EXPERIMENTAL AND MODELLING PROGRAMME FOR DIRECT CONTAINMENT HEATING

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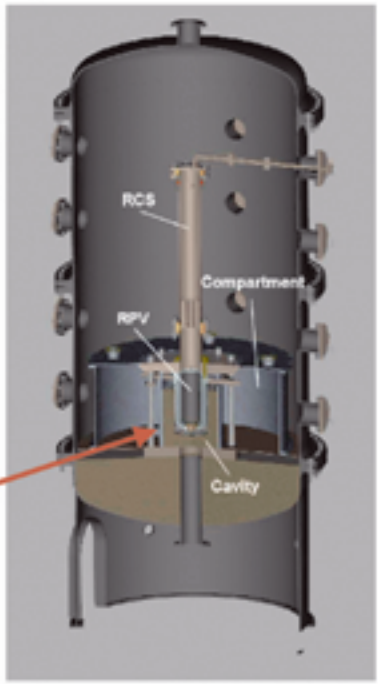
To evaluate the DCH consequences in a hypothetical severe accident in a French nuclear plant the IRSN uses ASTEC (Assessment of Source TErm Code). Inside ASTEC, RUPUICUV, a lumped-parameter code based on simplified models, evaluate the corium mass dispersed outside the reactor pit using a correlation established by KAERI on the basis of the experimental results. The module RUPUICUV is then coupled with the module CPA to model the phenomena occurring in the dome (hydrogen combustion, condensation of steam etc...) and to evaluate the containment pressurization. The main advantages of the ASTEC code are the possibility to analyse the complete accident sequence and, because of its relative reduced computing time, the possibility to investigate the influence of different parameters that have an influence on the considered accident. On the other hand, as ASTEC uses simplified models, the results so obtained should be independently corroborated.
At this purpose a research programme has been defined with the main objectives of corroborating the results of ASTEC concerning DCH, giving a deeper insight into the different phenomena occurring during DCH and guiding the future development of more accurate models. In particular the research programme develops around an experimental axis and a modelling axis.



Scheme of the DISCO-H facility

> The experimental programme

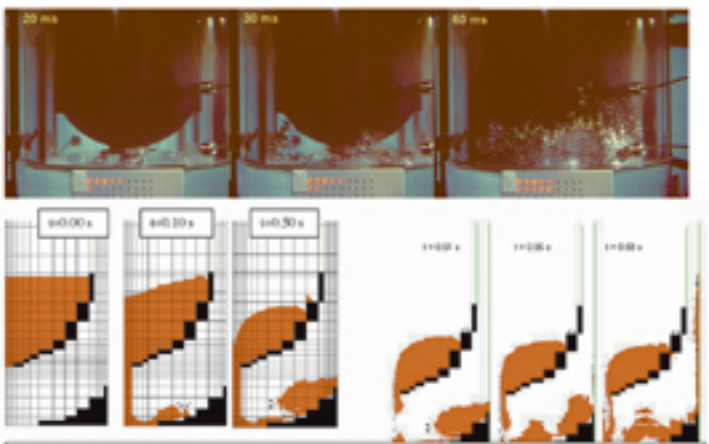
An experimental programme has been defined in the frame of a cooperation agreement between the "Forschungszentrum Karlsruhe" (FZK) and IRSN in order to investigate direct containment heating in the French reactors. The experiments are presently being carried out using the DISCO-C and DISCO-H facilities at FZK opportunely modified to represent the French reactor cavities.
The DISCO-C experiments investigate the issue of the corium dispersion and are carried out in a mock-up representing, at the length scale 1/16, the RPV, the RCS volume and the reactor pit. The experiments are performed at room temperature using water as corium simulant and nitrogen as steam simulant, for different pressure in the RCS, breach diameter and corium simulant mass. The corium masses dispersed in the dome and in the intermediate compartments are measured as well as the mass retained in the reactor pit. High-speed films give an insight into the phenomena occurring in the pit with a particular attention to the corium ejection, jet fragmentation and corium entrainment.
Representing, at the same length scale of the DISCO-C experiments, the RPV, the RCS volume, the reactor pit and the reactor containment. The experiments use an iron-alumina melt as corium simulant and steam as driving fluid in the RPV. The initial temperature of the melt is approximately 2400 K. The initial containment atmosphere is prototypic (air, steam and hydrogen) or inert. The dispersed corium mass and its distribution is measured as well as the size of the debris. Continuous pressure and temperature measurements in the dome and in the reactor pit are provided. Video films in the reactor containment allow reconstructing the melt flow and hydrogen burning timing. Pre and post test gas analysis in the containment are performed.

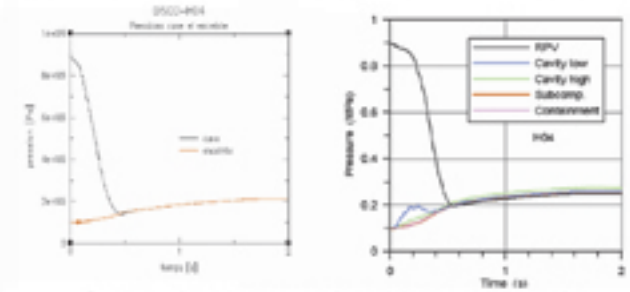

Detail level of the cavity in the DISCO facilities

> The modelling programme

Beside the simplified modelling approach used by ASTEC, a modelling research programme is carried out using sophisticated 3-dimensional multi-phase computational fluid dynamic codes. In particular the MC3D code, jointly developed by CEA and IRSN, and the AFDM module of the SIMMER family code are used to analyse in detail DCH (the latter code is used in cooperation with FZK). Both codes are used for pre and post test analyses of the DISCO experiments. Their use in conjunction with the experimental programme allows a better interpretation of the experimental results, gives an insight into the different phenomena occurring during DCH and guides the extrapolation to the reactor scale. The use of two independent codes corroborates their mutual results and points out their respective limits.

Although these codes prove to well model the main phenomena occurring during DCH and in some case may be used for reactor case analyses, their direct application for the evaluation of the consequences in a hypothetical severe accident cannot be presently generalized because of the large computing resources required and the impossibility to analyse the complete accident sequence. They however contribute, together with the experimental results, to improve the simplified models implemented in the ASTEC code.


Corium ejection from the RPV and fragmentation. DISCO experiment (above) and MC3D computation (below).



Pressure in the reactor pit and in the dome during DCH. Comparison between and MC3D computation (above) and the DISCO experiment (below).

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