Filtered Containment Venting and Primary Containment Integrity

Case study

Sir Robert McAlpine (SRM) and AMEC assessed the structural integrity of the containment structure and the containment pressure boundary respectively to establish the feasibility of installing a Filtered Containment Venting (FCV) system at a UK nuclear power station. EASL, in partnership with client SQEPs, reviewed these assessments to determine suitable venting strategies to an appropriate confidence level.

The findings will inform the precise definition of the final venting strategies. The final venting strategy will result from a balance between the integrity of the containment and the filter, and the radiological consequences of the releases through the filter. Studies to determine the risk profile of several venting strategies were developed, working in collaboration with severe accident and probabilistic safety assessment (PSA) specialists.

Our approach

The accident scenario considered is a station blackout with loss of all electrical and steam driven safeguards. This is a very infrequent event but one that occurred at the Fukushima plant following the earthquake-induced tsunami.

It is assumed that the containment is successfully isolated and containment cooling is not restored for another two weeks. So-called "optimistic" and "pessimistic" venting scenarios were studied, with the former characterised by early availability of mobile water injection equipment. For the latter, where no water is injected, the temperatures, pressures and levels of activity inside containment are expected to be higher for longer.

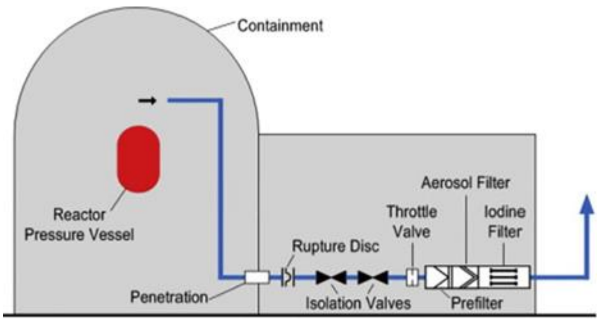

Figure 1 Schematic diagram of FCV system

The containment vessel structure review included the pre-stressed and reinforced concrete elements. The containment vessel pressure boundary review included the penetrations and liner. Code compliance to Sub-Section CC of the ASME Boiler and Pressure Vessel Code for concrete containments was considered.

The aim was to determine an allowable pressure and temperature envelope for the containment structure under the factored load category for one-off extreme event conditions. The results were initially assessed against acceptance criteria previously developed for assessment of a design basis fault.

Further insight was obtained from comparison with scale model tests conducted during the original design stage, but also from large scale model tests to failure conducted on similar structures and their associated analyses.

Conclusion

An allowable pressure and temperature envelope for the containment structure was determined for the optimistic venting scenario. Under some scenarios loading may cycle between venting operations, and further work was identified to assess the accumulation of strain against the material ductility. Notwithstanding the optimistic venting scenario is judged to be justifiable to a reasonably high degree of confidence.

Potentially significant concerns were raised associated with leakage from pre-existing leak paths and from seals to penetrations. These may be exacerbated during the event, particularly if it were possible for hot gases to leak into the pre-stressing system tendon ducts

An allowable pressure and temperature envelope for the containment structure was determined for the pessimistic venting scenario. However these were based on acceptance criteria for a single, monotonically increasing load and are inappropriate for cyclic loading. Further work was recommended to consider localized areas of the liner at the hottest fault temperatures and to consider flanged bolted joints.

The findings were used to inform the precise definition of the final venting strategies.

EASL’s approach provided an objective summary of the complex assessment findings and provided clear, definitive advice to the design authority.

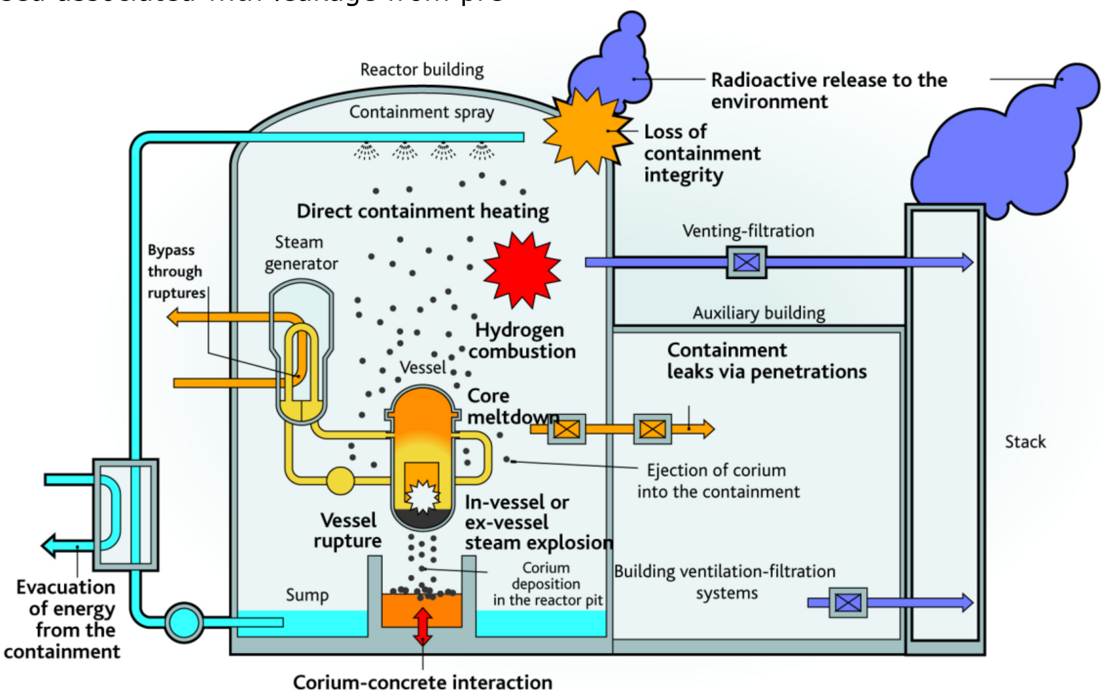

Figure 2   Schematic diagram illustrating potential threats to pressure boundary integrity

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