The Hanford Site Generic Component Failure-Rate Database Compared with Other Generic Failure-Rate Databases

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THE HANFORD SITE GENERIC COMPONENT FAILURE-RATE DATABASE

COMPARED WITH OTHER GENERIC FAILURE-RATE DATABASES

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ABSTRACT

The Risk Assessment Technology Group, Westinghouse Hanford Company (WHC), has compiled a component failure rate database to be used during risk and reliability analysis of nonreactor facilities. Because site-specific data for the Hanford Site are generally not kept or not compiled in a usable form, the database was assembled using information from a variety of other established sources (i.e., EG&G Idaho, Inc.; Savannah River Plant; WASH-1400). Generally, the most conservative failure rates were chosen from the databases reviewed. The Hanford Site database has since been used extensively in fault tree modeling of many Hanford Site facilities and systems. The purpose of this study was to evaluate the reasonableness of the data chosen for the Hanford Site database by comparing the values chosen with the values from the other databases.

I. THE HANFORD SITE COMPONENT FAILURE RATE DATABASE

The Hanford Site database was compiled so that probabilistic studies at the Hanford Site would use a common, consistent database. Failure rates were drawn from a number of databases as shown in Table 1.

<table>
<thead>
<tr>
<th>DATABASE</th>
<th>AUTHOR</th>
<th>SOURCE</th>
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</thead>
<tbody>
<tr>
<td>DP-1633</td>
<td>A. H. Dexter, W. C. Perkins</td>
<td>Nuclear fuel reprocessing plant data as collected at Savannah River Plant</td>
</tr>
<tr>
<td>IEEE-500</td>
<td>Nuclear Power Engineering Committee of the IEEE Power Engineering Society</td>
<td>From raw data and expert opinion</td>
</tr>
<tr>
<td>SAIC 163-03-00</td>
<td>Science Applications International Corporation</td>
<td>From generic and raw data of power plants</td>
</tr>
<tr>
<td>SAIC/SNM-038</td>
<td>Science Applications International Corporation</td>
<td>Review of existing databases</td>
</tr>
<tr>
<td>EGG-SSRE-8875</td>
<td>Idaho National Laboratory</td>
<td>Review of existing databases</td>
</tr>
<tr>
<td>NUREG/CR-2728 (Interim Reliability Evaluation Program)</td>
<td>David D. Carlson, Sandia National Laboratory, under contract to U.S. Nuclear Regulatory Commission</td>
<td>Review of existing databases</td>
</tr>
<tr>
<td>PLG-0300 (Seabrook Probabilistic Risk Assessment)</td>
<td>Pickard, Lowe, and Garrick</td>
<td>Review of existing databases and raw data</td>
</tr>
<tr>
<td>NUREG-75/014 (WASH-1400)</td>
<td>Staff performing study</td>
<td>Review of many databases</td>
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</table>

IEEE = Institute of Electrical and Electronics Engineers
A list of components and their failure modes as applicable to the Hanford Site was established. This was accomplished by a committee of experienced WHC analysts working on risk assessment studies. Values from the databases in Table 1 were compared with the list of applicable failure modes and typical equipment used at the Hanford Site. Data were selected by the committee using a delphi method. In most cases, the data selected tended to be the more conservative values.

The Hanford Site database addresses more than 80 different components and about 175 component/failure mode probabilities. For this comparison, 32 of the more commonly used component/failure mode combinations were chosen for examination. Twelve of these components and their associated failure probabilities are shown in Figures 1 through 13.

II. METHOD OF COMPARISON

The Reactor Safety Study (NUREG-75/014) was the first assessment of accident risks in a U.S. commercial nuclear power plant. This study was followed by other U.S. Nuclear Regulatory Commission-funded studies, such as the Interim Reliability Evaluation Program and the Accident Sequence Evaluation Program. All three studies included a database. Several national laboratories and private industries or utilities in their studies have released databases (i.e., Science Applications International Corporation, Seabrook). E. I. du Pont de Nemours & Company (DP-1633) assembled a database using plant-specific data from the Savannah River Plant of components found in a nuclear processing facility. Finally, the IEEE-500 was also released as a component failure database. All of these databases have been used in support of risk assessment studies of nuclear power plants and U.S. Department of Energy facilities. They are all generally considered reliable databases for such studies.

A graphical presentation method was used to compare the failure probabilities of the Hanford Site database with the others. Several examples are shown in this paper. Figures 1 through 4 are representative examples of how the comparison was done. Each shows failure rates from databases for a particular component/failure mode combination. The x-axis of each graph identifies the databases examined with the data points shown above them. Some graphs display several data points corresponding to a single database. In these cases, more than one failure probability was given in the original database.
probability; and the upper data point represents the 95th percentile of the log-normal distribution of data used to generate the failure probability.

An attempt to compare the failure probabilities of the other databases (assumed to be means) with the Hanford Site database failure rate and its 5th and 95th percentiles was made. The database from which the Hanford Site value was chosen was not considered in the comparison, as it would be redundant.

Failure rates for components can vary widely between databases, even by orders of magnitude. It is assumed that the databases examined collectively would encompass the true failure rates. Therefore, it follows that a component failure with a graph that shows a majority of failure rates from other databases within the high and low range of the Hanford Site data point would be desirable. Of course, because of specific equipment used at the Hanford Site and its age, condition, and particular use, valid variances between the generic databases and the values used at the Hanford Site may exist.

III. RESULTS

Overall, the numbers chosen for use in the Hanford Site database compared well with the generic databases. On the average, about 68% of the data points from the other databases fell within the high-low range of the number picked for the Hanford Site database. Additionally, 23 out of 32 of the component/failure-mode combinations have at least half of the values from the other databases falling within the 5th and 95th percentiles of the Hanford Site value. This indicates that the numbers chosen are reasonable, for the most part, within the capabilities of the simple analysis used. Most data chosen also exhibited either close grouping with the other database values or at least no greatly dispersed grouping, which further demonstrates the reasonableness of the data chosen.

Several component/failure mode combinations deserve a closer examination, however, as they do not generally agree with the other databases. These components are shown in Figures 5 through 13. In these cases, it is desirable to evaluate these outliers to determine if a valid reason exists for the variance. The final goal, of course, is to produce a Hanford Site database with failure values as representative of the general body of failure values as possible.
Figure 5 shows only the Seabrook value within the high-low range of the Hanford Site value 1.0E-07. The other databases are generally an order of magnitude higher. However, this would put fuses and electronic circuits at approximately the same failure rate. The Hanford Site personnel could not accept this decision as being appropriate for the circuits used at the Hanford Site. By engineering judgment, the value of 1.0E-07 per hour was selected.

FIGURE 5 FUSE SPURIOUSLY OPENS

Figure 6 shows only one out of five data points is within the high-low range of the Hanford Site value (1.0E-06). Most of the other values are higher than that chosen for the Hanford Site database. However, most of the databases do not distinguish between a tube failure and a shell failure in their rates. For heat exchangers used at the Hanford Site, this is a significant difference.

Figure 7 shows only three out of seven other database values falling within the high-low values of the Hanford Site value (1.0E-08). The grouping is somewhat scattered between 1E-6 and 1E-11, although a slightly greater number of the data points lie in the lower part of the range, below the chosen Hanford Site value. Piping failure data frequently are difficult to evaluate. For example, it is not always clear how long a piece of pipe is being considered or the number of welds. At the Hanford Site, the piping frequently is quite old, even though it may be hydrostatically tested prior to use. It is for this reason that a conservative value was chosen.

FIGURE 6 HEAT EXCHANGER LEAKS FROM THE TUBES

Figure 8 shows only three out of eight database values falling within the 5th and 95th percentiles of the Hanford Site value (7.6E-5). However, the database used as a source was the most recent database developed and included recent data from the utilities using it.

FIGURE 7 PIPING LEAKS OR RUPTURES
Figure 9 has only two out of seven data point values from the other databases falling within the high-low range of the Hanford Site database value (1.8E-6). The values from the other databases are distributed in two ranges, a high range from 2.0E-6 to 5.0E-6 and a low range from 3.0E-8 to 1.0E-7. The value chosen is slightly lower than the high range. Check valves used at the Hanford Site tend to be in paths in the medium pressure range as compared to the high and low pressures of a reactor. These pressures are less likely to break a stem, the likely failure mode of a spuriously closing check valve. However, to be conservative, a data point was chosen near the higher range.

Figure 10 and Figure 11 both show only one out of five database values within the high-low range of the Hanford Site values (1.5E-6 and 1.4E-6, respectively). The value selected by the Hanford Site is from a recently updated database that uses information from several utilities. It is for this reason that the Hanford Site chose this data instead of the older databases.
Figure 11 shows two out of five data points within the high-low range of the Hanford value (1.7E-6). Five of the six databases fall within the range of 4.0E-6 to 1.2E-5. Relief valve data frequently include reactor safety relief valves that are of a different design than the typical relief valve used at the Hanford Site. It is for this reason, along with that for the motor-operated valve, that the Hanford Site selected the value they are using.

Figure 13 shows only one of three points within the high-low range of the Hanford Site value (4.1E-7). The Hanford Site chose the most up-to-date database for the same reason as the values for the motor-operated valves and relief valves.

Although only a small portion of the Hanford database has been examined (about one-sixth of it), it appears that from a simple analysis, the data chosen to represent Hanford failure rates is generally in the mainstream of failure rates from a large body of well accepted databases. Some data points were found to be outliers, but reasonable judgement was used to select these points and they are felt to be appropriate.

V. REFERENCES


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