An Analysis Of
Valve Failure Data For LWR Nuclear Power Plants
1975-1978

W. H. Schmidt
Systems Safety Technology Division 4442
Sandia Laboratories
Albuquerque, NM 87185

ABSTRACT

A computer analysis of the Nuclear Regulatory Commission (NRC) data file, compiled from Licensee Event Report (LER) data sheets, has been performed to characterize and highlight valve failures in light water reactor (LWR) nuclear power plants and provide guidance for valve improvement programs. The analysis is based on data from 1975 through 1978. Over this period, 889 valve citations were reported for pressurized water reactor (PWR) plants and 891 for boiling water reactor (BWR) plants. This report presents the pertinent LER data in a manner which indicates valve performance areas toward which improvement efforts may be directed.

INTRODUCTION

The Department of Energy (DOE) is the sponsor of a number of Light Water Reactor (LWR) nuclear power plant safety improvement programs for which Sandia Laboratories is the technical management center. These programs are administered through the DOE Quality Assurance, Standards and Operations Safety Branch. Efforts to highlight problem areas and improve valve performance in LWR nuclear power plants constitute one of these DOE programs.

Valve failure in LWR nuclear power plants constitutes the most prevalent single factor presently degrading plant safety and operational efficiency.1,2,3,4 Control of the power production and support systems is largely administered through valves and, therefore, valve malfunctions can have serious consequences with respect to plant control.

The large effect which valve performance has on plant operation should not be surprising from the standpoint of statistics alone, because there are so many thousands of valves in each plant. In turn, the large numbers involved indicate the possibility of significant plant performance improvement with enhanced performance of the most troublesome valve types in selected reactor systems. The purpose of this report is to assist valve improvement programs by highlighting the findings from a computer analysis of valve
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and mechanical valve operator data included in the Licensee Event Report (LER) data file.

LER reports are required by the NRC for events designated as reportable occurrences. A reportable occurrence is divided into six cause categories (see Figure 1). However, only the "component failure" category directly relates to mechanical failure of a properly designed, installed, and operated component.

Continuously updated files of these data reports are routinely maintained at the Oak Ridge Nuclear Safety Information Center. R. L. Scott and R. B. Gallaher have published reviews of 1976, 1977 and 1978 nuclear power plant occurrences from these data.1,2,3 An average of reported values for these years shows that valves are responsible for 21% of the reported occurrences in BWR plants and 18% in PWR plants with the value steadily increasing over these years. A recent analysis of data in the Nuclear Safety Information Center files indicates that valve failures were involved in 19.3% of the light water reactor power plant shutdowns from 1972 through 1978.3

In 1979 a new LER data file with a somewhat different format was produced by the NRC and put on computer tape. It is that file which has been used to compile the information in this report.

The failure of a valve to function properly in a nuclear power plant system is regarded as a type of reportable occurrence for which a LER is required. This information is then incorporated into the computerized data files for LERs. More complete information relative to valve performance is often recorded in the plant records but this is proprietary information and not generally available.

The results presented in this report are taken from a much larger and more complete LER data file analysis, of interest primarily to the statistician, and is available on request.

RESULTS AND OBSERVATIONS

* Until recently the amount of information entered into the LER data sheets has been so sparse that use of the data files for failure analysis is severely restricted. However, there has been considerable improvement in completing the LER forms during the last year.

* The format of the LER leaves a great deal to be desired because it is not straightforward, and for many events it is not sufficiently comprehensive to assure clear and precise identification of failed components and root causes of failures. The LER data sheet is difficult to understand and interpret, both from the standpoint of the people who must fill in the form and those who need to interpret this information.
Seventy-one percent (71%) of the citations from 1975 through 1978 relate directly to the valve assembly and 29% to the mechanical valve operator. (Figure 1)

Sixty-nine percent (69%) of the valve failure citations relate to valve mechanical failure, 14% to personnel error, and the remaining 17% to minor causes. (Figure 1)

The power plant reactor systems for which most valve failures were reported are: 1) containment isolation systems and controls; 2) chemical, volume control, and liquid poison systems and controls; 3) reactor containment systems. Mechanical valve operators also followed this pattern with the addition of the main steam isolation system and controls for BWR plants. (Figures 2, 3)

The highest numbers of valve specific citations for all causes are for gate, globe, and check valves, in that order, for both PWR and BWR plants. (Figure 4)

From a functional standpoint, shutoff, isolation, and stop valves are the most important in terms of failures for both types of plants. (Figures 4, 5)

For PWR's, the second and third most important identified component failure categories are one-way flow and pressure relief valves, while for BWR's the second and third most important component failure categories are pressure relief and flow control valves. (Figures 4, 5)

Unfortunately, the required data on the LER form is not always adequate to permit association of a valve operator with the specific valve type. However, for the data available valve operator citations correlated with operator type are presented on the plot in Figure 6.

Correlation analysis of valve function and valve type for the sparse data available shows that, in order of importance, most valve citations for both PWR and BWR plants occur for: 1) shutoff, isolation, and stop gate valves 2) shutoff, isolation, and stop globe valves 3) check valves (one-way flow for PWR plants and vacuum relief for BWR plants) 4) shutoff, isolation, and stop butterfly valves.

METHOD OF ANALYSIS

The LER data on computer tape were screened by choosing only data categorized by the LER component code words "VALVEX" or "VALVOP" which eliminated all data not directly concerned with the valve assembly or the mechanical valve operator. This data was then divided into six cause categories, as indicated on the graph in Figure 1, and separated into PWR and BWR plant classifications. Within these sets all of the LER data was catalogued and summed.
Correlation analyses were made in order to classify failure citation correlations between valve type and function and between valve type and reactor system for both PWR and BWR plants. Similar correlations were also made for all possible combinations involving the valve operators. The correlations were badly affected by the lack of data on the LER’s. The most significant findings are included in the results presented.

**SUMMARY**

Highlighted for improvement, on the basis of LER citations, are gate, globe, and check valves. These function primarily as shutoff, isolation, stop, one-way flow, and pressure relief valves in containment isolation systems, chemical volume control systems, and reactor containment systems.

An appallingly large amount of required data is not filled in on the LER forms. However, a significant improvement in the amount of data on the forms is evident over the past year.

Much data necessary to accurately and precisely pinpoint problem areas, operational circumstances, and faulty components is not presently required on the LER data sheet, and is often not written in the description sections presently provided.

**DISCUSSION AND RECOMMENDATIONS**

Specific types of valves, valve operators, and reactor systems are designated in this report for possible improvement. This does not tell the whole story, however, because details of the operational environment, failure circumstances, and character of the component failure are not given. This information is sometimes given in the "description" sections of the LER. This type of information, when available, has been categorized by the Nuclear Safety Information Center at Oak Ridge and an analysis of this data has been made. The results from an analysis of the abstracts of the LER descriptive data are not in total agreement with the categorized codes on the LER data sheets. This is partly due to the fact that some of the citation categories are broad and subject to a great deal of personal interpretation. Also, there are sometimes inconsistencies within the LER’s. This points out the need for greater accuracy and fuller descriptions in filling out the data sheets.

Basic information and associations relative to failed components are of fundamental importance to component improvement programs. Failed or troublesome components must be clearly identified as to function, type, system, operating condition, manufacturer, and serial number if possible. The present LER, for example, requires the mechanical valve operator to be identified only as to type and does not require the type of valve with which it is associated to be specifically identified. Hopefully, the necessary additional information will be included in the description sections of the data sheets as is sometimes the case.
Rapid, thorough, and flexible LER data analysis is an important starting point for reactor power plant component improvement programs. This can be facilitated by computer analysis of categorized data on computer tape, such as the one produced by the NRC, and exemplified by this report. Of course, this has been done routinely by the Nuclear Safety Information Center in a general way from their own data files since 1973.

However, for maximum use and flexibility it should be possible to computer read the descriptive sections of LER's, where a large amount of information is in narrative form, and selectively compile a thesaurus of key words and abstracts for designated types of citations. This would permit much additional and important information to be required, recovered, and analysed.

REFERENCES


Figure 1. Cause vs. No. Citations for Valve Failures, 1975-1978.

Figure 2. PWR Systems Citations for Valve Failure, 1975-1978.
Figure 3. BWR Systems Citations for Valve Failures, 1975-1978.

Figure 4. PWR Major Valve Type and Function Citations, 1975-1978.
Figure 5. BWR Major Valve Type and Function Citations, 1975-1978.

Figure 6. Valve Operator Type Failure Citations, 1975-1978.