A THEORETICAL AND EXPERIMENTAL STUDY OF THE STRUCTURAL RESPONSES TO SAFETY/RELIEF VALVE DISCHARGE LOADS

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Summary

In a BWR the safety relief valves (SRV) generally discharge to the suppression pool, where the steam is quenched. This discharge will generate pressure pulsations in the suppression pool and these pulsations will cause vibrations of the submerged equipment and the structures in the pool, the reactor and all other structures and equipment in the containment.

Test measurements have been carried out on a plant with an ASEA-ATOM reactor in order to determine the pressure field in the pool and the vibratory response of the structure, piping and other mechanical equipment and those measurements are compared with predicted values.

The plant is equipped with the SRV mitigators which have been developed by ASEA-ATOM.

Single valve actuations. The test results indicate pressure pulsations with a fundamental frequency of 5-11 Hz for the single valve actuations and some significiant 2nd pressure peaks at 15-18 Hz. The maximum positive pressure amplitudes in the pool are generally in the order of 20 kPa at the containment wall (the highest value at that point was 37 kPa).

The pressure distribution in the pool is studied by a comparison between the pressure amplitudes and Fourier spectra of the signals from different sensors located in the pool and measurements of the analogue potential distribution in an electrolytic tank model of the pool as they both satisfy Laplace´s equation. This comparison indicated good uniformity between the potential fields.

Cross analysis of pressure signals from different sensors shows that the coherence values are high up to a frequency of about 20 Hz, which justifies the use of Laplace´s equation for Fourier components up to this frequency.

The evaluation of the test data shows that the amplitudes of the structural responses are well represented by calculations from a beam-type model of the containment, pedestal, reactor pressure vessel (RPV) and the internal parts of the reactor. The overall acceleration in the horizontal direction of the containment, pedestal and RPV was less than 0.1 g. The corresponding vertical accelerations are lower due to the natural hard rock foundation.

Response spectra calculations of the test data give maximum oscillator acceleration values approximating the predicted values, but the measured dominating vibration frequencies are higher probably due to shell mode vibrations.

Multiple valve actuations. The all-valve actuations gave a maximum pressure of 33 kPa at the containment wall. The fundamental pressure pulsation frequency was 4.5 - 8.5 Hz.

The maximum acceleration of the pedestal and the containment was in the pool 0.2 g in the horizontal direction, which is higher than the results from the calculations with the beam-model. Also in this case the dominating vibration frequency was higher in the test than in the prediction.

The experiment has shown a satisfactory coincidence with the calculations of the peak values in the time domain, but the dominating response frequencies are higher in the test data than in the predicted response. This high frequency response may be due to shell mode vibrations or some filtering in the transmission of the pressure to the concrete walls.