumable parts, but also from a scientific point of view, to close the balance of fission product and aerosol deposition in the circuits.

These requirements were satisfied through the concept of sophisticated decontamination circuits, able to treat independently various part of the circuit (heat exchanger loop, vessel, horizontal lines…), but also to set up chemical solutions adapted to the different requirements of the decontamination protocol (Water with various additives, cerium, solutions of nitric acid).

Moreover, the necessity to separate organic liquid from active water, for waste management problems, was at the origin of the conception of an original cryogenic vessel allowing the separation and filtration of the two liquids with a residual contamination of the organic liquid lower than 1000 Bq/I.

3) Dismantling of the circuit and decontamination of the caisson

The first operation which lasts about three months has two phases:

- a reduction of the hot points using remote handling devices which takes about 3 months,
- the manual dismantling. This part, with regard to the security of workers is the most delicate due to the limited time of operation per man (2 hours a day), the use of ventilated suit, the exiguity of the caisson and the necessity to limit the dispersion of the contamination.

A long preparation of the operations, using pictures, videos, a large number of different operators and a good management of the logistic are characteristic of this phase. Moreover the experience from the two first tests has been integrated in the design of equipment (improvement of access, remote handling command or dismantling, waste management…).

The release of contamination in the caisson, consequence of the previous operations, has an important goal: the reduction of activity level and in some places its fixation, in order to simplify the further performance of the rebuilding and commissioning tests by using for example non-ventilated suits for the operators. The main difficulty is the complexity of equipment inside the caisson, which limits the techniques that can be used (aspiration, smear, high pressure water…). This operation after the last experience (FPT1) lasts three months.

In conclusion, the PHEBUS FP experimental programme, with its scientific challenges, induces the development and the mastery of delicate operations in a very hostile environment. Including the feedback from the first two tests performed in 1993 and 1995, IPSN disposes presently of a solid and optimised technology for the subsequent four FP tests.