# TRANSIENT CAVITATION EFFECTS IN FLUID PIPING SYSTEMS

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## SUMMARY

An overall analysis of pressure transients, arising in reactor piping systems due to accidents or equipment malfunction, must consider the possibility of cavitation occurrence. Models of differing complexity, treating transient cavitation, have been developed in the past. However, these have usually been applied in situations where the locations of cavitation occurrence are known a priori or where the piping systems are quite simple. In general it is necessary to be able to predict cavitation occurring anywhere in a complex network. In addition the calculation procedure must be efficient and be compatible with a general fluidhammer analysis using solution techniques such as the method of characteristics.

For this purpose a treatment of transient cavitation based on a column separation model was developed. In this approach cavitation is assumed to be a local phenomenon occurring wherever the pressure drops below the vapor pressure. The cavity forms a free (constant pressure) boundary for the separated fluid columns and cavitation ceases when the separated columns reimpact. When a computational node is not cavitated it has a single particle velocity and conditions at the point are computed from the compatibility relationships along the positive and negative characteristics. When cavitation occurs, two interface or particle velocities exist at a node. These are determined using the appropriate compatibility equation along one characteristic together with the known value of the vapor pressure. Integration of the velocity histories of the two column interfaces yields the size of the cavity. The technique differs from other column separation models in that cavitation can occur simultaneously at many computational nodes of a pipe including its junctions. This permits the modeling of the propagation of strong rarefaction and compression waves and of the associated spatial distribution of cavitation inception and collapse. When a substantial region of a pipe undergoes cavitation, it is represented by multiple cavities centered at the node points and separated from each other by short (one internodal distance) fluid columns. While the model is simplification of the actual phenomena and does not represent all the details of cavity formation and recollapse, it represents at least the essential features of transient cavitation. Since the damping effect of vapor present in a cavity is neglected, the technique should in general provide conservative estimates of the pressure pulses generated by cavity collapse.

Computational results obtained for a variety of piping arrangements demonstrate the versatility and efficiency of the approach. Comparison of these results with values obtained by calculational procedures which either neglect cavitation entirely or simply set pressures equal to zero indicate that these latter techniques predict erroneous pressure histories and profiles in the piping systems. This holds true both for locations which cavitated as well as for those which did not, but which were influenced by cavitation occurring elsewhere. A comparison of calculated results with available experimental data, for a simple piping arrangement, indicates quite good agreement and thus provides validation for the computational cavitation model.