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REVIEW AND ANALYSIS OF CHECK VALVE FAILURE DATA

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Abstract

Check valve operating problems in recent years have resulted in significant operating transients, increased cost and decreased system availability. There has been, in response, additional attention given to check valves by utilities, as well as the U. S. Nuclear Regulatory Commission and the American Society of Mechanical Engineers Operation and Maintenance Committee. All these organizations have the fundamental goal of ensuring reliable operation of check valves.

A key ingredient to an engineering-oriented reliability improvement effort is a thorough understanding of relevant historical experience. Oak Ridge National Laboratory is currently conducting a detailed review of historical failure data available through the Institute of Nuclear Power Operation's Nuclear Plant Reliability Data System. The focus of the review is on check valve failures that have involved significant degradation of the valve internal parts. A variety of parameters are being considered during the review, including size, age, system of service, method of failure discovery, the affected valve parts, attributed causes, and corrective actions.

This work is being carried out under the auspices of the Nuclear Regulatory Commission's Nuclear Plant Aging Research program. At the time of this writing, the study is approximately 50% complete. All failure records have been reviewed and categorized, and preliminary tabulation and correlation of data is underway. The bulk of the tabulation and correlation portion of the work is expected to be completed by the end of June, 1992. A report draft is expected in the fall of 1992.

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REVIEW AND ANALYSIS OF CHECK VALVE FAILURE DATA

Introduction

Oak Ridge National Laboratory (ORNL) is carrying out a review of historical check valve failure data under the sponsorship of the Nuclear Regulatory Commission's (NRC's) Nuclear Plant Aging Research Program. The study involves the review and characterization of failure records from the Nuclear Plant Reliability Data System (NPRDS) data base. Failures in which significant internals degradation was detected are being characterized in detail. Parameters that are being considered include the age of the plant when the failure occurred, valve size, manufacturer, system of service, method of discovery, affected valve parts, attributed failure causes, and corrective actions.

Author's Note: Some pertinent background behind this study and the study approach are discussed below. Because the characterization of the data is not complete at the time this paper is being written (April, 1992), the results cannot be included. It is expected that a significant portion of the characterization will be completed by the date of the NRC/ASME Symposium. The results then available will be presented at the Symposium; updated copies of this paper which reflect our findings will also be made available. For additional information, address inquiries to:

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Background

The American Society of Mechanical Engineers (ASME) Committee on Operation and Maintenance (OM) of Nuclear Power Plants has established a Working Group on check valves, OM-22, which is chartered with developing check valve performance test requirements. The Working Group (WG) met for the first time in June, 1990.

Early on, the OM-22 membership recognized that a throrough understanding of historical failure patterns was critical to several aspects of the code development activities being pursued. A literature search found that while some historical failure data studies had been completed and documented, the studies were normally not oriented toward providing the kinds of information needed in code development activities.

One study that was initially selected by the WG as a basis for consideration in the development of disassembly and examination requirements (note that these requirements would apply only to valves that could not be properly tested) was a paper presented by M. L. Scott at the EPRI Power Plant Valves Symposium II[1]. Scott reviewed NPRDS failure records for events occurring during the years 1985-1987. Moderate seat leakage and external leakage events were then eliminated from the data. Failure rate vs. valve size, valve service time, and plant system were discussed. One of the conclusions drawn by Scott was that there was a tendency for a large number of failures relatively soon after installation, followed by a period of fewer failures during the four to nine year service period, and then subsequently followed by a sharp increase in failure occurrences. The sharp increase was attributed to wearout of the check valves.

As OM-22 deliberated on the establishment of appropriate disassembly and examination intervals, the conclusion in the Scott study regarding the sharp increase in failures beginning at about nine years was noted. The WG used this study as the basis for formulating requirements for eight year disassembly and examination limitations for those valves which could not be properly tested.

During WG consideration of the paper and its application to code development, some questions arose concerning the technical validity of the WG's basis. As a result, ORNL was asked to conduct a preliminary review of failure data. This review was conducted by non-qualitatively tabulating NPRDS reported failures and valve populations during the years 1985-1987 (the years of the Scott study) as well as the years 1984-1990.

The preliminary review indicated that the age-related aspects of the study used as the WG's basis appear to have been heavily influenced by the age of plants in operation during the years considered. Figures 1 and 2 illustrate the basis for this observation.

Figure 1 provides comparative plots of the number of valves in service during the period of the study and the failure data from the WG basis study. The similarity of the traces indicates that the failures vs. age trend noted in the WG basis study is strongly affected by the valve population in existence during the study period.

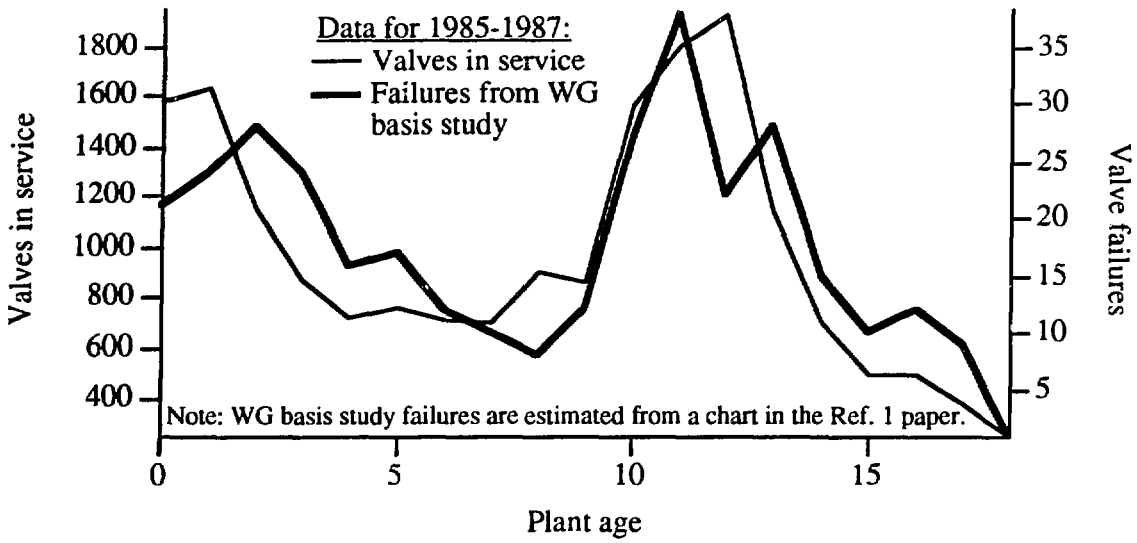

Figure 1. Comparison of Failures from Scott paper and Valves in Service

Figure 2 shows comparisons of all check valve failures (regardless of failure nature) and population during same period. It provides further indication of the importance of the valve population to overall valve failure rate.

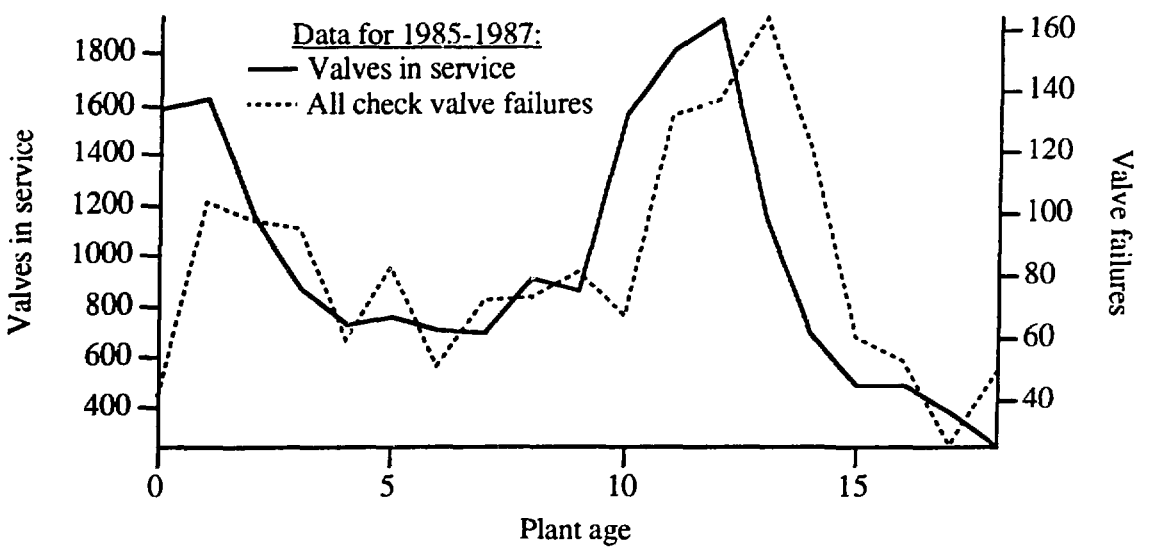

Figure 2. Comparison of All Check Valve Failures and Valves in Service

In order to provide a preliminary indication of the non-population influenced valve failure-age relationship, normalized plots of the WG basis study and all check valve failures during the 1985-1987 period are provided in Figure 3. There do not appear to be strong, conclusive trends from the data shown, based on preliminary review. It appears, based on our review of the 1985-87 data and the WG basis study data, that just over 20% of the failures were deemed by the WG basis study to have involved problems other than moderate seat leakage or external leakage.

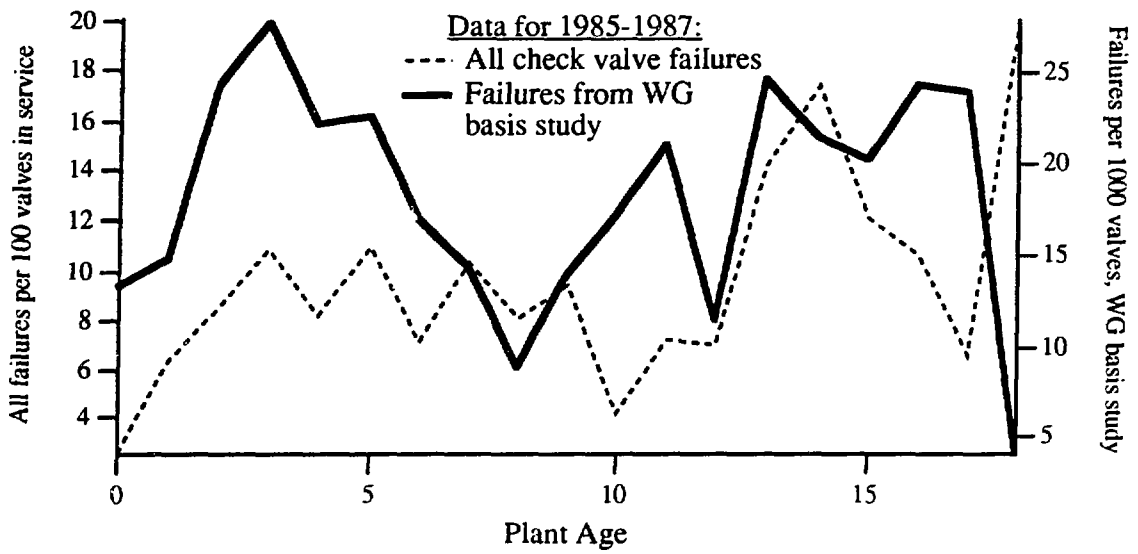

Figure 3. Comparison of Normalized Failure Data

The results of the preliminary review substantiated concerns about the use of the WG's basis study conclusions for further use in code development activities. The NRC's Nuclear Plant Aging Research program asked ORNL to conduct a more thorough assessment of the historical failure data. The study was initiated in early 1992.

Study Methodology

A primary study goal is to identify any apparent correlations of valve failure rates with age, size, system of service, and manufacturer. In addition, the study will categorize, to the extent possible, the affected parts of the valve, the method of failure detection, and corrective actions taken.

All failure data was acquired from the NPRDS system. Narratives and other pertinent information for all check valve failures, regardless of size or system of service were initially downloaded. The data was then filtered to eliminate failures which did not involve significant internals degradation. Minor seat leakage and external leakage events (if these were the only degradations noted) were eliminated from further consideration. The failures that were then further analyzed were those that appeared to involve significant internals degradation. It should be noted that some failures records have minimal information about the nature of the failure, noting only that certain parts were replaced.

It should also be noted that some of the eliminated failures may have technically made certain valves inoperable. For example, minor seat leakage may have been discovered during a containment isolation valve leak test that technically made the valve inoperable. Alternatively, significant external leakage may render certain valves inoperable. However, the primary area of interest in this study is the assessment of check valve failures which involve significant wear or other degradation of valve internal parts. Further, in the cases where minor failures render equipment technically inoperable, the problems could reasonably be expected to be routinely detected by current means (i.e., visual observation of external leakage and seat leakage measurement testing).

After eliminating the non-significant failures, it was decided to only consider failures that occurred between 1984 and 1990, inclusively. Failure reporting to NPRDS improved dramatically beginning in 1984, and it appeared that use of prior years' data would not reflect the reporting practices employed thereafter. Failure events occuring in 1991 and afterward were not considered because at the time the data was downloaded, all failure reports for 1991 were not filed.

The initial data downloaded contained 4680 failure records, which reflected all check valve failure records for all years (including part of 1991); 3761 of these failures were detected during the years 1984-1990. After the preliminary review of the individual narratives and elimination of those which did not involve significant internals degradation, 1239 failures, or about 33% of the overall failures occuring during the period, remain. This compares with our estimate of slightly over 20% of all failures deemed to have been significant by Scott.

The results of the ORNL study are expected to be published as a NUREG/CR report. A draft of the report is expected in the fall of 1992.

References

1. M. L. Scott, "Check Valve Failure Trends in the Nuclear Industry." EPRI Power Plant Valves Symposium II, Charlotte, NC, July, 1989.

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