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REACTOR SAFETY ANALYSIS

Background

Risk assessments of nuclear installations require more and more accurate safety and reliability analyses to estimate the consequences of accidental events and their probabilities of occurrence.

Objective

to develop expertise in probabilistic and deterministic reactor safety analysis

Programme

The research programme relates to two main activities:

▨ developing a software for reliability analysis of large systems,

▨ participating in the international PHEBUS-FP programme for severe accidents.

Achievements

Development of CAMERA

CAMERA is a software for computed-aided reliability analyses of large systems by means of two optional techniques, the Markovian approach and the Monte Carlo simulation, both allowing to treat much more general systems than the classical fault-tree method. The software is developed in collaboration by SCK•CEN and ULB.

Owing to a strong reduction of the resources devoted to further developments in CAMERA, no significant progress has been achieved in 1999. The software, which was operational under MS-Windows 3.1, has been converted into an MS-Windows 95/NT application.

Severe accidents

SCK•CEN aims at acquiring expertise in severe accident modelling and more particularly in the field of core degradation. For that purpose it participates in the international PHEBUS-FP programme since several years by detaching one scientist to CEN Cadarache for the phenomenological understanding of the degradation, notably by post-test examinations.

At CEN Cadarache the participation to the PHEBUS-FP programme included:

▨ material expertise in support to the preparation of the next tests (study of the consequences of the injection of boric acid and the presence of iron oxide, on the behaviour of the fuel and of the thoria and zirconia shroud of FPT2; study of the influence of B4C and its oxidation products on the fuel and the crucible materials of FPT3)

▨ contribution to the understanding of fuel degradation and relocation in the FPT1 test through FPT-1 Post-Irradiation Examination (PIE) completion (participation to the follow-up of the FPT-1 PIE).

Moreover, a proposal was prepared in the frame of the 5th Framework Programme of EURATOM (1998-2000; call of June 1999) and approved. The contract, named ENTHALPY was then prepared and signed end December 1999. Its objective is the validation of one unique corium thermodynamic database for in- and ex-vessel applications and the development of coupling methodologies to severe accident codes. 12 participants from 6 European countries, are participating incl. SCK•CEN(LHMA), ULB and UCL. The organisation in charge of the co-ordination is IPSN but the person in charge of this co-ordination belongs to SCK•CEN.

SCK•CEN undertakes also modelling activities with the SCDAP/RELAP5 code in agreement with Tractebel and in collaboration with FZK. The work performed in 1999 essentially consisted in sensivity studies with respect to:

- the refinement of the fuel modelling: the fuel rods in the PHEBUS-FP test sections have been discretised in 4 groups instead of 2 groups as it is usually done in most of the studies;

- the influence of the radiation view factors within the fuel bundle.

In parallel with these modelling activities, SCK•CEN collaborates to the development of the SCDAPSIM code (user-friendly version of SCDAP/RELAP5 available on PCs) by using a beta version of this tool.

Perspectives

As ULB intends to continue new developments in the Monte Carlo simulation technique, it is foreseen to adapt the pre-processor of CAMERA to the future processor using this methodology.

The participation in the PHEBUS-FP programme will continue, in particular with the PIE of the FPT-4 test (degradation of a UO_{2in}/ZrO_2 debris bed and release of U, Pu and low-volatile FPs) run in July 1999, and the preparation of the so-called FPT-2 test

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(degradation of a bundle of 20 UO_{2irr} pins with a central AgInCd absorber rod under steam starvation) foreseen in the course of the year. Post-calculations and pre-calculations with RELAP5/SCDAP respectively on the FPT-1 and FPT-2 experiments will be carried on.

The other activities will be related to the ENTHALPY project.

Scientific partners

ULB Université Libre de Bruxelles (Brussels, Belgium)

UCL Université Catholique de Louvain (Louvain-la-Neuve, Belgium)

Tractebel Energy Engineering (Brussels, Belgium)

CEU Commission of the European Union

IPSN (France)

Innovative Systems Software, LCC (Idaho, USA)

Presentations

S. HEUSDAIN, "Modelling of the FPT0 experiment: sensitivity studies on SCDAP simulations", 13th BIC meeting, Aix-en-Provence, November 4, 1999.

A. DE BREMAECKER, "Conséquences éventuelles sur la grappe de combustible et sur l'isolant de la présence d'oxydes de fer dans le dispositif d'essai et de l'injection d'acide borique", Document PHEBUS IP/99/460, 9 décembre 1999.

A. DE BREMAECKER, "Fuel interactions during the relocation and melting phases of a severe accident": Invited paper at the Workshop on "Impact of fuel chemistry on fission product behaviour" organised by SCK•CEN at Mol on 16-17.06.1999 (Summary in BLG-813)

A. DE BREMAECKER, "ENTHALPY: European Nuclear Thermodynamic Database validated and applicable in Severe Accident Codes" – EURATOM Contract FIS5-FIKS-CT1999-00001 – Technical Annex.

Reports

B. ARIEN, "The CAMERA Software: present status". SCK•CEN report R-3327, March 1999.