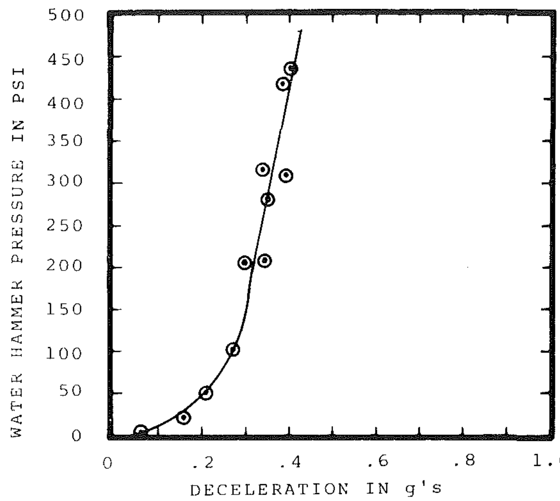

Fig. 12 Deceleration versus water hammer (6-in. swing check valve DC-93)

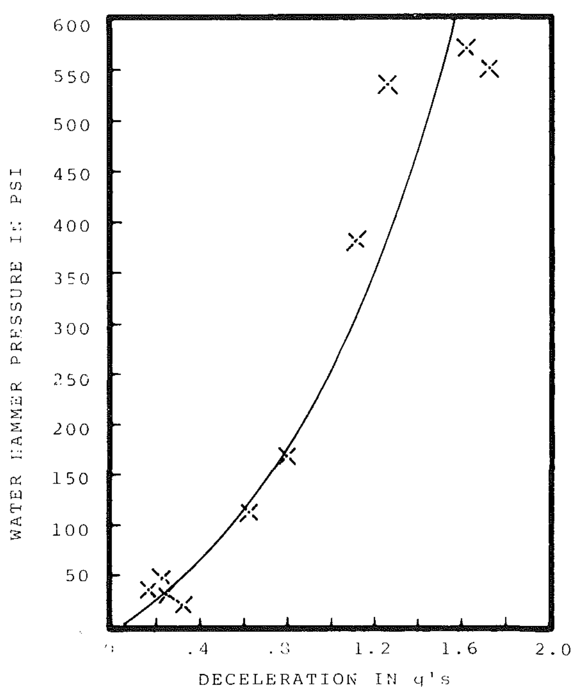

Fig. 13 Deceleration versus water hammer (6-in. dual flapper valve with springs DC-137)

of the system deceleration can be used to obtain performance characteristics of check valves. The tests also show that the valve design does result in a range of possible performance so that test data is necessary for the various possible valve configurations.

This first look at a possible way to determine check valve performance has been discussed with the intent of providing some preliminary information to industry and users to throw light on an old and difficult problem with the goal of encouraging more work on the subject to develop a practical guide to the specification of check valves in actual systems.

These tests are suggested as an experimental means of determining actual check valve behavior. An alternate mathematical approach can be developed from data like that presented in reference [4] interacting with the system characteristics. E. B. pool reports on runs from a computer program in reference [3]. The author has developed a proprietary program for line check valves and for valves operating in reciprocating mud pumps. The work is extensive and might be the subject of future papers. For modeling, the relations discussed in reference [4] can be used to predict the behavior of geometrically similar valves by making proper allowance for different dimensions, springs and mass moment of inertia. The torque coefficients are easily obtained for geometrically similar models.

The test system is flexible and although the reported runs had quick blowdown to simulate small modern motors that stop quickly, the blowdown could be programmed to simulate older, larger motors with longer coastdown time. The system can incorporate devices to add friction in order to obtain a family of performance curves. Thus, this proposed arrangement could be adjusted to evaluate more complex operating conditions if indicated by additional study.

References

1 Pool, E. B., Carlton, J. L. and Porwit, A. J., "Prediction of Surge Pressure from Check Valves for Nuclear Loops," ASME Paper 62-WA-219, presented at the Winter Annual Meeting, New York, N.Y., November 25-30, 1962.

2 Provoost, G. A., "The Dynamic Behavior of Non Return Valves," *presented at the Third International Conference on Pressure Surges*, Canterbury, England, March 25-27, 1980.

3 Pool, E. B., "Minimization of Surge Pressure from Check Valves for Nuclear Loops," ASME Paper 62-WA-220, presented at the Winter Annual Meeting, New York, N.Y., November 25-30, 1962.

4 Collier, S. L., and Hoerner, C. C., "Development of Affinity Relations for Modeling Characteristics of Check Valves," ASME Journal of Energy Resources Technology, Vol. 103, Sept 1981, pp. 196-200.

DISCUSSION

J. R. Kroon[1]

Collier and Hoerner should be commended for their efforts at increasing our understanding of the behavior of check valves in liquid pipeline systems. Although a check valve is one of the most mechanically simple devices used on a piping system, it is frequently one of the least understood in terms of its anticipated behavior and occasionally the cause of most problems. Methods presented in their paper provide a simple means of evaluating the likely response of a check valve to a pump power failure or shutdown event – if data defining the characteristics of the valve are available. Like so many other advances in analytical techniques for problemsolving, however, Collier's method will experience little practical use if the raw data on the quantitative behavior of check valves is not supplied.

Recognizing that a representative population of check valves must be tested for the method to have wide applicability, perhaps the authors would be willing to propose a standard testing program. The test program should include all types of widely used check valves, such as slanting disk swing, ball and piston check valves. Before a standard test program can be designed, however, the factors which significantly influence the behavior of a given valve must be identified. Specifically, it seems likely that changes in the piping configuration local to the check valve may have an effect on the valve behavior. For example, placement of the valve adjacent to an elbow or reducer can result in valve flutter due to vortex shedding [5]. Studies performed by Provoost [2] indicate that valve position prior to fluid deceleration is an important factor in resultant waterhammer pressures.

The test facilities used by Collier and Hoerner place the check valve in the middle of a straight section of pipe. Holding all other system conditions constant, what would be

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the effect of placing an elbow, tee, control valve, or other device immediately upstream or downstream from the check valve? I believe the different flow lines resulting from different connection configurations may have a significant influence on the behavior of the valve.

Another factor which should be investigated for its influence on the behavior of a given valve is the scale of the system. The authors have shown that for constant scale test rig, a definite correlation exists between the E/L measure of a system deceleration and the resultant waterhammer pressure due to check valve closure. In addition, they have provided test evidence to support the theory that the results will accurately scale up to a larger system [4]. However, the tests on the effects of scaling were performed using a specially fabricated, accurate scale model of a larger valve; whereas a typical line of products will have slightly different geometries. Given the realities of an extensive test program, in which it may not be feasible to fabricate accurate scale models, the effects of slight geometry differences should also be investigated.

Referring the author's analysis of the system deceleration for a simple system, a word of caution is in order. The author's analysis assumes an instantaneously stopped pump resulting in a system deceleration of Eg/L. If a system undergoes power failure, with subsequent rapid pump spindown, vapor cavity formation immediately downstream of the pumps is quite likely. In this event, the force driving the deceleration of the water column would be the difference in hydraulic gradelines with the upstream end at atmospheric pressure and downstream end at vapor pressure. Apparently, the test facility did not induce vapor cavity formation; hence the hypothetical and the test situations would more appropriately be analogous to a system experiencing relatively slow spindown, rather than instantaneous stoppage.

The foregoing observation leads to additional questions regarding check valve behavior in piping systems. Different transient inducing events, such as pump station power failure, control valve closure, linebreak, etc., result in different responses by the system. Check valve response may also be different. Of course, the authors did not intend to address all of the possible influences on check valve behavior. However, the method presented can provide a basis for comparison between various valves for a relatively simple application.

Collier and Hoerner's work should be taken as a challenge by all check valve manufacturers. Their analysis technique requires data for many different valves before meaningful analysis and comparisons can be made. Additionally, these data can be used by more sophisticated computer analysis procedures, which are presently available, but unimplemented, due to lack of quantifiable check valve data.

The need for additional work and additional data is clear. Valve manufacturers and others with test facilities could do a great service to the engineering community by helping remove the uncertainties in design, and problems in operation caused by check valves.

Additional References

5 Collier, S. L., Hoerner, C. C., Davila, C. E., "Behavior and Wear of Check, Valves," ASME Paper 82-PET-12, presented at Energy-Sources Technology Conference, New Orleans, Louisiana, March 7-10, 1982.

Author's Closure

The authors appreciate greatly Mr. Kroon's penetrating discussion accorded the paper. The purpose of the paper was to present a possible standard test procedure for check valves and to expose the proposal to detailed review. Check valve installations occur where the application is sophisticated and is analyzed extensively or where the application is mundane and in need of "rules of thumb" for direct practical application.

The proposed method uses a ratio to establish system deceleration; this ratio can easily be estimated for many operating units. The ratio is used with the performance curve to estimate expected water hammer pressure. Plant personnel can compare this to the equipment condition to determine if it is reasonable or excessive. If excessive, the performance curve for different styles of valves or different springs can be used to select a unit that produces less water hammer pressure.

The sophisticated installation will be designed by experts with computer analysis. This will require the modeling techniques and torque coefficients described in reference [4].

The data presented in both papers may possibly be the only test data available at this time. This data did cover the effect of the use of different springs in the dual flapper valve and the results of similar tests with the standard type of swing check. Much more data is needed. It is the author's opinion that one reason for the lack of such data is the lack of a statement as to the precise quantities needed and a technique that could be widely used for measurements. The proposed system was purposely designed to obtain the characteristics of the valve without complicating results. It is believed that piping elements, friction and pump effects must all be removed from the test system in order to obtain the isolated valve behavior. Once the understanding of the problem is brought into focus, handling of these complications can be attempted.

We do hope that our work will encourage more effort to standardize on a useful check valve test system and data format.