IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

International Source Term Programme Experimental Programmes [CHIP, EPICUR, PARIS, BECARRE, MOZART, VERDON]

SOURCE TERM is an international research programme carried out by IRSN and CEA (Commissariat à l'Energie Atomique) with the support of Electricité de France, the European Commission, the US Nuclear Regulatory Commission (US), GDF/ SUEZ/ Tractebel (Belgium), Atomic Energy Canada Limited (Canada), the Paul Scherrer Institute (Switzerland) and the Korea Institute of Nuclear Safety (representing a South Korean consortium). This programme sets out to reduce uncertainties when evaluating the environmental release of radioactive products such as iodine or ruthenium following a core meltdown accident in a pressurised water reactor (PWR). The experimental data gained from this programme are used to develop and validate numerical simulation tools needed to assess the consequences of such an accident and to evaluate the efficiency of the prevention means.

This programme has a budget of about €30 million over 5 years to investigate four different experimental topics

[1st topic: Studying iodine chemistry]

In the primary cooling system
CHIP programme

Objective: provide experimental data on the physico-chemical transformations of iodine in the core where it is released as gas into the reactor containment. The aim is to determine the quantity of gaseous iodine present in the reactor containment.

CHIP LP experimental bench

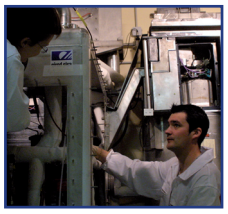
This topic has been divided into two parts:

- Phenomenological tests involving up to 10 chemical elements that are representative of the products released in large quantities from core at the same time as iodine (elements from the control rods, etc.). The aim is to identify the chemical elements likely to react with iodine during its transfer from the core into the containment (short transfer time, fast cooling in the presence of steam and hydrogen);
- Analytical tests involving a small number of elements. The aim is to collect kinetic data on the main reactions coming into play.

In the reactor containment
EPICUR & PARIS programmes

Objective: provide experimental data on the physicochemical transformations of iodine (formation & destruction of volatile iodine species) under the effect of radiation in the reactor containment. The aim is to estimate the quantities of gaseous iodine (especially organic iodine which is difficult to trap with filters) likely to be released into the environment in the event of a containment leak.

PARIS



EPICUR

Research specifically focuses on:

- Chemistry of iodine in aqueous phase under radiation,;
- Iodine interactions with surfaces (especially paints) that result in the formation of organic iodine;
- Iodine reactions with radiolytic products from air (including ozone).

This research is carried out within the scope of the EPICUR and PARIS programmes. The EPICUR facility has a gamma spectrometry device that is used for the on-line monitoring of the various gaseous species generated.

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International SOURCE TERME Programme

[2nd topic: Degradation of boron carbide (B_4C) control rods]

Objective: assess the impact of boron carbide control rod degradation on the core degradation, on the production of hydrogen, and on the volatility of certain radioactive products, especially iodine.

Research specifically focuses on:

- Degradation mechanisms of a boron carbide control rod in the presence of steam when heated to more than 1,300°C;
- Release of oxidation products, as well as borated and carbonated species.

The programme includes:

- Analytical tests to determine the steam oxidation kinetics of pellets made from boron carbide or mixtures of boron steel. These tests will also help to characterise the oxidation products formed;
- Semi-analytical tests to determine the degradation mechanisms of a 60 cm long control rod segment and its associated releases. These tests are performed in the VERDI, PICOLLO and INTERMEZZO facilities.

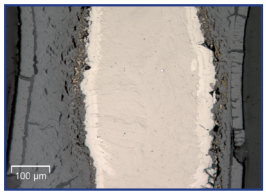
INTERMEZZO

[3rd topic: Consequences of fuel rod heating in air]

This situation is likely to occur, for example, during an accident involving reactor vessel rupture or during the uncovering of an irradiated fuel storage pool. Such situations can especially affect cladding degradation mechanisms and ruthenium releases.

MOZART experimental programme

Objective: study the oxidation of nuclear fuel cladding in air. This programme is studying several alloys (Zircaloy-4, M5™ and Zirlo) in different initial conditions (fresh, pre-oxidised or pre-hydrided) to simulate ageing in the reactor. The kinetic data collected from these tests is used to develop an air oxidation model for numerical simulation tools that are designed to assess releases.



Metallographic examination of a M5 sample oxidised in air at 950°C

Experimental programme
Ruthenium chemistry in the reactor containment

RuO_4 production device

Objective: provide experimental data on the physicochemical transformations of ruthenium under radiation in the reactor containment. This particularly involves characterising the mechanisms that lead to the formation or destruction of gaseous ruthenium species.
Research specifically focuses on:

- Surface deposition rate leading to the destruction of gaseous ruthenium RuO_4;
- Formation rate of gaseous ruthenium from surface deposits in particular.

[4th topic: Fission product releases from irradiated fuel at high temperature]

VERDON experimental programme and microanalysis

Objective: study the release of fission products from samples of highly-irradiated UO_2 fuel and MOX fuel, which have been the subject of very little research to date (the VERCORS programme conducted from 1989 to 2002 focused on moderately-irradiated UO_2 fuel). The tests consist in heating several fuel pellets to a very high temperature in steam and hydrogen so as to monitor the release of fission products on-line by means of gamma spectrometry.

VERDON

The microanalysis programme sets out to characterise the distribution and chemical composition of fission products in the different phases of fuel having been subjected to thermal transients during VERDON and VERCORS tests. This characterisation should make it possible to validate the test result interpretations.