Sensitivity Studies on Fluid Impact and Related Roof Loading Problems in HCDA's

D. Acker, C. De Cecco

Commissariat à l'Energie Atomique, C.E.N., Département de Sûreté Nucléaire, B.P. No. 6, F-92260 Fontenay-aux-Roses, France

J. Louvet

Commissariat à l'Energie Atomique, C.E.N. Cadarache, Département des Réacteurs à Neutrons Rapides, B.P. No. 1, F-13115 St Paul-lez-Durance, France

F. De Magistris

NIRA, Ingegneria Reattori Veloci, Largo R. Tasselli, Via dei Pescatori 35, I-16128 Genova, Italy

Summary :

Although computer codes developped for HCDA analysis can predict reasonably well the response of the primary containment, some deficiencies remain in the predictions. In particular, the description of the fluid impact on the reactor cover needs further analytical and experimental studies and improvement.

One of the most important difficulties is to take into account in the correct way all the parameters characterizing this kind of problems.

The purpose of this paper is to study the sensitivity of several parameters on fluid impact development and related roof loading.

We consider three classes of parameters :

- the first class contains the thickness and the density of the fluid coolant over the core and the (p, v, t) law of the explosive bubble influencing directly the global mechanical properties of the fluid slug (momentum and kinetic energy).

In particular, the pressure peak of the bubble and the fluid thickness determine the shape of the free surface and consequently the radial distribution of the impulses under the roof : when the fluid thickness increases, the free surface remains flat and the radial variations of the impulses are reduced.

- the second class contains the void gap thickness, the gas equation of state and the shape of the free surface.

It has to be noticed that our studies always consider a sufficiently large void or air gap to have a total bubble energy released and consequently an impact occurring when the fluid slug has reached its maximum velocity.

- the third class contains the flexibility and the inertia of the roof and the cavitation phenomenon ; the energy distribution between the fluid and the structures during the impact time depends on the parameters of this class.

The comparison between calculations performed with and without a cavitation model for the fluid (Pmin model) shows important discrepancies, in particular the field of the fluid velocities is not as homogeneous as in the first case. On the contrary, the choice of the equation of state for the fluid (polynomial, Mie Grüneisen) has negligible effects on the fluid slug behaviour.

These studies are performed with three axisymetric 2-D containment codes :

- SIRIUS (explicit, lagrangian)
- SEURBNUK (implicit, eulerian)
- CASSIOPEE (explicit, eulerian - lagrangian).

The main emphasis of these parameter sensitivity studies is placed on the comparison between the calculated impulses ; in addition, an illustration of the results obtained is done with experimental impulse measurements performed in a rigid bare vessel, partially filled with water and loaded with a low density explosive (CARAVELLE tests).