

RESOLUTION OF USI A-1, "WATER HAMMER"

by

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ABSTRACT

Water hammer events are large hydraulic loads which are the result of steam bubble collapse, steam-driven slugs of water, pump startup into voided lines and rapid valve closures. Since 1968, about 150 water hammer events have been reported in nuclear power plants. The increasing frequency of water hammer events noted in the early 1970's (which also correlates with an upsurge in plants being brought on-line) raised sufficient safety concerns to result in designation of this phenomena as an Unresolved Safety Issue A-1, Water Hammer in 1979. Since that time, the NRC staff with the help of subcontractors has developed a potential resolution of this issue. In the course of resolution, several approaches were used, including an analytic solution. This paper presents conclusions reached and development of the NRC staff position.

Examination of plant reported water hammer events reveals the following findings:

- (a) principal reported damage has been failures in snubbers and pipe hangers,
- (b) approximately one-half of the reported events have occurred during pre-operational testing and the first year of commercial operation (which suggests a learning process),
- (c) only approximately one-third of the operating reactors have reported water hammer related events,
- (d) cited causes are about equally related to operational effects and design mismatches. The results of close examinations of operating experience reveal that water hammer is less significant as a safety concern than previously viewed. In addition, safety systems have not been disabled.

The perspective gained is as follows: total elimination of water hammer will not be possible in view of the coexistence of steam, water and voids inherent to the operation of nuclear power plants; the prediction of occurrences in all plant systems, under all possible operational scenarios is also not feasible; finally, code analysis capabilities are limited with respect to predicting certain two-phase phenomena (i.e., steam-pocket collapse). The calculational approach was tried and did not succeed in resolving this safety issue.

The resolution developed for USI A-1 is based on recognition that water hammer events will occur, and that preventive measures can be taken. Key elements in reducing frequency and severity of water hammer can be summarized as: (1) increase operator awareness, (2) assure adequate plant operation and maintenance procedures are in effect, (3) utilize surveillance instrumentation to detect voids in systems having a history of water hammer occurrences, (4) incorporate design features (e.g., J-tubes in steam generator feed ring, jockey pump keep-fill systems in BWR's) which have demonstrated success in eliminating water hammer events, (5) address the design requirements associated with preventing water hammer through use of experience gained. This paper expands on these points and details the proposed method of implementation.