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Analysis of Valve Failures from the NUCLARR Data Base

by

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ANALYSIS OF VALVE FAILURES FROM THE NUCLARR DATA BASE

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ABSTRACT

The "Nuclear Computerized Library for Assessing Reactor Reliability" (NUCLARR) contains data on component failures with categorical and qualifying information such as component design, normal operating state, system application and safety grade information which is important to the development of risk-based component surveillance testing requirements. This report presents descriptions and results of analyses of valve component failure data and covariate information available in the document "Nuclear Computerized Library for Assessing Reactor Reliability Data Manual, Part 3: Hardware Component Failure Data" (NUCLARR Data Manual). Although there are substantial records on valve performance, there are many categories of the corresponding descriptors and qualifying information for which specific values are missing. Consequently this limits the data available for analysis of covariate effects. This report presents cross tabulations by different covariate categories and limited modeling of covariate effects for data subsets with substantive non-missing covariate information.

KEY WORDS: NUCLARR Data Manual, Binomial counts, Poisson counts, Logistic model, Log-linear model

1. INTRODUCTION

This letter report describes the results of work performed on Task 10: GLMM Analysis of Selected Reliability Data. The goal is to demonstrate the feasibility of identifying and quantifying the effect of categorical descriptive and qualifying information, such as component design, system application or safety grade category, on selected component failure rates. This report strictly considers valve failure rates based on data available in the document "Nuclear Computerized Library for Assessing Reactor Reliability Data Manual, Part 3: Hardware Component Failure Data" (NUCLARR Data Manual). The table titled "Aggregated Data" in Appendix A of the NUCLARR Data Manual indicates over 400 records available on valves, although there are also many categories of descriptive and qualifying information available with these failure records. There are more records on valves than any other

component listed in the "Aggregated Data" Table of Appendix A, so valves were selected as the basis for the study undertaken for Task 10.

Two types of failure records are identified in the NUCLARR Data Manual according to whether valve failure modes of interest are time related (time-related data) or demand related (demand-related data). In Section 2, definitions of the variables and records extracted from the NUCLARR Data Manual for the valve data sets are provided. Section 3 and Section 4 respectively deal with analysis of available demand-related and time-related valve records. Although there are substantial records available for valves, there are also many categories of the corresponding descriptors and qualifying information, referred to generally as covariates, for which specific covariate information is missing. Consequently, this further limits the data available for analysis of covariate effects. Among boiling water reactors (BWRs), there are a substantive number of records from Plant Y combining reactors Unit 1 and Unit 2. Among pressurized water reactors (PWRs), Plant X has a substantive number of records as well as specific covariate information available. Data records from the two reactor types will be studied separately, with BWR types in subsections 3.1 (demand-related data) and 4.1 (time-related data) and PWR types in subsections 3.2 and 4.2.

2. DEMAND-RELATED AND TIME-RELATED VALVE DATA SETS

The NUCLARR Data Manual lists 548 valve failure records, including 147 records that are missing pertinent failure information such as number of failures or total hours and total demands. The records with missing failure information are excluded from failure rate analysis. Of the remaining records, 222 are demand-related failure records and 179 are time-related failure records. Table A.1 and Table A.2 in Appendix A list respectively the demand-related and time-related valve failure information obtained from the NUCLARR Data Manual.

Nineteen variables, corresponding to table columns, are included in each of the data sets listed in Table A.1, demand-related data, and Table A.2, time-related data. Column headings in these tables indicate a label for the variable as well as a brief description. "Record", labeled recno, is the unique number from the NUCLARR Data Manual identifying each individual data record. "Failures" (numfail) and "demands" (totd) or "hours"(tothrs) are the observed failure information from the NUCLARR Data Manual. "Failures" is the observed count of failures on valves included in a record. All valve failures in the NUCLARR Data Manual are classified as catastrophic in severity. "Demands" and "hours", respectively are the exposure information for the failure records in the demand-

related and time-related data sets. "Demands" is the count of total demands on the valves in a record in the demand-related data set. "Hours", in the time-related data set, is the count of total hours on the valves in a record. The value of "failure rate" (frate) is computed as the ratio of "failures"/"demands" and "failures"/"hours" respectively in the demand-related and time-related data sets. "Failure rate" represents the observed failure rate for each record. For modeling demand-related data, the failure count response, numfail, is assumed to be distributed as a binomial random variable with totd ("demands") the number of trials. For time-related data, the failure count response, numfail, is assumed to be distributed as a Poisson random variable with tothrs ("hours") exposure time. Log-linear and logistic models for analyzing Poisson and binomial counts are described in depth in Atwood (1995) and these techniques form the basis for analysis of failure rates in this report. As in Atwood (1995), the SAS computer package, in particular the GENMOD procedure, is used for model fitting.

The remaining 15 variables constitute the available potential explanatory variables, or covariates, effecting the component failure rates from the NUCLARR Data Manual. In some cases the value of a covariate in the NUCLARR Data Manual is indicated as unknown or non-specific, so the covariate value is considered missing for modeling purposes and is indicated with a blank or "." in the appropriate field in Table A.1 and Table A.2. The following list defines the explanatory variables including the level descriptions and corresponding coded values that appear in Table A.1 and Table A.2.

- rtype: The two types of water reactor are pressurized, coded PWR, and boiling, coded BWR. Each facility is one of these types so that facility (of1) is nested in rtype.
- of1: The NUCLARR Data Manual includes a field identifying the plant from which the data was collected. This plant is referred to as the originating facility and Appendix E-4 of the NUCLARR Data Manual contains a list of all codes and data source names. The following is a list, by rtype, of facility codes and the NUCLARR Data Manual data source names for which there is valve data.

BWR facilities:

- Yx: Plant Y, 1st U or 2nd U (SAIC data)
- BRP1: Big Rock Point
- MNS1: Millstone 1
- BWR: All BWR Plants

–IP4: IPRDS Plant 4

PWR facilities:

–X: Plant X (SAIC Data)

–DBS1: Davis-Besse

–NEE3: Oconee 3

–IP1: IPRDS Plant 1

–B&W: Babcock & Wilcox

–FPRA: Proprietary PRA "F"

–Z1S1: Zion 1 and Zion 2

–BREL: Proprietary REL "B"

–EUR: European Comm (SAIC)

–IPS2: Indian Point 2

–RGLS: Ringhals 2 (Swedish)

–PWR: All PWR Plants

Facilities with unknown rtype:

–AREL: Proprietary REL "A"

- syst1: This variable identifies a specific system, if known, from which the valve data were collected. Appendix E-6 of the NUCLARR Data Manual lists two-character codes and descriptions for nuclear power plant systems. Some systems occur in only one of the two reactor types. The following lists the system codes and descriptions from the NUCLARR Data Manual for which there is valve data and indicates in parentheses which, if only one, of the reactor types include the identified system.

–AA: Control rod drive system

–AB: Reactor coolant system (PWR)

–AB/AP: AB and AP systems combined

–AP: Pressurizer system (PWR)

–BA: Auxiliary/emergency feedwater system (PWR)

–BE: Containment spray system (PWR)

- BG/BM: High or low pressure core spray system (BWR)
- BI: Essential service water system
- BL: Isolation condenser system (BWR)
- BN: Reactor core isolation cooling system (BWR)
- BP: Low pressure safety injection system (PWR)
- BS: Ultimate heat sink system
- BY: Automatic depressurization system
- CB: Chemical and volume control/Makeup and purification system (PWR)
- CC: Closed/component cooling water system
- CH: Residual heat removal system (BWR)
- CI: Residual heat removal system (PWR)
- JI: Turbine steam bypass control system
- JM: Containment isolation control system
- KA: Condensate storage and transfer system
- KE: Heat rejection system
- LD: Instrument air supply system
- MS: Main steam isolation valves
- NT: Drywell
- SB: Main/reheat steam system
- SD: Condensate system
- SG: Condenser system
- SJ: Feedwater system
- XC: ECCS

- cap11: This variable identifies the application environment for the valves included in the record. Appendix E-3 of the NUCLARR Data Manual contains the application codes. The following lists the application codes and descriptions from the NUCLARR Data Manual for which there is valve data.

–INTEAR: Air internal environment

- INTECS: Chemical solution other than boric acid
 - INTEST: Steam internal environment
 - INTEWB: Water, borated internal environment
 - INTEWC: Water, high purity/demineralized internal environment
 - INTEWD: Water, silt/particle entrained internal environment
 - INTEWS: Water, brackish sea internal environment
- optyp1: This variable identifies valve operator type. Its value is derived from the 5-character component type/component design code in the NUCLARR Data Manual, Appendix E-1. The following lists the operator type codes, a brief description and the corresponding component type/component design codes from the NUCLARR Data Manual, with * indicating all values.
 - 1: Pneumatic operator, NUCLARR codes VLP** and VLCPN
 - 2: Solenoid operator, NUCLARR codes VLS**
 - 3: Motor operator, NUCLARR codes VLM** and VLCMO
 - 4: Hydraulic operator, NUCLARR codes VLH**
 - 5: Manual operator, NUCLARR codes VLO**, VLCMN, VLCNO and VLCNT
 - 6: Mechanical operator, NUCLARR codes VLD**
 - 7: Relief valves/vacuum breaker, NUCLARR codes VLR** and VLV**
 - vlvtyp1: This variable identifies valve type. Its value is derived from the 5-character component type/component design code in the NUCLARR Data Manual, Appendix E-1. The following lists the valve type codes, a brief description and the corresponding component type/component design codes from the NUCLARR Data Manual, with * indicating all values.
 - 1: Ball valve, NUCLARR codes ***BL
 - 2: Butterfly valve, NUCLARR codes ***BF
 - 3: Check valve, NUCLARR codes VLC**
 - 4: Gate valve, NUCLARR codes ***GT
 - 5: Globe valve, NUCLARR codes ***GL
 - 6: Plug valve, NUCLARR codes ***PL

–7: Relief valves/vacuum breaker, NUCLARR codes VLR** and VLV**

–8: Angle valves, NUCLARR codes ***AN

- ic1: This variable is an indicator for records where the control circuitry is included in the component's boundary and consequently control circuitry failures are included in the failure counts. A value ic1=1 indicates that circuitry failures are included and a value ic1=0 indicates no or unknown. More than 50% of the records indicate that control circuitry failures are included.
- sg1: This variable is an indicator for whether the components associated with the record are safety graded with sg1=1 indicating the components are safety graded and sg1=0 indicating unknown or not safety graded. Less than 15% of the valve records are indicated as safety graded.
- pf1: This variable indicates cases where the failure counts include primary failures only. pf1=1 indicates only primary failures are included and pf1=0 indicates that secondary failures may also be included. Less than 15% of the valve records indicate that only primary failures are included.
- fmode: Failure mode describes how the failed component's state or condition differs from the desired or normal plant operating state for the recorded valves. Appendix E-2 of the NUCLARR Data Manual lists failure mode codes. The majority of failure modes are identified as failures to operate (FTO). In the case of demand-related data, all failure modes are equivalent to FTO and no modeling considerations are required for this covariate. For time-related failure data, separate analyses for data under different failure modes is considered appropriate. The following lists failure mode codes and descriptions that occur for the two data sets, demand-related data and time-related data.

Demand-related data:

–FTC: Failure to Close

–FTP: Failure to Open

–FTO: Failure to Operate

Time-related data:

–BP: Plugged

–LE: External leakage/rupture

–LI: Internal leakage

- SC: Spurious (transfer) close
 - SO: Spurious operation
 - SP: Spurious (transfer) open
 - FTO: Failure to Operate
- nstate: This variable identifies the normal operating state associated with the valves recorded. The normal operating state codes are listed in Appendix B of the NUCLARR Data Manual. In more than 75% of the valve records, nstate is unspecified and otherwise there are two values of nstate that occur: normally open, coded NO, and normally closed, coded NC. Data is insufficient to characterize an effect due to normal operating state so this variable is not considered in any modeling analyses.
 - fdorig: This variable indicates the origin or source of the failure count data and is described in Appendix B of the NUCLARR Data Manual. For the valve records, the majority of the failure counts are obtained from plant experience indicated by fdorig=PLNT. Only a few cases (8) indicate fdorig=OTHR for "other". It is not expected that the failure data source would have an impact on the plant component failure rates but the quality of the data may be affected according to source. With so few cases other than plant experience, there is limited ability to characterize differences in failure rates according to fdorig.
 - expsdat: This variable indicates the origin or source of the data on operating hours or number of demands and is described in Appendix B of the NUCLARR Data Manual. Again, the majority of valve records indicate plant experience, expsdat=PLNT, as source for exposure data. The following lists codes and descriptions that occur for the valve data sets.
 - PLNT: Plant experience
 - TCAL: Total calendar hours
 - TCRT: Total critical hours
 - OTHR: Other
 - ir: This variable indicates data records that achieve quality levels established through the Integrated Risk Assessment Data Acquisition Program (IRADAP). Almost 90% of the data records achieve IRADAP quality levels. It is not expected that IRADAP quality assessment of the data records would have any effect on plant component failure rates but the quality assessment of the data may be correlated with some more relevant

covariates. With relatively few records that are not IRADAP qualified, there is limited ability to characterize differences in failure rates according to it.

In addition to facility (of1) being nested in reactor type (rtype), cross tabulations in Tables A.3 and A.4 indicate that system is also, virtually, nested in reactor type. For demand-related valve records, Table A.3 is a cross tabulation including the number of records, the number of failure counts and the total demands for valve records in a given system and reactor type category. For time-related valve records, Table A.4 contains similar information. With the exceptions of systems BI and SJ, each system, for which there is data, uniquely coincides with one reactor type. This property is called collinearity or confounding of the variables system and reactor type and indicates dependency between the covariates. Thus, system and reactor type cannot be modeled independently. One solution in modeling is to include a system effect nested in reactor type; however, as will be seen in the following, there are several problems with collinearity between covariates that further restrict modeling options. For NUCLARR Data Manual valve records, separate analyses by reactor type will be conducted in turn in the following.

3. DEMAND-RELATED DATA ANALYSES

Of the 222 demand-related valve failure records, 64 are records on BWR plants, 135 are from PWR plants, and 23 are missing reactor type information. The BWR and PWR records are analyzed respectively in subsections 3.1 and 3.2.

3.1 Boiling Water Reactor Plants

For the 64 demand-related data records from BWR plants, the covariate pf1 is the same with pf1=0 indicating that failure counts may include secondary as well as primary failures. Tables B.1-B.13 provide cross tabulations listing the number of records, the total number of failure counts and total demands on all records, and the observed failure rate in the corresponding identified cell. With the exception of Table B.3, B.8 and B.10, Tables B.1-B.13 all have originating facility, of1, corresponding to the column dimension of the tables. These tables repeatedly demonstrate the major problem with the valve data set with there many empty counts. There is insufficient data available on covariate values to generally assess effects on failure rates.

Table B.1 is a cross tabulation between system and originating facility, of1, and clearly indicates collinearity between these two covariates. Only the 34 records for which there is a specified system value are included in the

tabled summary information. The collinearity property between system and originating facility means that a system effect estimate would be biased by an originating facility effect. From the bottom row of Table B.1, the summary of records by originating facility indicates some striking differences in the observed failure rates with plant BRP1 having a considerably higher observed failure rate. This suggests perhaps analyzing of1 cases separately; however, with the possible exception of plant Yx, there is insufficient data for each plant.

Table B.2 cross tabulates records by originating facility, of1, and component application environment, cap11. This table shows that, outside of plant Yx, there are only 7 records with component application environment specified and 4 of those are in the single environment cap11=INTEWC. Even restricted to plant Yx, the majority of records with cap11 specified have cap11=INTEWC. There is insufficient data to model cap11.

Table B.3, B.4, and B.5, are cross tabulations between originating facility (of1), operator type (optyp1) and valve type (vlvtyp1). Table B.3, cross tabulating by operator type and valve type, suggests some confounding between these two covariates so that only one of operator type or valve type might be modeled. Additionally, Table B.4 indicates very few cases in plants other than Yx where operator type is specified and Table B.5 indicates confounding between of1 and vlvtyp1. In order to assess some effect attributable to operator, again the data from plant Yx alone might be considered and it should be understood that the operator covariate also carries valve type information.

Table B.6 that cross tabulates the indicator covariate ic1 with of1, originating facility, is interesting and provides a possible illustration of the problems that can occur when collinearity or confounding between covariates occurs. Recall this covariate indicates whether circuitry failures are included in the failure count. It would be expected that inclusion of circuitry failures with component failures results in higher failure counts and thereby higher failure rates. However, the summary of observed failure rates by ic1 category in the last column of Table B.6 indicates that for cases where circuitry failures are not included, $ic1=0$, the observed failure rate is .00219407, which is larger than the observed failure rate .0007601 for records where $ic1=1$, where circuitry failures are included in failure counts. If the column corresponding to records from plant Yx alone is studied then the aggregate cases where $ic1=0$ and $of1=Yx$ have observed failure rate .00006378 which is smaller, as expected, than the observed failure rate .00056281 for plant Yx cases where $ic1=1$. Excluding the plant Yx cases, Table B.6 shows that the covariates $ic1$ and $of1$ are fully collinear with records from plants BRP1 and MNS1 having $ic1=0$ and records from plants

BWR (a compilation of several BWR plants) and IP4 having $ic1=1$. It just so happens that records from plant BRP1 (where $ic1=0$) seem to have relatively high failure rates and those (few) from plant BWR (where $ic1=1$) seem to have low failure rates. This alignment of data perhaps masks the expected effect of $ic1$ in the overall results aggregating across all originating facilities. This again provides an argument for looking at data from different originating facilities separately since covariate levels are not fully represented in each facility allowing aggregation for assessment of covariate effects.

Table B.7 cross tabulates $sg1$, the indicator for safety graded components, with originating facility. The only records on safety graded components come from plants BRP1 and MNS1. A similar phenomena may be occurring here as occurred with the covariate $ic1$. Safety graded components might be expected to perform better and this appears to be the case for the few records from plant MNS1. However, the reverse trend occurs for plant BRP1 and this trend is sustained in the summary across of $of1$ appearing in the last column of Table B.7. The data is clearly insufficient to make a definitive statement regarding the affect of use of safety graded components on failure rates.

Tables B.8 and B.9 provide some information regarding failure mode ($fmode$), normal operating state ($nstate$) and originating facility ($of1$). Table B.8 indicates that $fmode$ and $nstate$ are collinear, or equivalent, in cases where $nstate$ is specified. Table B.9 indicates that the cases where a failure mode is specified alternative to $fmode=FTO$ all occur in plants BRP1, MNS1 and BWR. Considering previous reservations regarding operating facilities and noting that observed failure rates are not substantively different in columns corresponding to alternative failure modes, failure mode is not considered as a potential covariate for modeling the demand related BWR data records.

Tables B.10, B.11 and B.12 illustrate that, for the majority of records, failure data and exposure information sources are plant experience. Since there are so few cases of other sources, these covariates are assessed unimportant to modeling considerations.

Table B.13 indicates that very few data records are not IRADAP qualified. It is interesting that the few that are not qualified come from originating facilities that have previously been put forth as problematic. However, since the observed failure rates do not seem substantively affected and there are so few cases where $ir=N$, this covariate is not considered further.

Table B.14 lists the 35 demand-related data records from Plant Yx in order according to the observed number of failures, with only non-degenerate covariates included. Specifically, each of the set of Plant Yx demand-related

data records has $sg1=0$, $pf1=0$, $fmode=FTO$, $fdorig=expsdat=PLNT$ and $ir=Y$ so these values are not listed in Table B.14. Also, $nstate=XX$ except in 6 cases where $nstate=NC$ and $nstate$ is considered equivalent to $fmode$ so $nstate$ is not included. Table B.14 demonstrates still many missing values of the remaining 5 covariates: $syst1$, $cap11$, $optyp1$, $vlvtyp1$ and $ic1$. In fact, there are only 15 records with specific values for each of the 5 covariates and only 3 of these cases has non-zero failure count. This is insufficient data to evaluate effects of all 5 covariates, or even subsets of 2 or 3, on failure rate. Even considering only modeling one variable at a time there are few cases (1 or 2) on most levels of each covariate and there is no variability in the observed failure counts which are often 0. Tables B.15-19 show aggregate number of records, observed failure counts, total demands and observed failure rates by level respectively for each of the 5 non-degenerate covariates. Fits of logistic regression models each with a single covariate, $syst1$, $cap11$, $optyp1$, $vlvtyp1$ or $ic1$, indicate significant differences in failure rates with different levels of any one of these covariates; however, given the problems stated above, the estimates obtained from these limited models are suspect and they are not included here.

3.2 Pressurized Water Reactor Plants

Of the 135 demand-related data records from PWR type reactors, 64 are from Plant X. Table C.1 is a cross tabulation of number of records, observed failure counts, total demands and observed failure rate by system ($syst1$) and plant ($of1$). Only the 88 records for which there is a specific system value are included in the tabled summary counts. Although collinearity of these two covariates is somewhat less striking than the same table for BWR demand-related data, it is clear again that many cells are missing data. In fact, there are few cases where specific system information is available in plant data other than Plant X. For reasons similar to those given previously, we focus analyses of demand-related data from PWR type reactors on Plant X records, eliminating consideration of an originating facility (plant) effect.

For Plant X records, $pf1=0$, $ir=Y$, $fdorig=expsdat=PLNT$, $fmode=FTO$ and $nstate=XX$ except for 3 cases where $nstate=NC$. Additionally, there are relatively few cases, 33, where valve type is specified, and Table C.2 illustrates that operator type and valve type are confounded, with valve type 3 occurring when operator is type 3 or 5 and valve type 7 occurring when operator is also 7. This means that operator type does not strictly represent operator and actually represents a combination of valve and operator type. For this reason valve type is eliminated from modeling consideration. This leaves 5 covariates for modeling failure rates in Plant X: $syst1$ (system), $cap11$ (application

environment), optyp1 (operator type), ic1 (circuitry inclusion indicator), and sg1 (safety grade indicator).

Table C.8 lists 26 records which form a basis for identifying and quantifying the effect on failure rates of the categorical descriptive and qualifying information available for component system, application environment and operator type. With the exception of valve type and sg1, values of the other covariates are fixed. The following discussion describes how the data of Table C.8 was obtained. For 47 records in Plant X, values for all 5 of the covariates syst1, cap11, optyp1, ic1 and sg1 are specified. Initial restriction to this set of records allowed the possibility of simultaneously assessing the effects of these 5 covariates without missing information, at least among the original set of covariates, and without potentially unknown collinearity or confounding problems that could lead to errors in inference. Among these limited number of records, there are some cases of covariate values for which there are very few records or total failure count values of 0. This means that there is insufficient information to assess the effect for that particular value of the covariate and that it does not contribute to modeling differences in covariate levels. Specifically, Table C.3 lists several systems (SB, CI, KA, LD) with few records or total failure counts of 0. Table C.4 lists the number of records, total failure counts and total demands for the values of cap11 that occur. Except for cap11 values INTEWC and INTEWB, there are very few records with alternate values of cap11 and as a result insufficient data for assessing the effect of these alternate values of cap11. Restricting to the records for which cap11 is INTEWC or INTEWB allows the possibility of modeling whether there is an effect of cap11 at least for these two values of cap11. Table C.5 demonstrates that operator type 2 has 0 failure counts based on 4 records. There is no variability measured in such a performance and hence the best estimate of the failure probability associated with operator type 2 is 0. Atwood (1995) observed that based on this type of data there is no information contributed about differences between operators and hence this is not of use in modeling an operator effect. Table C.6 demonstrates that once data is restricted to cases for which cap11 is INTEWC or INTEWB, then there is no failure count among records for which ic1=0 so these records are eliminated to focus on covariate effects in cases where ic1=1. Table C.7 indicates very few cases for which sg1=1, and with the restrictions on cap11, sg1 becomes confounded with system. Rather than delete the few cases for which sg1=1 and dilute the data set further, it is understood that an estimate for system effect may be biased by a potential effect due to sg1. To summarize, the data of Table C.8 is a subset of the demand-related valve data from PWR Plant X obtained by deleting cases as follows:

1. If capl1 is missing or capl1=INTECS or capl1=INTEST or capl1=INTEWS then delete;
2. If syst1 is missing or syst1=KA or syst1=CI then delete;
3. If optyp1 is missing or optyp1=2 then delete;
4. If ic1=0 then delete.

The data of Table C.8 constitutes a subset of the demand-related valve records with constant (known) values of the potential covariates rtype, of1, ic1, pf1, fmode, nstate, fdorig, and expsdad. The remaining covariates are syst1, capl1, optyp1, vlvtyp1 and sg1. The two covariates vlvtyp1 and sg1 are not considered for modeling as they are respectively confounded with optyp1 and syst1; however, it should be noted that estimates of operator type effects or system effects will be biased by any true effect due to valve type or safety grade category. It should also be cautioned that this data is limited to evaluating the effects of the covariates with respect to the few levels that occur.

Table C.9 and Table C.10 list analysis results for fitting a logistic model to the data of Table C.8. The model for Table C.9 is the simple intercept model while the model for Table C.10 fits main effects due to optyp1, capl1 and syst1. The intercept model fits with a deviance of 402.9678 with 25 error degrees of freedom. The main effects model based on optyp1, capl1 and syst1 fits with a deviance of 51.1245 with 15 error degrees of freedom. This reduction in deviance from the intercept model to the main effects model with a cost of 10 degrees of freedom is significant at any reasonable level. The test of forward and backward inclusion of each covariate presented under the titles "LR Statistics for Type 1 Analysis" and "LR Statistics for Type 3 Analysis" in Table C.10 indicates that each covariate is a significant contributor to the model. The table of parameter estimates in Table C.10 indicates significantly non-zero estimates for most parameters, with exceptions being effects of systems BA, SD and SJ. Graphs C.1 and C.2 are diagnostic plots. The purpose of Graph C.1 which plots the deviance residuals against predicted values is to evaluate goodness of fit. There is a seemingly random scatter of the deviance residuals relative to the horizontal with no clear pattern although there are a couple of large residual values. This together with the relatively large deviance value for 15 error degrees of freedom for the main effects model suggests that the model falls some short of explaining all of the variability in the data. However, the limited data set will not support estimation of a much more complicated model so this model is accepted as adequate. The purpose of Graph C.2 which plots the adjusted dependent variable value, predicted + residual/predicted, against predicted is to evaluate

the goodness of the logistic link function. Graph C.2 suggests that the logistic link is adequate.

Table C.11 provides a listing of failure rate predictions and bounds for each of the possible combinations of the three covariates optyp1, capl1 and syst1 by levels which occur in the data of Table C.8. Graph C.3 is a graphical display of the failure rate interval estimates listed in Table C.11 with an overlay of the observed failure rates. The labels on the x-axis correspond respectively to a numeric coding of optyp1, capl1 and syst1 that is used and described in Table C.11. The order of the cases on the x-axis is by system within operator within application environment. It is apparent from this plot that the model estimates of all three covariates lead to significantly different modeled failure rates.

4. TIME-RELATED DATA ANALYSES

Of the 179 time-related valve failure records, 41 are records on BWR plants, 129 are from PWR plants, and 9 are missing reactor type information. The BWR and PWR records are analyzed respectively in subsections 4.1 and 4.2.

Also, for the time-related failure data, failure mode categories provide more detail for the type of failure that occurs. Generally separate failure rate analyses are conducted for each category. Recall the failure mode categories include the following:

- BP: Plugged
- LE: External leakage/rupture
- LI: Internal leakage
- SC: Spurious (transfer) close
- SO: Spurious operation
- SP: Spurious (transfer) open
- FTO: Failure to Operate.

4.1 Boiling Water Reactor Plants

The available time-related data for BWR facilities is insufficient to model covariate effects on failure rates for the different failure mode categories. Table D.1 is a cross tabulation between originating facility, of1, and failure mode, fmode and indicates that there is very little data with the possible exception of plant Yx and failure modes

LI and FTO. For all 41 time-related data records from BWR plants, the potential covariate sg1 is fixed with sg1=0. The same is true for the potential covariate pf1 which has value pf1=0 except for records (2) that occur in failure mode fmode=LE where pf1=1. In fact, for failure modes LE, SC and SP all potential covariate information is either fixed or missing within the failure mode category. For failure mode SO there are only four records with only operator/valve type (optyp1 and vlvtyp1) having four distinct values. This is insufficient data to assess effects on failure rates for these failure mode categories.

Table D.2 lists number of records, observed failures, exposures in total hours, and observed failure rate for cell categories determined by system (syst1) and operating facility (of1) listed by the two failure mode categories FTO and LI. Table D.3 lists the same information for cell categories defined by operator type (optyp1) and operating facility (of1) listed by the two failure mode categories FTO and LI. Other potential covariates, including cap11, vlvtyp1, nstate, fdorig, expsdat, ic1 and ir, are either missing values, constant for all but perhaps a single record, or collinear with one of the covariates of Tables D.2 and D.3. Tables D.2 and D.3 indicate many empty cells and substantial missing covariate information in spite of what initially appears to be a large number of valve records. As result of these limitations, there is insufficient data to model covariate effects.

4.2 Pressurized Water Reactor Plants

Of the 129 time-related records from PWR type reactors, 74 are from Plant X (51 under failure mode category FTO, 22 under category LI, and 1 under category SP). Table E.1 provides cross tabulation of number of records, observed failure counts, exposure in total hours, and observed failure rate by failure mode (fmode) and plant (of1). This table indicates there is very little data with the possible exception of plant X and failure modes FTO and LI, so the remainder of this section focuses on plant X data for these two failure modes in turn.

The 22 time-related records from plant X with failure mode LI are listed in Table E.2 in order of observed number of failures. These records have common values for the potential covariates fdorig, expsdat, ir, and pf1 so these covariates are not included in the listing in Table E.2. The covariates nstate, optyp1 and vlvtyp1 also have common values with one exception (record number 938) which is missing a specific value for system and cap11 and eliminated from modeling considerations. Only four potential covariates remain: syst1, cap11, ic1 and sg1. Table E.3, a cross tabulation of records by system and application environment, shows collinearity between these two covariates. Also, there are only two records for which sg1=1 and there is no failure count for these records

and thereby insufficient information to contribute about differences in failure rates for safety graded components. In fact there are few records (5) with non-zero failure count. Table E.4, a cross tabulation of records by system and ic1, shows that there are 13 system categories (11 if the two records for which sg1=1 are eliminated). This means that there are few records, less than 3 in all but one case, on any single system and as a result insufficient data to model even a single effect due to system. Generally, as a result of the sparseness of this data, there is insufficient information for modeling the two covariates which do vary.

The 51 time-related records from plant X with failure mode FTO are listed in Table E.5 in order of observed number of failures. These records have common values for the potential covariates nstate, fdorig, expsdad, and pf1 so these covariates are not included in Table E.5. Also, the potential covariate vlvtyp1 is not included in Table E.5 since it is missing in all but 16 records and in those records is identical to optyp1. Six potential covariates remain: syst1, cap11, optyp1, ic1, sg1, and ir. As with the failure records for failure mode LI, there are few records (6) with non-zero failure counts, and almost a dozen categories of system and almost half that many of operator type (5) occur. This makes for a sparse data set with insufficient information for modeling covariates independently. Fits of Poisson regression models, each with a single covariate restricted to categories for which there is either failure count or a substantive number of records, indicates significant differences in failure rates with different levels of all of the six above potential covariates except for ic1; however, the covariates are pairwise collinear to some degree so there is no clear identification of a single covariate effect and given the problems stated above, estimates obtained from these limited models are suspect and these are not included here. Tables E.6-10 show aggregate number of records, observed failure counts, exposures in total hours, and observed failure rates cross tabulated by system (syst1) and each of application environment (cap11), operator type (optyp1), inclusion of circuit indicator (ic1), safety grade indicator (sg1), and IRADAP quality data indicator (ir).

5. SUMMARY AND CONCLUSIONS

Although the NUCLARR Data Manual valve failure data is limited by missing covariate information and small numbers in some covariate cells, there are clear significant covariate effects particularly for the data of Plant X and for covariates operator type, application environment and system. As a result of these significances it is inappropriate to ignore many missing covariate values and analyze data across levels of certain covariates. Instead we identified subsets of the data for which some covariate values are fixed and others that vary are known. This

resulted in limited data and in some cases insufficient data for model fitting. The model fitting that is possible demonstrates significant covariate effects but with the limited data available specific estimates of effects of covariate levels are limited to a few and likely suspect.

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APPENDIX A: Demand-related and Time-related Failure Data from NUCLARR Data Manual

Table A.1

c2demand.ssd: Demand-related failure data

recno	rtype	ofl	systl	capll Applica- tion	enviroment	optyp1	vlvtyp1	icl	sgl	pfl	fmode	nstate	fdorig Fail- ure	expdat -sure	ir	numfail	totd	frate
Record	Type	Facility	System			Type	Type	Circuit?	Graded?	Failures Only?	Failure Mode	Normal State	Data Source	Data Source	IRADAP?	Failures	Demands	Failure Rate
571						.	3	0	1	1	FTP	NC	PLNT	PLNT	N	3	46544	0.00006
592						.	3	1	0	0	FTO	XX	PLNT	TCRT	Y	2	632	0.00316
803						1	.	0	1	1	FTO	XX	PLNT	PLNT	N	8	8843	0.00090
549						1	3	1	0	0	FTO	XX	PLNT	TCRT	Y	8	1236	0.00647
967						2	.	0	1	1	FTO	XX	PLNT	PLNT	N	94	8843	0.01063
678						3	.	0	1	1	FTO	XX	PLNT	PLNT	N	235	56282	0.00418
727						3	.	1	0	0	FTO	XX	PLNT	TCRT	Y	30	6181	0.00485
728						3	.	1	0	0	FTO	XX	PLNT	TCRT	Y	5	1486	0.00336
453						3	3	1	0	0	FTO	XX	PLNT	TCRT	Y	1	600	0.00167
454						3	3	1	0	0	FTO	XX	PLNT	TCRT	Y	5	983	0.00509
455						3	3	1	0	0	FTO	XX	PLNT	TCRT	Y	18	2512	0.00717
456						3	3	1	0	0	FTO	XX	PLNT	TCRT	Y	22	3059	0.00719
457						3	3	1	0	0	FTO	XX	PLNT	TCRT	Y	22	2012	0.01093
747						5	.	0	1	1	FTO	XX	PLNT	PLNT	N	4	63073	0.00006
849						7	7	1	0	0	FTC	XX	PLNT	TCRT	Y	1	845	0.00118
850						7	7	1	0	0	FTC	XX	PLNT	TCRT	Y	2	1281	0.00156
855						7	7	1	0	0	FTP	XX	PLNT	TCRT	Y	1	1281	0.00078
856						7	7	1	0	0	FTP	XX	PLNT	TCRT	Y	7	845	0.00828
890						7	7	0	1	1	FTC	XX	PLNT	PLNT	N	20	6524	0.00307
927						7	7	0	1	1	FTP	NC	PLNT	PLNT	N	58	6524	0.00889
928						7	7	0	1	1	FTP	NC	PLNT	PLNT	N	7	1783	0.00393
986		AREL				.	.	0	1	1	FTP	XX	PLNT	PLNT	Y	4	1542	0.00259
700		AREL				3	.	0	1	1	FTO	XX	PLNT	PLNT	Y	21	5500	0.00382
977	BWR	BRP1				.	.	0	0	0	FTC	NO	PLNT	PLNT	N	16	621	0.02576
983	BWR	BRP1				.	.	0	0	0	FTP	NC	PLNT	PLNT	N	16	750	0.02133
985	BWR	BRP1	BY			.	.	0	0	0	FTP	NC	PLNT	PLNT	Y	1	215	0.00465
978	BWR	BRP1	JM			.	.	0	1	0	FTC	NO	PLNT	PLNT	Y	19	227	0.08370
982	BWR	BRP1	J1	INTEST		.	.	0	0	0	FTP	NC	PLNT	PLNT	Y	4	28	0.14286
984	BWR	BRP1	BL	INTEWC		.	.	0	0	0	FTP	NC	PLNT	PLNT	Y	2	125	0.01600
667	BWR	BRP1				3	.	0	0	0	FTC	NO	PLNT	PLNT	Y	10	639	0.01565
702	BWR	BRP1				3	.	0	0	0	FTP	NC	PLNT	PLNT	Y	7	989	0.00708
666	BWR	BRP1	MS	INTEST		3	.	0	1	0	FTC	NO	PLNT	PLNT	Y	2	52	0.03846
703	BWR	BRP1	BG/BM	INTEWB		3	.	0	1	0	FTP	NC	PLNT	PLNT	Y	3	230	0.01304
566	BWR	BWR				.	3	1	0	0	FTC	XX	OTHR	TCRT	N	2	3628	0.00055
567	BWR	BWR				.	3	1	0	0	FTC	XX	OTHR	TCRT	N	11	3211	0.00343
577	BWR	BWR				.	3	1	0	0	FTP	XX	OTHR	OTHR	N	0	3628	0.00000
580	BWR	BWR				.	3	1	0	0	FTP	XX	OTHR	TCRT	N	1	3211	0.00031
800	BWR	BWR				1	.	1	0	0	FTO	NC	OTHR	TCRT	N	14	2366	0.00592
799	BWR	BWR	AA	INTEWC		1	.	1	0	0	FTO	NC	OTHR	OTHR	N	4	27816	0.00014
786	BWR	IP4				1	2	1	0	0	FTO	XX	PLNT	OTHR	Y	19	7060	0.00269
791	BWR	IP4				1	5	1	0	0	FTO	XX	PLNT	OTHR	Y	1	1440	0.00069
612	BWR	IP4				3	2	1	0	0	FTO	XX	PLNT	OTHR	Y	9	2160	0.00417
630	BWR	IP4				3	4	1	0	0	FTO	XX	PLNT	OTHR	Y	7	6700	0.00104
609	BWR	IP4				3	8	1	0	0	FTO	XX	PLNT	OTHR	Y	1	504	0.00198
564	BWR	MNS1	XC			.	3	0	1	0	FTC	XX	PLNT	PLNT	Y	0	1272	0.00000
575	BWR	MNS1	XC			.	3	0	1	0	FTP	XX	PLNT	PLNT	Y	0	1272	0.00000
565	BWR	MNS1	SJ	INTEWC		.	3	0	0	0	FTC	XX	PLNT	PLNT	Y	3	676	0.00444
576	BWR	MNS1	SJ	INTEWC		.	3	0	0	0	FTP	XX	PLNT	PLNT	Y	0	676	0.00000
668	BWR	MNS1				3	.	0	0	0	FTC	NO	PLNT	PLNT	Y	19	5497	0.00346
704	BWR	MNS1				3	.	0	0	0	FTP	NC	PLNT	PLNT	Y	29	5497	0.00528
669	BWR	MNS1	NT			3	.	0	0	0	FTC	NO	PLNT	PLNT	Y	7	369	0.01897
705	BWR	MNS1	NT			3	.	0	0	0	FTP	NC	PLNT	PLNT	Y	5	369	0.01355
980	BWR	Yx	CH	INTEWB		.	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	429	0.00000
981	BWR	Yx	CH	INTEWB		.	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	463	0.00000
569	BWR	Yx				.	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	724	0.00000
810	BWR	Yx				1	.	1	0	0	FTO	XX	PLNT	PLNT	Y	18	49889	0.00036
553	BWR	Yx				1	3	1	0	0	FTO	XX	PLNT	PLNT	Y	4	102	0.03922
551	BWR	Yx	BG/BM	INTEWC		1	3	1	0	0	FTO	XX	PLNT	PLNT	Y	1	588	0.00170
554	BWR	Yx	BG/BM	INTEWC		1	3	1	0	0	FTO	XX	PLNT	PLNT	Y	1	708	0.00141
555	BWR	Yx	BN	INTEWC		1	3	1	0	0	FTO	XX	PLNT	PLNT	Y	3	106	0.02830
550	BWR	Yx	CH	INTEWC		1	3	1	0	0	FTO	XX	PLNT	PLNT	Y	0	926	0.00000
552	BWR	Yx	CH	INTEWC		1	3	1	0	0	FTO	XX	PLNT	PLNT	Y	0	856	0.00000
951	BWR	Yx				2	.	1	0	0	FTO	XX	PLNT	PLNT	Y	1	73	0.01370
952	BWR	Yx				2	.	1	0	0	FTO	XX	PLNT	PLNT	Y	1	98	0.01020
953	BWR	Yx	BG/BM			2	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	704	0.00000
950	BWR	Yx	BG/BM	INTEWC		2	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	582	0.00000
684	BWR	Yx				3	.	1	0	0	FTO	XX	PLNT	PLNT	Y	33	46983	0.00070
602	BWR	Yx				4	.	1	0	0	FTO	XX	PLNT	PLNT	Y	1	199	0.00503
603	BWR	Yx				4	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	1522	0.00000
749	BWR	Yx				5	.	0	0	0	FTO	XX	PLNT	PLNT	Y	2	5292	0.00038
472	BWR	Yx				5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	1	971	0.00103
478	BWR	Yx				5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	816	0.00000
470	BWR	Yx	BG/BM			5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	3493	0.00000
474	BWR	Yx	BN			5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	704	0.00000
471	BWR	Yx	CH			5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	10273	0.00000
473	BWR	Yx	BG/BM	INTEWC		5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	4230	0.00000
476	BWR	Yx	BN	INTEWC		5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	504	0.00000
469	BWR	Yx	CH	INTEWC		5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	11112	0.00000
477	BWR	Yx				5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	891	0.00000
475	BWR	Yx	BI	INTEWD		5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	7855	0.00000
488	BWR	Yx	BI	INTEWD		5	3	1	0	0	FTO	XX	PLNT	PLNT	Y	0	7665	0.00000
894	BWR	Yx				7	7	0	0	0	FTO	NC	PLNT	PLNT	Y	0	131	0.00000
973	BWR	Yx				7	7	1	0	0	FTO	NC	PLNT	PLNT	Y	0	25	0.00000
974	BWR	Yx	BN	INTEAR		7	7	1	0	0	FTO	NC	PLNT	PLNT	Y	0	20	0.00000
891	BWR	Yx	BG/BM	INTEWC		7	7	0	0	0	FTO	NC	PLNT	PLNT	Y	0	10	0.00000
892	BWR	Yx	BN	INTEWC		7	7	0	0	0	FTO	NC	PLNT	PLNT	Y	0	18	0.00000
893	BWR	Yx	BN	INTEWC		7	7	0	0	0	FTO	NC	PLNT	PLNT	Y	0	15	0.00000
682	PWR	B4W	CI			3	.	1	0	0	FTO	XX	PLNT	PLNT	Y	13	1760	0.00739
680	PWR	B4W	SB			3	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	973	0.00000
599	PWR	B4W	SB	INTEST		4	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	605	0.00000
765	PWR	B4W	CI			5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	1	5532	0.00018
767	PWR	B4W	CI			5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	14612	0.00000

Table A.1 (continued)

c2demand.ssd: Demand-related failure data

recno	rtype	ofl	systl	capll	optyp1	vlvtyp1	icl	sgl	pfl	fmode	nstate	fdrig	expdat	ir	numfail	totd	frate
Record	Reactor	Facility	System	Applica- tion	Operator	Valve	Includes	Safety	Primary	Failure	Normal	Fail	Expo	IRADAP?	Failures	Demands	Failure Rate
Type	Type	Type	Type	-ment	Type	Type	Circuit?	Graded?	Only?	Mode	State	Source	Source				
763	PWR	B&W	SB		5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	25876	0.00000
899	PWR	B&W	CI		7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	1	568	0.00176
901	PWR	B&W	CI		7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	0	90	0.00000
896	PWR	B&W	SB		7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	0	735	0.00000
581	PWR	BREL			.	3	0	1	1	FTP	XX	PLNT	PLNT	Y	0	2084	0.00000
827	PWR	BREL			1	.	0	1	1	FTP	XX	PLNT	PLNT	Y	0	167	0.00000
671	PWR	BREL			3	.	0	1	1	FTC	XX	PLNT	PLNT	Y	1	1693	0.00059
706	PWR	BREL			3	.	0	1	1	FTP	XX	PLNT	PLNT	Y	0	50	0.00000
568	PWR	DBS1			.	3	0	0	0	FTC	XX	PLNT	PLNT	U	3	4126	0.00073
804	PWR	DBS1			1	.	0	0	0	FTO	XX	PLNT	PLNT	U	21	4276	0.00491
679	PWR	DBS1			3	.	0	0	0	FTO	XX	PLNT	PLNT	U	80	9798	0.00816
627	PWR	DBS1	SB		3	4	0	0	0	FTC	NO	PLNT	PLNT	U	1	159	0.00629
597	PWR	DBS1	SB		4	.	0	0	0	FTC	NC	PLNT	PLNT	U	2	727	0.00275
604	PWR	DBS1	SB		4	.	0	0	0	FTP	NC	PLNT	PLNT	U	3	727	0.00413
467	PWR	DBS1			5	3	0	0	0	FTC	XX	PLNT	PLNT	U	3	1438	0.00209
516	PWR	DBS1			5	3	0	0	0	FTP	XX	PLNT	PLNT	U	2	1438	0.00139
858	PWR	DBS1	AB/AP		7	7	0	0	0	FTC	NC	PLNT	PLNT	U	2	175	0.01143
861	PWR	DBS1	AB/AP		7	7	0	0	0	FTP	NC	PLNT	PLNT	U	1	175	0.00571
838	PWR	DBS1	SB		7	7	0	0	0	FTC	NC	PLNT	PLNT	U	2	1873	0.00107
839	PWR	DBS1	SB		7	7	0	0	0	FTP	NC	PLNT	PLNT	U	2	1873	0.00107
889	PWR	DBS1	SB		7	7	0	0	0	FTC	NC	PLNT	PLNT	U	5	253	0.01976
929	PWR	DBS1	SB		7	7	0	0	0	FTP	NC	PLNT	PLNT	U	2	253	0.00791
809	PWR	EUR			1	.	1	0	0	FTO	XX	PLNT	PLNT	Y	2	869	0.00230
670	PWR	EUR			3	.	1	0	0	FTC	NO	PLNT	PLNT	Y	7	2388	0.00293
748	PWR	EUR			5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	1	1949	0.00051
925	PWR	EUR			7	7	1	0	0	FTP	NC	PLNT	PLNT	Y	0	84	0.00000
570	PWR	FPRA			.	3	0	1	1	FTO	XX	PLNT	PLNT	Y	12	8716	0.00138
826	PWR	FPRA			1	.	0	1	1	FTO	XX	PLNT	PLNT	Y	7	2720	0.00257
701	PWR	FPRA			3	.	0	1	1	FTO	XX	PLNT	PLNT	Y	50	14200	0.00352
860	PWR	FPRA	AP		7	7	0	1	1	FTP	NC	PLNT	PLNT	Y	0	18	0.00000
926	PWR	FPRA	AP		7	7	0	1	1	FTP	NC	PLNT	PLNT	Y	0	131	0.00000
785	PWR	IP1			1	2	1	0	0	FTO	XX	PLNT	OTHR	Y	4	1560	0.00256
795	PWR	IP1			1	4	1	0	0	FTO	XX	PLNT	OTHR	Y	25	2520	0.00992
792	PWR	IP1			1	5	1	0	0	FTO	XX	PLNT	OTHR	Y	28	7080	0.00395
946	PWR	IP1			2	5	1	0	0	FTO	XX	PLNT	OTHR	Y	2	120	0.01667
613	PWR	IP1			3	2	1	0	0	FTO	XX	PLNT	OTHR	Y	13	1800	0.00722
629	PWR	IP1			3	4	1	0	0	FTO	XX	PLNT	OTHR	Y	6	5700	0.00105
616	PWR	IP1			3	5	1	0	0	FTO	XX	PLNT	OTHR	Y	16	1740	0.00920
739	PWR	IP1			5	4	1	0	0	FTO	XX	PLNT	OTHR	Y	3	1200	0.00250
738	PWR	IP1			5	5	1	0	0	FTO	XX	PLNT	OTHR	Y	2	600	0.00333
888	PWR	IP1			7	7	1	0	0	FTC	NC	PLNT	OTHR	Y	4	7860	0.00051
895	PWR	IP1			7	7	1	0	0	FTO	NC	PLNT	OTHR	Y	6	7860	0.00076
574	PWR	IPS2			.	3	0	0	1	FTP	XX	PLNT	PLNT	Y	0	1444	0.00000
802	PWR	IPS2			1	.	0	0	1	FTO	XX	PLNT	PLNT	Y	1	1050	0.00095
677	PWR	IPS2			3	.	0	0	1	FTO	XX	PLNT	PLNT	Y	3	1261	0.00238
563	PWR	NEE3			.	3	0	0	0	FTC	XX	PLNT	PLNT	Y	1	321	0.00312
572	PWR	NEE3			.	3	0	0	0	FTP	XX	PLNT	PLNT	Y	0	251	0.00000
798	PWR	NEE3			1	.	0	0	0	FTO	NC	PLNT	PLNT	Y	3	1349	0.00222
674	PWR	NEE3			3	.	0	0	0	FTO	NO	PLNT	PLNT	Y	42	6725	0.00625
675	PWR	NEE3	SG	INTEWC	3	.	0	0	0	FTO	NO	PLNT	PLNT	Y	5	30	0.16667
598	PWR	NEE3			4	.	0	0	0	FTO	NO	PLNT	PLNT	Y	10	2564	0.00390
468	PWR	NEE3			5	3	0	0	0	FTC	XX	PLNT	PLNT	Y	0	426	0.00000
515	PWR	NEE3			5	3	0	0	0	FTP	XX	PLNT	PLNT	Y	0	427	0.00000
531	PWR	NEE3			5	3	0	0	0	FTC	XX	PLNT	PLNT	Y	1	2719	0.00037
539	PWR	NEE3			5	3	0	0	0	FTP	XX	PLNT	PLNT	Y	0	2707	0.00000
847	PWR	NEE3			7	7	0	0	0	FTC	NO	PLNT	PLNT	Y	1	31	0.03226
851	PWR	NEE3			7	7	0	0	0	FTP	NC	PLNT	PLNT	Y	0	31	0.00000
848	PWR	NEE3	AP		7	7	0	0	0	FTC	NO	PLNT	PLNT	Y	0	10	0.00000
852	PWR	NEE3	AP		7	7	0	0	0	FTP	NC	PLNT	PLNT	Y	0	10	0.00000
578	PWR	RGLS			.	3	1	0	0	FTP	XX	PLNT	OTHR	Y	0	1844	0.00000
579	PWR	RGLS			.	3	1	0	0	FTP	XX	PLNT	OTHR	Y	0	658	0.00000
593	PWR	X	SB		.	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	564	0.00000
808	PWR	X	CI		1	.	1	0	0	FTO	XX	PLNT	PLNT	Y	2	554	0.00361
816	PWR	X	KE		1	.	1	0	0	FTO	XX	PLNT	PLNT	Y	14	68	0.20588
806	PWR	X	SB		1	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	1538	0.00000
811	PWR	X	BP	INTEWB	1	.	1	1	0	FTO	XX	PLNT	PLNT	Y	3	24	0.12500
812	PWR	X	CB	INTEWB	1	.	1	0	0	FTO	XX	PLNT	PLNT	Y	15	862	0.01740
813	PWR	X	BA	INTEWC	1	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	89	0.00000
814	PWR	X	CC	INTEWC	1	.	1	0	0	FTO	XX	PLNT	PLNT	Y	13	222	0.05856
815	PWR	X	SD	INTEWC	1	.	1	0	0	FTO	XX	PLNT	PLNT	Y	5	813	0.00615
801	PWR	X	SJ	INTEWC	1	.	1	0	0	FTO	XX	PLNT	PLNT	Y	6	1715	0.00350
958	PWR	X	BE	INTECS	2	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	1488	0.00000
960	PWR	X	AB	INTEWC	2	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	105	0.00000
965	PWR	X	BA	INTEWC	2	.	0	0	0	FTO	XX	PLNT	PLNT	Y	0	356	0.00000
959	PWR	X	CB	INTEWC	2	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	67	0.00000
689	PWR	X	BE		3	.	1	0	0	FTO	XX	PLNT	PLNT	Y	3	215	0.01395
686	PWR	X	BP	INTEWB	3	.	1	1	0	FTO	XX	PLNT	PLNT	Y	3	60	0.05000
692	PWR	X	CB	INTEWB	3	.	1	0	0	FTO	XX	PLNT	PLNT	Y	18	855	0.02105
688	PWR	X	AB	INTEWC	3	.	1	1	0	FTO	XX	PLNT	PLNT	Y	15	97	0.15464
687	PWR	X	BA	INTEWC	3	.	1	0	0	FTO	XX	PLNT	PLNT	Y	5	879	0.00569
690	PWR	X	SD	INTEWC	3	.	1	0	0	FTO	XX	PLNT	PLNT	Y	1	367	0.00272
691	PWR	X	SJ	INTEWC	3	.	1	0	0	FTO	XX	PLNT	PLNT	Y	22	3679	0.00598
461	PWR	X	BA	INTEWC	3	3	1	0	0	FTO	XX	PLNT	PLNT	Y	0	191	0.00000
460	PWR	X	SJ	INTEWC	3	3	1	0	0	FTO	XX	PLNT	PLNT	Y	0	346	0.00000
756	PWR	X	BE		5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	2	225	0.00889
758	PWR	X	BS		5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	2	199	0.01005
754	PWR	X	KE		5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	9	598	0.01505
755	PWR	X	LD		5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	2	515	0.00388
753	PWR	X	SB		5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	7866	0.00000
759	PWR	X	AB	INTEWB	5	.	1	1	0	FTO	XX	PLNT	PLNT	Y	2	1329	0.00150
752	PWR	X	BP	INTEWB	5	.	1	1	0	FTO	XX	PLNT	PLNT	Y	0	297	0.00000
761	PWR	X	CB	INTEWB	5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	5	1184	0.00422

Table A.1 (continued)

c2demand.ssd: Demand-related failure data

recno	rtype	ofl	systl	capll	optyp1	vlvtyp1	icl	sql	pfl	fmode	nstate	fdorig	expdat	ir	numfail	totd	frate
Record	Reactor	Facility	System	Applica- tion Environ- ment	Operator	Valve	Includes	Safety	Primary	Failure	Normal	Fail- ure Data	Expo- sure Data	IRADAP?	Failures	Demands	Failure Rate
760	PWR	X	BA	INTEWC	5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	201	0.000000
757	PWR	X	CC	INTEWC	5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	12	1064	0.011278
751	PWR	X	SJ	INTEWC	5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	21051	0.000000
487	PWR	X	KE	INTEWC	5	3	1	0	0	FTO	XX	PLNT	PLNT	Y	0	19	0.000000
482	PWR	X	BE	INTECS	5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	2245	0.000000
534	PWR	X	BE	INTECS	5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	700	0.000000
479	PWR	X	SB	INTEST	5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	431	0.000000
449	PWR	X		INTEWC	5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	134	0.000000
538	PWR	X	BA	INTEWC	5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	716	0.000000
537	PWR	X	CB	INTEWC	5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	327	0.000000
483	PWR	X	CC	INTEWC	5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	38	0.000000
535	PWR	X	CC	INTEWC	5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	381	0.000000
485	PWR	X	CI	INTEWC	5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	182	0.000000
486	PWR	X	CI	INTEWC	5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	320	0.000000
481	PWR	X	KA	INTEWC	5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	631	0.000000
533	PWR	X	SD	INTEWC	5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	140	0.000000
448	PWR	X	SJ	INTEWC	5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	147	0.000000
480	PWR	X	SJ	INTEWC	5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	572	0.000000
532	PWR	X	SJ	INTEWC	5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	1425	0.000000
484	PWR	X	BS	INTEWS	5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	22	0.000000
536	PWR	X	BS	INTEWS	5	3	0	0	0	FTO	XX	PLNT	PLNT	Y	1	371	0.002695
908	PWR	X	BE		7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	0	21	0.000000
902	PWR	X	BS		7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	0	30	0.000000
906	PWR	X	KE		7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	0	14	0.000000
907	PWR	X	LD		7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	0	30	0.000000
904	PWR	X	SB		7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	0	200	0.000000
859	PWR	X	SB	INTEST	7	7	1	0	0	FTO	NC	PLNT	PLNT	Y	0	172	0.000000
905	PWR	X	AB	INTEWB	7	7	1	1	0	FTO	XX	PLNT	PLNT	Y	1	42	0.023810
903	PWR	X	BP	INTEWB	7	7	1	1	0	FTO	XX	PLNT	PLNT	Y	0	12	0.000000
912	PWR	X	CB	INTEWB	7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	0	93	0.000000
909	PWR	X	CC	INTEWC	7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	1	307	0.003257
910	PWR	X	SD	INTEWC	7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	0	24	0.000000
911	PWR	X	SJ	INTEWC	7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	4	621	0.006441
573	PWR	Z1S1			.	3	0	0	0	FTP	XX	PLNT	PLNT	Y	0	6968	0.000000
817	PWR	Z1S1			1	.	0	0	0	FTO	XX	PLNT	PLNT	Y	3	1540	0.001948
676	PWR	Z1S1			3	.	0	0	0	FTO	XX	PLNT	PLNT	Y	14	11310	0.001238
672	PWR	Z1S1	BE	INTEWB	3	.	0	1	0	FTO	NC	PLNT	PLNT	Y	10	1647	0.006072
673	PWR	Z1S1	CB	INTEWB	3	.	0	0	0	FTO	NC	PLNT	PLNT	Y	7	1720	0.004070

Table A.2

c2time.ssd: Time-related failure data

recno	rtype	ofl	systl	capll Applica- tion	optyp1	vlvtyp1	icl	sgl	pfl	fmode	nstate	fdorig	expsdat	ir	numfail	tothrs	frate
Record	Reactor	Facility	System	Environ	Operator	Valve	Includes	Safety	Primary	Failure	Normal	Data	Data	IRADAP?	Failures	Hours	Failure
Type	Type	Type	Type	ment	Type	Type	Circuit?	Graded?	Only?	Mode	State	Source	Source				Rate
746						5	.	0	1	1	BP	XX	PLNT	PLNT	N	0	137818032 .0000000
582						.	3	0	1	1	LE	XX	PLNT	PLNT	N	5	101566848 .0000000
828						1	.	0	1	1	LE	XX	PLNT	PLNT	N	2	19322736 .0000001
583						.	3	0	1	1	LI	NC	PLNT	PLNT	N	55	101566848 .0000005
710						3	.	1	1	1	SC	NO	PLNT	PLNT	N	2	123802872 .0000000
836						1	.	1	1	1	SO	XX	PLNT	PLNT	N	4	19322736 .0000002
942						7	7	0	1	1	SP	NC	PLNT	PLNT	N	23	6646920 .0000035
943						7	7	0	1	1	SP	NC	PLNT	PLNT	N	14	4175880 .0000034
944						7	7	1	0	0	SP	XX	PLNT	TCRT	Y	7	4040000 .0000017
994	BWR	BRP1				.	.	0	0	0	SC	XX	PLNT	PLNT	Y	4	3944160 .0000010
995	BWR	BRP1				.	.	0	0	0	SP	XX	PLNT	PLNT	Y	3	3944160 .0000008
715	BWR	BRP1				3	.	0	0	0	SP	XX	PLNT	PLNT	Y	1	1254960 .0000008
949	BWR	BWR				2	.	1	0	0	FTO	XX	OTHR	TCRT	N	16	2260000 .0000007
989	BWR	BWR				.	.	0	0	1	LE	XX	PLNT	PLNT	Y	38	378000000 .0000000
990	BWR	BWR				.	.	0	0	1	LE	XX	PLNT	PLNT	Y	1	378000000 .0000000
787	BWR	IP4				1	2	1	0	0	LI	XX	PLNT	TCAL	Y	2	5150000 .0000004
930	BWR	IP4				7	7	1	0	0	LI	NC	PLNT	TCAL	Y	1	2150000 .0000005
789	BWR	IP4				1	2	1	0	0	SO	XX	PLNT	TCAL	Y	1	5150000 .0000002
614	BWR	IP4				3	2	1	0	0	SO	XX	PLNT	TCAL	Y	1	1580000 .0000006
641	BWR	IP4				3	4	1	0	0	SO	XX	PLNT	TCAL	Y	7	4890000 .0000014
939	BWR	IP4				7	7	1	0	0	SO	NC	PLNT	TCAL	Y	1	2150000 .0000005
979	BWR	MNS1	SJ	INTEWC		.	.	0	0	0	FTO	NC	PLNT	PLNT	Y	18	148479 .0001212
955	BWR	Yx				2	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	89 .0000000
956	BWR	Yx				2	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	131 .0000000
954	BWR	Yx	BG/BM	INTEWC		2	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	295 .0000000
957	BWR	Yx	BG/BM	INTEWC		2	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	357 .0000000
685	BWR	Yx				3	.	1	0	0	FTO	XX	PLNT	PLNT	Y	10	239117 .0000418
601	BWR	Yx				4	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	262 .0000000
975	BWR	Yx		INTEAR		7	7	1	0	0	FTO	NC	PLNT	PLNT	Y	0	655 .0000000
976	BWR	Yx	BN	INTEAR		7	7	1	0	0	FTO	NC	PLNT	PLNT	Y	0	488 .0000000
991	BWR	Yx	CH	INTEWB		.	.	1	0	0	LI	XX	OTHR	PLNT	Y	0	2501 .0000000
992	BWR	Yx	CH	INTEWB		.	.	1	0	0	LI	XX	PLNT	PLNT	Y	0	3737 .0000000
587	BWR	Yx				3	.	1	0	0	LI	XX	PLNT	PLNT	Y	4	890 .0044944
588	BWR	Yx				.	3	0	0	0	LI	XX	PLNT	PLNT	Y	2	966700 .0000021
829	BWR	Yx				1	.	1	0	0	LI	XX	PLNT	PLNT	Y	8	5348898 .0000015
559	BWR	Yx				1	3	1	0	0	LI	XX	PLNT	PLNT	Y	0	131 .0000000
557	BWR	Yx	BG/BM	INTEWC		1	3	1	0	0	LI	XX	PLNT	PLNT	Y	0	295 .0000000
560	BWR	Yx	BG/BM	INTEWC		1	3	1	0	0	LI	XX	PLNT	PLNT	Y	1	357 .0028011
561	BWR	Yx	BN	INTEWC		1	3	1	0	0	LI	XX	PLNT	PLNT	Y	1	122 .0081967
556	BWR	Yx	CH	INTEWC		1	3	1	0	0	LI	XX	PLNT	PLNT	Y	0	5002 .0000000
558	BWR	Yx	CH	INTEWC		1	3	1	0	0	LI	XX	PLNT	PLNT	Y	0	7474 .0000000
518	BWR	Yx				5	3	0	0	0	LI	XX	PLNT	PLNT	Y	5	187067 .0000267
520	BWR	Yx	BI	INTEWD		5	3	1	0	0	LI	XX	PLNT	PLNT	Y	0	7690 .0000000
931	BWR	Yx				7	7	1	0	0	LI	NC	PLNT	PLNT	Y	0	262 .0000000
934	BWR	Yx				7	7	1	0	0	LI	NC	PLNT	PLNT	Y	0	178 .0000000
935	BWR	Yx				7	7	1	0	0	LI	NC	PLNT	PLNT	Y	0	75151 .0000000
932	BWR	Yx	BG/BM	INTEWC		7	7	1	0	0	LI	NC	PLNT	PLNT	Y	0	295 .0000000
933	BWR	Yx	BG/BM	INTEWC		7	7	1	0	0	LI	NC	PLNT	PLNT	Y	0	357 .0000000
936	BWR	Yx	BN	INTEWC		7	7	1	0	0	LI	NC	PLNT	PLNT	Y	0	366 .0000000
937	BWR	Yx	BN	INTEWC		7	7	1	0	0	LI	NC	PLNT	PLNT	Y	0	264 .0000000
683	PWR	B4W	CI			3	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	163280 .0000000
681	PWR	B4W	SB			3	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	403572 .0000000
600	PWR	B4W	SB	INTEST		4	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	269048 .0000000
764	PWR	B4W	CI			5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	530660 .0000000
766	PWR	B4W	CI			5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	2630396 .0000000
762	PWR	B4W	SB			5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	11602695 .0000000
898	PWR	B4W	CI			7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	0	57148 .0000000
900	PWR	B4W	CI			7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	0	288702 .0000000
897	PWR	B4W	SB			7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	0	538096 .0000000
596	PWR	BREL	BA			6	.	0	1	1	SO	XX	PLNT	PLNT	Y	8	184104 .0000435
945	PWR	DBS1				2	5	0	0	0	FTO	NO	PLNT	PLNT	U	12	364728 .0000329
584	PWR	DBS1				.	3	0	0	0	LI	NC	PLNT	PLNT	U	0	4324632 .0000000
711	PWR	DBS1				3	.	0	0	0	SO	XX	PLNT	PLNT	U	3	4012008 .0000007
589	PWR	EUR				.	3	1	0	0	LI	XX	PLNT	PLNT	Y	5	1497730 .0000033
833	PWR	EUR				1	.	1	0	0	SC	NO	PLNT	PLNT	Y	0	699596 .0000000
782	PWR	EUR				5	.	1	0	0	SC	NO	PLNT	PLNT	Y	0	2939265 .0000000
834	PWR	EUR				1	.	1	0	0	SO	XX	PLNT	PLNT	Y	5	1120765 .0000045
941	PWR	EUR				7	7	1	0	0	SP	NC	PLNT	PLNT	Y	0	53130 .0000000
590	PWR	FPRA				.	3	0	1	1	LI	XX	PLNT	PLNT	Y	9	376000 .0000239
835	PWR	FPRA				1	.	0	1	1	SO	XX	PLNT	PLNT	Y	7	1580000 .0000044
969	PWR	FPRA				2	.	0	1	1	SO	XX	PLNT	PLNT	Y	0	812000 .0000000
790	PWR	IP1				1	1	1	0	0	LI	XX	PLNT	TCAL	Y	3	1840000 .0000016
796	PWR	IP1				1	4	1	0	0	LI	XX	PLNT	TCAL	Y	1	1840000 .0000005
793	PWR	IP1				1	5	1	0	0	LI	XX	PLNT	TCAL	Y	2	5170000 .0000004
788	PWR	IP1				1	2	1	0	0	SO	XX	PLNT	TCAL	Y	3	1140000 .0000026
797	PWR	IP1				1	4	1	0	0	SO	XX	PLNT	TCAL	Y	5	1840000 .0000027
794	PWR	IP1				1	5	1	0	0	SO	XX	PLNT	TCAL	Y	6	5170000 .0000012
947	PWR	IP1				2	5	1	0	0	SO	XX	PLNT	TCAL	Y	1	88000 .0000114
615	PWR	IP1				3	2	1	0	0	SO	XX	PLNT	TCAL	Y	2	1310000 .0000015
642	PWR	IP1				3	4	1	0	0	SO	XX	PLNT	TCAL	Y	10	4160000 .0000024
617	PWR	IP1				3	5	1	0	0	SO	XX	PLNT	TCAL	Y	2	1270000 .0000016
743	PWR	IP1				5	4	1	0	0	SO	XX	PLNT	TCAL	Y	1	876000 .0000011
586	PWR	IPS2				.	3	0	0	1	LI	XX	PLNT	PLNT	Y	1	444000 .0000023
832	PWR	IPS2				1	.	0	0	1	SC	NO	PLNT	PLNT	Y	0	444000 .0000000
709	PWR	IPS2				3	.	0	0	1	SC	NO	PLNT	PLNT	Y	0	6000000 .0000000
781	PWR	IPS2				5	.	0	0	1	SC	NO	PLNT	PLNT	Y	0	6000000 .0000000
837	PWR	IPS2				1	.	0	0	1	SP	NC	PLNT	PLNT	Y	0	37000 .0000000
713	PWR	IPS2				3	.	0	0	1	SP	NC	PLNT	PLNT	Y	0	703 .0000000
714	PWR	IPS2				3	.	0	0	1	SP	NC	PLNT	PLNT	Y	0	818 .0000000
887	PWR	IPS2				7	7	0	0	1	SP	NC	PLNT	PLNT	Y	1	301000 .0000033
591	PWR	NEE3				.	3	0	0	0	SC	NO	PLNT	PLNT	Y	0	342000 .0000000
830	PWR	NEE3				1	.	0	0	0	SC	NO	PLNT	PLNT	Y	1	194000 .0000052

Table A.2 (continued)

c2time.ssd: Time-related failure data																		
recno	rtype	of1	syst1	capl1	optyp1	vlvtyp1	icl	sgl	pf1	fmode	nstate	fdorig	expdat	ir	numfail	tothrs	frate	
Record	Reactor	Facility	System	Applica-tion	Operator	Valve	Includes	Safety	Primary	Failure	Normal	Fail	Expo	IRADAP?	Failures	Hours	Failure	
Type	Type	Type	Type	-ment	Type	Type	Circuit?	Graded?	Only?	Mode	State	Source	Source				Rate	
707	PWR	NEE3			3	.	0	0	0	SC	NO	PLNT	PLNT	Y	0	1890000	.0000000	
605	PWR	NEE3			4	.	0	0	0	SC	NO	PLNT	PLNT	Y	0	274000	.0000000	
780	PWR	NEE3			5	.	0	0	0	SC	NO	PLNT	PLNT	Y	1	3090000	.0000003	
530	PWR	NEE3			5	3	0	0	0	SC	NO	PLNT	PLNT	Y	0	148000	.0000000	
548	PWR	NEE3			5	3	0	0	0	SC	NO	PLNT	PLNT	Y	0	239000	.0000000	
987	PWR	PWR			.	.	0	0	1	LE	XX	PLNT	PLNT	Y	86	9500000000	.0000000	
988	PWR	PWR			.	.	0	0	1	LE	XX	PLNT	PLNT	Y	6	9500000000	.0000000	
595	PWR	X	SB	INTEST	.	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	269048	.0000000	
594	PWR	X	BP	INTEWB	.	3	0	0	0	FTO	XX	PLNT	PLNT	Y	0	168155	.0000000	
807	PWR	X	CI		1	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	96234	.0000000	
820	PWR	X	KE		1	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	311841	.0000000	
821	PWR	X	LD		1	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	50688	.0000000	
805	PWR	X	SB		1	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	672620	.0000000	
818	PWR	X	BP	INTEWB	1	.	1	1	0	FTO	XX	PLNT	PLNT	Y	1	201786	.0000050	
819	PWR	X	CB	INTEWB	1	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	1200000	.0000000	
825	PWR	X	BA	INTEWC	1	.	1	1	0	FTO	XX	PLNT	PLNT	N	0	54	.0000000	
822	PWR	X	CC	INTEWC	1	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	1571328	.0000000	
823	PWR	X	SD	INTEWC	1	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	369941	.0000000	
824	PWR	X	SJ	INTEWC	1	.	1	0	0	FTO	XX	PLNT	PLNT	Y	1	336310	.0000030	
963	PWR	X	LD	INTEAR	2	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	101376	.0000000	
962	PWR	X	BE	INTECS	2	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	1120	.0000000	
964	PWR	X	AB	INTEWC	2	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	315504	.0000000	
966	PWR	X	BA	INTEWC	2	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	216	.0000000	
961	PWR	X	CB	INTEWC	2	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	101376	.0000000	
696	PWR	X	BE		3	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	560	.0000000	
695	PWR	X	AB	INTEWB	3	.	1	1	0	FTO	XX	PLNT	PLNT	Y	0	157752	.0000000	
693	PWR	X	BP	INTEWB	3	.	1	1	0	FTO	XX	PLNT	PLNT	Y	5	201786	.0000248	
694	PWR	X	CB	INTEWB	3	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	1100000	.0000000	
699	PWR	X	BA	INTEWC	3	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	486	.0000000	
697	PWR	X	SD	INTEWC	3	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	168155	.0000000	
698	PWR	X	SJ	INTEWC	3	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	706251	.0000000	
458	PWR	X	BA	INTEWC	3	3	1	0	0	FTO	XX	PLNT	PLNT	N	0	108	.0000000	
459	PWR	X	SJ	INTEWC	3	3	1	0	0	FTO	XX	PLNT	PLNT	Y	0	67262	.0000000	
750	PWR	X			5	.	0	0	0	FTO	XX	PLNT	PLNT	Y	4	101561962	.0000000	
774	PWR	X	BE		5	.	1	0	0	FTO	XX	PLNT	PLNT	N	2	5320	.0003759	
768	PWR	X	BI		5	.	1	1	0	FTO	XX	PLNT	PLNT	Y	0	2027520	.0000000	
772	PWR	X	KE		5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	2771920	.0000000	
773	PWR	X	LD		5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	18000000	.0000000	
778	PWR	X	SB		5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	3654886	.0000000	
771	PWR	X	AB	INTEWB	5	.	1	1	0	FTO	XX	PLNT	PLNT	Y	0	5915700	.0000000	
769	PWR	X	BP	INTEWB	5	.	1	1	0	FTO	XX	PLNT	PLNT	Y	1	15806571	.0000001	
770	PWR	X	CB	INTEWB	5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	17000000	.0000000	
779	PWR	X	BA	INTEWC	5	.	1	0	0	FTO	XX	PLNT	PLNT	N	0	1512	.0000000	
775	PWR	X	CC	INTEWC	5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	18084928	.0000000	
776	PWR	X	SD	INTEWC	5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	6154473	.0000000	
777	PWR	X	SJ	INTEWC	5	.	1	0	0	FTO	XX	PLNT	PLNT	Y	0	4809233	.0000000	
919	PWR	X	BE		7	7	1	0	0	FTO	XX	PLNT	PLNT	N	0	280	.0000000	
913	PWR	X	BI		7	7	1	1	0	FTO	XX	PLNT	PLNT	Y	0	202752	.0000000	
917	PWR	X	KE		7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	0	69298	.0000000	
918	PWR	X	LD		7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	0	304128	.0000000	
923	PWR	X	SB		7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	0	134524	.0000000	
916	PWR	X	AB	INTEWB	7	7	1	1	0	FTO	XX	PLNT	PLNT	Y	0	197190	.0000000	
914	PWR	X	BP	INTEWB	7	7	1	1	0	FTO	XX	PLNT	PLNT	Y	0	67262	.0000000	
915	PWR	X	CB	INTEWB	7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	0	861696	.0000000	
924	PWR	X	BA	INTEWC	7	7	1	0	0	FTO	XX	PLNT	PLNT	N	0	54	.0000000	
920	PWR	X	CC	INTEWC	7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	0	2889216	.0000000	
921	PWR	X	SD	INTEWC	7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	0	134524	.0000000	
922	PWR	X	SJ	INTEWC	7	7	1	0	0	FTO	XX	PLNT	PLNT	Y	0	134524	.0000000	
527	PWR	X	BE		5	3	1	0	0	LI	XX	PLNT	PLNT	Y	0	2240	.0000000	
523	PWR	X	BI		5	3	1	1	0	LI	XX	PLNT	PLNT	Y	0	1115136	.0000000	
519	PWR	X	CI		5	3	0	0	0	LI	XX	PLNT	PLNT	Y	3	2665402	.0000011	
526	PWR	X	KE		5	3	1	0	0	LI	XX	PLNT	PLNT	Y	2	103947	.0000192	
543	PWR	X	LD	INTEAR	5	3	0	0	0	LI	XX	PLNT	PLNT	Y	0	101376	.0000000	
544	PWR	X	BE	INTECS	5	3	0	0	0	LI	XX	PLNT	PLNT	Y	1	700	.0014286	
521	PWR	X	SB	INTEST	5	3	1	0	0	LI	XX	PLNT	PLNT	Y	0	201786	.0000000	
525	PWR	X	BP	INTEWB	5	3	1	1	0	LI	XX	PLNT	PLNT	Y	0	134524	.0000000	
522	PWR	X	CI	INTEWB	5	3	1	0	0	LI	XX	PLNT	PLNT	Y	0	32656	.0000000	
524	PWR	X	CI	INTEWB	5	3	1	0	0	LI	XX	PLNT	PLNT	Y	0	32078	.0000000	
541	PWR	X	BA	INTEWC	5	3	0	0	0	LI	XX	PLNT	PLNT	Y	0	432	.0000000	
452	PWR	X	CB	INTEWC	5	3	0	0	0	LI	XX	PLNT	PLNT	Y	0	709632	.0000000	
547	PWR	X	CB	INTEWC	5	3	0	0	0	LI	XX	PLNT	PLNT	Y	0	912384	.0000000	
528	PWR	X	CC	INTEWC	5	3	1	0	0	LI	XX	PLNT	PLNT	Y	1	304128	.0000033	
545	PWR	X	CC	INTEWC	5	3	0	0	0	LI	XX	PLNT	PLNT	Y	0	253440	.0000000	
529	PWR	X	SD	INTEWC	5	3	1	0	0	LI	XX	PLNT	PLNT	Y	0	302679	.0000000	
542	PWR	X	SD	INTEWC	5	3	0	0	0	LI	XX	PLNT	PLNT	Y	0	67262	.0000000	
450	PWR	X	SJ	INTEWC	5	3	0	0	0	LI	XX	PLNT	PLNT	Y	0	33631	.0000000	
540	PWR	X	SJ	INTEWC	5	3	0	0	0	LI	XX	PLNT	PLNT	Y	0	336310	.0000000	
451	PWR	X	BS	INTEWS	5	3	0	0	0	LI	XX	PLNT	PLNT	Y	0	50688	.0000000	
546	PWR	X	BS	INTEWS	5	3	0	0	0	LI	XX	PLNT	PLNT	Y	1	152064	.0000066	
938	PWR	X			7	7	1	0	0	LI	NC	PLNT	PLNT	Y	0	6138382	.0000000	
862	PWR	X	SB	INTEST	7	7	1	0	0	SP	NC	PLNT	PLNT	Y	0	134524	.0000000	
585	PWR	Z1S1			.	3	0	0	0	LI	XX	PLNT	PLNT	Y	0	608000	.0000000	
993	PWR	Z1S1			.	.	0	0	0	SC	NO	PLNT	PLNT	Y	0	11100000	.0000000	
831	PWR	Z1S1			1	.	0	0	0	SC	NO	PLNT	PLNT	Y	0	2130000	.0000000	
708	PWR	Z1S1			3	.	0	0	0	SC	NO	PLNT	PLNT	Y	0	11100000	.0000000	
712	PWR	Z1S1			3	.	0	0	0	SC	NC	PLNT	PLNT	Y	0	695000	.0000000	
857	PWR	Z1S1			7	7	0	0	0	SP	NC	PLNT	PLNT	Y	2	619000	.0000032	

Table A.3

Demand-related failure data: Cross tabulation of total number of records, total failures, total demands and observed cell failure rate by System and Reactor Type

System		Reactor Type			ALL
		PWR	BWR	missing	
missing	N	47	30	23	100
	failures	377	223	578	1178
	demands	137796	155617	228411	521824
	rate	0.00273593	0.00143301	0.00253053	0.00225747
SB	N	17	.	.	17
	failures	17	.	.	17
	demands	44825	.	.	44825
	rate	0.00037925	.	.	0.00037925
CI	N	8	.	.	8
	failures	17	.	.	17
	demands	23618	.	.	23618
	rate	0.00071979	.	.	0.00071979
CB	N	7	.	.	7
	failures	45	.	.	45
	demands	5108	.	.	5108
	rate	0.00880971	.	.	0.00880971
BE	N	7	.	.	7
	failures	15	.	.	15
	demands	6541	.	.	6541
	rate	0.00229323	.	.	0.00229323
BA	N	6	.	.	6
	failures	5	.	.	5
	demands	2432	.	.	2432
	rate	0.00205592	.	.	0.00205592
CC	N	5	.	.	5
	failures	26	.	.	26
	demands	2012	.	.	2012
	rate	0.01292247	.	.	0.01292247
AP	N	4	.	.	4
	failures	0	.	.	0
	demands	169	.	.	169
	rate	0.00000000	.	.	0.00000000
KE	N	4	.	.	4
	failures	23	.	.	23
	demands	699	.	.	699
	rate	0.03290415	.	.	0.03290415
BP	N	4	.	.	4
	failures	6	.	.	6
	demands	393	.	.	393
	rate	0.01526718	.	.	0.01526718
SD	N	4	.	.	4
	failures	6	.	.	6
	demands	1344	.	.	1344
	rate	0.00446429	.	.	0.00446429
AB	N	4	.	.	4
	failures	18	.	.	18
	demands	1573	.	.	1573
	rate	0.01144310	.	.	0.01144310
BS	N	4	.	.	4
	failures	3	.	.	3
	demands	622	.	.	622
	rate	0.00482315	.	.	0.00482315
AB/AP	N	2	.	.	2
	failures	3	.	.	3
	demands	350	.	.	350
	rate	0.00857143	.	.	0.00857143
LD	N	2	.	.	2
	failures	2	.	.	2
	demands	545	.	.	545
	rate	0.00366972	.	.	0.00366972
SG	N	1	.	.	1
	failures	5	.	.	5
	demands	30	.	.	30
	rate	0.16666667	.	.	0.16666667
KA	N	1	.	.	1
	failures	0	.	.	0
	demands	631	.	.	631
	rate	0.00000000	.	.	0.00000000
SJ	N	8	2	.	10
	failures	32	3	.	35
	demands	29556	1352	.	30908
	rate	0.00108269	0.00221893	.	0.00113239
BG/BM	N	.	8	.	8
	failures	.	5	.	5
	demands	.	10545	.	10545
	rate	.	0.00047416	.	0.00047416

(CONTINUED)

Table A.3 (continued)

Demand-related failure data: Cross tabulation of total number of records, total failures, total demands and observed cell failure rate by System and Reactor Type

System		Reactor Type			ALL
		PWR	BWR	missing	
CH	N	.	6	.	6
	failures	.	0	.	0
	demands	.	24059	.	24059
	rate	.	0.00000000	.	0.00000000
BN	N	.	6	.	6
	failures	.	3	.	3
	demands	.	1367	.	1367
	rate	.	0.00219459	.	0.00219459
XC	N	.	2	.	2
	failures	.	0	.	0
	demands	.	2544	.	2544
	rate	.	0.00000000	.	0.00000000
NT	N	.	2	.	2
	failures	.	12	.	12
	demands	.	738	.	738
	rate	.	0.01626016	.	0.01626016
BI	N	.	2	.	2
	failures	.	0	.	0
	demands	.	15520	.	15520
	rate	.	0.00000000	.	0.00000000
BY	N	.	1	.	1
	failures	.	1	.	1
	demands	.	215	.	215
	rate	.	0.00465116	.	0.00465116
JM	N	.	1	.	1
	failures	.	19	.	19
	demands	.	227	.	227
	rate	.	0.08370044	.	0.08370044
JI	N	.	1	.	1
	failures	.	4	.	4
	demands	.	28	.	28
	rate	.	0.14285714	.	0.14285714
BL	N	.	1	.	1
	failures	.	2	.	2
	demands	.	125	.	125
	rate	.	0.01600000	.	0.01600000
MS	N	.	1	.	1
	failures	.	2	.	2
	demands	.	52	.	52
	rate	.	0.03846154	.	0.03846154
AA	N	.	1	.	1
	failures	.	4	.	4
	demands	.	27816	.	27816
	rate	.	0.00014380	.	0.00014380
ALL	N	135	64	23	222
	failures	600	278	578	1456
	demands	258244	240205	228411	726860
	rate	0.00232338	0.00115734	0.00253053	0.00200314

Table A.4

Time-related failure data: Cross tabulation of total number of records, total failures, total demands and observed cell failure rate by System and Reactor Type

System		Reactor Type			ALL
		PWR	BWR	missing	
missing	N	47	25	9	81
	failures	179	105	112	396
	hours	19195840719	7619632811	518262872	27333736402
	rate	0.00000001	0.00000001	0.00000022	0.00000001
SB	N	10	.	.	10
	failures	0	.	.	0
	hours	17880799	.	.	17880799
	rate	0.00000000	.	.	0.00000000
CI	N	9	.	.	9
	failures	3	.	.	3
	hours	6496556	.	.	6496556
	rate	0.00000046	.	.	0.00000046
BA	N	8	.	.	8
	failures	8	.	.	8
	hours	186966	.	.	186966
	rate	0.00004279	.	.	0.00004279
CB	N	7	.	.	7
	failures	0	.	.	0
	hours	21885088	.	.	21885088
	rate	0.00000000	.	.	0.00000000
BP	N	6	.	.	6
	failures	7	.	.	7
	hours	16580084	.	.	16580084
	rate	0.00000042	.	.	0.00000042
SD	N	6	.	.	6
	failures	0	.	.	0
	hours	7197034	.	.	7197034
	rate	0.00000000	.	.	0.00000000
BE	N	6	.	.	6
	failures	3	.	.	3
	hours	10220	.	.	10220
	rate	0.00029354	.	.	0.00029354
LD	N	5	.	.	5
	failures	0	.	.	0
	hours	18557568	.	.	18557568
	rate	0.00000000	.	.	0.00000000
CC	N	5	.	.	5
	failures	1	.	.	1
	hours	23103040	.	.	23103040
	rate	0.00000004	.	.	0.00000004
KE	N	4	.	.	4
	failures	2	.	.	2
	hours	3257006	.	.	3257006
	rate	0.00000061	.	.	0.00000061
AB	N	4	.	.	4
	failures	0	.	.	0
	hours	6586146	.	.	6586146
	rate	0.00000000	.	.	0.00000000
BS	N	2	.	.	2
	failures	1	.	.	1
	hours	202752	.	.	202752
	rate	0.00000493	.	.	0.00000493
SJ	N	7	1	.	8
	failures	1	18	.	19
	hours	6423521	148479	.	6572000
	rate	0.00000016	0.00012123	.	0.00000289
BI	N	3	1	.	4
	failures	0	0	.	0
	hours	3345408	7690	.	3353098
	rate	0.00000000	0.00000000	.	0.00000000
BG/BM	N	.	6	.	6
	failures	.	1	.	1
	hours	.	1956	.	1956
	rate	.	0.00051125	.	0.00051125
BN	N	.	4	.	4
	failures	.	1	.	1
	hours	.	1240	.	1240
	rate	.	0.00080645	.	0.00080645
CH	N	.	4	.	4
	failures	.	0	.	0
	hours	.	18714	.	18714
	rate	.	0.00000000	.	0.00000000
ALL	N	129	41	9	179
	failures	205	125	112	442
	hours	19327552907	7619810890	518262872	27465626669
	rate	0.00000001	0.00000002	0.00000022	0.00000002

APPENDIX B: Analyses for BWR Plants, Demand-related Failure Data

Table B.1: Cross tabulation by system and originating facility for the BWR demand-related data of Table A.1

System		OF1				ALL
		Yx	BRP1	MNS1	BWR	
BG/BM	N	7	1	.	.	8
	failures	2	3	.	.	5
	demands	10315	230	.	.	10545
	rate	0.00019389	0.01304348	.	.	0.00047416
CH	N	6	.	.	.	6
	failures	0	.	.	.	0
	demands	24059	.	.	.	24059
	rate	0.00000000	.	.	.	0.00000000
BN	N	6	.	.	.	6
	failures	3	.	.	.	3
	demands	1367	.	.	.	1367
	rate	0.00219459	.	.	.	0.00219459
BI	N	2	.	.	.	2
	failures	0	.	.	.	0
	demands	15520	.	.	.	15520
	rate	0.00000000	.	.	.	0.00000000
BY	N	.	1	.	.	1
	failures	.	1	.	.	1
	demands	.	215	.	.	215
	rate	.	0.00465116	.	.	0.00465116
JM	N	1	.	.	.	1
	failures	.	19	.	.	19
	demands	.	227	.	.	227
	rate	.	0.08370044	.	.	0.08370044
JI	N	1	.	.	.	1
	failures	.	4	.	.	4
	demands	.	28	.	.	28
	rate	.	0.14285714	.	.	0.14285714
BL	N	.	1	.	.	1
	failures	.	2	.	.	2
	demands	.	125	.	.	125
	rate	.	0.01600000	.	.	0.01600000
MS	N	.	1	.	.	1
	failures	.	2	.	.	2
	demands	.	52	.	.	52
	rate	.	0.03846154	.	.	0.03846154
XC	N	.	.	2	.	2
	failures	.	.	0	.	0
	demands	.	.	2544	.	2544
	rate	.	.	0.00000000	.	0.00000000
SJ	N	.	.	2	.	2
	failures	.	.	3	.	3
	demands	.	.	1352	.	1352
	rate	.	.	0.00221893	.	0.00221893
NT	N	.	.	2	.	2
	failures	.	.	12	.	12
	demands	.	.	738	.	738
	rate	.	.	0.01626016	.	0.01626016
AA	N	.	.	.	1	1
	failures	.	.	.	4	4
	demands	.	.	.	27816	27816
	rate	.	.	.	0.00014380	0.00014380
ALL	N	21	6	6	1	34
	failures	5	31	15	4	55
	demands	51261	877	4634	27816	84588
	rate	0.00009754	0.03534778	0.00323694	0.00014380	0.00065021

Table B.2: Cross tabulation by application environment and originating facility for the BWR demand-related data of Table A.1

Application Environment		OF1				ALL
		Yx	BRP1	MNS1	BWR	
INTEWC	N	12	1	2	1	16
	failures	5	2	3	4	14
	demands	19655	125	1352	27816	48948
	rate	0.00025439	0.01600000	0.00221893	0.00014380	0.00028602
INTEWB	N	2	1	.	.	3
	failures	0	3	.	.	3
	demands	892	230	.	.	1122
	rate	0.00000000	0.01304348	.	.	0.00267380
INTEWD	N	3	.	.	.	3
	failures	0	.	.	.	0
	demands	16411	.	.	.	16411
	rate	0.00000000	.	.	.	0.00000000
INTEAR	N	2	.	.	.	2
	failures	0	.	.	.	0
	demands	45	.	.	.	45
	rate	0.00000000	.	.	.	0.00000000
INTEST	N	.	2	.	.	2
	failures	.	6	.	.	6
	demands	.	80	.	.	80
	rate	.	0.07500000	.	.	0.07500000
ALL	N	19	4	2	1	26
	failures	5	11	3	4	23
	demands	37003	435	1352	27816	66606
	rate	0.00013512	0.02528736	0.00221893	0.00014380	0.00034531

Table B.3: Cross tabulation by operator type and valve type for the BWR demand-related data of Table A.1

Operator Type		Valve Type						ALL
		3	7	2	5	4	8	
5	N	11	.	.	.	.	.	11
	failures	1	.	.	.	.	.	1
	demands	48514	.	.	.	.	.	48514
	rate	0.00002061	.	.	.	.	.	0.00002061
1	N	6	.	1	1	.	.	8
	failures	9	.	19	1	.	.	29
	demands	3286	.	7060	1440	.	.	11786
	rate	0.00273889	.	0.00269122	0.00069444	.	.	0.00246055
7	N	.	6	.	.	.	.	6
	failures	.	0	.	.	.	.	0
	demands	.	219	.	.	.	.	219
	rate	.	0.00000000	.	.	.	.	0.00000000
3	N	.	.	1	.	1	1	3
	failures	.	.	9	.	7	1	17
	demands	.	.	2160	.	6700	504	9364
	rate	.	.	0.00416667	.	0.00104478	0.00198413	0.00181546
ALL	N	17	6	2	1	1	1	28
	failures	10	0	28	1	7	1	47
	demands	51800	219	9220	1440	6700	504	69883
	rate	0.00019305	0.00000000	0.00303688	0.00069444	0.00104478	0.00198413	0.00067255

Table B.4: Cross tabulation by operator type and originating facility for the BWR demand-related data of Table A.1

Operator Type		OF1					ALL
		Yx	IP4	BRP1	MNS1	BWR	
3	N	1	3	4	4	.	12
	failures	33	17	22	60	.	132
	demands	46983	9364	1910	11732	.	69989
	rate	0.00070238	0.00181546	0.01151832	0.00511422	.	0.00188601
5	N	12	.	.	.	.	12
	failures	3	.	.	.	.	3
	demands	53806	.	.	.	.	53806
	rate	0.00005576	.	.	.	.	0.00005576
1	N	7	2	.	.	2	11
	failures	27	20	.	.	18	65
	demands	53175	8500	.	.	30182	91857
	rate	0.00050776	0.00235294	.	.	0.00059638	0.00070762
7	N	6	.	.	.	.	6
	failures	0	.	.	.	.	0
	demands	219	.	.	.	.	219
	rate	0.00000000	.	.	.	.	0.00000000
2	N	4	.	.	.	.	4
	failures	2	.	.	.	.	2
	demands	1457	.	.	.	.	1457
	rate	0.00137268	.	.	.	.	0.00137268
4	N	2	.	.	.	.	2
	failures	1	.	.	.	.	1
	demands	1721	.	.	.	.	1721
	rate	0.00058106	.	.	.	.	0.00058106
ALL	N	32	5	4	4	2	47
	failures	66	37	22	60	18	203
	demands	157361	17864	1910	11732	30182	219049
	rate	0.00041942	0.00207120	0.01151832	0.00511422	0.00059638	0.00092673

Table B.5: Cross tabulation by valve type and originating facility for the BWR demand-related data of Table A.1

Valve Type		OF1				ALL
		Yx	IP4	BWR	MNS1	
3	N	18	.	4	4	26
	failures	10	.	14	3	27
	demands	52524	.	13678	3896	70098
	rate	0.00019039	.	0.00102354	0.00077002	0.00038518
7	N	6	.	.	.	6
	failures	0	.	.	.	0
	demands	219	.	.	.	219
	rate	0.00000000	.	.	.	0.00000000
2	N	.	2	.	.	2
	failures	.	28	.	.	28
	demands	.	9220	.	.	9220
	rate	.	0.00303688	.	.	0.00303688
5	N	.	1	.	.	1
	failures	.	1	.	.	1
	demands	.	1440	.	.	1440
	rate	.	0.00069444	.	.	0.00069444
4	N	.	1	.	.	1
	failures	.	7	.	.	7
	demands	.	6700	.	.	6700
	rate	.	0.00104478	.	.	0.00104478
8	N	.	1	.	.	1
	failures	.	1	.	.	1
	demands	.	504	.	.	504
	rate	.	0.00198413	.	.	0.00198413
ALL	N	24	5	4	4	37
	failures	10	37	14	3	64
	demands	52743	17864	13678	3896	88181
	rate	0.00018960	0.00207120	0.00102354	0.00077002	0.00072578

Table B.6: Cross tabulation by icl and originating facility for the BWR demand-related data of Table A.1

		OF1					ALL
Includes Circuit?		Yx	BRP1	MNS1	BWR	IP4	
0	N	16	10	8	.	.	34
	failures	3	80	63	.	.	146
	demands	47039	3876	15628	.	.	66543
	rate	0.00006378	0.02063983	0.00403123	.	.	0.00219407
1	N	19	.	.	6	5	30
	failures	63	.	.	32	37	132
	demands	111938	.	.	43860	17864	173662
	rate	0.00056281	.	.	0.00072959	0.00207120	0.00076010
ALL	N	35	10	8	6	5	64
	failures	66	80	63	32	37	278
	demands	158977	3876	15628	43860	17864	240205
	rate	0.00041515	0.02063983	0.00403123	0.00072959	0.00207120	0.00115734

Table B.7: Cross tabulation by sgl and originating facility for the BWR demand-related data of Table A.1

		OF1					ALL
Safety Graded?		Yx	BRP1	MNS1	BWR	IP4	
0	N	35	7	6	6	5	59
	failures	66	56	63	32	37	254
	demands	158977	3367	13084	43860	17864	237152
	rate	0.00041515	0.01663202	0.00481504	0.00072959	0.00207120	0.00107104
1	N	.	3	2	.	.	5
	failures	.	24	0	.	.	24
	demands	.	509	2544	.	.	3053
	rate	.	0.04715128	0.00000000	.	.	0.00786112
ALL	N	35	10	8	6	5	64
	failures	66	80	63	32	37	278
	demands	158977	3876	15628	43860	17864	240205
	rate	0.00041515	0.02063983	0.00403123	0.00072959	0.00207120	0.00115734

Table B.8: Cross tabulation by failure mode and normal operating state for the BWR demand-related data of Table A.1

		Normal State			ALL
Failure Mode		XX	NC	NO	
FTO	N	34	8	.	42
	failures	103	18	.	121
	demands	176622	30401	.	207023
	rate	0.00058317	0.00059209	.	0.00058448
FTP	N	4	8	.	12
	failures	1	67	.	68
	demands	8787	8203	.	16990
	rate	0.00011380	0.00816774	.	0.00400235
FTC	N	4	.	6	10
	failures	16	.	73	89
	demands	8787	.	7405	16192
	rate	0.00182087	.	0.00985820	0.00549654
ALL	N	42	16	6	64
	failures	120	85	73	278
	demands	194196	38604	7405	240205
	rate	0.00061793	0.00220184	0.00985820	0.00115734

Table B.9: Cross tabulation by failure mode and originating facility for the BWR demand-related data of Table A.1

		OF1					ALL
Failure Mode		Yx	BRP1	MNS1	BWR	IP4	
FTO	N	35	.	.	2	5	42
	failures	66	.	.	18	37	121
	demands	158977	.	.	30182	17864	207023
	rate	0.00041515	.	.	0.00059638	0.00207120	0.00058448
FTP	N	.	6	4	2	.	12
	failures	.	33	34	1	.	68
	demands	.	2337	7814	6839	.	16990
	rate	.	0.01412067	0.00435116	0.00014622	.	0.00400235
FTC	N	.	4	4	2	.	10
	failures	.	47	29	13	.	89
	demands	.	1539	7814	6839	.	16192
	rate	.	0.03053931	0.00371129	0.00190086	.	0.00549654
ALL	N	35	10	8	6	5	64
	failures	66	80	63	32	37	278
	demands	158977	3876	15628	43860	17864	240205
	rate	0.00041515	0.02063983	0.00403123	0.00072959	0.00207120	0.00115734

Table B.10: Cross tabulation by fdorig and expsdad for the BWR demand-related data of Table A.1

Failure Data Source		Exposure Data Source			ALL
		PLNT	OTHR	TCRT	
PLNT	N	53	5	.	58
	failures	209	37	.	246
	demands	178481	17864	.	196345
	rate	0.00117099	0.00207120	.	0.00125290
OTHR	N	.	2	4	6
	failures	.	4	28	32
	demands	.	31444	12416	43860
	rate	.	0.00012721	0.00225515	0.00072959
ALL	N	53	7	4	64
	failures	209	41	28	278
	demands	178481	49308	12416	240205
	rate	0.00117099	0.00083151	0.00225515	0.00115734

Table B.11: Cross tabulation by fdorig and originating facility for the BWR demand-related data of Table A.1

Failure Data Source		OF1					ALL
		Yx	BRP1	MNS1	BWR	IP4	
PLNT	N	35	10	8	.	5	58
	failures	66	80	63	.	37	246
	demands	158977	3876	15628	.	17864	196345
	rate	0.00041515	0.02063983	0.00403123	.	0.00207120	0.00125290
OTHR	N	.	.	.	6	.	6
	failures	.	.	.	32	.	32
	demands	.	.	.	43860	.	43860
	rate	.	.	.	0.00072959	.	0.00072959
ALL	N	35	10	8	6	5	64
	failures	66	80	63	32	37	278
	demands	158977	3876	15628	43860	17864	240205
	rate	0.00041515	0.02063983	0.00403123	0.00072959	0.00207120	0.00115734

Table B.12: Cross-tabulation of expsdad and originating facility for the BWR demand-related data of Table A.1

Exposure Data Source		OF1					ALL
		Yx	BRP1	MNS1	BWR	IP4	
PLNT	N	35	10	8	.	.	53
	failures	66	80	63	.	.	209
	demands	158977	3876	15628	.	.	178481
	rate	0.00041515	0.02063983	0.00403123	.	.	0.00117099
OTHR	N	.	.	.	2	5	7
	failures	.	.	.	4	37	41
	demands	.	.	.	31444	17864	49308
	rate	.	.	.	0.00012721	0.00207120	0.00083151
TCRT	N	.	.	.	4	.	4
	failures	.	.	.	28	.	28
	demands	.	.	.	12416	.	12416
	rate	.	.	.	0.00225515	.	0.00225515
ALL	N	35	10	8	6	5	64
	failures	66	80	63	32	37	278
	demands	158977	3876	15628	43860	17864	240205
	rate	0.00041515	0.02063983	0.00403123	0.00072959	0.00207120	0.00115734

Table B.13: Cross tabulation by ir and originating facility for the BWR demand-related data of Table A.1

IRADAP quality data?		OF1					ALL
		Yx	BRP1	MNS1	BWR	IP4	
Y	N	35	8	8	.	5	56
	failures	66	48	63	.	37	214
	demands	158977	2505	15628	.	17864	194974
	rate	0.00041515	0.01916168	0.00403123	.	0.00207120	0.00109758
N	N	.	2	.	6	.	8
	failures	.	32	.	32	.	64
	demands	.	1371	.	43860	.	45231
	rate	.	0.02334063	.	0.00072959	.	0.00141496
ALL	N	35	10	8	6	5	64
	failures	66	80	63	32	37	278
	demands	158977	3876	15628	43860	17864	240205
	rate	0.00041515	0.02063983	0.00403123	0.00072959	0.00207120	0.00115734

Table B.14

BWR Plant Y, both Unit 1 and Unit 2: Demand-related failure data

OBS	RECNO	OF1	SYST1	CAPL1	OPTYP1	VLVTYP1	IC1	NUMFAIL	TOTD	FRATE
1	980	Yx	CH	INTEWB	.	.	1	0	429	0.000000
2	981	Yx	CH	INTEWB	.	.	1	0	463	0.000000
3	569	Yx			.	3	0	0	724	0.000000
4	550	Yx	CH	INTEWC	1	3	1	0	926	0.000000
5	552	Yx	CH	INTEWC	1	3	1	0	856	0.000000
6	953	Yx	BG/BM		2	.	1	0	704	0.000000
7	950	Yx	BG/BM	INTEWC	2	.	1	0	582	0.000000
8	603	Yx			4	.	1	0	1522	0.000000
9	478	Yx			5	3	0	0	816	0.000000
10	470	Yx	BG/BM		5	3	0	0	3493	0.000000
11	474	Yx	BN		5	3	0	0	704	0.000000
12	471	Yx	CH		5	3	0	0	10273	0.000000
13	473	Yx	BG/BM	INTEWC	5	3	0	0	4230	0.000000
14	476	Yx	BN	INTEWC	5	3	0	0	504	0.000000
15	469	Yx	CH	INTEWC	5	3	0	0	11112	0.000000
16	477	Yx		INTEWD	5	3	0	0	891	0.000000
17	475	Yx	BI	INTEWD	5	3	0	0	7855	0.000000
18	488	Yx	BI	INTEWD	5	3	1	0	7665	0.000000
19	894	Yx			7	7	0	0	131	0.000000
20	973	Yx		INTEAR	7	7	1	0	25	0.000000
21	974	Yx	BN	INTEAR	7	7	1	0	20	0.000000
22	891	Yx	BG/BM	INTEWC	7	7	0	0	10	0.000000
23	892	Yx	BN	INTEWC	7	7	0	0	18	0.000000
24	893	Yx	BN	INTEWC	7	7	0	0	15	0.000000
25	551	Yx	BG/BM	INTEWC	1	3	1	1	588	0.001701
26	554	Yx	BG/BM	INTEWC	1	3	1	1	708	0.001412
27	951	Yx			2	.	1	1	73	0.013699
28	952	Yx			2	.	1	1	98	0.010204
29	602	Yx			4	.	1	1	199	0.005025
30	472	Yx			5	3	0	1	971	0.001030
31	749	Yx			5	.	0	2	5292	0.000378
32	555	Yx	BN	INTEWC	1	3	1	3	106	0.028302
33	553	Yx			1	3	1	4	102	0.039216
34	810	Yx			1	.	1	18	49889	0.000361
35	684	Yx			3	.	1	33	46983	0.000702

Table B.15: Cross tabulation by system for BWR Plant Y demand-related data of Table B.14

	N	failures	demands	rate
System				
BG/BM	7	2	10315	0.00019389
CH	6	0	24059	0.00000000
BN	6	3	1367	0.00219459
BI	2	0	15520	0.00000000
ALL	21	5	51261	0.00009754

Table B.16: Cross tabulation by application environment for BWR Plant Y demand-related data of Table B.14

	N	failures	demands	rate
Application Environment				
INTEWC	12	5	19655	0.00025439
INTEWD	3	0	16411	0.00000000
INTEWB	2	0	892	0.00000000
INTEAR	2	0	45	0.00000000
ALL	19	5	37003	0.00013512

Table B.17: Cross tabulation by operator type for BWR Plant Y demand-related data of Table B.14

	N	failures	demands	rate
Operator Type				
5	12	3	53806	0.00005576
1	7	27	53175	0.00050776
7	6	0	219	0.00000000
2	4	2	1457	0.00137268
4	2	1	1721	0.00058106
3	1	33	46983	0.00070238
ALL	32	66	157361	0.00041942

Table B.18: Cross tabulation by valve type for BWR Plant Y demand-related data of Table B.14

	N	failures	demands	rate
Valve Type				
3	18	10	52524	0.00019039
7	6	0	219	0.00000000
ALL	24	10	52743	0.00018960

Table B.19: Cross tabulation by icl for BWR Plant Y demand-related data of Table B.14

	N	failures	demands	rate
Includes Circuit?				
1	19	63	111938	0.00056281
0	16	3	47039	0.00006378
ALL	35	66	158977	0.00041515

APPENDIX C: Analyses for PWR Plants, Demand-related Failure Data

Table C.1: Cross tabulation by system and originating facility for the PWR demand-related data of Table A.1

		OF1						ALL
		X	B&W	DBS1	NEE3	FPRA	Z1S1	
System								
SB	N	6	4	7	.	.	.	17
	failures	0	0	17	.	.	.	17
	demands	10771	28189	5865	.	.	.	44825
	rate	0.00000000	0.00000000	0.00289855	.	.	.	0.00037925
CI	N	3	5	.	.	.	.	8
	failures	2	15	.	.	.	.	17
	demands	1056	22562	.	.	.	.	23618
	rate	0.00189394	0.00066483	.	.	.	.	0.00071979
SJ	N	8	.	.	.	.	.	8
	failures	32	.	.	.	.	.	32
	demands	29556	.	.	.	.	.	29556
	rate	0.00108269	.	.	.	.	.	0.00108269
CB	N	6	.	.	.	.	1	7
	failures	38	.	.	.	.	7	45
	demands	3388	.	.	.	.	1720	5108
	rate	0.01121606	.	.	.	.	0.00406977	0.00880971
BE	N	6	.	.	.	.	1	7
	failures	5	.	.	.	.	10	15
	demands	4894	.	.	.	.	1647	6541
	rate	0.00102166	.	.	.	.	0.00607165	0.00229323
BA	N	6	.	.	.	.	.	6
	failures	5	.	.	.	.	.	5
	demands	2432	.	.	.	.	.	2432
	rate	0.00205592	.	.	.	.	.	0.00205592
CC	N	5	.	.	.	.	.	5
	failures	26	.	.	.	.	.	26
	demands	2012	.	.	.	.	.	2012
	rate	0.01292247	.	.	.	.	.	0.01292247
KE	N	4	.	.	.	.	.	4
	failures	23	.	.	.	.	.	23
	demands	699	.	.	.	.	.	699
	rate	0.03290415	.	.	.	.	.	0.03290415
BP	N	4	.	.	.	.	.	4
	failures	6	.	.	.	.	.	6
	demands	393	.	.	.	.	.	393
	rate	0.01526718	.	.	.	.	.	0.01526718
SD	N	4	.	.	.	.	.	4
	failures	6	.	.	.	.	.	6
	demands	1344	.	.	.	.	.	1344
	rate	0.00446429	.	.	.	.	.	0.00446429
AB	N	4	.	.	.	.	.	4
	failures	18	.	.	.	.	.	18
	demands	1573	.	.	.	.	.	1573
	rate	0.01144310	.	.	.	.	.	0.01144310
BS	N	4	.	.	.	.	.	4
	failures	3	.	.	.	.	.	3
	demands	622	.	.	.	.	.	622
	rate	0.00482315	.	.	.	.	.	0.00482315
LD	N	2	.	.	.	.	.	2
	failures	2	.	.	.	.	.	2
	demands	545	.	.	.	.	.	545
	rate	0.00366972	.	.	.	.	.	0.00366972
KA	N	1	.	.	.	.	.	1
	failures	0	.	.	.	.	.	0
	demands	631	.	.	.	.	.	631
	rate	0.00000000	.	.	.	.	.	0.00000000
AB/AP	N	.	.	2	.	.	.	2
	failures	.	.	3	.	.	.	3
	demands	.	.	350	.	.	.	350
	rate	.	.	0.00857143	.	.	.	0.00857143
AP	N	.	.	.	2	2	.	4
	failures	.	.	.	0	0	.	0
	demands	.	.	.	20	149	.	169
	rate	.	.	.	0.00000000	0.00000000	.	0.00000000
SG	N	.	.	.	1	.	.	1
	failures	.	.	.	5	.	.	5
	demands	.	.	.	30	.	.	30
	rate	.	.	.	0.16666667	.	.	0.16666667
ALL	N	63	9	9	3	2	2	88
	failures	166	15	20	5	0	17	223
	demands	59916	50751	6215	50	149	3367	120448
	rate	0.00277055	0.00029556	0.00321802	0.10000000	0.00000000	0.00504901	0.00185142

Graph C.1: Subset of PWR Plant X Demand-related Valve Failure Data

Model with optyp1, cap1 and syst1

Table C.2: Cross tabulation by operator type and valve type for the PWR Plant X demand-related failure data

		Valve Type		ALL
		3	7	
Operator Type				
5	N	18	18	18
	failures	1	1	1
	demands	8801	8801	8801
	rate	0.00011362	0.00011362	0.00011362
3	N	2	2	2
	failures	0	0	0
	demands	537	537	537
	rate	0.00000000	0.00000000	0.00000000
7	N	12	12	12
	failures	6	6	6
	demands	1566	1566	1566
	rate	0.00383142	0.00383142	0.00383142
ALL	N	20	32	32
	failures	1	7	7
	demands	9338	1566	10904
	rate	0.00010709	0.00383142	0.00064197

Table C.3: Cross tabulation by system for the PWR Plant X demand-related failure data

	N	failures	demands	rate
System				
SJ	8	32	29556	0.00108269
SB	6	0	10771	0.00000000
BA	6	5	2432	0.00205592
BE	6	5	4894	0.00102166
CB	6	38	3388	0.01121606
CC	5	26	2012	0.01292247
AB	4	18	1573	0.01144310
BP	4	6	393	0.01526718
BS	4	3	622	0.00482315
KE	4	23	699	0.03290415
SD	4	6	1344	0.00446429
CI	3	2	1056	0.00189394
LD	2	2	545	0.00366972
KA	1	0	631	0.00000000
ALL	63	166	59916	0.00277055

Table C.4: Cross tabulation by application environment for the PWR Plant X demand-related failure data

	N	failures	demands	rate
Application Environment				
INTEWC	31	84	37207	0.00225764
INTEWB	10	47	4758	0.00987810
INTECS	3	0	4433	0.00000000
INTEWS	2	1	393	0.00254453
INTEST	2	0	603	0.00000000
ALL	48	132	47394	0.00278516

Table C.5: Cross tabulation by operator type for the PWR Plant X demand-related failure data

	N	failures	demands	rate
Operator Type				
5	29	35	43330	0.00080775
7	12	6	1566	0.00383142
1	9	58	5885	0.00985556
3	9	67	6689	0.01001644
2	4	0	2016	0.00000000
ALL	63	166	59486	0.00279057

Graph C.2: Subset of PWR Plant X Demand-related Valve Failure Data

Model with optyp1, capl1 and syst1

Graph C.3: Subset of PWR Plant X Demand-related Valve Failure Data
Model with optyp1, capl1 and syst1

Table C.6: Cross tabulation by application environment and icl for the PWR Plant X demand-related failure data

		Includes Circuit?		ALL
		1	0	
Appli- cation Envir- onment				
INTEWB	N	10	.	10
	failures	47	.	47
	demands	4758	.	4758
	rate	0.00987810	.	0.00987810
INTEWC	N	18	13	31
	failures	84	0	84
	demands	31838	5369	37207
	rate	0.00263836	0.00000000	0.00225764
INTECS	N	1	2	3
	failures	0	0	0
	demands	1488	2945	4433
	rate	0.00000000	0.00000000	0.00000000
INTEST	N	1	1	2
	failures	0	0	0
	demands	172	431	603
	rate	0.00000000	0.00000000	0.00000000
INTEWS	N	.	2	2
	failures	.	1	1
	demands	.	393	393
	rate	.	0.00254453	0.00254453
ALL	N	30	18	48
	failures	131	1	132
	demands	38256	9138	47394
	rate	0.00342430	0.00010943	0.00278516

Table C.7: Cross tabulation by sgl for the PWR Plant X demand-related failure data

	N	failures	demands	rate
Safety Graded?				
0	57	142	58189	0.00244032
1	7	24	1861	0.01289629
ALL	64	166	60050	0.00276436

Table C.8
Subset of PWR Plant X Demand-related Failure Data

OBS	RECNO	OF1	SYST1	CAPL1	OPTYP1	VLVTYP1	SG1	NUMFAIL	TOTD	FRATE
1	752	X	BP	INTEWB	5	.	1	0	297	0.00000
2	903	X	BP	INTEWB	7	7	1	0	12	0.00000
3	912	X	CB	INTEWB	7	7	0	0	93	0.00000
4	813	X	BA	INTEWC	1	.	0	0	89	0.00000
5	461	X	BA	INTEWC	3	3	0	0	191	0.00000
6	460	X	SJ	INTEWC	3	3	0	0	346	0.00000
7	760	X	BA	INTEWC	5	.	0	0	201	0.00000
8	751	X	SJ	INTEWC	5	.	0	0	21051	0.00000
9	910	X	SD	INTEWC	7	7	0	0	24	0.00000
10	759	X	AB	INTEWB	5	.	1	2	1329	0.00150
11	690	X	SD	INTEWC	3	.	0	1	367	0.00272
12	909	X	CC	INTEWC	7	7	0	1	307	0.00326
13	801	X	SJ	INTEWC	1	.	0	6	1715	0.00350
14	761	X	CB	INTEWB	5	.	0	5	1184	0.00422
15	687	X	BA	INTEWC	3	.	0	5	879	0.00569
16	691	X	SJ	INTEWC	3	.	0	22	3679	0.00598
17	815	X	SD	INTEWC	1	.	0	5	813	0.00615
18	911	X	SJ	INTEWC	7	7	0	4	621	0.00644
19	757	X	CC	INTEWC	5	.	0	12	1064	0.01128
20	812	X	CB	INTEWB	1	.	0	15	862	0.01740
21	692	X	CB	INTEWB	3	.	0	18	855	0.02105
22	905	X	AB	INTEWB	7	7	1	1	42	0.02381
23	686	X	BP	INTEWB	3	.	1	3	60	0.05000
24	814	X	CC	INTEWC	1	.	0	13	222	0.05856
25	811	X	BP	INTEWB	1	.	1	3	24	0.12500
26	688	X	AB	INTEWC	3	.	1	15	97	0.15464

Table C.9: Analysis Results

Subset of PWR Plant X Demand-related Failure Data: Intercept Only Model
The GENMOD Procedure

Model Information

Description	Value	Label
Data Set	WORK.TEMP	
Distribution	BINOMIAL	
Link Function	LOGIT	
Dependent Variable	NUMFAIL	Failures
Dependent Variable	TOTD	Demands
Observations Used	26	
Number Of Events	131	
Number Of Trials	36424	

Class Level Information

Class	Levels	Values
OPTYP1	4	1 3 5 7
SYST1	7	AB BA BP CB CC SD SJ
CAPL1	2	INTEWB INTEWC

Parameter Information

Parameter	Effect
PRM1	INTERCEPT

Criteria For Assessing Goodness Of Fit

Criterion	DF	Value	Value/DF
Deviance	25	402.9678	16.1187
Scaled Deviance	25	402.9678	16.1187
Pearson Chi-Square	25	1172.4070	46.8963
Scaled Pearson X2	25	1172.4070	46.8963
Log Likelihood	.	-868.0041	.

Analysis Of Parameter Estimates

Parameter	DF	Estimate	Std Err	ChiSquare	Pr>Chi
INTERCEPT	1	-5.6242	0.0875	4128.8147	0.0001
SCALE	0	1.0000	0.0000	.	.

NOTE: The scale parameter was held fixed.

Normal Confidence Intervals For Parameters

Two-Sided Confidence Coefficient: 0.9500

Parameter Confidence Limits

PRM1	Lower	-5.7957
PRM1	Upper	-5.4526

LR Statistics For Type I Analysis

Source	Deviance	DF	ChiSquare	Pr>Chi
INTERCEPT	402.9678	0	.	.

Table C.10: Analysis Results

Subset of PWR Plant X Demand-related Failure Data: Model with optyp1, capl1 and syst1
The GENMOD Procedure

Model Information

Description	Value	Label
Data Set	WORK.TEMP	
Distribution	BINOMIAL	
Link Function	LOGIT	
Dependent Variable	NUMFAIL	Failures
Dependent Variable	TOTD	Demands
Observations Used	26	
Number Of Events	131	
Number Of Trials	36424	

Class Level Information

Class	Levels	Values
OPTYP1	4	1 3 5 7
SYST1	7	AB BA BP CB CC SD SJ
CAPL1	2	INTEWB INTEWC

Parameter Information

Parameter	Effect	OPTYP1	SYST1	CAPL1
PRM1	INTERCEPT			
PRM2	OPTYP1	1		
PRM3	OPTYP1	3		
PRM4	OPTYP1	5		
PRM5	OPTYP1	7		
PRM6	CAPL1			INTEWB
PRM7	CAPL1			INTEWC
PRM8	SYST1		AB	
PRM9	SYST1		BA	
PRM10	SYST1		BP	
PRM11	SYST1		CB	
PRM12	SYST1		CC	
PRM13	SYST1		SD	
PRM14	SYST1		SJ	

Criteria For Assessing Goodness Of Fit

Criterion	DF	Value	Value/DF
Deviance	15	51.1245	3.4083
Scaled Deviance	15	51.1245	3.4083
Pearson Chi-Square	15	58.3583	3.8906
Scaled Pearson X2	15	58.3583	3.8906
Log Likelihood	.	-692.0824	.

Analysis Of Parameter Estimates

Parameter	DF	Estimate	Std Err	ChiSquare	Pr>Chi
INTERCEPT	1	-7.1285	0.4856	215.4884	0.0001
OPTYP1 1	1	1.5139	0.4593	10.8641	0.0010
OPTYP1 3	1	1.7615	0.4887	12.9911	0.0003
OPTYP1 5	1	-0.9428	0.4896	3.7091	0.0541
OPTYP1 7	0	0.0000	0.0000	.	.
CAPL1 INTEWB	1	-1.7663	0.7096	6.1948	0.0128
CAPL1 INTEWC	0	0.0000	0.0000	.	.
SYST1 AB	1	3.6684	0.3458	112.5150	0.0001
SYST1 BA	1	-0.0694	0.4889	0.0201	0.8872
SYST1 BP	1	4.3589	0.8412	26.8511	0.0001
SYST1 CB	1	3.3989	0.7618	19.9089	0.0001
SYST1 CC	1	2.9745	0.3059	94.5703	0.0001
SYST1 SD	1	0.2503	0.4563	0.3010	0.5833
SYST1 SJ	0	0.0000	0.0000	.	.
SCALE	0	1.0000	0.0000	.	.

NOTE: The scale parameter was held fixed.

Estimated Correlation Matrix

Parameter Number	PRM1	PRM2	PRM3	PRM4	PRM6	PRM8	PRM9	PRM10	PRM11	PRM12	PRM13
PRM1	1.0000	-0.8633	-0.9142	-0.8234	-0.1039	-0.1123	-0.0867	0.0076	0.0095	-0.5290	-0.1587
PRM2	-0.8633	1.0000	0.8741	0.7974	0.0929	-0.0231	-0.0194	-0.0744	-0.1065	0.2088	-0.0581
PRM3	-0.9142	0.8741	1.0000	0.7982	0.1791	-0.1295	-0.0784	-0.1474	-0.1649	0.3941	0.0270
PRM4	-0.8234	0.7974	0.7982	1.0000	-0.0887	0.0283	0.0206	0.0765	0.1071	0.2305	0.0580
PRM6	-0.1039	0.0929	0.1791	-0.0887	1.0000	-0.4285	-0.0671	-0.8422	-0.9459	0.1242	-0.0184
PRM8	-0.1123	-0.0231	-0.1295	0.0283	-0.4285	1.0000	0.2326	0.4687	0.5191	0.1859	0.1847
PRM9	-0.0867	-0.0194	-0.0784	0.0206	-0.0671	0.2326	1.0000	0.1325	0.1484	0.1453	0.1352
PRM10	0.0076	-0.0744	-0.1474	0.0765	-0.8422	0.4687	0.1325	1.0000	0.8453	0.0183	0.0967
PRM11	0.0095	-0.1065	-0.1649	0.1071	-0.9459	0.5191	0.1484	0.8453	1.0000	0.0293	0.1220
PRM12	-0.5290	0.2088	0.3941	0.2305	0.1242	0.1859	0.1453	0.0183	0.0293	1.0000	0.2764
PRM13	-0.1587	-0.0581	0.0270	0.0580	-0.0184	0.1847	0.1352	0.0967	0.1220	0.2764	1.0000

Table C.10 (continued): Analysis Results

Subset of PWR Plant X Demand-related Failure Data: Model with optyp1, cap11 and syst1

Normal Confidence Intervals For Parameters

Two-Sided Confidence Coefficient: 0.9500
Parameter Confidence Limits

PRM1	Lower	-8.0803
PRM1	Upper	-6.1767
PRM2	Lower	0.6137
PRM2	Upper	2.4142
PRM3	Lower	0.8036
PRM3	Upper	2.7193
PRM4	Lower	-1.9024
PRM4	Upper	0.0167
PRM6	Lower	-3.1572
PRM6	Upper	-0.3754
PRM8	Lower	2.9905
PRM8	Upper	4.3462
PRM9	Lower	-1.0276
PRM9	Upper	0.8889
PRM10	Lower	2.7102
PRM10	Upper	6.0076
PRM11	Lower	1.9059
PRM11	Upper	4.8920
PRM12	Lower	2.3750
PRM12	Upper	3.5740
PRM13	Lower	-0.6440
PRM13	Upper	1.1446

LR Statistics For Type 1 Analysis

Source	Deviance	DF	ChiSquare	Pr>Chi
INTERCEPT	402.9678	0		
OPTYP1	231.1275	3	171.8403	0.0001
CAP11	202.5210	1	28.6065	0.0001
SYST1	51.1245	6	151.3965	0.0001

LR Statistics For Type 3 Analysis

Source	DF	ChiSquare	Pr>Chi
OPTYP1	3	114.9624	0.0001
CAP11	1	7.4516	0.0063
SYST1	6	151.3965	0.0001

Observation Statistics

NUMFAIL	TOTD	Pred	Xbeta	Std	HessWgt	Lower	Upper	Resraw	Reschi	Resdev
0	297	0.004157	-5.4787	0.4751	1.2296	0.001642	0.0105	-1.2347	-1.1135	-1.5731
0	12	0.0106	-4.5359	0.6133	0.1259	0.003211	0.0344	-0.1272	-0.3586	-0.5058
0	93	0.004087	-5.4958	0.4821	0.3785	0.001593	0.0104	-0.3801	-0.6178	-0.8728
0	89	0.003389	-5.6839	0.5008	0.3006	0.001272	0.008993	-0.3016	-0.5501	-0.7773
0	191	0.004336	-5.4364	0.4485	0.8246	0.001805	0.0104	-0.8282	-0.9121	-1.2884
0	346	0.004646	-5.3670	0.2018	1.6002	0.003133	0.006885	-1.6076	-1.2709	-1.7952
0	201	0.000291	-8.1407	0.5401	0.0585	0.000101	0.000839	-0.0586	-0.2420	-0.3423
0	21051	0.000312	-8.0713	0.2898	6.5715	0.000177	0.000551	-6.5736	-2.5643	-3.6262
0	24	0.001029	-6.8782	0.6113	0.0247	0.000311	0.003402	-0.0247	-0.1572	-0.2223
2	1329	0.002088	-6.1692	0.5792	2.7697	0.000672	0.006470	-0.7755	-0.4660	-0.4907
1	367	0.005960	-5.1167	0.4366	2.1743	0.002542	0.0139	-1.1873	-0.8052	-0.9018
1	307	0.0155	-4.1540	0.4150	4.6725	0.006913	0.0342	-3.7459	-1.7329	-2.1032
6	1715	0.003631	-5.6146	0.2484	6.2049	0.002235	0.005895	-0.2275	-0.0913	-0.0919
5	1184	0.001596	-6.4387	0.3144	1.8866	0.000863	0.002951	3.1104	2.2645	1.8756
5	879	0.004336	-5.4364	0.4485	3.7951	0.001805	0.0104	1.1884	0.6100	0.5820
22	3679	0.004646	-5.3670	0.2018	17.0143	0.003133	0.006885	4.9063	1.1894	1.1387
5	813	0.004659	-5.3642	0.4185	3.7703	0.002057	0.0105	1.2120	0.6242	0.5948
4	621	0.000801	-7.1285	0.4856	0.4972	0.000309	0.002073	3.5024	4.9670	3.1127
12	1064	0.006079	-5.0968	0.2990	6.4286	0.003392	0.0109	5.5320	2.1819	1.9488
15	862	0.0183	-3.9819	0.2107	15.4932	0.0122	0.0274	-0.7822	-0.1987	-0.2004
18	855	0.0233	-3.7344	0.1969	19.4827	0.0160	0.0339	-1.9481	-0.4413	-0.4487
1	42	0.005344	-5.2264	0.7344	0.2233	0.001272	0.0222	0.7755	1.6414	1.2048
3	60	0.0587	-2.7744	0.4291	3.3165	0.0262	0.1264	-0.5234	-0.2874	-0.2945
13	222	0.0666	-2.6401	0.2383	13.8013	0.0428	0.1022	-1.7861	-0.4808	-0.4903
3	24	0.0464	-3.0219	0.4529	1.0629	0.0197	0.1058	1.8853	1.8287	1.5263
15	97	0.1546	-1.6987	0.2808	12.6804	0.0954	0.2408	-3.55E-15	-9.98E-16	0

Table C.11
Predictions Based on Model including optyp1, cap11, and syst1 Fit to
Subset of PWR Plant X Demand-related Failure Data in Table C.8

Code corresponding to factor levels defined in Section 2:
optyp1=1,3,5, or 7 as defined previously in section 2
cap11=1 or 2 respectively for INTEWB or INTEWC
syst1=1-7 respectively for systems AB, BA, BP, CB, CC, SD, SJ

optyp1 Operator Type	cap11 Application Environment	syst1 System	Prediction	Lower 95% Bound	Upper 95% Bound
3	1	1	0.03033	0.008644	0.10087
3	1	2	0.00074	0.000143	0.00387
3	1	3	0.05872	0.026200	0.12638
3	1	4	0.02333	0.015982	0.03394
3	1	5	0.01539	0.003004	0.07495
3	1	6	0.00102	0.000191	0.00547
3	1	7	0.00080	0.000176	0.00362
1	1	1	0.02383	0.006824	0.07984
1	1	2	0.00058	0.000113	0.00298
1	1	3	0.04644	0.019653	0.10580
1	1	4	0.01831	0.012189	0.02741
1	1	5	0.01205	0.002655	0.05295
1	1	6	0.00080	0.000164	0.00390
1	1	7	0.00062	0.000145	0.00267
7	1	1	0.00534	0.001272	0.02216
7	1	2	0.00013	0.000022	0.00075
7	1	3	0.01060	0.003211	0.03443
7	1	4	0.00409	0.001593	0.01045
7	1	5	0.00268	0.000547	0.01299
7	1	6	0.00018	0.000031	0.00101
7	1	7	0.00014	0.000028	0.00068
5	1	1	0.00209	0.000672	0.00647
5	1	2	0.00005	0.000011	0.00023
5	1	3	0.00416	0.001643	0.01048
5	1	4	0.00160	0.000863	0.00295
5	1	5	0.00104	0.000257	0.00424
5	1	6	0.00007	0.000015	0.00032
5	1	7	0.00005	0.000014	0.00020
3	2	1	0.15465	0.095441	0.24081
3	2	2	0.00434	0.001805	0.01038
3	2	3	0.26735	0.071229	0.63454
3	2	4	0.12259	0.033530	0.36009
3	2	5	0.08375	0.047585	0.14325
3	2	6	0.00596	0.002542	0.01391
3	2	7	0.00465	0.003133	0.00689
1	2	1	0.12497	0.064790	0.22745
1	2	2	0.00339	0.001272	0.00899
1	2	3	0.22172	0.051344	0.59991
1	2	4	0.09835	0.024097	0.32517
1	2	5	0.06660	0.042814	0.10220
1	2	6	0.00466	0.002056	0.01052
1	2	7	0.00363	0.002235	0.00589
7	2	1	0.03047	0.010304	0.08664
7	2	2	0.00075	0.000206	0.00271
7	2	3	0.05899	0.009197	0.29742
7	2	4	0.02344	0.004039	0.12440
7	2	5	0.01546	0.006913	0.03420
7	2	6	0.00103	0.000311	0.00340
7	2	7	0.00080	0.000309	0.00207
5	2	1	0.01209	0.005358	0.02707
5	2	2	0.00029	0.000101	0.00084
5	2	3	0.02384	0.003947	0.13080
5	2	4	0.00926	0.001707	0.04863
5	2	5	0.00608	0.003392	0.01087
5	2	6	0.00040	0.000151	0.00106
5	2	7	0.00031	0.000177	0.00055

APPENDIX D: Analyses for BWR Plants, Time-related Failure Data

Table D.1: Cross tabulation by failure mode and originating facility for the BWR time-related data of Table A.2

Failure Mode		OF1					ALL
		Yx	IP4	BRP1	BWR	MNS1	
LI	N	20	2	.	.	.	22
	failures	21	3	.	.	.	24
	times	6607737	7300000	.	.	.	13907737
	rate	0.00000318	0.00000041	.	.	.	0.00000173
FTO	N	8	.	.	1	1	10
	failures	10	.	.	16	18	44
	times	241394	.	.	22600000	148479	22989873
	rate	0.00004143	.	.	0.00000071	0.00012123	0.00000191
SO	N	.	4	.	.	.	4
	failures	.	10	.	.	.	10
	times	.	13770000	.	.	.	13770000
	rate	.	0.00000073	.	.	.	0.00000073
SP	N	.	.	2	.	.	2
	failures	.	.	4	.	.	4
	times	.	.	5199120	.	.	5199120
	rate	.	.	0.00000077	.	.	0.00000077
SC	N	.	.	1	.	.	1
	failures	.	.	4	.	.	4
	times	.	.	3944160	.	.	3944160
	rate	.	.	0.00000101	.	.	0.00000101
LE	N	.	.	.	2	.	2
	failures	.	.	.	39	.	39
	times	.	.	.	756000000	.	756000000
	rate	.	.	.	0.00000001	.	0.00000001
ALL	N	28	6	3	3	1	41
	failures	31	13	8	55	18	125
	times	6849131	21070000	9143280	758260000	148479	7619810890
	rate	0.00000453	0.00000062	0.00000087	0.00000001	0.00012123	0.00000002

Table D.2: Cross tabulation by originating facility and system, listed by failure mode for BWR time-related data of Table A.2.

System		Failure Mode				
		LI		FTO		
		OF1		OF1		ALL
		Yx	ALL	Yx	MNS1	
BG/BM	N	4	4	2	.	2
	failures	1	1	0	.	0
	hours	1304	1304	652	.	652
	rate	0.00076687	0.00076687	0.00000000	.	0.00000000
BN	N	3	3	1	.	1
	failures	1	1	0	.	0
	hours	752	752	488	.	488
	rate	0.00132979	0.00132979	0.00000000	.	0.00000000
CH	N	4	4	.	.	.
	failures	0	0	.	.	.
	hours	18714	18714	.	.	.
	rate	0.00000000	0.00000000	.	.	.
SJ	N	.	.	.	1	1
	failures	.	.	.	18	18
	hours	.	.	.	148479	148479
	rate	.	.	.	0.00012123	0.00012123
BI	N	1	1	.	.	.
	failures	0	0	.	.	.
	hours	7690	7690	.	.	.
	rate	0.00000000	0.00000000	.	.	.
ALL	N	12	12	3	1	4
	failures	2	2	0	18	18
	hours	28460	28460	1140	148479	149619
	rate	0.00007027	0.00007027	0.00000000	0.00012123	0.00012031

Table D.3: Cross tabulation by originating facility and operator type, listed by failure mode for BWR time-related data of Table A.2.

Operator Type		Failure Mode					
		LI			FTO		
		OF1		ALL	OF1		ALL
		Yx	IP4		Yx	BWR	
7	N	7	1	8	2	.	2
	failures	0	1	1	0	.	0
	hours	76873	215000	2226873	1143	.	1143
	rate	0.00000000	0.00000047	0.00000045	0.00000000	.	0.00000000
1	N	7	1	8	.	.	.
	failures	10	2	12	.	.	.
	hours	5362279	515000	10512279	.	.	.
	rate	0.00000186	0.00000039	0.00000114	.	.	.
2	N	.	.	.	4	1	5
	failures	.	.	.	0	16	16
	hours	.	.	.	872	22600000	22600872
	rate	.	.	.	0.00000000	0.00000071	0.00000071
5	N	2	.	2	.	.	.
	failures	5	.	5	.	.	.
	hours	194757	.	194757	.	.	.
	rate	0.00002567	.	0.00002567	.	.	.
3	N	.	.	.	1	.	1
	failures	.	.	.	10	.	10
	hours	.	.	.	239117	.	239117
	rate	.	.	.	0.00004182	.	0.00004182
4	N	.	.	.	1	.	1
	failures	.	.	.	0	.	0
	hours	.	.	.	262	.	262
	rate	.	.	.	0.00000000	.	0.00000000
ALL	N	16	2	18	8	1	9
	failures	15	3	18	10	16	26
	hours	5633909	730000	12933909	241394	22600000	22841394
	rate	0.00000266	0.00000041	0.00000139	0.00004143	0.00000071	0.00000114

APPENDIX E: Analyses for PWR Plants, Time-related Failure Data

Table E.1: Cross tabulation by failure mode and originating facility for the PWR time-related data of Table A.2

OF1		Failure Mode						ALL
		FTO	LI	SC	SO	SP	LE	
X	N	51	22	.	.	1	.	74
	failures	14	8	.	.	0	.	22
	hours	208959430	13650877	.	.	134524	.	222744831
B&W	rate	0.00000007	0.00000059	.	.	0.00000000	.	0.00000010
	N	9	.	.	.	.	.	9
	failures	0	.	.	.	.	.	0
DBS1	hours	16483597	.	.	.	.	.	16483597
	rate	0.00000000	.	.	.	.	.	0.00000000
	N	1	1	.	1	.	.	3
IP1	failures	12	0	.	3	.	.	15
	hours	364728	4324632	.	4012008	.	.	8701368
	rate	0.00003290	0.00000000	.	0.00000075	.	.	0.00000172
IPS2	N	.	3	.	8	.	.	11
	failures	.	6	.	30	.	.	36
	hours	.	8850000	.	15854000	.	.	24704000
Z1S1	rate	.	0.00000068	.	0.00000189	.	.	0.00000146
	N	.	1	3	.	4	.	8
	failures	.	1	0	.	1	.	2
EUR	hours	.	444000	12444000	.	339521	.	13227521
	rate	.	0.00000225	0.00000000	.	0.00000295	.	0.00000015
	N	.	1	3	.	2	.	6
FPRA	failures	.	0	0	.	2	.	2
	hours	.	608000	24330000	.	1314000	.	26252000
	rate	.	0.00000000	0.00000000	.	0.00000152	.	0.00000008
NEE3	N	.	1	2	1	1	.	5
	failures	.	5	0	5	0	.	10
	hours	.	1497730	3638861	1120765	53130	.	6310486
BREL	rate	.	0.00000334	0.00000000	0.00000446	0.00000000	.	0.00000158
	N	.	1	.	2	.	.	3
	failures	.	9	.	7	.	.	16
PWR	hours	.	376000	.	2392000	.	.	2768000
	rate	.	0.00002394	.	0.00000293	.	.	0.00000578
	N	.	.	7	.	.	.	7
ALL	failures	.	.	2	.	.	.	2
	hours	.	.	6177000	.	.	.	6177000
	rate	.	.	0.00000032	.	.	.	0.00000032
PWR	N	.	.	.	1	.	.	1
	failures	.	.	.	8	.	.	8
	hours	.	.	.	184104	.	.	184104
ALL	rate	.	.	.	0.00004345	.	.	0.00004345
	N	.	.	.	.	.	2	2
	failures	.	.	.	.	.	92	92
ALL	hours	.	.	.	.	.	19000000000	19000000000
	rate	.	.	.	.	.	0.00000000	0.00000000
	N	61	30	15	13	8	2	129
ALL	failures	26	29	2	53	3	92	205
	hours	225807755	29751239	46589861	23562877	1841175	19000000000	19327552907
	rate	0.00000012	0.00000097	0.00000004	0.00000225	0.00000163	0.00000000	0.00000001

Table E.2

PWR Plant X, Failure Mode LI records: Time-related Failure Data

OBS	RECNO	OF1	SYST1	CAP11	OPTYP1	VLTYP1	IC1	SG1	FMODE	NSTATE	IR	NUMFAIL	TOTHR	FRATE
1	527	X	BE		5	3	1	0	LI	XX	Y	0	2240	.0000000
2	523	X	BI		5	3	1	1	LI	XX	Y	0	1115136	.0000000
3	543	X	LD	INTEAR	5	3	0	0	LI	XX	Y	0	101376	.0000000
4	521	X	SB	INTEST	5	3	1	0	LI	XX	Y	0	201786	.0000000
5	525	X	BP	INTEWB	5	3	1	1	LI	XX	Y	0	134524	.0000000
6	522	X	CI	INTEWB	5	3	1	0	LI	XX	Y	0	32656	.0000000
7	524	X	CI	INTEWB	5	3	1	0	LI	XX	Y	0	32078	.0000000
8	541	X	BA	INTEWC	5	3	0	0	LI	XX	Y	0	432	.0000000
9	452	X	CB	INTEWC	5	3	0	0	LI	XX	Y	0	709632	.0000000
10	547	X	CB	INTEWC	5	3	0	0	LI	XX	Y	0	912384	.0000000
11	545	X	CC	INTEWC	5	3	0	0	LI	XX	Y	0	253440	.0000000
12	529	X	SD	INTEWC	5	3	1	0	LI	XX	Y	0	302679	.0000000
13	542	X	SD	INTEWC	5	3	0	0	LI	XX	Y	0	67262	.0000000
14	450	X	SJ	INTEWC	5	3	0	0	LI	XX	Y	0	33631	.0000000
15	540	X	SJ	INTEWC	5	3	0	0	LI	XX	Y	0	336310	.0000000
16	451	X	BS	INTEWS	5	3	0	0	LI	XX	Y	0	50688	.0000000
17	938	X			7	7	1	0	LI	NC	Y	0	6138382	.0000000
18	544	X	BE	INTECS	5	3	0	0	LI	XX	Y	1	700	.0014286
19	528	X	CC	INTEWC	5	3	1	0	LI	XX	Y	1	304128	.0000033
20	546	X	BS	INTEWS	5	3	0	0	LI	XX	Y	1	152064	.0000066
21	526	X	KE		5	3	1	0	LI	XX	Y	2	103947	.0000192
22	519	X	CI		5	3	0	0	LI	XX	Y	3	2665402	.0000011

Table E.3: Cross tabulation by system and application environment for the PWR Plant X time-related failure data, for failure mode fmode=LI

System		Application Environment						ALL
		INTEWC	INTEWB	INTEWS	INTEAR	INTEST	INTECS	
CB	N	2	.	.	.	.	.	2
	failures	0	.	.	.	.	.	0
	hours	1622016	.	.	.	.	.	1622016
CC	rate	0.00000000	.	.	.	.	.	0.00000000
	N	2	.	.	.	.	.	2
	failures	1	.	.	.	.	.	1
SD	hours	557568	.	.	.	.	.	557568
	rate	0.00000179	.	.	.	.	.	0.00000179
	N	2	.	.	.	.	.	2
SJ	failures	0	.	.	.	.	.	0
	hours	369941	.	.	.	.	.	369941
	rate	0.00000000	.	.	.	.	.	0.00000000
BA	N	2	.	.	.	.	.	2
	failures	0	.	.	.	.	.	0
	hours	369941	.	.	.	.	.	369941
CI	rate	0.00000000	.	.	.	.	.	0.00000000
	N	1	.	.	.	.	.	1
	failures	0	.	.	.	.	.	0
BP	hours	432	.	.	.	.	.	432
	rate	0.00000000	.	.	.	.	.	0.00000000
	N	2	.	.	.	.	.	2
BS	failures	.	2	.	.	.	.	2
	hours	.	64734	.	.	.	.	64734
	rate	0.00000000	.	.	.	.	.	0.00000000
LD	N	.	1	.	.	.	.	1
	failures	.	0	.	.	.	.	0
	hours	.	134524	.	.	.	.	134524
SB	rate	0.00000000	.	.	.	.	.	0.00000000
	N	.	2	.	.	.	.	2
	failures	.	1	.	.	.	.	1
BE	hours	.	202752	.	.	.	.	202752
	rate	.	0.00000493	.	.	.	.	0.00000493
	N	.	.	1	.	.	.	1
ALL	failures	.	.	0	.	.	.	0
	hours	.	.	101376	.	.	.	101376
	rate	.	.	0.00000000	.	.	.	0.00000000
ALL	N	.	.	.	1	.	.	1
	failures	.	.	.	0	.	.	0
	hours	.	.	.	201786	.	.	201786
ALL	rate	.	.	.	0.00000000	.	.	0.00000000
	N	.	.	.	.	1	.	1
	failures	.	.	.	.	0	.	0
ALL	hours	.	.	.	.	700	.	700
	rate	.	.	.	.	0.00142857	.	0.00142857
	N	9	3	2	1	1	1	17
ALL	failures	1	0	1	0	0	1	3
	hours	2919898	199258	202752	101376	201786	700	3625770
	rate	0.00000034	0.00000000	0.00000493	0.00000000	0.00000000	0.00142857	0.00000083

Table E.4: Cross tabulation by system and icl, indicator for inclusion of circuit failures in observed failure count, for the PWR Plant X time-related failure data, for failure mode fmode=LI

System		Includes Circuit?		ALL
		0	1	
CB	N	2	.	2
	failures	0	.	0
	hours	1622016	.	1622016
	rate	0.00000000	.	0.00000000
SJ	N	2	.	2
	failures	0	.	0
	hours	369941	.	369941
	rate	0.00000000	.	0.00000000
BS	N	2	.	2
	failures	1	.	1
	hours	202752	.	202752
	rate	0.00000493	.	0.00000493
LD	N	1	.	1
	failures	0	.	0
	hours	101376	.	101376
	rate	0.00000000	.	0.00000000
BA	N	1	.	1
	failures	0	.	0
	hours	432	.	432
	rate	0.00000000	.	0.00000000
CI	N	1	2	3
	failures	3	0	3
	hours	2665402	64734	2730136
	rate	0.00000113	0.00000000	0.00000110
BE	N	1	1	2
	failures	1	0	1
	hours	700	2240	2940
	rate	0.00142857	0.00000000	0.00034014
CC	N	1	1	2
	failures	0	1	1
	hours	253440	304128	557568
	rate	0.00000000	0.00000329	0.00000179
SD	N	1	1	2
	failures	0	0	0
	hours	67262	302679	369941
	rate	0.00000000	0.00000000	0.00000000
BI*	N	.	1	1
	failures	.	0	0
	hours	.	1115136	1115136
	rate	.	0.00000000	0.00000000
SB	N	.	1	1
	failures	.	0	0
	hours	.	201786	201786
	rate	.	0.00000000	0.00000000
BP*	N	.	1	1
	failures	.	0	0
	hours	.	134524	134524
	rate	.	0.00000000	0.00000000
KE	N	.	1	1
	failures	.	2	2
	hours	.	103947	103947
	rate	.	0.00001924	0.00001924
ALL	N	12	9	21
	failures	5	3	8
	hours	5283321	2229174	7512495
	rate	0.00000095	0.00000135	0.00000106

* For the single records of system BI and BP, sgl=1. All other records included in this table have sgl=0.

Table E.5

PWR Plant X, Failure Mode FTO records: Time-related Failure Data

OBS	RECNO	OF1	SYST1	CAPL1	OPTYP1	IC1	SG1	FMODE	IR	NUMFAIL	TOTHR5	FRATE
1	595	X	SB	INTEST	.	0	0	FTO	Y	0	269048	.00000000
2	594	X	BP	INTEWB	.	0	0	FTO	Y	0	168155	.00000000
3	807	X	CI		1	1	0	FTO	Y	0	96234	.00000000
4	820	X	KE		1	1	0	FTO	Y	0	311841	.00000000
5	821	X	LD		1	1	0	FTO	Y	0	50688	.00000000
6	805	X	SB		1	1	0	FTO	Y	0	672620	.00000000
7	819	X	CB	INTEWB	1	1	0	FTO	Y	0	1200000	.00000000
8	825	X	BA	INTEWC	1	1	1	FTO	N	0	54	.00000000
9	822	X	CC	INTEWC	1	1	0	FTO	Y	0	1571328	.00000000
10	823	X	SD	INTEWC	1	1	0	FTO	Y	0	369941	.00000000
11	963	X	LD	INTEAR	2	1	0	FTO	Y	0	101376	.00000000
12	962	X	BE	INTECS	2	1	0	FTO	Y	0	1120	.00000000
13	964	X	AB	INTEWC	2	1	0	FTO	Y	0	315504	.00000000
14	966	X	BA	INTEWC	2	1	0	FTO	Y	0	216	.00000000
15	961	X	CB	INTEWC	2	1	0	FTO	Y	0	101376	.00000000
16	696	X	BE		3	1	0	FTO	Y	0	560	.00000000
17	695	X	AB	INTEWB	3	1	1	FTO	Y	0	157752	.00000000
18	694	X	CB	INTEWB	3	1	0	FTO	Y	0	1100000	.00000000
19	699	X	BA	INTEWC	3	1	0	FTO	Y	0	486	.00000000
20	697	X	SD	INTEWC	3	1	0	FTO	Y	0	168155	.00000000
21	698	X	SJ	INTEWC	3	1	0	FTO	Y	0	706251	.00000000
22	458	X	BA	INTEWC	3	1	0	FTO	N	0	108	.00000000
23	459	X	SJ	INTEWC	3	1	0	FTO	Y	0	67262	.00000000
24	768	X	BI		5	1	1	FTO	Y	0	2027520	.00000000
25	772	X	KE		5	1	0	FTO	Y	0	2771920	.00000000
26	773	X	LD		5	1	0	FTO	Y	0	18000000	.00000000
27	778	X	SB		5	1	0	FTO	Y	0	3654886	.00000000
28	771	X	AB	INTEWB	5	1	1	FTO	Y	0	5915700	.00000000
29	770	X	CB	INTEWB	5	1	0	FTO	Y	0	17000000	.00000000
30	779	X	BA	INTEWC	5	1	0	FTO	N	0	1512	.00000000
31	775	X	CC	INTEWC	5	1	0	FTO	Y	0	18084928	.00000000
32	776	X	SD	INTEWC	5	1	0	FTO	Y	0	6154473	.00000000
33	777	X	SJ	INTEWC	5	1	0	FTO	Y	0	4809233	.00000000
34	919	X	BE		7	1	0	FTO	N	0	280	.00000000
35	913	X	BI		7	1	1	FTO	Y	0	202752	.00000000
36	917	X	KE		7	1	0	FTO	Y	0	69298	.00000000
37	918	X	LD		7	1	0	FTO	Y	0	304128	.00000000
38	923	X	SB		7	1	0	FTO	Y	0	134524	.00000000
39	916	X	AB	INTEWB	7	1	1	FTO	Y	0	197190	.00000000
40	914	X	BP	INTEWB	7	1	1	FTO	Y	0	67262	.00000000
41	915	X	CB	INTEWB	7	1	0	FTO	Y	0	861696	.00000000
42	924	X	BA	INTEWC	7	1	0	FTO	N	0	54	.00000000
43	920	X	CC	INTEWC	7	1	0	FTO	Y	0	2889216	.00000000
44	921	X	SD	INTEWC	7	1	0	FTO	Y	0	134524	.00000000
45	922	X	SJ	INTEWC	7	1	0	FTO	Y	0	134524	.00000000
46	818	X	BP	INTEWB	1	1	1	FTO	Y	1	201786	.00000496
47	824	X	SJ	INTEWC	1	1	0	FTO	Y	1	336310	.00000297
48	769	X	BP	INTEWB	5	1	1	FTO	Y	1	15806571	.00000006
49	774	X	BE		5	1	0	FTO	N	2	5320	.00037594
50	750	X			5	0	0	FTO	Y	4	101561962	.00000004
51	693	X	BP	INTEWB	3	1	1	FTO	Y	5	201786	.00002478

Table E.6: Cross tabulation by system and application environment for the PWR Plant X time-related failure data, for failure mode fmode=FTO

System		Application Environment					ALL
		INTEWC	INTEWB	INTEST	INTEAR	INTECS	
BA	N	6	.	.	.	.	6
	failures	0	.	.	.	.	0
	hours	2430	.	.	.	.	2430
	rate	0.00000000	.	.	.	.	0.00000000
SJ	N	5	.	.	.	.	5
	failures	1	.	.	.	.	1
	hours	6053580	.	.	.	.	6053580
	rate	0.00000017	.	.	.	.	0.00000017
SD	N	4	.	.	.	.	4
	failures	0	.	.	.	.	0
	hours	6827093	.	.	.	.	6827093
	rate	0.00000000	.	.	.	.	0.00000000
CC	N	3	.	.	.	.	3
	failures	0	.	.	.	.	0
	hours	22545472	.	.	.	.	22545472
	rate	0.00000000	.	.	.	.	0.00000000
CB	N	1	4	.	.	.	5
	failures	0	0	.	.	.	0
	hours	101376	20161696	.	.	.	20263072
	rate	0.00000000	0.00000000	.	.	.	0.00000000
AB	N	1	3	.	.	.	4
	failures	0	0	.	.	.	0
	hours	315504	6270642	.	.	.	6586146
	rate	0.00000000	0.00000000	.	.	.	0.00000000
BP	N	.	5	.	.	.	5
	failures	.	7	.	.	.	7
	hours	.	16445560	.	.	.	16445560
	rate	.	0.00000043	.	.	.	0.00000043
SB	N	.	.	1	.	.	1
	failures	.	.	0	.	.	0
	hours	.	.	269048	.	.	269048
	rate	.	.	0.00000000	.	.	0.00000000
LD	N	.	.	.	1	.	1
	failures	.	.	.	0	.	0
	hours	.	.	.	101376	.	101376
	rate	.	.	.	0.00000000	.	0.00000000
BE	N	.	.	.	.	1	1
	failures	.	.	.	.	0	0
	hours	.	.	.	.	1120	1120
	rate	.	.	.	.	0.00000000	0.00000000
ALL	N	20	12	1	1	1	35
	failures	1	7	0	0	0	8
	hours	35845455	42877898	269048	101376	1120	79094897
	rate	0.00000003	0.00000016	0.00000000	0.00000000	0.00000000	0.00000010

Table E.7: Cross tabulation by system and operator type for the PWR Plant X time-related failure data, for failure mode fmode=FTO

System		Operator Type					ALL
		5	7	1	3	2	
BA	N	1	1	1	2	1	6
	failures	0	0	0	0	0	0
	hours	1512	54	54	594	216	2430
	rate	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
CB	N	1	1	1	1	1	5
	failures	0	0	0	0	0	0
	hours	1700000	861696	1200000	1100000	101376	20263072
	rate	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
SJ	N	1	1	1	2	1	5
	failures	0	0	1	0	1	1
	hours	4809233	134524	336310	773513	1	6053580
	rate	0.00000000	0.00000000	0.00000297	0.00000000	1	0.00000017
BP	N	1	1	1	1	1	4
	failures	1	0	1	5	1	7
	hours	15806571	67262	201786	201786	1	16277405
	rate	0.00000006	0.00000000	0.00000496	0.00002478	1	0.00000043
SD	N	1	1	1	1	1	4
	failures	0	0	0	0	1	0
	hours	6154473	134524	369941	168155	1	6827093
	rate	0.00000000	0.00000000	0.00000000	0.00000000	1	0.00000000
LD	N	1	1	1	1	1	4
	failures	0	0	0	1	0	0
	hours	18000000	304128	50688	101376	1	18456192
	rate	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000	0.00000000
KE	N	1	1	1	1	1	3
	failures	0	0	0	1	1	0
	hours	2771920	69298	311841	1	1	3153059
	rate	0.00000000	0.00000000	0.00000000	1	1	0.00000000
SB	N	1	1	1	1	1	3
	failures	0	0	0	1	1	0
	hours	3654886	134524	672620	1	1	4462030
	rate	0.00000000	0.00000000	0.00000000	1	1	0.00000000
CC	N	1	1	1	1	1	3
	failures	0	0	0	1	1	0
	hours	18084928	2889216	1571328	1	1	22545472
	rate	0.00000000	0.00000000	0.00000000	1	1	0.00000000
BE	N	1	1	1	1	1	4
	failures	2	0	1	0	0	2
	hours	5320	280	1	560	1120	7280
	rate	0.00037594	0.00000000	1	0.00000000	0.00000000	0.00027473
AB	N	1	1	1	1	1	4
	failures	0	0	1	0	0	0
	hours	5915700	197190	1	157752	315504	6586146
	rate	0.00000000	0.00000000	1	0.00000000	0.00000000	0.00000000
BI	N	1	1	1	1	1	2
	failures	0	0	1	1	1	0
	hours	2027520	202752	1	1	1	2230272
	rate	0.00000000	0.00000000	1	1	1	0.00000000
CI	N	1	1	1	1	1	1
	failures	1	1	0	1	1	0
	hours	1	1	96234	1	1	96234
	rate	1	1	0.00000000	1	1	0.00000000
ALL	N	12	12	10	9	5	48
	failures	3	0	2	5	0	10
	hours	94232063	4995448	4810802	2402360	519592	106960265
	rate	0.00000003	0.00000000	0.00000042	0.00000208	0.00000000	0.00000009

Table E.8: Cross tabulation by system and icl, indicator for inclusion of circuit failures in observed failure count, for the PWR Plant X time-related failure data, for failure mode fmode=FTO

		Includes Circuit?		ALL
		1	0	
System				
BA	N	6		6
	failures	0		0
	hours	2430		2430
	rate	0.00000000		0.00000000
CB	N	5		5
	failures	0		0
	hours	20263072		20263072
	rate	0.00000000		0.00000000
SJ	N	5		5
	failures	1		1
	hours	6053580		6053580
	rate	0.00000017		0.00000017
LD	N	4		4
	failures	0		0
	hours	18456192		18456192
	rate	0.00000000		0.00000000
SD	N	4		4
	failures	0		0
	hours	6827093		6827093
	rate	0.00000000		0.00000000
BE	N	4		4
	failures	2		2
	hours	7280		7280
	rate	0.00027473		0.00027473
AB	N	4		4
	failures	0		0
	hours	6586146		6586146
	rate	0.00000000		0.00000000
KE	N	3		3
	failures	0		0
	hours	3153059		3153059
	rate	0.00000000		0.00000000
CC	N	3		3
	failures	0		0
	hours	22545472		22545472
	rate	0.00000000		0.00000000
BI	N	2		2
	failures	0		0
	hours	2230272		2230272
	rate	0.00000000		0.00000000
CI	N	1		1
	failures	0		0
	hours	96234		96234
	rate	0.00000000		0.00000000
BP	N	4	1	5
	failures	7	0	7
	hours	16277405	168155	16445560
	rate	0.00000043	0.00000000	0.00000043
SB	N	3	1	4
	failures	0	0	0
	hours	4462030	269048	4731078
	rate	0.00000000	0.00000000	0.00000000
ALL	N	48	2	50
	failures	10	0	10
	hours	106960265	437203	107397468
	rate	0.00000009	0.00000000	0.00000009

Table E.9: Cross tabulation by system and sgl, indicator for safety graded components, for the PWR Plant X time-related failure data, for failure mode fmode=FTO

System		Safety Graded?		ALL
		0	1	
CB	N	5	.	5
	failures	0	.	0
	hours	20263072	.	20263072
SJ	rate	0.00000000	.	0.00000000
	N	5	.	5
	failures	1	.	1
SB	hours	6053580	.	6053580
	rate	0.00000017	.	0.00000017
	N	4	.	4
LD	failures	0	.	0
	hours	4731078	.	4731078
	rate	0.00000000	.	0.00000000
SD	N	4	.	4
	failures	0	.	0
	hours	18456192	.	18456192
BE	rate	0.00000000	.	0.00000000
	N	4	.	4
	failures	0	.	0
KE	hours	6827093	.	6827093
	rate	0.00000000	.	0.00000000
	N	4	.	4
CC	failures	2	.	2
	hours	7280	.	7280
	rate	0.00027473	.	0.00027473
CI	N	3	.	3
	failures	0	.	0
	hours	3153059	.	3153059
BA	rate	0.00000000	.	0.00000000
	N	3	.	3
	failures	0	.	0
BP	hours	22545472	.	22545472
	rate	0.00000000	.	0.00000000
	N	1	.	1
AB	failures	0	.	0
	hours	96234	.	96234
	rate	0.00000000	.	0.00000000
BI	N	5	1	6
	failures	0	0	0
	hours	2376	54	2430
ALL	rate	0.00000000	0.00000000	0.00000000
	N	1	4	5
	failures	0	7	7
	hours	168155	16277405	16445560
	rate	0.00000000	0.00000043	0.00000043
	N	1	3	4
	failures	0	0	0
	hours	315504	6270642	6586146
	rate	0.00000000	0.00000000	0.00000000
	N	.	2	2
	failures	.	0	0
	hours	.	2230272	2230272
	rate	.	0.00000000	0.00000000
	N	40	10	50
	failures	3	7	10
	hours	82619095	24778373	107397468
	rate	0.00000004	0.00000028	0.00000009

Table E.10: Cross tabulation by system and ir, indicator for IRADAP quality data, for the PWR Plant X time-related failure data, for failure mode fmode=FTO

System		IRADAP?		ALL
		Y	N	
BP	N	5	.	5
	failures	7	.	7
	hours	16445560	.	16445560
	rate	0.00000043	.	0.00000043
CB	N	5	.	5
	failures	0	.	0
	hours	20263072	.	20263072
	rate	0.00000000	.	0.00000000
SJ	N	5	.	5
	failures	1	.	1
	hours	6053580	.	6053580
	rate	0.00000017	.	0.00000017
SB	N	4	.	4
	failures	0	.	0
	hours	4731078	.	4731078
	rate	0.00000000	.	0.00000000
LD	N	4	.	4
	failures	0	.	0
	hours	18456192	.	18456192
	rate	0.00000000	.	0.00000000
SD	N	4	.	4
	failures	0	.	0
	hours	6827093	.	6827093
	rate	0.00000000	.	0.00000000
AB	N	4	.	4
	failures	0	.	0
	hours	6586146	.	6586146
	rate	0.00000000	.	0.00000000
KE	N	3	.	3
	failures	0	.	0
	hours	3153059	.	3153059
	rate	0.00000000	.	0.00000000
CC	N	3	.	3
	failures	0	.	0
	hours	22545472	.	22545472
	rate	0.00000000	.	0.00000000
BI	N	2	.	2
	failures	0	.	0
	hours	2230272	.	2230272
	rate	0.00000000	.	0.00000000
CI	N	1	.	1
	failures	0	.	0
	hours	96234	.	96234
	rate	0.00000000	.	0.00000000
BA	N	2	4	6
	failures	0	0	0
	hours	702	1728	2430
	rate	0.00000000	0.00000000	0.00000000
BE	N	2	2	4
	failures	0	2	2
	hours	1680	5600	7280
	rate	0.00000000	0.00035714	0.00027473
ALL	N	44	6	50
	failures	8	2	10
	hours	107390140	7328	107397468
	rate	0.00000007	0.00027293	0.00000009

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