IAEA-TECDOC-478

COMPONENT RELIABILITY DATA FOR USE IN PROBABILISTIC SAFETY ASSESSMENT

A TECHNICAL DOCUMENT ISSUED BY THE
INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 1988

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IAEA, VIENNA, 1988
IAEA-TECDOC-478
ISSN 1011–4289

Printed by the IAEA in Austria
October 1988

FOREWORD

Generic component reliability data is indispensable in any probabilistic safety analysis. It is not realistic to assume that all possible component failures and failure modes modeled in a PSA would be available from the operating experience of a specific plant in a statistically meaningful way.

The degree that generic data is used in PSAs varies from case to case. Some studies are totally based on generic data while others use generic data as prior information to be specialized by plant specific data. Most studies, however, finnaly use a combination where data for certain components come from generic data sources and others from Bayesian updating.

The IAEA effort to compile a generic component reliability data base aimed at facilitating the use of data available in the literature and at highlighting pitfalls which deserve special consideration. It was also intended to complement the fault tree and event tree package (PSAPACK) and to facilitate its use.

Moreover,it should be noted, that the IAEA has recently initiated a Coordinated Research Program in Reliability Data Collection, Retrieval and Analysis. In this framework the issues identified as most affecting the quality of existing data bases would be addressed.

This report presents the results of a compilation made from the specialized literature and includes reliability data for components usually considered in PSA.

This report was prepared under the framework of IAEA's Programme on Probabilistic Safety Assesment by Mr. Bojan Tomic, Division Of Nuclear Safety - Reliability and Risk Assessment (NENS-RRA). Mr Luis Lederman (NENS-RRA) was the project officer.

EDITORIAL NOTE

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EXECUTIVE SUMMARY

In response to the needs of Member States conducting or planning to initiate probabilistic safety assessments (PSAs) the IAEA carried out a compilation of component reliability data from the publicly available literature.

The work was undertaken under framework of the IAEA's PSA Programme with an effort which amounted to 7 man months.

The IAEA Data Base Version 1.0 consist of about 1000 records compiled from 21 different data sources (listed in Appendix 1) and include all data for nuclear power plant components usually modelled in PSAs.

No attempt was made to interpret or adapt the information contained in the original sources. Therefore the records of the IAEA Data Base are established directly from the information from the sources surveyed. A peer review was conducted at the end of the compilation and all records have been verified. The possibility of errors is, however, not to be excluded and the prompt notification of any errors encountered by the users to the IAEA is highly appreciated.

Two of the data sources namely, Heavy Water Reactor and Old PWR have been compiled by the IAEA in the framework of various activities including workshops and technical assistance missions to Member States. Therefore their accuracy cannot be verified. They are included in the Data Base only for illustrative purposes.

The Data Base is compiled on an IBM compatible personal computer using dBASE III software and it is available for distribution in form of diskettes which can be obtained upon request from the IAEA Division of Nuclear Safety. On diskettes it can be distributed in dBASE III format (in this case the dBASE III software is needed for use of the Data Base) or in the plain textual format (any full screen editor can be used).

This report describes in detail the Data Base format, including the record form and associated coding system. It also described each data source surveyed and briefly qualifies special features of each.

Problem areas connected with data bases found in literature are also highlighted in the report.

Appendix 2 to the report provides detail description and definition of major generic failure modes considered during compilation of the Data Base.

Two appendices provide listing of the component groups and types together with associated codes. These appendices help the user in selecting the most appropriate components according to codes.

Finally, all Data Base records sorted in alphabetic order of components are listed in last Appendix.

1. INTRODUCTION

Reliability data are an essential part of a probabilistic safety assessment. The quality of data can determine the quality of the study as a whole.

Component failure data originating from the plant being analyzed would be the most appropriate. However, reliance on experience at the plant is rarely possible, mainly owning to the rather limited operating experience and usually small number of recorded failures. The use of generic component reliability data is therefore unavoidable.

A relatively large amount of component reliability data is available in the open literature today. Some of these data were used in PSA studies; others were collected from sources, such as nuclear or conventional operating experience, and industrial and military records.

All these data are scattered throughout many different publications. Some are not easily obtainable, and others may not be readily available to the user. To faciliate the use of generic data from the existing literature by PSA analysts IAEA has compiled the data available from a number of different sources.

The other reason for compilation is to have the data base as part of the PSAPACK code package (developed at the IAEA). PSAPACK is the package used to perform of Level 1 of the PSA, including event tree and fault tree analysis.

2. USE OF THE DATA BASE

The IAEA's Component Reliability Data Base can be used in two ways: alone as data source, and as a part of the PSAPACK.

2.1. Use as a stand-alone

The IAEA Data Base was compiled using dBASE III commercial software; this software package is therefore needed to use the Data Base alone.

Using the dBASE software one can browse through records, list them, and retrieve information stored to the screen or print it in different ways. With dBASE III commands it is possible to select individual records or groups of records with given common characteristics (for example source, component type etc.).

The purpose of the Data Base for stand-alone use is to have readily available several data sources for each single component. The data base can also be used for assessing total ranges of data (extremes).

One of the peculiarities of the Data Base is that failure rates (as well as upper and lower bounds) are stored in the character format (instead of numerical), so direct calculation is not possible. The reason for it is that dBASE III software does not allow numbers to be presented in exponential format.

2.2. Use with the PSAPACK computer code package

For use with PSAPACK code package the IAEA Data Base is stored in textual format, what means that each record is presented as a 900 character line. PSAPACK includes a small interface code which enables viewing of each single record in the Data Base. After assessing the most appropriate record for particular analysis, it is retrieved and stored in the small data base. At this point the user can append or change any data point. Failure rates (or probabilities) stored in the newly formed small data base are then automatically used in the analysis. More detail about use with PSAPACK can be found in its users manual.

3. DATA BASE FORMAT

3.1. Record form

With many different sources providing different types of information, it was necessary to define a unique record form which would enable inclusion of information in a systematic and consistent manner. The second objective was to have a system which can enable easy information overview and retrieval.

The record form was defined as having 21 lines, presenting 10 categories of information (table 1).

Table 1: Record categories

1. code	1 line
2. component type	4 lines
3. operating mode	1 line
4. operating environment	1 line
5. failure mode	2 lines
6. failure rate	5 lines
7. repair time	1 line
8. source	2 lines
9. component boundary	1 line
10.comments	3 lines.

1. Every record has a code which is a unique combination of 5 alphanumeric characters. A detail description of the coding system is presented later.

2. Component type is described in 4 lines, namely: type, subtype, detail type 1 and 2. Type characterizes a basic component type (e.g. "pump", "valve"). Subtype characterizes more specifically the component category (e.g. motor driven pump, solenoid operated valve, pressure sensor, AC motor). Some of the components do not have information at this level (e.g.battery charger). Detail type 1 contains information about the system where the component belongs or other detail characteristics as voltage, or pipe diameter etc. Valve types (e.g. gate, butterfly, etc.) are also included in this line. "General" means that further characterization is not possible. Detail type 2 is the last entry of the component description. Usually, very detailed information about component type is not available. When information is available on component size or about the system to which the component belongs this is found in this line.

3. Operating mode is the next category. Operating mode is a particularly important characteristic for pumps (standby, alternating or running). For other components this information is of less importance. Precise, information of that type are seldom found in data sources. When the component operating mode is obvious, (e.g. safety injection pump is a standby pump) this information is included. In other cases "all" operating modes was the default value chosen.

4. Operating environment is the next entry which, similar to the previous one, is seldom found in data sources. It is obvious that volatile environment should influence the component failure rate, but very few sources address that fact. For example IEEE 500 provides multiplication

factors for most of components listed and for environments like high radiation, temperature or humidity.

WASH 1400 provides different failure rates for pumps and motors in extreme, post accident environment. Failure rates are, particularly in the cases where the operating experience is the basis for determining the failure rate, usually based on normal operating environment.

When addressing component operating environment, some of the sources define "normal NPP environment" as the usual one.

A default value "normal" was chosen in all cases where no other environmental condition was indicated.

5. The failure mode category is presented in two entries, one describing "generic" failure mode and other presenting failure mode found in the original source. Details about the failure modes are discussed in Appendix # 2. Briefly, a generic failure mode was assigned because the coding system was not able to cope with the number and differences in failure modes found in the sources. The original failure mode was, however left in the record for users' clarification.

6. The failure rate is presented in 5 entries. The first entry is the failure rate description, containing information about the failure rate (mean or median), upper and lower bounds (percentiles of the distribution, low and high or maximal and minimal values), and defining the failure rate as per hour (operational or standby) or per demand. The failure rate entry provides the actual numerical value for the mean, median, or best estimate value. Upper and lower bound entries provides respective numerical values. If the error factor is available it is given in the fifth line. Upper and lower bounds and error factors are not always available. When not available, n/a (meaning not available) is written.

7. Repair time is the next category. It indicates the average repair time associated with a component failure. It is also rarely found in generic sources. Some sources provide duration based on recorded repair times, others consider repair time as a mean value of several maintenance durations on a particular component. For the real case generic information of this kind is not of much use.

8. Information regarding source of data is presented in two lines, one indicating the exact source (name of publication, page #., table #.) and second information about the ultimate source of data (e.g. expert opinion, operating experience).

9. Component boundary is a main problem area when using generic data sources. Very few sources provide adequate information about component boundary. The best information is found in the Swedish Reliability Data Book, where a sketch showing exact component boundaries is provided for each component. Whenever exact boundary information is not available, "detail not available" is written.

10. Comment entries are the last category of a record. Usually all the information found in the sources and considered relevant are written here. If the data source is a generic source updated with specific plant operating experience, the prior source and/or mean and operating experience (total population covered, number of demands or operational time, number of failures) used in updating is recorded. Additional failure

rates relevant to the component (e.g. failure rate with or without command faults) are also included in the comment lines.

Practically all information which could be used to clarify failure rates, failure modes or component description are written. The comment category is an integral part of each record and it is very important to consider information included there when choosing any record for further calculation or comparison.

The complete record form is shown in Table 2 below.

Table 2: Complete record form

MODE	10	spaces
TYPE	65	"
SUBTYPE	65	"
DETAILTY	65	"
DETILTY1	65	"
OPMODE	30	"
OPENVIRO	65	"
GENFAILMOD	50	"
FAILMODE	50	"
FRATEDESCP	37	"
FAILRATE	10	"
UPBOUND	10	"
LOWBOUND	10	"
ERRORFCTOR	10	"
REPAIRTM	10	"
SOURCE	30	"
ULTSOURCE	65	"
COMMENTS	65	"
COMMENTS1	65	"
COMMENTS2	65	"

3.2. Coding system

Coding system is the area where the PSAPACK code mostly influenced the IAEA Data Base structure. In accordance to the PSAPACK requirements, each record code could have up to 4 alphanumeric characters. The fifth character in the code is the character describing the source but the PSAPACK does not use this information.

Some of the fault tree analysis codes included in the PSAPACK limit identification of basic event to eight alphanumeric characters. It was felt that at least 4 characters are needed for further identification of components (including its physical position for eventual common cause or dependency analysis). Therefore only 4 characters were used for basic component identification and failure mode description.

Three positions were used to code the component type. There is a hierarchical structure associated with components' coding.

The first character of the code define the category to which the component belongs to. There are 22 distinct component categories.

The next hierarchical level is the component group level. There are between 1 and 10 groups in each category, totaling more than 100 component groups. Each group has a unique two alphanumeric characters code. List of component groups is provided in Appendix 3.

The lowest hierarchical level is the component type. IAEA Data Base contains more than 420 different component types. Each component type has a unique three alphanumeric character code (list of component types and associated codes is given in Appendix 5).

Some of the component groups do not have subdivisions, in these cases the component type is defined on the second hierarchical level. The word "general" is sometimes used to describe that the failure rate in that particular record is for general use irrespectively of the detailed component type. In these cases the third character of the code is "A" meaning that no information about detail type is available for the particular component.

As there is no space in the coding system for operating mode or environment, sometimes the same component is coded differently because of operating conditions (e.g. motor driven pump (general) is coded 'PMB'when in alternating operating mode, and'PMR'when in running mode).

The next position in the code describes the component failure mode. Originally, there were more than 100 different failure modes coming from various sources. To code all of them two positions were required. As the generic failure modes were designed, one character was sufficient to describe the component failure mode.

Appendix 2 provides an inclusive list of generic failure modes and associated codes.

The last position of the code is describing the source of data. The list of source codes is provided in Appendix 1.

3.3. Generic failure mode definitions and usage

More than 100 failure modes were identified during the data base compilation. Such a high number of failure modes caused problems not only in coding but also makes any failure rate comparison difficult and sometimes impossible. On the other side, the majority of failure modes differ only in wording (e.g. 'fail to run'; 'failure to run'; 'failure during operation' describing running failure of pump). Therefore, a set of generic failure modes was defined (covering practically all component failure modes accounted for in PSAs) and each of the original failure modes was listed under one of the generic categories.

Details about generic failure mode definition process and rather definition of each of the major failure modes are found in Appendix 2.

4. COMPONENTS OF THE DATA BASE

The IAEA Data Base contains about 1000 records. More than 430 different components are addressed, having on average 2.2 failure modes. There are two main reasons for the existence of such a high number of component types (high compared to about 50 components used in average PSA). The first is the relatively large number of sources, so sometimes the same component is defined in different way (more or less detail). A second reason is that the primary objective of some of the data sources was not PSA. Therefore components in these sources are defined with greater detail (sizes of valves etc.) causing distinction between components..

Components found in the IAEA data base can be divided in four major categories :

mechanical components
electrical components
instrumentation and control (I & C) equipment
emergency power sources

Mechanical components category include the following component categories (unique first character of the code for respective category is given in brackets):

-piping	(F)
-heat exchangers	(H)
-control rods and drive mechanisms	(O)
-pumps	(P)
-HVAC and air handling equipment	(Q)
-valves	(V)
-strainers/filters	(Y)
-other mechanical equipment	(J)

Electrical equipment category include following:

-transformers	(T)
-relays	(R)
-motors	(M)
-conductors	(C)
-batteries and chargers	(B)
-circuit breakers	(K)
-other electrical equipment	(E)

Instrumentation and control equipment category consist of following:

-sensors	(A)
-instrumentation (channel)	(I)
-transmitters	(L)
-signal conditioning systems	(N)
-switches	(S)
-other I & C equipment	(U)

Emergency power sources category include diesel generators and gas turbine driven generators. (D)

4.1. Component groups

Each of the above listed categories contain several component groups (up to 10). Component groups are defined as the aggregation of the component having similarity on the second level. The examples of component groups are 'motor operated valves', 'diesel driven pumps', 'flow sensor' and 'main power transformer'. Group is also a second hierarchical level in the component coding system. There are more than 100 component groups in the IAEA data base.

4.2. Component types

Component detailed type is the lowest hierarchical level. Sometimes the component group is equal to the component detailed type. In other cases components in the group are different in sizes, system they belong to, detailed design characteristics etc. The population of each group as well as the level of detail vary substantially.

4.3. Selection of applicable data

The selection of data for a particular study greatly depends on the type of study, status of system (or plant) analyzed (planned, in design process, operational) and level of resolution needed. Data selected for the study should as close as possible match analysis requirements and major characteristics of data sources (including characteristics pertinent to ultimate source).

When selecting data the user has to consult Chapter 6 of this manual where the basic information about each of the sources included are presented. The user has to be aware that the data from a single source could be based on several different ultimate data sources (e.g. operating experience and expert opinion). Therefore in addition to the description of the source found in the manual, the ultimate data source entry in each record provides additional guidance. Sometimes information found in comment lines can also help in data selection.

In general it is recommended that sources having characteristics similar to the plant under consideration should be selected.

Another important point in data selection is the type of the analysis intended (point estimate or uncertainty analysis). Inclusion of uncertainties limit available data to sources which have either confidence limits or upper and lower bounds. Out of 1000 records in the Data Base, about 700 have upper bound, and less than 650 include lower bound. Error factors are found in about 300 records.

If the analysis require generic repair time, it further limit available data. Repair time is given in about 320 records. Problem with the repair time is that it is unequally distributed (e.g. few sources include repair time).

To faciliate the selection of a particular component the user should consult Appendices 3 and 4, where component groups and types are listed in alphabetical order together with respective two or three character codes. After selecting the component type which is applicable for the case studied, the user can locate a particular record by its code.

Most of the components listed have more than one failure mode. It is expected that component types and failure mode needed in PSA are contained in the IAEA Data Base. It is suggested that prior to final fault tree construction, analyst familiarize himself with the information available.

5. DATA SOURCES FOR THE DATA BASE

5.1. General characteristics

One of the objectives of the data base compilation was to have data from many different sources. Twenty one sources were chosen for inclusion. The amount of information contained in the various sources, however, differ substantially. Some of the sources provide up to 180 different records, while one source was cited in only two of the records.

All the sources can be put into three basic categories. Each category show some unique characteristics. However, some of the sources belong to more than one category, since data contained were derived from different ultimate sources.

The three categories are now described, followed by a description of the characteristics of each single data source.

5.1.1. Plant specific data

Two basic subgroups exist inside this category. The first is plant specific data drawn directly from sources available at the plant (logbooks, maintenance records, work orders, etc.), and the second one is when generic data is updated with plant specific information.

The first subgroup is normally considered to be the best source of data for the plant analyzed, but this is not necessarily the case when one uses these data at another plant. Generally, this is a source that is rarely found in the literature. The only source in the IAEA Data Base fully in this category is NUREG 4550 (Vol.3, Surry NPP) and this provides only ten records.

The second subgroup is of generic data updated with single plant operating experience. This procedure is usually applied either when limited plant specific data are available, or when available data could tend to overestimate or underestimate component reliability. In fact, in most of the recently completed PSA studies (which are not using generic data bases) component reliability data are derived in this manner. The IAEA Data Base includes several sources of this kind (e.g. Oconee NPP PRA, Zion NPP PRA and a source identified as "Old W PWR").

5.1.2. Data extracted from reporting systems

A widely known NPP event reporting system is the Licensee Event Report System used in the USA. Safety significant events occurring at NPPs have to be reported, and it is therefore possible to identify component failures related to these events. Identification of component failures is not always straightforward, and other means of identifying the components involved have to be used.

The IAEA Data Base includes four sources of this kind. These are NUREG/CR-1205, NUREG/CR-1363, NUREG/CR-1331 and NUREG/CR-1740. All these sources provide failure rates assessed from licensee event reports.

Simirar in a way to the LER based rates are the failure rates published in the Swedish "Reliability Data Book", which provides the reliability parameters derived from Swedish LERs, the ATV system (The Swedish Thermal Power Reliability Data System) and information provided by the plant staff.

The advantage of reliability parameters derived in this manner are that the actual component population covered is very large which guarantees more reliable statistics. However, LER systems are event oriented and not component oriented, so actual component failure could be misinterpreted or overlooked. In addition, some component failures are not reported in the system because the failures either caused no safety significant event or were not required to be reported. Furthermore, a small percentage of events is not reported because of the plant personnel's general attitude to the reporting system. All these factors may lead to possible overestimates of component reliability.

Another problem area is the operating time and the number of demands on the component. Operating time is usually estimated on the basis of reactor operating time, and the number of demands is estimated as an average also based on the operating time. Assessment of these parameters (instead of recording them) opens a possibility of substantial errors. This can drive calculated failure rates in either direction.

Compilations of this kind tend to underestimate differences in component design, operational practices and environment, which is sometimes very important information and can greatly influence component reliability.

To conclude, reliability parameters found in this type of source should be used with care in PSA studies.

5.1.3. Data based on expert opinion, nuclear and non-nuclear experience

Categories in this group include single expert opinion, aggregate expert opinion, aggregation of several non-nuclear sources, aggregation of expert opinion and other sources and aggregation of operating experience of several NPPs. Even a single data source usually includes several of these categories. Aggregation of data (if properly performed) provides more reliable data than single expert opinion or a single source.

The most widely known representative of this category is the IEEE Standard 500. Its 1977 version mostly includes expert opinion, while the 1984 version also includes nuclear and non-nuclear experience. Other examples of data sources which are included in the IAEA Data Base are: NUREG/CR-2728 Interim Reliability Evaluation Program Procedure Guide, (which adopted the data base from EGG-EA-5887), NUREG/CR-2815 Probabilistic Safety Analysis procedure guide (data from expert opinion combined with the IREP data base) Sizewell B assessment (operating experience, including nuclear and other industrial sources).

The WASH-1400, Reactor Safety Study, (a combination of expert opinion and non-nuclear and nuclear sources) also belongs to this category and it is important to mention that it is still a widely used source. Two sources

included in the IAEA Data Base (NUREG 2886 and NUREG 3831) provide component failure rates derived from operating experience of a limited group of plants. Another example is the Shoreham NPP PRA-GE data, which draw data only from General Electric operating plants.

The quality and reliability of data in this category can vary substantially, depending on the ultimate source, the method of collecting raw data and the methods used to derive failure rates.

Although expert opinion is sometimes considered to be a low quality data source, it is important to mention that is proved several times to be in very good agreement with data from actual operating experience.

5.2. Characteristics of single data sources

In addition to the general characteristics of the data sources described in the previous paragraph, each data source included in the IAEA Data Base show some unique characteristics. To facilitate proper use of the data base and to avoid misinterpretation due to limited knowledge of the ultimate data source, some characteristics of each data source are presented. Sources which seem to be more important, or simply widely used or cited more often, are described in greater detail.

The data sources used for the compilation of the IAEA's Generic Component Reliability Data Base are listed in Appendix 1 (in alphabetical order).

5.2.1. WASH 1400 Reactor Safety Study

5.2.1.1. General

WASH 1400 was the first and is the most widely known probabilistic safety study performed. Considerable effort was made in the study to develop the data needed. Although the study is rather old, it is even today sometimes still used as a source of data.

5.2.1.2. Data sources

The data used in the study were derived from different sources, including reports, handbooks, industrial operating experience and NPP experience. Ultimate data sources included the US Department of Defense (Navy, Air Force), NASA data, general industrial operating experience and nuclear power plant experience.

The log normal distribution was used to describe data variability (the log normal distribution is also used in most of the data sources). Log normal distribution is a two parameter distribution and two end points in a defined range determine a unique distribution. In the study the 90% range was selected, the lower end being 5% bound

and the upper 95% bound. This definition of range implies that there is a 90% probability that the data value would be within this range.

The ultimate data sources considered represent a variety of applications and conditions, with some sources apparently being more applicable than others. However, data sources are in general within one or two orders of magnitude.

Since order of magnitude accuracy was required, endpoints were determined to the nearest half integer on the exponent scale (i.e.1E-1 or 1E-1.5). The half integer on the scale corresponds to the assignment of 3 or 1 for the significant figure (i.e. 1E-1 or 3E-2).

The actual range was assessed after a number of iterations, involving a large number of components. Data points selected came from various sources (including nuclear experience), and the range was chosen to cover approximately 90% of the points. The actual determination of the range required data plotting with a decision made on the weight of each data point. The assessment decisions were based on the experience of individuals involved in reliability studies and NPP operation. Because of the order of magnitude accuracy, components were generally classified only according to their generic types. When available, actual nuclear plant experience was used as the principal basis for determining and checking the assessed range.

Sources, other than commercial nuclear experience, which provide the data points used in range assessment can be divided into two categories: general sources and special sources. Some of sources which provide most of the data points are:

1. System Reliability Service, UKAEA (all service publications)

2. Reliability Engineering Data Services Failure Rates, AVCO Corp.1962 (Contains failure rates assessment for primary military hardware)

3. FARADA, Converged Failure Rate Data Handbook, Fleet Missile System Analysis and Evaluation Group Annex, all current issues (contains failure rate assessment derived from US Army, Navy, Air Force and NASA sources)

4. Failure Data Handbook for Nuclear Power Facilities, Liquid Metal Engineering Center, 1969, (compilation of failure rates derived from test and research reactor operating experience)

5. National Reactor Testing Station Idaho: Failure History 1968-1972.

Commercial reactor operating experience was examined to serve as important data for an assessment of data ranges. Sources for failure examinations included 1971-73 incident files and reports of operating occurrences, Nuclear Safety Information Center files, environmental reports, individual technical reports and other pertinent sources. In particular, a one year period (January -December 1972) was used to evaluate the summarized and averaged nuclear data statistics.

Out of a total number of 700 failures reported that year, the number of failures and abnormalities that occurred at plants operational for the full year (eight PWRs and nine BWRs) and that were safety related was 303. These failures were categorized by generic component into classes. A statistical evaluation was performed in order to estimate failure rates and demand probabilities.

The pertinent environment for all components, except pumps, is that of standard nuclear power plant operational conditions. The assessed ranges should cover variations occurring in that environment. Failure of a pump to run was also assessed for extreme temperature and pressure conditions characteristic of a severe accident.

The advantage of the data in WASH-1400 is that a variety of different ultimate sources were considered in the assessment process. Nuclear operating experience was also considered (although in limited scope) and the assessed range was checked for applicability.

The disadvantage of the process lies in the obvious difference in ultimate data sources. The difference comes from the variety of applications, maintenance practices, design differences, etc. Another problem is the different methods of collecting and reporting data, component definitions and environmental and related factors. However, by assessing ranges instead of point values, these differences can be made less important.

The data from WASH-1400 were widely used afterwards, and many reports on nuclear components reliability data provide some kind of comparison with WASH-1400 data on components analyzed.

During the review process of WASH-1400 it was concluded that the ranges (confidence levels) of several components were too narrow; in other words, confidence levels tended towards overconfidence. Some of the later PSA studies (Zion PSS for example) used WASH-1400 confidence limits, but instead of 5% and 95% bounds, they used the limits as the 20% and 80% bounds, implying that with a 40% probability the true value lies outside these bounds.

5.2.1.3.Data available in the IAEA Data Base

In the IAEA Data Base, 'failrate' is the median value from WASH-1400 Appendix 3, Tables 4-1 and 4-2, 'upbound' is the 95% value and 'lowbound' is the 5% value, thus representing 90% confidence levels. The error factor for assumed lognormal distribution found in the records is the upper limit of the range divided by the median, and since the median is a geometric midpoint, it is also equal to the median divided by the lower limit.

5.2.1.4. Source independence

WASH-1400 is the source widely used as a prior in data updating or for the comparison of failure rates derived from other ultimate data sources. Therefore, in terms of independence, WASH-1400 data have been repeated many times and also influenced most of the data bases compiled since. All

the data sources in the IAEA Data Base which do not rely fully on operational experience are more or less dependent on WASH-1400 data.

5.2.2. Swedish Reliability Data Book

5.2.2.1.General

The Swedish Reliability Data Book which provided the data for the IAEA Data Base is the 1985 updated version. It was compiled by ASEA-ATOM for the Nuclear Safety Board of Swedish Utilities and Swedish Nuclear Power Inspectorate. The main aim of the compilation was to provide (or improve) failure data for reliability calculations as a part of the safety analysis for Swedish NPPs.

5.2.2.2. Data sources

The sources of information were the following:

-Failure reports in the ATV system (the Swedish Thermal Power Reliability Data System)

-Licensee Event Reports to the Swedish Nuclear Power Inspectorate

-Information provided by the operation and maintenance staff of each plant.

In order to obtain well defined basic data, reports covering startup periods and periods when reporting was found not to be satisfactory were excluded. Also, the annual refueling outage and other extended shutdowns were not included in component statistics.

Altogether about 35 reactor years of BWR operating experience were analyzed. The following NPP's were covered in the study: Barsebäck 1 and 2; Forsmark 1 and 2; Oskarshamn 1 and 2; Ringhals 1. The only PWR plant covered in the study is Ringhals 2, with about 4.5 years of operating experience (ATV reports) analyzed in the Ringhals 2 Safety Study. Another 1.5 reactor years of experience was analyzed using the same sources as for BWR plants.

The total number of ATV reports analyzed was 3575. Of these 590 represent critical failures. In addition, 60 Licensee Event Reports were analyzed.

The Data Book presents reliability parameters for pumps, valves, control rods and drives, electrical components and instrumentation. Components included are mainly those belonging to safety related systems.

The number of demands used for calculating probabilities of failure per demand has been obtained from the test interval defined in Technical Specification and from other demands connected with plant disturbances (e.g. scram).

The operating time needed for failure rate calculations was estimated from the operation profiles of the plant together with readings of operating time (e.g. pumps).

The repair time which appears in the Data Base is calculated as the arithmetic mean of the repair times given in the failure reports.

Two types of failure probabilities were determined:

- Failure rate (lambda), stating the probability of a component failing per unit time (applicable for components in continuous [running] and intermittent [alternating] operation)

  -Failure per demand (q) stating the probability that a component does not work when demanded.

Basic assumptions applicable to statistical models for estimating parameters were the following:

- Each individual component is assumed to have a constant failure rate within the interval studied. This leads to a Poisson distribution for time related failures and Binomial distribution for demand related failures.

- Failure rate and probability vary for the analyzed population (for whatever reason). The failure characteristic in question is therefore looked upon as a stochastic variable having suitable distribution.

- The observed failure data for similar components were assumed to be stochastically independent.

The variation of parameters within the observed population of components is described in a double parametric distribution. A gamma distribution was chosen for failure rates and Beta distribution for the variation of failure probabilities.

5.2.2.3. Data available in the IAEA Data Base

Two sets of data are available in IAEA Data Base. One is composite value of all BWR plants, and other is Ringhals 2 PWR. In the IAEA Data Base 'failrate' is the mean value, while 'upbound' represents 95% of the distribution. Since the 5th percentile of most of the distributions is very small, it is not presented in the original tables. It is therefore suggested that the interval from the origin to the 95th percentile should be regarded as a measure of the uncertainty around the mean value.

In the comment lines of most of the records in the IAEA Data Base which originated from the Swedish Data Book, values for alpha and beta (abbreviated as 'a' and 'b' respectively), the parameters uniquely describing the distributions, are found. These parameters were obtained using different methods, namely:

The Maximum Likelihood Method;
The Weighted Marginal Moment Method;
and the Weighted aPriori Moment Method.

These parameters could be used for a Bayesian estimate of the failure rate or the probability for a specific component. The procedure is relatively simple thanks to the choice of gamma and beta as prior distributions. Posterior distributions are then of the same kind and mean values of these distributions are easy to calculate. The detailed procedure can be found in paragraph 5.2. of the Swedish Data Book.

5.2.2.4. Special features

One of the great advantages of the Swedish Data Book is its component boundary definitions. For most of the components found in the Data Book, sketches indicate the exact interface points.

The components in the Swedish Data Book (mostly pumps and valves) are also allocated to very specific categories in accordance with their main design characteristics or sizes.

Generally this source is considered to be very good, in the sense of the total number studied (for most of the components), the number of recorded failures and the definitions of components and failure mode.

As with the other sources which draw the raw data from plant experience collected in either event or failure reporting systems, the exact number of demands or operating time (for standby or alternating components) is estimated rather than recorded. The error is usually on the conservative side.

5.2.2.5. Source independence

As regards independence, the Swedish Reliability Data Book is completely independent of all the other sources included in the IAEA Data Base.

5.2.3. NUREG 2815, Probabilistic Safety Analysis Procedure Guide

5.2.3.1. General

Appendix C of NUREG 2815 provides a generic data base which includes about 40 component types (commonly found in PSA studies), with appropriate failure modes. The data base was generated from the estimates produced at a two days Reliability Data Workshop held at NRC in Washington in April 1982.

This data base is meant for general use, in cases where plant specific data are lacking. The level of detail is therefore not high. Component types represented in NUREG 2815 are basically generic categories broad enough to accommodate general use. The same applies to the failure modes assigned.

5.2.3.2. Data sources

Participants at the workshop were experts in data analysis and risk assessment and represented the NRC, utilities, national laboratories and nuclear consulting firms. For each component failure mode a nominal failure rate value and an error factor representing an approximate 90% upper bound and a 10% lower bound value were generated. Failure rates and error factors generated in this way were combined with failure rates and error factors given in the IREP users' guide (NUREG/CR-2728). The results of that combination were the failure rates given in NUREG 2815 and reproduced in the IAEA Data Base.

The procedure for the combination of expert generated estimates and IREP values was as follows:

(1) For the given component failure mode, the maximum nominal value and the maximum error factor were selected from the two sources.

(2) The selected nominal value was then multiplied and divided by the appropriate error factor to obtain upper the 90% and lower the 10% bounds.

(3) A truncated log uniform distribution (i.e. flat on the log scale) was fitted to the two bounds and a mean value was then calculated.

For most components, expert estimates and IREP values agreed. Where there was a disagreement, either in the nominal value of the error factor, it was by a factor of three or less. In these cases generic values were conservatively biased and had the largest assigned error factors.

5.2.3.3. Special features

For some of the components there is a description of what is included in the component boundary considered. However, precise interface points and other information for most of the components are not available. This is a general characteristic of all the sources not directly linked to operating experience. For future use of this data source, the component boundary shall be considered as if the component were an 'off-the-shelf' item.

The same thing applies to the operating environment. It is recommendable to consider a normal nuclear power plant environment.

It is important to mention that all the failure rates in NUREG 2815 are defined as per hour values. For the standby components starting failures are defined per hour standby, while for operating components (as well as for failures of standby components to run) the operating time is used as a basis.

This source does not give a generic repair time in the sense of a mean duration. Instead, it is suggested that the maximum allowed unscheduled downtime given in the plant technical specification should be used.

Although it is not clearly stated, expert estimates seems to be consensus estimates. Consensus is considered to be the highest ranking of all group expert estimates.

5.2.3.4. Data available in the IAEA Data Base

In the IAEA Data Base 'failrate' is the mean value of the truncated log uniform distribution, while 'upbound' is the maximum and 'lowbound' the minimum bound of the truncated log uniform.

5.2.3.5. Source independence

This source closely linked with IREP data base. As its major ultimate source is expert opinion, it can be expected that the experts estimates were relatively highly influenced by other data bases which were published prior to this. Also there is a high probability that the same experts were contributing to the other data bases, as well (for example IEEE 500 1984). Therefore NUREG 2815 data have to be considered relatively highly dependent on other US sources published at that time or before.

5.2.4. NUREG 2728 IREP (Interim Reliability Evaluation Program Procedure Guide)

5.2.4.1. General

The IREP Procedure Guide provides a generic data base which was used for screening calculations for preliminary point estimates. As the level of resolution given by the use of plant specific data is greater than that with generic data, dominant accident sequences were evaluated using plant specific data whenever possible.

5.2.4.2. Data sources

The IREP generic data base has been adapted from information contained in the EGG-EA-5887 (A.J.Oswald et al.:Generic Data Base and Models chapter of the NREP Guide, EG&G Idaho, June, 1982). Nominal values from this report were taken as medians. Associated means were calculated from the medians and error factors (representing 10% and 90% bounds), assuming a log normal distribution.

The IREP generic data base contains failure rates and demand probabilities for classes of equipment commonly found in NPP's (about 40). Four types of values are found in the data base:

Component standby failure rates, which are the reciprocals of the mean time to failure of components that are normally in standby;

Component operating failure rates, which are the reciprocals of the mean time to failure of components that are normally operating;

Demand failure probabilities for selected standby component types such as valves and pumps.

Error factors for each failure rate and demand failure probabilities representing upper and lower bounds on the value of reliability parameters. These bounds represent a range of values for each parameter that the parameter can reasonably be expected to assume.

5.2.4.3. Data available in the IAEA Data Base

The IREP generic data base contains failure rates and demand probabilities for classes of equipment commonly found in NPPs (about 40). The full set of data found in this source is reproduced in the IAEA Data Base.

The IAEA Data Base contains the mean value of the lognormal distribution as 'failrate' and an error factor.

5.2.4.4. Special features

The failure rates are in units of failures per hour. The demand probabilities represent failures per demand of the component. The median and error factor define a log normal distribution that describes the uncertainty in the reliability parameter for the failure mode, if the error factor is interpreted as representing a 90th percentile region of the parameter.

Demand probabilities in the IREP data base require further explanation. Although they are listed as demand probabilities, in reality they were originally generated by multiplying failure rates by one half of the assumed test period (one month). The demand probabilities should therefore not be taken as true demand probabilities, which depend only on the number of cycles between standby and operation. For components whose test period is not substantially different from one month (up to five or six months), the demand probability is considered to be adequate for use.

5.2.4.5.Source independence

The IREP data base and the data base from NUREG 2815 are heavily interdependent, because one draws the data from the other. These two sources should be used one at a time; they should not be mixed. Other dependences commented on in the paragraph describing dependence of NUREG 2815 are also applicable here.

5.2.5. IEEE Standard 500

5.2.5.1. General

The IEEE Standard 500 included in the IAEA data base is the 1984 edition, which is a follow up to the first, 1977 edition of the Standard. IEEE 500 is the richest source of information considered in the IAEA Data Base. It provides reliability data for electrical, electronic and sensing components, as well as for mechanical equipment. The data contained in it are intended for the use of either nuclear system reliability analysts or design engineers.

5.2.5.2. Data sources

IEEE Standard 500 draws data from a variety of sources. As it is a follow up to the 1977 edition, some of the data come directly from there. Among the other sources, the most important are:

(1) Corps of Engineers (HND) R/M Data Base, Ground Stationary Equipment, Rep.No.16, 04/12/73

(2) Non electric Parts Reliability Data (NPRD-2), Summer 1981, Reliability Analysis Center, Rome Air Development Center, Griffiss Air Force Base, NY 13441.3

(3) NUREG/CR-2232 Nuclear Plant Reliability Data System (NPRDS), 1980, Annual Report of Cumulative System and Component Reliability.

All the NUREG/CR publications providing reliability parameters derived from LER reports (NUREG/CR 1205, 1331, 1363, 1740) are also included here. Also included is the NUREG/CR 2886 IPRD report on pumps.

In addition, a number of other reports providing data about particular components as well as some of the in-plant sources and architect-engineer companies provide input for the IEEE 500.

The data for some of the component categories (annunciator modules, batteries and chargers, circuit breakers, relays, motors and generators, heaters, transformers, valve operators, instruments, controls and sensors and conductors) partly resulted from the analysis of estimates made by over 200 experts. The collection of expert opinions was performed by the extensive multistep DELPHI method. (The Delphi method is a formal way of collecting information by establishing a feedback system for written communication of data and information among the group of professionals. Detailed information about the method and its use can be found in IEEE 500 (1984), Appendix B and elsewhere.) It is important to mention that individual experts were instructed to estimate data only when statistical sources of data remained unavailable to them. In some cases, the data developed (for respective categories) represent either recorded data or the best collective judgement of a group of specialists.

To summarize, the raw data from which the values appearing in the IEEE 500 were synthesized were found in the following forms:

1. Statistical operating data from nuclear power plants

2. Statistical operating data from fossil fired generating stations and other data from large industries (such as the chemical industry)

3. Statistical failure data from transmission grids and industrial plants, with use of judgement to estimate the population from which the failures were observed so that a failure rate could be calculated.

4. Data on failure and population estimated by individuals familiar with the operating and failure histories of specific generic types of devices.

5. Data extracted from published sources for other industries which were judged to have some level of applicability to components of nuclear power generating stations.

It is stated that on the average 80% of the data included in the IEEE 500 resulted from statistical data in one of the first three categories mentioned above.

5.2.5.3. Data available in the IAEA Data Base

IEEE 500 provides the data for a variety of components found in NPPs. Intended use of data from the IEEE 500 is in the area of general reliability calculation and not PSA studies in particular. Therefore the level of detail is much greater than elsewhere.

The IEEE 500 utilize a hierarchical structure to group component in categories. The broadest hierarchical breakdown is 'chapter', which identifies a general component category (example of 'chapters' are transformer, driven equipment and conductors). There are 17 chapters and respective component categories included in the IEEE 500. The second breakdown level is called 'section'; the division into sections is based on functional or physical differences between components. The third level, when present, is called 'subsection'. The 'item or equipment' description is the last hierarchical level. It can be either third or fourth level, depending on the existence of "subsection" level.

For each data entry there is a failure mode defined. In general, failure modes are divided into three categories: catastrophic, degraded and incipient failures. These categories are sometimes subdivided into the more detailed modes, which heavily depend on each component category. All three categories are summed together under the 'all modes' numerical value. Detailed discussion of the failure mode is provided in Appendix A and in the preface of each data chapter of IEEE Standard 500.

IEEE 500 provides single data entries, but also the composite values on the hierarchical levels where the composite value provides a certain overview.

Failure rates are presented with three data points: recommended value, high value and low value. The recommended value should be used to determine the best estimate. The high and low values represent best and

worst data points and can be used as a range estimate (usually they should not be interpreted as specific confidence bounds). Two types of data are found in the IEEE 500. One is failure rate in terms of failures per 1E+6 hours, and the other is in terms of failures per 1E+6 cycles. The cyclic failure rate is used in specific instances to describe demand probabilities. Some of the data entries provide recommended values only.

In addition to failure rates, the outage times are sometimes found in the IEEE 500 data sheets. Outage times are divided into three categories: out of service duration, restoration time and repair time. Consistently with the failure rates, recommended, high and low value (representing the highest and lowest data points) are presented.

The IEEE Standard 500 provided about 180 records for IAEA Data Base. These 180 records cover the whole spectrum of components found in NPPs and usually taken into account in PSA studies. Most of the records in the IAEA data base come from the identifiable ultimate data source that seems to be the most applicable for PSA use. In several cases, where deemed appropriate, composite values were included to give the user an illustration of the expected range of data. In all cases the comment lines provide information about the data.

Failure modes considered where those which are of interest for PSA studies. In most cases these are catastrophic failure modes and in a few cases degraded failure modes. Whenever available, the failure rate is given for precisely defined failure modes (for example, a short to ground). Sometimes the failure rate is given for catastrophic (or degraded) mode and in comment lines it is stated what is being considered in that failure mode. For some of the components only the 'all modes' failure mode was available without indication of the proportion of catastrophic, degraded and incipient failures in the total. If the component was considered to be of major interest for PSA studies, it was then included in the IAEA Data Base.

For uniformity throughout the data base, the failure rates and demand probabilities are presented as per hour and per cycle (being equivalent to per demand) values, respectively. Whenever available, the repair time for a particular component was included in the IAEA Data Base. The repair time in the IAEA data base is always the recommended value from IEEE 500.

5.2.5.4.Special features

The IEEE 500 draws information from a variety of sources, so the failure data are for the items and conditions discussed in the individual sources.

The special feature of the IEEE Standard 500 is an environmental factor matrix provided for the number of components included. The multipliers for high temperature, humidity and radiation are taken from the 1977 edition of Standard. They are not included in the IAEA Data Base.

5.2.5.5. Source independence

As mentioned, IEEE 500 contains several sources which are also individually included in the IAEA Data Base. In addition, other sources providing operating experience at US NPP's draw the information from the

same population of plants (although in a different manner), so the data points are not statistically independent.

Some of the data points originating from expert opinion also cannot be considered independent. Although they are collected by use of the Delphi method, bias in expert opinion should be properly considered.

Some of the other sources in the IAEA Data Base also use the IEEE 500 data for priors in Bayesian updating (Oconee PRA, for example). In these cases dependences should be properly considered.

5.2.6. Shoreham Nuclear Power Plant PSA

5.2.6.1. General

At the time of the PSA study for Shoreham NPP, no operating history was available, thus several sources of generic BWR operating experience were used to provide a surrogate basis for failure data. Among several data sources considered in the study, of special interest for inclusion in the IAEA Data Base was the General Electric collection of operating experience.

General Electric has collected and evaluated BWR operating experience data on a wide variety of components to estimate their failure rates. This source is pertinent to BWRs and lists specific components on which data are not usually available elsewhere.

5.2.6.2. Data sources

Detailed information about the ultimate data source as well as about the methodology used to evaluate data and derive reliability parameters is not available. It is clear that GE collected operating experience, but it is not clear weather it was in the form of licensee event reports (LER) or otherwise.

5.2.6.3. Data available in the IAEA Data Base

The complete set of GE data available from the source was included in the IAEA Data Base. That is about 25 records, containing mean failure rates for valves (MOV, check, ADS valve), pumps, motors, heat exchangers and a variety of instrumentation and control equipment.

5.2.6.4. Special features

The same set of GE data was used in the PRA study for the Limerick NPP, where the comparison between GE data, WASH-1400 data and data from the analysis of LERs (LER rates) was made. Many of the data from the three

sources are similar and there is generally good agreement between all three sources.

Another important feature of the GE data is the concept of treatment of demand related failures. The constant hourly failure rate is used for components in standby. The probability of failure is then calculated by multiplying failure rate by one half of the scheduled test interval (e.g. monthly, annually).

Quantification of the fault trees in the Shoreham PSA was done using four data sources, and in the following hierarchy:

1. LER rates
2. GE data
3. WASH-1400
4. IEEE 500 (1977).

5.2.6.5. Source independence

As the ultimate data source is not clear (in the sense of number of plants, the time interval covered and means of data collection) strictly defining the dependence is not simple.

The source is said to contain the data based on operating experience of GE BWR plants, and since these plants are also considered in estimation of LER rates, there is relatively high dependance between this source and NUREG documents with LER rates.

This is also the case with IPRD (In-Plant Reliability Data, NUREG/CR-2886 and NUREG/CR-3831) sources, which contain data drawn from operating experience of a couple of BWR plants.

5.2.7. NUREG/CR 4550 Vol.1, Analysis of Core Damage Frequency From Internal Events: Methodology Guidelines

5.2.7.1. General

NUREG 4550 Vol.1 summarizes the methodology for accident sequence analysis for reference plants examined as a part of NUREG 1150 program. Chapter VIII provide generic data base which was used when reasonable plant specific data were not available.

Generic data base in NUREG 4550 is the updated ASEP (Accident Sequence Evaluation Program) data base which was originally used to calculate accident sequence frequencies for 100 light water reactors. It was updated in April 1984 and June 1985. The last update occurred in August 1987 using information from the Risk Methods Integration Evaluation Program. Data in the IAEA Data Base comes from this last update.

5.2.7.2. Data sources

ASEP data base was formed from ab broad information base. A number of PSA studies and other sources of information were reviewed and ranges established. Some examples of the sources that were used are the following:

-WASH 1400
-NUREG/CR 1659 Reactor Safety Study Methodology Application Program (all plant analysis)
-IREP Procedure guide and plant analysis
-Zion NPP PSS
-Limerick Generating Station Probabilistic Risk Assessment, Rev.4, Philadelphia Electric Co. June 1982
-Oconee PRA
-IEEE Standard 500 1984
-NUREG/CR 3226 Station Blackout Accident Analysis, Sandia National Laboratory, May, 1983
-NUREG/CR 1032 Evaluation of Station Blackout Accidents at Nuclear Power Plants NRC, May 1985

5.2.7.3. Data available in the IAEA Data Base

The complete set of component reliability data provided in the source is included in the IAEA Data Base. The source provide about 20 records, addressing components like pumps, valves, DGs, batteries etc.

ASEP data base provide two parameters for each component, mean value and log normal distribution error factor. Although several sources were reviewed for each component, the mean value is always taken from a single source which is then identified in the comment lines of each record. Also all additional information found in the original source are also included in the comment lines.

5.2.7.4. Source independence

As there is no operating experience behind this source, it is heavily influenced by all the sources which were reviewed. Practically all available US data sources were used in compilation of ASEP data base. Therefore this source should be considered greatly dependant to all of the others.

5.2.8. NUREG/CR 4550 Vol.3 Surry NPP

5.2.8.1. General

NUREG/CR 4550 is the document containing the accident sequence analysis for Surry Unit 1 NPP. This is one of the reference plants being examined as part of the NUREG 1150 work, which will document risks for selected group of nuclear power plants.

The accident sequence quantification was performed using generic as well as plant specific data. For inclusion in IAEA Data Base only the plant specific data were of interest. There are 10 data records from this source in the IAEA Data Base.

5.2.8.2. Data sources

The ultimate data source is plant operating experience. Whenever plant specific operating experience was sufficient (or where potential plant specific common cause failures were identified), these data were used for quantification. However, it is not clear what kind of in-plant records or other means were used to derive information. It is difficult to judge about the quality of the data or the operating experience behind them.

5.2.8.3. Data available in the IAEA Data Base

The complete set of plant specific data provided in the source was included in the IAEA Data Base. The data cover different kinds of pumps, diesel generators and strainers.

The failure rate given is a median value together with an error factor (assuming lognormal distribution). Failure rates are defined as per hour values, while starting failures are defined as per demand probabilities.

5.2.8.4. Special features

The failure mode for auxiliary feedwater pumps (motor and turbine driven) is called 'failure to start/run' and is defined as per demand probability. It was not possible to identify the eventual mission time associated with this failure mode. It is unclear what proportion of the failure probability to assign to starting failure and what (if any) to running failure.

As with other sources of this kind (PSA studies), the component boundary is not strictly defined, but can be assessed in accordance with the fault tree entry.

The operating mode found in the IAEA Data Base was determined in accordance with the function of each component.

There was no indication either of the operating environment of the components listed. However, a normal nuclear power plant environment was assumed.

5.2.8.5. Source independence

As is the case with other US sources which draw data from a single plant (or group of plants), there is a relatively high dependence to LER

rates, because each US nuclear power plant is contributing to the LER system. The level of dependency is difficult to asses without knowing the ultimate source of data at the plant.

5.2.9.Sizewell B PWR Preconstruction Report

5.2.9.1. General

This report provides a list of component failure rates that were used in the safety assessment of the proposed PWR nuclear power plant at Sizewell in the UK. The data used for safety assessment were assigned to each component and failure mode based on an overview of several data sources.

The items which were identified as having the highest contributions for the failure probability of the safeguards systems were the following: non-return valves (check), relief valves, MOVs, pneumatic valves, pumps (motor and turbine), diesel generators, fan coolers and circuit breakers. For each of these components appropriate failure modes were assigned.

5.2.9.2. Data sources

Several data sources were used to assess failure rates. These were:

1. Westinghouse Reliability Data Base. A major survey of failure rates for selected components associated with Westinghouse Nuclear Steam Supply System (NSSS)

2. UKAEA System Reliability Service, which provides a comprehensive review of reliability information and provides generic data for use in safety and availability assessment. Many of the data relate mainly to typical industrial applications.

3. WASH-1400, Reactor Safety Study.

4.Other sources including Electricite de France(EdF) sources, US LWR safety related occurrence 1967-74, Nuclear Plant Reliability Data System (NPRDS) 1978 and others.

It should be noted that the ultimate data sources are a variety of sources of information, coming from different areas and collected in different ways. However, it seems that no formal statistical data assessment procedure was used to obtain failure rates. Engineering judgement seems to be utilized for that purpose.

Data from source No.1 (Westinghouse) are proprietary, and were not available, so it is difficult to judge which data source most influenced the assessed failure rates.

5.2.9.3. Data available in the IAEA Data Base

The full set of data available in the source is reproduced in the IAEA Data Base. Component failure rates and demand probabilities are mean values.

In addition to the data utilized in calculations, every record of the IAEA Data Base originated from this source contains all the available information which served as a basis for failure rate determination. The ultimate source of the data as well as the particular values are included in the comment lines of every record.

Altogether there are 22 records in the IAEA Data Base drawing information from this source.

5.2.9.4. Special features

There is no component boundary definition included in the document. As the purpose of the report was to provide data for preliminary calculations detailed component boundary definition is not necessary.

The operating environment is considered to be a normal power plant environment, except for the fan coolers, for which it is stated that failure rates are applicable to fan coolers operating in a post-LOCA/SLB (Loss of Coolant Accident/Steam Line Break) environment.

5.2.9.5. Source independence

One basis for failure rate assessment was the Westinghouse data base. It is assumed that this data base takes into account the subset of failures considered in the LER rates in NUREG documents.

Also, WASH-1400 is one of the sources considered in the failure rate assessment, so partial dependence will have to be considered here.

However, as failure rates are not assessed by any formal method, and it is not clear which source most influenced the process, some of dependance mentioned could be negligible.

Some of the records in the IAEA Data Base provides data from UKAEA SRD.This values are applicable either to PWR reactors or to general industrial use. Data items characterizing industrial use can be considered completely independent of all the other data in the IAEA Data Base.

5.2.10. Oconee Nuclear Power Plant PRA

5.2.10.1. General

In the Oconee PSA much effort was put into the development of the data base. The data base was developed according to Bayesian methodology to

combine generic information (obtained from industry experience) with plant specific data from the Oconee plant records.

Plant specific failure data were combined with generic failure rate distributions using the one stage Bayes theorem. Although the generic prior data used were discretized truncated log normal failure rate distributions, the updated distributions are not necessarily log normal and should not be considered as such.

The mean values of the updated distributions were used to quantify the system and sequence models. The discretized form of updated distribution (which is the direct output of the updating process) was used in the propagation of the uncertainty for the dominant cut sets of the dominant sequences identified in the analysis.

5.2.10.2. Data sources

The first step in developing the data base was development of the generic data base. After defining components and failure modes for which data were needed, all available data were thoroughly reviewed, analyzed and tabulated.

The generic failure rate distributions developed for Oconee PRA contain, in each case, the range of information embodied in the literature. Each distribution was presented as a lognormal distribution.

The median value of the each distribution was almost always taken directly from one of the published data summaries. The range factor (ratio of 95th percentile to the median) was in most cases subjectively assigned. The 5th and 95th percentiles of the distribution represent realistic bounds for expected or observed component failure rates.

Plant specific failure data were derived from three in-plant sources, namely:

- Work requests (WR) written whenever maintenance is required on any piece of equipment in the plant;

- Incident reports (IR), prepared for any event that may be a candidate for license event report to the NRC or for other utility purpose (in general, IRs are written only for events affecting the systems or equipment addressed in Technical Specifications)

- Licensee event reports, which are actually condensed versions of IRs.

These information sources were analyzed for the period 10 January 1975 to 30 June 1980. Each of these sources has its unique advantages and disadvantages. Further explanation of these aspects can be found in Oconee PRA, Chapter 5.1.

In addition to data on failures, information on success as well as operating time and number of demands was needed. Sources which provide failure data do not provide information about successes. For the component demand data, periodic test reports and the control room operating logbooks

were the most important sources. Component service hours needed to develop plant specific time related failure rates, were derived from records of annual operating times for large motor driven components, normal plant operating procedures and system lineups and periodic tests.

5.2.10.3.Data available in the IAEA Data Base

Practically all the data given in the Oconee PRA are reproduced in the IAEA Data Base, making 54 records.

The values appearing in the records are the mean, the 95th percentile and the 5th percentile of the updated distributions for the failure rate, the upper bound and the lower bound, respectively. In addition, in the comment lines, information regarding generic prior (the exact source of the mean and respective distribution percentiles) together with recorded plant experience (number of failures, number of demands or operating time) is provided.

Some of the records also contain the repair times. The repair time is usually the mean of updated maintenance durations for particular components as found in Table 5.5 of the Oconee PRA.

5.2.10.4. Special features

The definitions of the components and their boundaries do not exist in the formal sense. However, the component boundary can be directly assessed from the fault trees.

Neither was any information found about environmental effects and applicability of failure rates to different component environments. Normal nuclear power plant environment was considered instead.

Some of the records in the IAEA Data Base contain information about component operating modes drawn from knowledge of the usual operating mode for particular components. In most cases 'all' operating modes were considered.

5.2.10.5. Source independence

As one of the data sources for the Oconee plant specific failure data was LER reports, there is a certain interdependence with LER rates (NUREGs).

Data included in the IAEA Data Base are products of an updating process, so dependence on the prior is obvious and in some cases extreme (where operating experience is sparse). As the generic distribution was developed for each component in question, it is not generally possible to indicate dependence on particular generic sources; this should therefore be assessed on record by record basis. As mentioned, each record contains information about prior (mean value and distribution percentiles) uses in the updating process.

5.2.11. Old PWR reactor

5.2.11.1. General

Under this name is a data base compiled by updating the generic data with plant specific operating experience. This source was useful for inclusion because it contains rather extensive plant specific operating experience.

This data source provides very detailed component divisions, especially in some of support systems rarely found in PSA studies.

This data has been compiled by the IAEA in the framework of various activities (workshops, technical assistance missions etc.) and therefore its accuracy cannot be verified.

5.2.11.2. Data sources

Plant specific operating experience was extracted from the plant operating records.

5.2.11.3. Data available in the IAEA Data Base

This source provided more than 110 records to the IAEA Data Base. Each record contains mean value and 95th and 5th percentiles of the updated failure rate distribution. Comment lines of each record provide information about the mean of generic distribution which was used as a prior in updating as well as the exact number of component failures and number of demands or the operating time recorded (or assessed).

Some of the records provide repair times, which are usually the mean of the maintenance duration.

5.2.11.4.Special features

The special feature of this source is the availability of failure rates for support systems like heating, ventilation and air conditioning (HVAC) components, different compressors, etc.

No detailed component boundary descriptions, or information about operating mode or environment was available. In some of the records the component operating mode was assessed from knowledge of the particular components function in the NPP.

5.2.11.5. Source independence

Plant specific data are completely independent of all the other sources in IAEA data base, and the failure and success data provided in the comment lines can therefore be used as statistically independent evidence.

Generic data used as the prior in updating process are dependent to other sources in the IAEA Data Base, but it is not possible to assess the magnitude of dependence.

5.2.12. Heavy Water Reactor (HWR) assessment

5.2.12.1. General

The source included in the IAEA Data Base under this name provides data compiled from accumulated operating experience. This is the second largest source in the IAEA Data Base, yielding more that 150 records. The source gives a rather detailed division into component sizes (valves) and functions (pumps). The total amount of operating experience used to assess failure rates is substantial.

This data has been compiled by the IAEA in the framework of various activities (workshops, technical assistance missions etc.) and therefore its accuracy cannot be verified.

5.2.12.2. Data sources

The ultimate data source is operating experience assessed from the comprehensive overview of the plant records. In a few cases details of operating experience are not given, and these data may be assessed on the basis of engineering judgement.

5.2.12.3. Data available in IAEA Data Base

The data on each component found in the source are reproduced in the IAEA Data Base.

As mentioned, there are more than 150 records from this source in the IAEA Data Base, addressing about 70 component types divided into mechanical, electrical and instrumentation and control categories. For most of the component mean values, 95% and 5% confidence limits are included.

Also, a factor (called in the source error factor) indicating the ratio between the 95th percentile and the median is given in most of the records (in all records having confidence limits in the original source).

The mean time to repair is given for most of the components and in most of the cases it is the actual recorded time; however, in some cases it was conservatively estimated.

The comment lines of each record form provide information about the total population considered, the cumulative component operating time and the number of failures recorded. If the failure mode is 'all modes', usually in the comment lines it is stated which failure modes are considered under 'all modes'. Characteristics of the contribution of each particular failure mode to 'all modes' in terms of dominant or negligible contributions are also provided in the comment lines.

5.2.12.4. Special features

One of the special features of this source is the cumulative failure mode 'all modes' which simply adds several single failure modes in the cases where breakdown was possible. Usually out of five failure modes considered under all modes, two or three are significant, while the others are practically negligible. An 'all modes' failure rate is, therefore always provided, together with failure modes having significant failure rates.

For some of the components (for example pumps classified according to their function) the source does not provide a breakdown into detailed failure modes; only 'all modes' failure rate is therefore provided in the IAEA Data Base.

All failure rates are given as per hour values.

In the original source, failure rates were given as occurrences per 1000 component operating years. To be consistent in the IAEA Data Base, failure rates are presented as per hour values.

This source also has rather detailed division into categories according to dimension (valves). However, details about component boundaries were not available.

The operating mode and environment are also not known, so all operating modes and normal power plant environment is considered throughout.

5.2.12.5. Source independence

This source is considered to be completely independent of all the other sources in the IAEA Data Base.

5.2.13. Zion Nuclear Power Plant PSS

5.2.13.1. General

This source is the data base compiled from Zion NPP Probabilistic Safety Study. It consists of generic data updated with plant specific

operating experience. Almost the full set of data found in the source is reproduced in the IAEA Data Base.

5.2.13.2. Data sources

The generic sources used as the priors in updating were WASH-1400, IEEE 500 (1977) and NUREG documents.

The mean values for most of the pumps, valves and diesel generators were taken from NUREG documents. The population variability was obtained by taking the 95%/5% ratio from WASH-1400 as the 80%/20% ratio for the generic distribution. This approach broadens the original WASH-1400 distributions substantially.

The data for electrical, electronic and sensing components were taken from IEEE 500 (1977). The 'recommended' value from IEEE 500 was taken as the median, and the 'maximum' value as the 80th percentile of the population variability curve. These two values were used to generate the 20th percentile.

In some cases where there were no applicable data in NUREGs or in the IEEE 500, the WASH-1400 5th and 95th percentile values were used as the 20th and 80th percentiles of the population variability curve.

The primary source of component failure data used for updating was the licensee event reports. A compilation of all LERs submitted by Zion NPP 1 and 2 from initial criticality (20 June and 25 December, respectively) to December 1979 provided the basic event description from which the corresponding failure rates were assessed.

A number of other sources were used for specific items requiring more detailed information than was available in LERs. These sources included control room logs, component maintenance records, testing records and internal event reporting documents (deviation reports).

The operating time or number of demands corresponding to the failures derived from the afore mentioned sources were assessed from the operational history, considering total time, time on power, number of tests in accordance with the technical specification, etc.

5.2.13.3. Data available in the IAEA Data Base

Zion PSS provide 38 records to the IAEA Data Base. All the data points except those for which no plant specific data exist were included in the IAEA Data Base.

The failure rate values included in the IAEA Data Base are updated mean values.

The comment lines of each record contain information about the exact prior used in updating for particular components, including source and exact failure mode (if different than failure mode in Zion data base). In the cases where the prior mean and the variability ranges were taken from different sources, information on both was included.

Plant specific information regarding the operating time or the number of demands and the corresponding number of failures is also provided in the comment lines of each record.

5.2.13.4. Special features

As with the other sources that are PSA studies, component boundaries are defined in fault trees.

The operating environment is not clearly stated and the normal power plant environment was assumed for all records.

5.2.13.5. Source independence

This source is highly dependent on its priors (WASH-1400, IEEE 500 and NUREG documents) for respective components.

As the sources of plant specific data are plant LERs, there is an additional dependency to the NUREG documents which draw the raw data from LERs.

5.2.14. NUREG documents with LER rates

5.2.14.1. General

In the IAEA Data Base there are four sources based on the raw data drawn from LER reports in the USA. These are:

1. NUREG/CR-1205, Data Summaries of Licencee Events Reports of Pumps at U.S. Commercial Nuclear Power Plants EG&G Idaho, Inc., January 1982

2. NUREG/CR-1331, Data Summaries of Licensee Event Reports of Control Rods and Drive Mechanisms at US Commercial Nuclear Power Plants, EG&G Idaho, February 1980.

3. NUREG/CR-1363, Data Summaries of Licensee Event Reports of Valves at US Commercial Nuclear Power Plants, EG&G Idaho, Inc., October 1982.

4. NUREG/CR-1740, Data Summaries of Licensee Event Reports of Selected Instrumentation and Control Components at US Commercial Nuclear Power Plants, EG&G Idaho, Inc., July 1984.

All these sources have common characteristics and therefore are treated together.

The common characteristic of these sources is that the ultimate data source is the operating experience of group of plants, collected through the Licensee event report system. The population size, operating time or

number of demands needed to evaluate recorded failures statistically, was judged from the information available.

Because of the process of judgement involved, the component failure rates estimated should be interpreted as only tentative gross indicators of the true failure rates. It is necessary for the individual analyst to validate the applicability of the LER derived failure rates in each case separately.

5.2.14.2. NUREG 1205

NUREG/CR-1205, providing rates for the pump components drew information from LERs from 1 January 1972 to 30 September 1980. In that period a total of 1103 pump faults were discovered. Of these, 552 faults were classified as pump failures, while the remaining 551 were identified as command faults.

For the purpose of the report the pump component is defined as the pumping unit, prime mover, coupling and associated mechanical control. All the failures in this category are considered to be pump failures, while any fault outside this boundary is considered to be command fault.

In this source pumps are classified according to their prime mover (motor, turbine or diesel driven) and by operating mode category (running, alternating and standby). Operating mode category is assessed on the basis of the system to which the pump belongs. (Detailed definitions of boundaries and an explanation of operating modes can be found in the source.)

NUREG/CR-1205 define four failure mode categories: 'leakage/rupture'; 'does not start'; 'loss of function' and 'does not continue to run'.

The final LER rates from this source are standby failure rates, operating failure rates and demand failure rates, calculated as failures per hour or per demand. Operating rates were estimated for 'leakage/rupture',for 'loss of function' and for 'does not continue to run'. Standby rates were estimated for the failure mode 'does not start'. Operating LER rates were estimated as the aggregation of failure modes 'leakage/rupture', 'loss of function' and 'does not continue to run'.

All LER rates were calculated with and without command failures (except for 'leakage/rupture' for alternating pumps).

In addition to LER rate estimate, multipliers for 95% and 5% confidence limits are given for most data points.

Data available in the IAEA Data Base

There are nine records containing information from this source in the IAEA Data Base.

As the failure modes 'leakage/rupture', 'loss of function' and 'does not continue to run' were aggregated in original source, only the aggregate value was included in the IAEA Data Base (it was felt that only this is of importance for PSA uses).

Each record from NUREG/CR-1205 in the IAEA Data Base contains the LER rate estimate (point value) and the upper and lower bounds calculated from mean value using multiplication factors. All values do not include command faults.

In the comment lines of each record the respective population and number of failures used to calculate LER rates are given. The respective LER rates with command faults are also included in the comment lines.

LER rates for failures to start are given in failures per demand. When available, failure rate in terms of number of failures per hour standby are also given in the comment lines.

5.2.14.3. NUREG 1331

The LER rates on control rods and drive mechanisms (CRDM) were derived from events between 1 January 1972 and 30 April 1978. In that period 504 failures were discovered.

Control rod and drive mechanism was defined as the control rod, the drive mechanism (electric for PWR and hydraulic for BWR), the housing containing the drive mechanism and all parts connecting the control rod to the drive mechanism. The cables or piping external to the drive mechanism were not considered to be part of the CRDM.

Altogether, 12 failure modes were identified during the LER search. Six of these were considered to be relevant and were included in the IAEA Data Base. These are: 'failure to insert at least 96% during scram'; 'failure to inset during normal shutdown'; 'fails to move during power changes/testing'; 'dropped rod'; 'uncoupled/overtravelled rod' and 'improper rod movement'. The first three of these are defined as failure per demand; others are defined as failures per hour standby.

Data available in the IAEA Data Base

This source provided 10 records to the IAEA Data Base. Each record contain the LER rate mean value as the failrate and 95% and 5% confidence bound as the upper and lower bound, respectively.

Generally, the rates are without command faults. Whenever available, rates with command faults are provided in the comment lines. When the failure rate is defined in numbers of failures per demand, the standby hourly failure rate is provided in the comment lines.

5.2.14.4. NUREG 1363

Failure rates in this source were derived from LERs submitted between 1 January 1976 and 31 December 1980. The total number of events considered failures or command faults in that period was 4209. Of these, 3233 events were considered to be failures, while the other 976 were considered to be command faults.

Seven categories of valves were considered for LER rate assessment. These are:

-motor operated valves;
-remote operated plus motor operated valves;
-air operated valves; check valves;
-manual operated valves;
-safety valves (PWR) and
-relief valves (BWR).

Of these, 'remote operated plus motor operated valves' is a special category. Some of the LERs did not specify the valve type, but provided information to permit their classification as remote operated. As most of the remote operated valves in safety systems are motor operated, it is believed that most of the failures reported are actually failures of motor operated valves. Therefore, this category should be a more realistic representation of LER rates for motor operated valves.

From the LERs, 11 failure modes were identified for valves. Detailed descriptions and definitions of each of them are found in the source.

For the purpose of deriving LER rates, the valve component is defined as the valve body and all its internal parts, the valve operator and any attached functional accessories (e.g. limit or torque switch) that are needed to make the entire assembly functional. Supply systems to the valve operator (such as electrical, air or hydraulic) are considered to be outside the bounds. Failures involving supply systems are considered to be command faults to the valve assembly.

For most of the valve categories and failure modes, LER rates with and without command failures are provided.

Data available in the IAEA Data Base

This source provides 17 records to the IAEA Data Base, addressing all valve categories except motor operated valves. As mentioned, the category 'remote operated and MOV' better represent MOV failure rates, and it was included as motor operated valves.

The LER rate is given in each record as the failrate, while 95% and 5% confidence limits are given as the upper and lower bound, respectively. The rates given are without command faults.

In the comment line of each record the LER rate with command faults is given. In cases where the LER rate is defined as per demand value, the standby hourly rate (when available) is also provided.

In most cases the overall rate is given (all vendors). Where it seemed to be important, PWR and BWR rates were distinguished.

5.2.14.5. NUREG 1740

NUREG/CR-1740 is a summary of the evaluation of LERs submitted between 1 January 1976 and 31 December 1981 that pertain to electrical and

electronic components in instrumentation and control systems. Owning to the limited availability of the component population, LER rates were estimated only for I & C components that are parts of the channel that performs the reactor trip. In this period 6764 faults were found; 6180 were classified as actual failures while the rest were identified as command faults.

LER rates were estimated for the following components:

- -sensors;
- -transmitters;
- -signal conditioning systems;
- -comparators and bistables;
- -switches and radiation monitors.

Also the major components of analog systems were combined, depending upon the parameter they were monitoring, to form the instrument channel. LER rates were then estimated for the following analog instrument channels:

- -nuclear core flux;
- -temperature;
- -flow;
- -level and pressure.

In the digital systems, switches were considered a channel and LER rates were estimated for level and pressure/vacuum switches.

Two failure modes were assessed for each component: reduced capability and inoperable. Reduced capability failure mode describes an event where the component is operational, but does not perform its function within defined limits. Example of these events are instrument drift, out of calibration or spurious operation.

Data available in the IAEA Data Base

This source provide 28 records to the IAEA Data Base. Half describe single components, while the rest provide instrument channel data. LER rates (point estimates) are found in the failrate line, while 95% and 5% confidence limits are given in upbound and lowbound, respectively. Contrary to other LER sources, point estimates and confidence limits from this source include command faults.

In the comment lines of each record, the failure rate point estimate without command faults is given.

5.2.14.6. Source independence

All NUREG LER rates sources draw raw data from plant experience. In terms of statistics they are completely independent.

Several sources included in the IAEA Data Base use failure rates derived from LER as a prior in data updating process. Interdependence in those cases is obvious.

5.2.15. The In-Plant Reliability Data Base (IPRD) for Nuclear Plant Components

5.2.15.1. General

There are two sources from IPRD in the IAEA Data Base. These are:

1. NUREG/CR-2886 In-Plant Reliability Data Base for Nuclear Plant Components: Interim Data Report, the Pump Component, Oak Ridge National Lab. December 1982.

2. NUREG/CR-3831 In-Plant Reliability Data Base for Nuclear Plant Components: Interim Data Report, Diesel Generators, Batteries, Chargers and Inverters, Oak Ridge National Lab. January 1985.

The objective of the IPRD was to develop a comprehensive, component specific data base for probabilistic risk assessment and for other statistical analysis relevant to component reliability evaluation. Contrary to LER rates, the primary sources of data were in plant maintenance files, including all corrective maintenance actions on each component.

5.2.15.2. NUREG 2886, the pump component

Failure rates for the pump components were derived from maintenance and repair records from six NPPs (two PWR and four BWR) providing 27 reactor years of experience. About 4000 records were collected. The total population of all pumps is about 1500.

From data collected, point estimate and confidence limits (95% and 5%) were calculated for time and demand related failures.

The approach taken when defining the pump boundary considers a 'super' component or pumping function. It means that failure of the pump component includes failures of pump impeller, shaft, motor, local switches and instrumentation and control circuitry. Command faults (such as loss of steam) are considered to be outside the boundary.

The pump population was divided according to operating mode (running, alternating and standby) and driver (motor driven, turbine driven and diesel driven). Point estimate failure rates and the ranges were assessed for each of these.

Data available in the IAEA Data Base

This source provided seven records to the IAEA data base. In the IAEA Data Base failure rates are given in form of point estimate and upper and lower bounds in form of confidence limits. In the comment lines information regarding population size, number of failures and total operational time or number of demands are included.

Normal nuclear power plant environment was assumed for all records.

5.2.15.3. NUREG 3831, diesel generators, batteries, battery chargers and inverters

For these components, about 700 relevant maintenance and repair records from five plant were collected, covering a time-span of 33 years.

The components considered are defined as having the following boundaries:

DG: general criterion is to include local systems and components that are integral to starting and sustaining the electrical generating capability of the diesel generator. Detailed description of interface points are to be found in the original source.

Battery: the boundary is defined to include the battery container, the seismic design battery rack and straps, internal parts including plates and electrolyte, terminal connections including cables with lugs, posts or connectors, and any switches or meters for the normal operation of the battery.

Battery charger: (only static battery chargers are included) the boundary is defined to include the connecting feeder breaker to the alternating current (AC) source (motor control center or bus) and the connecting output breaker to the direct current (DC) bus. Included in the boundary between these two points are the electronic and non electronic components within the charger enclosure, and the associated instrumentation, control and protective devices, including meters, relays, fuses, switches and circuit breakers.

Inverter: the boundary is defined to include all electronic and non electronic components within the inverter unit, the rectifier, the static transfer switch, associated instrumentation and local control and protective devices (meters, relays, fuses, switches and circuit breakers).

All the failures in the source were divided into three categories in accordance with the failure severity (catastrophic, degraded and incipient). Only catastrophic failures seems to be interesting from the point of view of PSA analyst.

The source provides aggregate failure rates as well as the plant specific failure rates. For the IAEA Data Base only the aggregate rates were of interest because of the relatively short operating periods and the sparse failure data for single plants.

A special feature of this source is the definition of DG failure modes. The failure mode 'failure to start' includes an initial running time of 30 minutes, because it was considered that 30 minutes is the time needed for the DG to warm up. This source also uniquely defines the DG running failure mode by splitting it into two categories, namely 'failure

to run once started' and 'improper operation'. The first includes all failures which prevent the DG from continuing to run after initial 30 minute warm-up period. The second one is used to cover cases where the DG was tripped owning to local problems (running hot is one example), but in emergencies it would continue running. The source suggested that combining these two would allow the comparison of the failure rate with failure rates for DG failure to run found in other sources.

Both of the DG running failure rates are included in the IAEA Data Base. They are marked with an asterix to indicate that they are not comparable with other sources. An additional record combining these two is also provided.

Data available in the IAEA Data Base

This source provided eight records to the IAEA Data Base. Each record contains recommended failure rates (or demand probability) value, and high and low value as the upper and lower bounds, respectively. Some of the records contain repair times which are ranges of recorded medians.

The comment lines of each record contain information regarding the population observed, the number of recorded failures and the corresponding number of demands or operating times.

5.2.15.4. Source independence

There is moderate interdependence between this source and NUREG LER sources because in a number of cases the same failures are accounted for in both.

5.2.16. EPRI NP-2433, Diesel generators data

5.2.16.1. General

The objective of this project was to provide high quality data on diesel generators for use in risk assessment. What makes this source interesting for inclusion in the IAEA Data Base is the methodology and sources of raw data.

5.2.16.2. Data sources

The raw data were collected from a variety of sources, including:

-utility supplied accounts of diesel start attempts and failures;

-data obtained by project personnel through on-site inspection of plant operator logs, test records and maintenance logs;

-data collected from four plants by IEEE personnel through review of plant maintenance records.

-In addition the licensee event reports were searched for supporting information.

For starting failures, data from 13 nuclear plants were used, representing 123 diesel years, with 6910 demands. Running failures were calculated for two plants (three reactors) only.

5.2.16.3. Data available in the IAEA Data Base

Only two records in the IAEA Data Base are drawn from this source. One is the aggregate value for DG failures to start (13 plants), which is represented as a point value. The second is the failure to run calculated for Peach Bottom 2 & 3 plants, and, in addition to the point value, 95% and 5% confidence limits are given.

The exact number of demands and related failures as well as the population size are given in the comment lines.

5.2.16.4. Source independence

This is the only source in the IAEA data base which reflects DG operating experience of the population of US plants. Therefore it can be considered independent of all the other sources except Zion NPP PSS and IEEE 500 which are partially based on data from the same population.

5.2.17. The German Risk Study (phase A)

5.2.17.1. General

The principal objective of the German Risk Study was to assess one of the German nuclear plants using the WASH-1400 methodology. Originally it was intended to use the failure rates and probabilities from WASH-1400, but later, owning to certain differences, a set of data for exclusive use was developed.

5.2.17.2. Data sources

Three sources were used to obtain the reliability data for the study. These were:

-review of the relevant literature

-review of operating experience from NPPs Biblis and Stade

-failure effect analysis for part of the I & C component.

Weighting factors for each of the data sources were assessed from the available information for each component.

The components for which the data were assessed are not defined in detail to accommodate differences in design, operational and other parameters.

Log normal distribution was used throughout the study for the failure rates of components.

5.2.17.3. Data available in the IAEA Data Base

This source provided about 36 records to the IAEA Data Base. Each record has either a mean or a median value and the error factor associated with it. Comment lines usually provide more detailed information on the ultimate source of data.

5.2.17.4. Source independence

Failure data which originated entirely from operating experience of German plants are independent from all other sources in the IAEA Data Base. Failure rates obtained by literature review are in many cases based on similar sources as WASH-1400 failure rates. In this case the dependence is rather high.

6. PROBLEM AREAS CONNECTED WITH THE DATA BASES FOUND IN THE LITERATURE

When using a generic data base one has to be aware of possible problem areas. Considering the areas where misinterpretation can occur, the following 4 areas have been identified in the following order of importance:

-component boundary definition
-failure mode definition
-operating mode definition
-operating environment definition

Even when deriving failure rates from raw data from the plant being analyzed, these are issues which can lead to substantial errors.

During the development of the IAEA Data Base insights were gained in how different data bases address each one of these issues. These insights and possible ways of avoiding or solving such problems are addressed next.

6.1. Component boundary

It is obvious that a main source of misinterpretation is the component boundary definition. Some of the experts agree that variations in component boundaries are the primary reason for failure rate fluctuation between sources. Although that statement seems to be too rigid, component boundaries could, depending on the particular component, change failure rates substantially.

It is therefore interesting to see how different sources address this issue.

Probably the best defined component boundaries are in the Swedish Reliability Data Book, because practically each component category has a sketch exactly indicating the component boundary and points of interface with other systems or components. Usually, in the component boundary, local control and protection (if any) are included.

Some of the 'NUREG' documents also have adequately defined component boundaries, with precise definition of interface points.

Other sources are defining a component as being an "off-the-shelf" item. This is an interesting and remarkable definition, but it assumes that "off-the-shelf" items have the same meaning everywhere, what is not necessarily the case for all the components.

Data bases which are part of PSAs, usually do not provide detailed definition of the component boundary. This is understandable, because these sources were compiled for specific use. When performing data updating, component boundary gain importance because of the need for matching the prior with the plant specific operating experience.

The sources which base their failure rate upon the combination of nuclear and non-nuclear experience (or even expert opinion) do not provide detailed boundary description. The level of similarity of different sources combined is not known, but it can be expected that certain differences would exist.

For the sources mostly based on expert opinion, the question of strictly defined boundary becomes a more academic one. However, cases like lube oil being part of diesel or breaker included or not in a pump boundary must be addressed to avoid significant (orders of magnitude) variations in the failure rates.

One way of avoiding serious problems with component boundary definitions is to define 'generic' component boundaries. That, of course, does not help in already existing data sources, but could save considerable trouble in the future. However, this is mainly applicable to data collection efforts undertaken during the performance of a PSA. In that case component boundaries should reflect two, sometimes opposite, requirements: the level of detail needed (or wanted) by the system model and the level of detail of plant records where raw data are retrieved from.

There are generally three major interfaces to be defined in connection with the component boundary definition, namely:

- -mechanical interface (incl.cooling system,lubricating system, etc. where appropriate)
- -power supply interface
- -control system interface

6.2. Failure mode

Component failure mode is another problem area, although of a different character than the boundary definition. Failure modes found in various sources show significant difference even when describing basically the same failure. For example, in the sources which were included in the IAEA Generic Data Base over 100 different failure modes were found. Difference between some of this failure modes is basically in wording (e.g. fail to run vs. failure to run) and it is therefore easy to understand that they describe the same failure. In other cases it is sometimes difficult to understand the exact failure mode and compare it among sources.

To compare failure modes and also to enhance the IAEA Generic Data Base coding system, considerable effort was undertaken to define generic failure modes.

Details about generic failure mode definition process as well as definitions for 18 major generic failure modes is found in Appendix 2.

6.3. Operating mode

Component operating mode is of importance for active components, while generally have much less meaning for passive components. Even for active components there are cases where the operating mode has more or less importance, depending primarily on the way and mechanism of how the failure occurs.

Obviously operating mode is of great importance for pumps and other components which perform their function by continuously moving. These components have operating modes defined in three categories:

standby,
alternating and
running (operating).

For components which perform their function changing between discrete states, (e.g. valves), operating mode as defined above is actually status of the system they belong to. Operating mode pertinent to the component itself should be normally open or normally closed position.

The majority of the sources do not define the component operating mode. The only sources which define operating mode are some of the NUREG LER sources.

PSA studies used as the data sources usually define the system where the component is located. For most of the systems it is possible to determine the operating mode, what could be used for defining active components operating mode.

Although not directly connected with the operating mode, one very important characteristic which sometimes is overlooked is the duration of the operation. For standby components, if the failure rate is determined based on operating experience, it is based on recorded operation during test performance, what is usually one or several hours. In the real case, particular components are required to operate for times which substantially differ from the one which was the base for the failure rate determination. Most of the sources do not address that problem.

When modeling standby components, failures during standby must be accounted for. Failures occurring during standby are not revealed until a test or an actual component demand, therefore are usually included in the model as a demand related failure. In this cases the demand related failure should comprise those failures whose mechanism is purely related to the demand (e.g. high current to motor windings during start) and also failures related to the time which the component spent in a standby condition.

However,if data base provides only demand related failure rate without indication how long is the component in standby between two demands, this overlooks the fact that component failure during standby is time related and could vary substantially with variation in time between tests or actual demands.

Some of the sources recognized this fact and provide hourly failure rate for standby condition. On the other hand that approach is a possible source of error, because it is normally impossible to distinguish between time and demand related failures.

6.4. Operating environment

As mentioned earlier, the component operating environment is rather poorly defined in most of the sources. Most of the sources do not address it at all, while some of them are defining environment as the normal power plant environment. This definition could basically hold for normal operation or accidents which do not change environmentally affected parameters. However, when performing a PSA one is interested to predict the outcome of accident in environments, that could in certain cases change component failure rates substantially.

WASH 1400 is a source which provides separate failure rate for post accident situation for pumps and motors. The IEEE Standard 500 lists the environment multipliers for most of the components included, for environmental effects like high radiation, humidity, temperature and pressure.

Environmental effects could obviously affect component failure rate in different manners, therefore careful consideration should be given to this issue. Data from plant operating experience assume a normal environment, because operating experience data are normally either from normal operation or from test data, both of which are quite different from accident conditions.

On the other hand, the number and types of components affected by post accident conditions are usually rather limited. The extent of that is greatly dependent on plant design and type of accident.

Other type of extreme environment condition which can occur in NPP-s are high temperature condition occurring after the failure of room cooling systems. For most of electronic components or systems it is relatively easy and accurate to predict the effects of extreme environment and experimental data is available. For mechanical components like pumps, high temperature condition and consequently accelerated failure rates are relatively more complicated to predict.

6.5. Problems specifically related with in-plant data collection

In addition to the problems encountered in defining component boundaries and failure modes, the means of acquiring raw data at the plant have the greatest impact on the quality of the reliability data derived.

There are basically two sources for raw data at the plant. These are logbooks and maintenance work orders. Both have advantages and disadvantages.

Deriving raw data from the maintenance work orders is usually easier and less time consuming (especially when work orders are computerized). Because every work order respond, in principle, to an abnormal occurrence, events related to each single component could be easily compiled. The quality of information found in the work orders is generally not very good, because work order forms are filled by the personnel actually performing the work. Cases such as work orders open for months or years and work done on one component identified as being done on another are common. Logbooks, especially those filled by control room personnel, are

more accurate, but deriving raw data from them is extremely time consuming.

Even if the raw data are drawn from the logbook or maintenance records, it is still not certain whether all the failures of a certain component have been reported. If both sources are searched, the probability of failures not being reported is lower. However, it is still possible and it can result in an overestimate of component reliability.

It is understandable that the quality of component failure data is directly related to the quality of the plant records. If the plant has a dedicated collection system for reliability data in place, this would obviously be the best possible source of raw data.

The problem is even worse for demand related failures, when the actual number of demands is not readily available and has to be assessed on the basis of average time on power or calendar time. If a component is started for testing purpose, it is usually not known weather it started immediately or after a number of trials.

Operating experience for running (operational) failures involving standby systems is usually limited to a running time of about 1 hour (usual test running time). However it is often used (in analysis) as the long term failure rate, without any evidence that the long term failure rate is equal or comparable to the calculated short term rate.

Appendix 1

DATA SOURCES FOR THE IAEA DATA BASE

This Appendix provides an alphabetic listing of sources which were used in the compilation of the IAEA Data Base. The full name of the source is identified with a character which is part of the code. This character appears on the 5th position in the code of each record.

SOURCE NAME	CODE
1. HWR assessment	F
2. EPRI-NP-2433, Diesel-Generator Reliability at Nuclear power Plants:Data and Preliminary Analysis, Science Application, Inc.,June, 1982.	R
3. German Risk Study (Deutsche Risikostudie Kernkraftwerke), GRS, FRG, 1979.	G
4. IEEE Standard 500, IEEE Guide to the Collection and Presentation of Electrical, Electronic, Sensing Component, and Mechanical Equipment Reliability Data for Nuclear-Power Generating Stations, Appendix D, Reliability Data for Nuclear-Power Generating Stations, IEEE 1984.	E
5. NUREG/CR-2728 Interim Reliability Evaluation Program Procedure Guide, Sandia National Laboratories, January 1983.	I
6. NUREG/CR-1205 Data Summaries of Licencee Events Reports of Pumps at U.S. Commercial Nuclear Power Plants EG & Idaho, Inc.,January 1982	P
7. NUREG/CR-1331 Data Summaries of Licencee Event Reports of Control Rods and Drive Mechanisms at US Commercial Nuclear Power Plants, EG & G Idaho, Feb, 1980.	C
8. NUREG/CR-1363 Data Summaries of Licencee Event Reports of Valves at US Commercial Nuclear Power Plants, EG & G Idaho,Inc.,October 1982.	V

9. NUREG/CR-1740 Data Summaries of Licencee Event Reports of Selected Instrumentation and Control Components at US Commercial Nuclear Power Plants, EG & G Idaho,Inc.,July,1984.
M

10. NUREG/CR-2815 Probabilistic Safety Analysis Procedure Guide, Brookhaeven National Laboratory, August 1985.
B

11. NUREG/CR-2886 In-Plant Reliability Data Base for Nuclear Plant Components: Interim Data Report, the Pump Component, Oak Ridge National Lab, December 1982.
D

12. NUREG/CR-3831 In-Plant Reliability Data Base for Nuclear Plant Components: Interim Data Report, Diesel Generators, Batteries, Chargers and Inverters. Oak Ridge National Lab, January 1985.
N

13.NUREG/CR 4550 Vol.1 Analysis of Core Damage Frequency From Internal Events: Methodology Guidelines September 1987.
J

14. NUREG/CR 4550 Vol.3, Analysis of Core Damage Frequency from Internal Events :Surry, Unit 1. Sandia National Laboratory, November 1986.
A

15. NASC 60, OCONEE PRA, A Probabilistic Risk Assessment of Oconne Unit 3, The Nuclear Safety Research Center, EPRI, and Duke Power Co..June, 1984.
O

16. Old PWR reactor
H

17. Shoreham Nuclear Power Station Probabilistic Safety Assessment, Science Application, Inc.,
S

18. PWR/RX 312 Sizewell 'B' PWR Pre-Construction Safety Report, Component Failure Data for PWR System Reliability Assessment, NNC, UK, June, 1982.
U

19. RKS 85-25 Reliability Data Book for Components in Swedish Nuclear Power Plants, RKS, SKI Sweden
T

20. WASH-1400, Reactor Safety Study, An Assessment of Accident in U.S. Commercial Nuclear Power Plants, US NRC, October 1975
W

21. Zion Nuclear Power Station, Probabilistic Safety Study, Commonwealth Edison Co., 1981.
Z

Appendix 2

GENERIC FAILURE MODE DEFINITION AND CODES

A set of generic failure modes was developed to cover practically every failure which is accounted for in PSAs. Appendix 2 provides detail of the definition process, specific definitions of each of the major generic failure modes and the coding of generic failure modes.

1. Definition process

During the process of developing the generic failure modes the following was considered:

-The development of failure modes was to a great extent oriented towards component operation.

-During the definition process two distinctive models were considered:

-demand related failure rates (failure probabilities) and
-time related failure rates (subdivided in operating and standby related)

-Three effects of failures were considered in the definition process:
-loss of function of the component
-change of state without the command
-failure to change state with command

-Another topic which to a certain extent influenced the determination of generic failure modes are the requirement of the system analyst on how to model (define) a particular event in fault trees.

-Finally, all the failure modes which are found in the various sources were considered to determine the final list of failure modes.

Altogether 26 failure modes were defined. 18 of them are considered to be of major importance, while the rest are only single component related (e.g. 'overheated' is pertinent to the electric heaters only), or very unique like control rod 'fail to insert'. These failure modes are self explanatory, so a detailed definition process was not necessary for them.

Major failure modes were described and defined and general use for each of them was suggested. To enable the data base user to follow the logic of placing particular failure mode under one of the generic categories, information on major failure modes is included below.

List of failure modes and associated codes is provided at the end of the Appendix.

2. Definitions of major failure modes

1. ALL MODES

Characterizes ANY failure which could possibly occur on certain components. Integrates: critical, degraded and incipient failures but their respective contribution to the total is not always known.

It is used in cases where detailed failure mode definition or data for particular failure mode is not available. It indicate that the component is or should be taken out of service under normal operation conditions.

2. DEGRADED

Failure which causes the component not to perform its function in the expected manner, or expected (designed) capacity but, which is not a catastrophic failure.

Usually pertinent to I & C components.

Time related, operation or standby

3. FAILURE TO CHANGE POSITION

Characterizes failure of components to move to a new required position.

Usually pertains to components which perform its function by changing (moving) between two discrete states (valves, breakers) (or change state discretely between two end points - regulating).

Applicable to components which perform its function by moving from one state to the other but limited to the situations where the required final state is irrelevant or characterized by other means, or not defined.

Demand related failure.
Failure to change state with command.

4. FAILURE TO REMAIN IN POSITION

Characterizes failure of components to remain in the required position.

Usually pertinent to components which perform its function by changing state between two discrete states (valves, breakers), or charge state regulating between two end points.

Used for two-state components which are required to remain in position during a mission time. Failure would cause move to opposite positions. Required position is irrelevant, characterized by other means or not defined at all.

Time related, operational or standby.
Change of state without command.

5. FAIL TO CLOSE

Characterizes failure of a component to move to a new, closed position.

Subset of failure mode FAIL TO CHANGE POSITION.

Used for components which perform their function by moving from one state to another, but its closing is necessary to complete the mission.

Demand related failure.
Failure to change state with command.

6. FAIL TO OPEN

Characterizes the failure of a component to move to a new, open position.

Subset of failure mode FAIL TO CHANGE POSITION.
Opposite from FAIL TO CLOSE

Used for components which perform their function by moving from one state to another, when opening is necessary to complete mission.

Demand related failure.
Failure to change state with command.

7. FAIL TO FUNCTION

One of the general failure modes, applicable mainly to components which do not move (macroscopically) to perform their function, (battery transformer, I & C equipment) or which have a complex function such as air-cooler, M-G sets etc. FAIL TO RUN does not adequately characterizes the component failure mode in these cases.

Characterizes the failure of components to function in required manner either continuously or when demanded.

Used for components which perform their function without movement on a macroscopic level, and for components which are characterized by providing output given an input or a command (continuously in time).

This failure mode is also applicable (and being used) as a composite failure mode for a pump not able to perform its function (pump fail to start, run, ruptured during operation or fail to accomplish the mission for any other reason)

Time related - operational.
Demand related
Loss of function of the component.

8. SHORT TO GROUND

Characterizes ground connections of any component where electric current is isolated on a higher-than-ground voltage.

Applicable to the electrical or I & C components which in any way conduct, transfer or modify electric current. Subset of failure mode SHORT CIRCUIT.

Used for components which are unable to perform their function or can cause disturbance to other equipment when isolation to ground is broken and a power to ground circuit is formed.

Time related failure operation or standby.
Loss of function of component.

9. SHORT CIRCUIT

Characterize connections between two or more conductors (or conducting materials) which are normally isolated (insulated).

Applicable to practically all electrical and I & C components.

Used for components which are unable to perform their function, or cause disturbance to other equipment when insulation between two normally separated conductors disappear and a short circuit is formed.

Time related failure, operation or standby.
Loss of function of the component

10. OPEN CIRCUIT

Characterizes disconnection (isolation) an electric circuit.

Applicable to practically all electrical and I & C components.

Used for components which are disabled to perform their function when electric conductor becomes internally isolated (insulated).

Time related failure, operation or standby.
Loss of function of component.

11. PLUG/RUPTURE

Unique failure mode applicable to piping.

Characterizes plugging or rupture of a pipe segment in manner that the required flow through that segment cannot be established or maintained.

Applicable to all kinds of pipes (but in IAEA data base used only for piping from source 'WASH-1400').

Time related failure, operation or standby.
Loss of function of the component.

12. PLUG

Characterizes any means of preventing flow in a required direction not caused by normal operation of component.

Applicable to most of the components through which flow of liquid/steam/gas flow is established or maintained. It is of particular interest to components whose internal parts can become loose and prevent normal flow (valves) or depositions can reduce flow below required level (filter/strainers).

Characterize any means of preventing flow in required direction not caused by normal operation of component.

Time related failure, operation or standby.
Loss of function of component.
Change of state without command.

13. SPURIOUS FUNCTION

Characterizes failure of components to retain their current status, e.g. to change state without being called to.

Complement to FAIL TO REMAIN IN POSITION, and applicable to components which perform their function by other means and not by changing state between two distinctive states.

Used for components which perform their function by being in a certain (usually dormant) state, but failure will cause changing state (operation of component).

Time related failure, standby or operation
Change of state without command.

14. FAIL TO RUN

Characterizes failure of a component to continue operation (usually rotating movement) during a the required mission time.

Applicable to all components which perform their function by continuous movement.

Time related failure, operational.
Loss of function.

15. FAIL TO START

Characterizes the failure of components to start when demanded.

Applicable to all components which perform their function by starting and subsequently continuously moving (rotating).

Demand related failure.
Loss of function of component.

16. OTHER CRITICAL FAULTS

Characterizes the failures that would cause the component to FAIL TO FUNCTION if demanded before repair.

Uniquely defined failure mode taken from Swedish Reliability Data Book.

Applicable to sensors representing sensor failures discovered prior to an actual demand.

Time related failure, standby.
Loss of function.

17. LEAKAGE/EXTERNAL LEAK

Characterizes a failure of component boundary to remain intact (to retain liquid). If the component performs another function, (e.g. pump) this failure will not necessary prevent that other function.

Applicable to all components which retain liquid by any means. Not necessarily a catastrophic component failure. This failure mode sometimes overlap with failure mode RUPTURE. It was not possible to strictly separate this two failure modes in all cases.

In the IAEA data base its used almost entirely in cases of external leak.

Time related failure, standby or operation.
Loss of function of component (partial).

18. RUPTURE

Characterizes a large breach in liquid retaining boundary.

Applicable to all components which retain liquid by any means. It is always a catastrophic component failure. If the component performs some other function, not only to retain liquid (pump), this failure will completely prevent the component from functioning.

Used in the IAEA Data Base in cases where the original failure mode was rupture. Sometimes rupture also refers to component internal (e.g. valve), and there is a possibility of overlapping between this failure mode and failure mode INTERNAL LEAK.

Time related failure, operational or standby.
Loss of function of component

3. Failure modes and associated codes

Generic failure modes and respective codes

FAILURE MODE	FAILURE MODE CODE
ALL MODES	A
DEGRADED	B
FAIL TO CHANGE POSITION	C
FAIL TO REMAIN IN POSITION	D
FAIL TO CLOSE	E
FAIL TO FUNCTION	F
SHORT TO GROUND	G
SHORT CIRCUIT	H
OPEN CIRCUIT	I
PLUG/RUPTURE	J
SPURIOUS FUNCTION	K
FAIL TO OPEN	O
PLUG	Q
FAIL TO RUN	R
FAIL TO START	S
RUPTURE	T
OTHER CRITICAL FAULTS	X
LEAKAGE/EXTERNAL LEAK	Y
DROPPED/UNCOUPLED/OVERTRAVELED ROD	1
FAIL TO INSERT	2
IMPROPER MOVEMENT	3
CONTROL ROD FAILURE	4
OVERHEATED	5
LEAKAGE (SHELL)	6
LEAKAGE (TUBE)	7
INTERNAL LEAK	8

Generic failure modes as proposed in the IAEA Generic Data Base are one of a number of possible ways of defining them. It is, therefore, not unique and it would be indeed possible to define them in other ways.

Appendix 3

COMPONENT GROUPS IN THE IAEA DATA BASE

This Appendix provides a listing of component groups and associated codes. The main listing include all component groups found in the IAEA Data Base. There are also separate listing for mechanical, electrical, instrumentation and control and emergency power sources categories.

****

RELIABILITY DATA BASE

Listing of components groups and codes

****

QA	air cooler
UN	annunciator
BT	battery
BC	battery charger
QB	blower fan
CB	bus
CC	cable
KA	circut breaker
KG	circut breaker generator
KC	circut breaker molded type
JE	clutch
QC	compressor
NK	computational module
OC	control rod
OD	control rod and drive mechanism
OR	control rod drive
UC	controler
EC	converter
QD	damper
DE	diesel engine
DG	diesel generator emergency AC
QF	fan cooler containment
KS	feeder(ABZWEIG)
YF	filter
KT	fuse
DT	gas turbine driven generator emergency AC
FY	gasket
EG	generator
HX	heat exchanger
JH	heater
EH	heater electric
QV	hvac unit annulus ventilation
UI	indicating instrument
IA	instrumentation
IC	instrumentation channel analog
ID	instrumentation channel digital
YT	intake screen
EI	inverter
JL	lube oil cooler
UM	manual control device
MA	motor
MS	motor servo
MG	motor generator
FX	orifice
EB	panelboard
JP	penetration
FE	piping expansion joint
FN	piping nozzle
FR	piping rupture diaphragm
FS	piping straight section
FT	piping tees
FW	piping welds
EP	power supply
PD	pump diesel driven
PM	pump motor driven
PT	pump turbine driven
PW	pump without driver
AR	radiation monitors
UR	reactor scram system
ER	rectifier
RW	relay
RA	relay auxiliary
RC	relay control
RP	relay power
RR	relay protective
RT	relay time delay
RY	relay coil
RX	relay contacts
AC	sensor core flux
AF	sensor flow
AL	sensor level
AP	sensor pressure
AT	sensor temperature
NS	signal conditioning system
NM	signal modifier
UE	solid state devices
YS	strainer
SD	switch digital chanel
SF	switch flow
SL	switch level
SI	switch limit
SM	switch manual
SP	switch pressure
ST	switch temperature
SQ	switch torque
SC	switch contacts
JT	tank
TA	transformer
TT	transformer auto
TI	transformer instrument
TM	transformer main power generator or unit
TV	transformer regulating
TE	transformer station service including excitation
TX	transformer station start and auxiliary
TU	transformer substation
LF	transmitter flow
LA	transmitter flow, level, pressure
LL	transmitter level
LP	transmitter pressure
LT	transmitter temperature
JU	turbine
VA	valve air operated
VE	valve explosive operated
VH	valve hydraulic operated
VX	valve manual
VM	valve motor operated
VP	valve piston operated
VC	valve self operated
VD	valve solenoid operated
VW	valve without operator
CW	wire

****

RELIABILITY DATA BASE

Mechanical components groups and codes

****

QA	air cooler
QB	blower fan
JE	clutch
QC	compressor
OC	control rod
OD	control rod and drive mechanism
OR	control rod drive
QD	damper
QF	fan cooler containment
YF	filter
FY	gasket
HX	heat exchanger
JH	heater
QV	hvac unit annulus ventilation
YT	intake screen
JL	lube oil cooler
FX	orifice
JP	penetration
FE	piping expansion joint
FN	piping nozzle
FR	piping rupture diaphragm
FS	piping straight section
FT	piping tees
FW	piping welds
PD	pump diesel driven
PM	pump motor driven
PT	pump turbine driven
PW	pump without driver
YS	strainer
JT	tank
JU	turbine
VA	valve air operated
VE	valve explosive operated
VH	valve hydraulic operated
VX	valve manual
VM	valve motor operated
VP	valve piston operated
VC	valve self operated
VD	valve solenoid operated
VW	valve without operator

****

RELIABILITY DATA BASE

Electrical components groups and codes

****

BT	battery
BC	battery charger
CB	bus
CC	cable
KA	circut breaker
KG	circut breaker generator
KC	circut breaker molded type
EC	converter
KS	feeder(ABZWEIG)
KT	fuse
EG	generator
EH	heater electric
EI	inverter
MA	motor
MS	motor servo
MG	motor generator
EB	panelboard
EP	power supply
ER	rectifier
RW	relay
RA	relay auxiliary
RC	relay control
RP	relay power
RR	relay protective
RT	relay time delay
RY	relay coil
RX	relay contacts
TA	transformer
TT	transformer auto
TI	transformer instrument
TM	transformer main power generator or unit
TV	transformer regulating
TE	transformer station service including excitation
TX	transformer station start and auxiliary
TU	transformer substation
CW	wire

****

RELIABILITY DATA BASE

Instrumentation and control equipment groups and codes

****

UN	annunciator
NK	computational module
UC	controler
UI	indicating instrument
UM	manual control device
AR	radiation monitors
UR	reactor scram system
AC	sensor core flux
AF	sensor flow
AL	sensor level
AP	sensor pressure
AT	sensor temperature
NS	signal conditioning system
NM	signal modifier
UE	solid state devices
SD	switch digital chanel
SF	switch flow
SL	switch level
SI	switch limit
SM	switch manual
SP	switch pressure
ST	switch temperature
SQ	switch torque
SC	switch contacts
LF	transmitter flow
LA	transmitter flow, level, pressure
LL	transmitter level
LP	transmitter pressure
LT	transmitter temperature

****

RELIABILITY DATA BASE

Emergency power sources groups and codes

****

DE	diesel engine
DG	diesel generator emergency AC
DT	gas turbine driven generator emergency AC

Appendix 4

COMPONENT TYPES IN THE IAEA DATE BASE

This Appendix provides a listing of all component types and the associated three character code found in the IAEA Data Base. As in the Appendix 3, a main list and separate listings of mechanical, electrical, instrumentation and control and emergency power sources categories is given.

****

RELIABILITY DATA BASE

Listing of components types and codes

****

QAA	air cooler
UNA	annunciator
UNS	annunciator module solid state
BTA	battery
BTV	battery 125 V
BTL	battery lead acid
BTN	battery nickel cadmium
BTW	battery (power system) wet cell
BCA	battery charger
BC1	battery charger 120 V
BCR	battery charger rectifier
BCS	battery charger solid state
QBF	blower fan
QBV	blower ventilator air circulating fan
CBA	bus
CB5	bus <= 500V
CB2	bus 120 V AC , 220 V AC
CB1	bus 120 V DC
CB3	bus 380 V
CB6	bus 6 kV
CBD	bus DC
CBB	bus bare outdoor switchgear
CBH	bus high voltage,indoor voltage >= 4 kV
CBI	bus insulated switchgear bus 601-15 kV
CBL	bus low voltage indoor voltage <= 600 V
CBM	bus metal entclosed
CCC	cable control copper conductors
CCP	cable power
CCS	cable signal (supervisory)
KAA	circut breaker
KA4	circut breaker 4.16 kV
KA6	circut breaker 6 kV
KAL	circut breaker 600 V
KAM	circut breaker Voltage between 6 and 10 kV
KDC	circut breaker DC
KBF	circut breaker bus feed breaker AC
KFT	circut breaker fixed type including molden case
KGB	circut breaker generator Manufactured by BBC
KAH	circut breaker high power (leistungschalter)
KIA	circut breaker indoor AC application
KID	circut breaker indoor DC application
KIS	circut breaker isolation
KMT	circut breaker metal clad
KCT	circut breaker molded type
KM3	circut breaker motor operated 380 V
KOA	circut breaker outdoor AC application
KRP	circut breaker reactor protection
JEM	cluch mechanical
JEE	clutch electrical
QCM	compressor MSIV air compressor
QCC	compressor containemnt air control
QCI	compressor instrument air
QCP	compressor pumpback (annulus ventilation)
NKA	computational module
OCS	control rod clustered silver, indium, cadmium control rods
OCC	control rod cruciform, boron carbide control rods
OCB	control rod BWR application
OCK	control rod KWU PWR type
OCR	control rod single control rod assembly
ODB	control rod and drive mechanism BWR-s
ODE	control rod and drive mechanism PWR-s
ORA	control rod drive
ORL	control rod drive lead screw roller nut drive mechanism
ORM	control rod drive BWR appliaction mechanical insertion function
ORH	control rod drive BWR application hydraulic scram function
UCA	controler
UCE	controler electronic
UCP	controler pneumatic
ECE	converter E/S
ECS	converter square root
QDA	damper
QDP	damper Automatic backdraft, paralel blade
QDO	damper Modulating, opposed blade, 36X48 inches
QDT	damper shut off, two position paralel blade
QDC	damper containment fan coolers system

QDM	damper manual (HVAC)
DEA	diesel engine
DEI	diesel engine No.2 fuel oil, 4 stroke, in-line
DEV	diesel engine no.2 fuel oil,4 stroke, V block
DGA	diesel generator emergency AC
DG4	diesel generator emergency AC 4160 V AC
QFV	fan containment ventilation Yan
QFC	fan cooler containment
QFH	fan cooler reactor building cooling units
KSF	feeder(ABZWEIG)
YFM	filter liquid, mechanical restriction
UCF	flow controler
KTA	fuse all voltage levels
DTG	gas turbine driven generator emergency AC
FYA	gasket
EGS	generator AC steam turbine driven
EGD	generator DC
HXA	heat exchanger
HXR	heat exchanger residual heat removal HX
HXS	heat exchanger secondary component cooling HX
HXH	heat exchanger U tube horisontal shell and tube
HXD	heat exchanger U tube shell and tube plus steam drum
HXV	heat exchanger U tube veritcal shell and tube
HXC	heat exchanger helical coil
HXB	heat exchanger straight tube horizontal shell and tube
HXZ	heat exchanger straight tube radiator type
HXM	heat exchanger straight tube vertical shell and tube
EHT	heat tracing pipe heater
EHA	heater air heater
JHF	heater feedwater
EHP	heater pressurizer heater
QVA	hvac unit annulus ventilation
QVX	hvac unit auxiliary building
QVB	hvac unit battery room ventilation
QVC	hvac unit cable spreading room
QVR	hvac unit control room ventilation
QVE	hvac unit electric eqiupment area ventilation
QVI	hvac unit intermediate building
UIE	indicating instrument electronic
IAA	instrumentation
ICC	instrumentation channel analog core flux
ICF	instrumentation channel analog flow
ICL	instrumentation channel analog level
ICP	instrumentation channel analog pressure
ICT	instrumentation channel analog temperature
IDL	instrumentation channel digital level
IDP	instrumentation channel digital pressure
YTS	intake screen service water system
EIA	inverter
EII	inverter instrument
EIS	inverter solid state 120 volts AC
EIZ	inverter static single phase
EIX	inverter static three phase
UEY	isolating diode assembly
JLC	lube oil cooler
UMC	manual control device pushbutton
MAA	motor
MPH	motor HP emergency coolant injection pump motor
MPL	motor LP emergency coolant injection pump motor
MPS	motor LP service water pump motor
MPF	motor auxiliary boiler feed pump motor
MPC	motor circulating water pump motor
MPE	motor condensate extraction pump motor
MPZ	motor emergency service water pump motor
MPX	motor end shield tank cooling pump motor
MPB	motor generator main lube oil pump motor
MPM	motor main moderator pump motor
MPQ	motor powerhouse upper level service water pump motor
MPP	motor primary heat transport feed circut pump motor
MPV	motor primary heat transport pump motor
MPW	motor shutdown cooling water pump motor
MAC	motor AC
MAI	motor AC induction
MAS	motor AC split phase
MAW	motor AC synchronous single phase
MPK	motor boiler feed pump
MSS	motor servo
MGX	motor generator
MGA	motor generator AC 220 V
MGD	motor generator D-C
MGR	motor generator D-C rotating converter
FXA	orifice

FXT	orifice, test valve, flow meter
EB1	panelboard 120 V AC
JPE	penetration electrical
JPP	penetration piping
FSS	pipe (nuclear grade) straight section diameter size less than 1 inch
FS3	piping <= 3" diameter
FSM	piping > 3" diameter
FE5	piping elbow 4-6 inches
FEA	piping expansion joint
FE3	piping expansion joint 3 " 400 PSI corrugated steel
FNA	piping nozzle
FNS	piping nozzle spray
FRL	piping rupture diaphragm 10-16 inches
FSA	piping straight section
FTA	piping tees
FTL	piping thermowell 6-10 inches
FWS	piping welds less than 4" conecting weld
EPA	power supply
PWW	pump
PWA	pump auxiliary boiler feed pump
PWC	pump centrifugal
PWD	pump centrifugal horisontal flow 22-820 l/s
PWB	pump centrifugal horizontal flow 22-820 l/s
PWE	pump centrifugal vertical flow 70-1900 l/s
PWF	pump condensate extraction pump
PWP	pump positive displacement
PDA	pump diesel driven
PDC	pump diesel driven containment spray pump
PMA	pump motor driven
PMX	pump motor driven auxiliary feedwater pump
PMD	pump motor driven centrifugal horisontal flow rate 130-200 kg/s;head .7 MPa
PMO	pump motor driven centrifugal horisontal and vertical flow rate 30 kg/s; head 2.2-6.7 MPa
PMM	pump motor driven centrifugal horisontal and vertical flow rate 75-250 kg/s; head .3-.9 MPa
PMN	pump motor driven centrifugal horizontal flow rate: 40-60kg/s; head .5-.7MPa
PMP	pump motor driven centrifugal reactor coolant pump flow rate 1036-2347 kg/s; head .3-.4 MPa
PMW	pump motor driven centrifugal wet flow rate 75-150 kg/s; head 1.3-1.8 MPa
PMQ	pump motor driven centrifugal,horisontal and vertical flow rate 120-240 kg/s;head 1.2-1.8 MPa
PMH	pump motor driven charging/high pressure injection
PME	pump motor driven component cooling
PMC	pump motor driven containment spray
PMG	pump motor driven electrical equipment area ventilation cooling pump

PMF	pump motor driven emergency feedwater pump
PMV	pump motor driven high pressure injection
PMI	pump motor driven high pressure(> 20 bar) applicable to HHSI,CVCS and auxiliary feedwater pumps
PMZ	pump motor driven include CCW,SW,RHR,boric acid transfer,boron injection recirc.
PMT	pump motor driven include containment spray,standby liquid control
PMJ	pump motor driven includes reactor coolant,reactor recirculating,CW,feedwater,cond.
PUL	pump motor driven low pressure <20 bar applicable to ESWS, CCWS,LHSI/RHR, CSS, boric acid transfer pumps
PML	pump motor driven low pressure injection
PUM	pump motor driven main feed pumps
PUR	pump motor driven main steam relief hydraulic pump
PUE	pump motor driven primary component cooling water pump
PUB	pump motor driven primary service water booster pump
PUK	pump motor driven primary service water pump
PUP	pump motor driven reciprocating(positive displacement) flow rate 2.5-3.9kg/s; head 8.7 MPa;
PUZ	pump motor driven recirculation pump
PUW	pump motor driven residual heat removal pump
PMS	pump motor driven safety injection pump
PUS	pump motor driven screw flow rate 550 kg/s; head 0.3 MPa
PUF	pump motor driven secondary component cooling water
PMK	pump motor driven secondary service water
PUC	pump motor driven service water pump used in charging pump cooling system
PUV	pump motor driven well water pump
PTA	pump turbine driven
PTF	pump turbine driven auxiliary feedwater
PTC	pump turbine driven centrifugal pump flow rate 240 kg/s; head 1.8 MPa
PTX	pump turbine driven emergency feedwater pump
PTS	pump turbine driven high pressure > 20 bar include CVCS,emergency charging system,aux.feedwater pumps
ARB	radiation monitors BWR main steam line
URS	reactor scram system
ERE	rectifier excitation rectifier over 600 V
ERP	rectifier precipitator rectifier over 600 V
ERS	rectifier static
RWA	relay
RAA	relay auxiliary
RCL	relay control
RCA	relay control AC
RCD	relay control DC
RCE	relay control electromechanical
RPH	relay power 300-460 A
RPL	relay power 40-60 A

RRA	relay protective
RRO	relay protective overload protection
RRS	relay protective switchgear protection
RRV	relay protective voltage protection
RTA	relay time delay
RTB	relay time delay bimetallic
RTP	relay time delay pneumatic
RTS	relay time delay solid state
RYA	relay coil
RXA	relay contacts
ACA	sensor core flux
AFA	sensor flow
ALA	sensor level
ALR	sensor level reactor water level
APA	sensor pressure
APR	sensor pressure reactor and containment sensor
APD	sensor pressure difference
ATA	sensor temperature
NCA	signal comparator bistable
NSA	signal conditioning system for core flux,level,flow,pressure,temperature general
NMA	signal modifier
NMT	signal modifier current-current transducer
NMP	signal modifier current-pneumatic transducer
NMV	signal modifier current-voltage transducer
NMS	signal modifier square root extractor
NMO	signal modifier voltage-pneumatic transducer
UEH	solid state devices high power application
UEL	solid state devices low power application
ECM	static converter for reactor main coolant pumps
YSD	strainer service water (charging pump cooling system) duplex
YSF	strainer/filter
SDA	switch digital chanel pressure/vacuum, pressure,level
SFA	switch flow
SLA	switch level
SIA	switch limit
SIE	switch limit electronic
SMA	switch manual
SPA	switch pressure
STA	switch temperature
SQA	switch torque

SCC	switch contacts
JTF	tank storage FWST
JTR	tank storage RWST
EBA	terminal board
TAA	transformer
TA2	transformer 220/120 V
TA5	transformer 50/6 kV
TA6	transformer 6kV/380 V
TA8	transformer 8 kV / 6 kV
TAD	transformer dry 4 kV/600 V
TAE	transformer dry 600 V/208 V
TTS	transformer auto liquid filled, single phase
TTT	transformer auto liquid filled, three phase
TIP	transformer instrument potential
TIC	transformer instrument transformer current transformer
TSA	transformer main power generator or unit liquid filled, single phase
TS4	transformer main power generator or unit liquid filled, single phase 146-242 kV
TS2	transformer main power generator or unit liquid filled, single phase 2-30 kV
TMA	transformer main power generator or unit liquid filled, three phase
TM2	transformer main power generator or unit liquid filled, three phase 2-30 kV
TM5	transformer main power generator or unit liquid filled, three phase 347-550 kV
TM4	transformer main power generator or unit liquid filled, three phase 46-242 kV
TS5	transformer main power generator or unit transformer liquid filled, single phase 347-550 kV
TVR	transformer regulating 120 V AC
TET	transformer station service including excitation dry type, three phase
TES	transformer station service including excitation dry type,single phase all voltage levels
TEG	transformer station service including excitation liquid filled, single phase <=40 kV
TEH	transformer station service including excitation liquid filled, three phase <=-40 kV
TXA	transformer station start and auxiliary Voltage levels: 130/6 kV, 70/6 kV, 20/6 kV
TUS	transformer substation liquid filled, single phase
TUT	transformer substation liquid filled, three phase
LFF	transmitter flow
LAD	transmitter flow, level, pressure
LLL	transmitter level
LPP	transmitter pressure
LXR	transmitter presure difference
LTT	transmitter temperature
JUC	turbine combustion
JUP	turbine steam driven
JUS	turbine steam driven condensing, single stage, 500-999 HP

JUN	turbine steam driven non condensing 1000-5000 HP
JUM	turbine steam driven non condensing, multi stage, less than 500 HP
JUH	turbine turbine/HPCI assembly
VWO	valve ADS depressurization valve
VWA	valve angle valve
VWB	valve ball valve
VWT	valve butterfly valve
VWD	valve condenser steam discharge valve
VWP	valve diaphragm
VWF	valve flow control 1/2 inch, air fixed flow
VWG	valve gate
VWL	valve globe valve
VWE	valve high pressure shifting valve (steam dump)
VWN	valve needle valve
VWU	valve nozzle valve
VWJ	valve plug valve
VWX	valve pressure regulating
VWZ	valve pressure regulating 2-6 inches
VRB	valve primary relief valve BWR
VRA	valve relief
VRM	valve relief main steam atmosferic relief valve
VR6	valve relief & safety diameter between 2 and 6 inches
VR8	valve relief & safety diameter larger than 6 inches
VR2	valve relief & safety diameter less than 2 inches
VSA	valve safety
VWV	valve vent 3/4 inch, float operated,tank vent
VA1	valve air operated
VAR	valve air operated all systems except raw water return line
VAP	valve air operated purge isolation
VAQ	valve air operated raw water return line
VAZ	valve air operated turbine stop valve
VAI	valve air operated vent isolation
VAE	valve air operated PWR + BWR (ESF systems valves only)
VAT	valve air operated butterfly diameter larger than 24 inches
VAB	valve air operated general (BWR application)
VAW	valve air operated general (PWR application)
VAK	valve air operated globe diameter between 2 and 6 inches
VAL	valve air operated globe diameter less than 2 inches
VWH	valve air operated turbine governor valve
VWW	valve composite by design
VEA	valve explosive operated

VHA	valve hydraulic operated
VXA	valve manual
VXE	valve manual PWR + BWR (ESF systems valves only)
VXT	valve manual butterfly all systems except HVAC
VXG	valve manual gate diameter between 12 and 24 inches
VXH	valve manual gate diameter between 2 and 6 inches
VXI	valve manual gate diameter between 6 and 12 inches
VXS	valve manual gate diameter less than 2 inches
VMA	valve motor operated
VMC	valve motor operated Chemical and volume control system valves
VMB	valve motor operated all except condenser circulating water
VMJ	valve motor operated all except for use in CVCS and CCS systems
VMD	valve motor operated condenser circulating water valves
VME	valve motor operated containment spray system valves
VMI	valve motor operated main steam isolation valve
VM1	valve motor operated BWR (ESF systems valves only)
VMM	valve motor operated MSIV (FD-Schnellschlusschieber) gate
VMH	valve motor operated PWR (ESF system valves only)
VMS	valve motor operated butterfly diameter between 12 and 24 inches
VMU	valve motor operated butterfly diameter between 2 and 6 inches
VMT	valve motor operated butterfly diameter between 6 and 12 inches
VMF	valve motor operated control v
VMG	valve motor operated gate diameter between 12 and 24 inches
VML	valve motor operated globe diameter between 2 and 6 inches
VMO	valve motor operated isolation valve pipe dimension 100< DN < 200 mm
VMN	valve motor operated isolation valve pipe dimension > 200mm
VMK	valve motor operated isolation valve pipe dimension<=100 mm
VMR	valve motor operated regualting
VSO	valve pilot valve operated safety valve (pressurizer or main steam line) with one pilot valve
VST	valve pilot valve operated safety valve (pressurizer or main steam line) with two or three pilot valves
VPA	valve piston operated
VPT	valve piston operated butterfly used in HVAC
VAG	valve pneumatic operated isolation hydraulic scram system valve,pipe dimension <100 mm
VAH	valve pneumatic operated isolation pipe dimension <=100mm
VPR	valve power operated relief PORV
VWC	valve remote operated PORV block valve
VCA	valve self operated check
VCE	valve self operated check ECCS & RHR systems
VCF	valve self operated check ESF systems valves
VCS	valve self operated check diameter betweeen 2 nad 6 inches

VCL	valve self operated check diameter between 12 and 24 inches
VCT	valve self operated check diameter between 6 and 12 inches
VCH	valve self operated check diameter larger than 24 inches
VCB	valve self operated check diameter less than 2 inches
VCM	valve self operated check main steam check valve
VCJ	valve self operated check pipe dimension > 100mm
VWI	valve self operated check pipe dimension 500mm, 600 mm (main steam system)
VCI	valve self operated check pipe dimension <=100 mm
VCW	valve self operated check swing
VCN	valve self operated check testable
VCZ	valve self operated check tilting disc
VSC	valve self operated code safety valve
VWK	valve self operated pilot valve
VSD	valve self operated pressurizer safety valve short inlet piping
VSB	valve self operated primary safety valve
VSM	valve self operated safety main steam
VSP	valve self operated safety valves PWR
VVA	valve self operated vacuum valve
VCU	valve self operated (motor operated) stop check
VSR	valve self operated (pilot operated) safety valve (pressure relief system) pipe dimensions 125,150,300 mm
VRR	valve self operated (pilot or power operated) pressurizer relief
VWM	valve self operated, motor operated (redundant closure) stop chech pipe dimension 500mm, 600mm (main steam system valve)
VDA	valve solenoid operated
VDO	valve solenoid operated all systems, except HVAC
VDH	valve solenoid operated used in HVAC
CWA	wire
CWC	wire control circut typical circut, several joints

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RELIABILITY DATA BASE

Mechanical components types and codes

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QAA	air cooler
QBF	blower fan
QBV	blower ventilator air circulating fan
JEM	cluch mechanical
JEE	clutch electrical
QCM	compressor MSIV air compressor
QCC	compressor containemnt air control
QCI	compressor instrument air
QCP	compressor pumpback (annulus ventilation)
OCS	control rod clustered silver, indium, cadmium control rods
OCC	control rod cruciform, boron carbide control rods
OCB	control rod BWR application
OCK	control rod KWU PWR type
OCR	control rod single control rod assembly
ODB	control rod and drive mechanism BWR-s
ODE	control rod and drive mechanism PWR-s
ORA	control rod drive
ORL	control rod drive lead screw roller nut drive mechanism
ORM	control rod drive BWR appliaction mechanical insertion function
ORH	control rod drive BWR application hydraulic scram function
QDA	damper
QDP	damper Automatic backdraft, paralel blade
QDO	damper Modulating, opposed blade, 36X48 inches
QDT	damper shut off, two position paralel blade
QDC	damper containment fan coolers system
QDM	damper manual (HVAC)
QFV	fan containment ventilation Yan
QFC	fan cooler containment
QFH	fan cooler reactor building cooling units
YFM	filter liquid, mechanical restriction
FYA	gasket
HXA	heat exchanger
HXR	heat exchanger residual heat removal HX
HXS	heat exchanger secondary component cooling HX
HXH	heat exchanger U tube horisontal shell and tube
HXD	heat exchanger U tube shell and tube plus steam drum
HXV	heat exchanger U tube veritcal shell and tube
HXC	heat exchanger helical coil
HXB	heat exchanger straight tube horizontal shell and tube
HXZ	heat exchanger straight tube radiator type
HXM	heat exchanger straight tube vertical shell and tube
JHF	heater feedwater
QVA	hvac unit annulus ventilation
QVX	hvac unit auxiliary building
QVB	hvac unit battery room ventilation
QVC	hvac unit cable spreading room
QVR	hvac unit control room ventilation
QVE	hvac unit electric eqiupment area ventilation
QVI	hvac unit intermediate building
YTS	intake screen service water system
JLC	lube oil cooler
FXA	orifice
FXT	orifice, test valve, flow meter
JPE	penetration electrical
JPP	penetration piping
FSS	pipe (nuclear grade) straight section diameter size less than 1 inch
FS3	piping <= 3" diameter
FSM	piping > 3" diameter
FE5	piping elbow 4-6 inches
FEA	piping expansion joint
FE3	piping expansion joint 3 " 400 PSI corrugated steel
FNA	piping nozzle
FNS	piping nozzle spray
FRL	piping rupture diaphragm 10-16 inches
FSA	piping straight section
FTA	piping tees
FTL	piping thermowell 6-10 inches
FWS	piping welds less than 4" conecting weld
PWW	pump
PWA	pump auxiliary boiler feed pump
PWC	pump centrifugal
PWD	pump centrifugal horisontal flow 22-820 l/s
PWB	pump centrifugal horizontal flow 22-820 l/s
PWE	pump centrifugal vertical flow 70-1900 l/s
PWF	pump condensate extraction pump

PWP	pump positive displacement
PDA	pump diesel driven
PDC	pump diesel driven containment spray pump
PMA	pump motor driven
PMX	pump motor driven auxiliary feedwater pump
PMD	pump motor driven centrifugal horisontal flow rate 130-200 kg/s;head .7 MPa
PMO	pump motor driven centrifugal horisontal and vertical flow rate 30 kg/s; head 2.2-6.7 MPa
PMM	pump motor driven centrifugal horisontal and vertical flow rate 75-250 kg/s; head .3-.9 MPa
PMN	pump motor driven centrifugal horizontal flow rate: 40-60kg/s; head .5-.7MPa
PMP	pump motor driven centrifugal reactor coolant pump flow rate 1036-2347 kg/s; head .3-.4 MPa
PMW	pump motor driven centrifugal wet flow rate 75-150 kg/s; head 1.3-1.8 MPa
PMQ	pump motor driven centrifugal,horisontal and vertical flow rate 120-240 kg/s;head 1.2-1.8 MPa
PMH	pump motor driven charging/high pressure injection
PME	pump motor driven component cooling
PMC	pump motor driven containment spray
PMG	pump motor driven electrical equipment area ventilation cooling pump
PMF	pump motor driven emergency feedwater pump
PMV	pump motor driven high pressure injection
PMI	pump motor driven high pressure(> 20 bar) applicable to HHSI,CVCS and auxiliary feedwater pumps
PMZ	pump motor driven include CCW,SW,RHR,boric acid transfer,boron injection recirc.
PMT	pump motor driven include containment spray,standby liquid control
PMJ	pump motor driven includes reactor coolant,reactor recirculating,CW,feedwater,cond.
PUL	pump motor driven low pressure <20 bar applicable to ESWS, CCWS,LHSI/RHR, CSS, boric acid transfer pumps
PML	pump motor driven low pressure injection
PUM	pump motor driven main feed pumps
PUR	pump motor driven main steam relief hydraulic pump
PUE	pump motor driven primary component cooling water pump
PUB	pump motor driven primary service water booster pump
PUK	pump motor driven primary service water pump
PUP	pump motor driven reciprocating(positive displacement) flow rate 2.5-3.9kg/s; head 8.7 MPa;
PUZ	pump motor driven recirculation pump
PUW	pump motor driven residual heat removal pump
PMS	pump motor driven safety injection pump
PUS	pump motor driven screw flow rate 550 kg/s; head 0.3 MPa
PUF	pump motor driven secondary component cooling water
PMK	pump motor driven secondary service water
PUC	pump motor driven service water pump used in charging pump cooling system
PUV	pump motor driven well water pump
PTA	pump turbine driven
PTF	pump turbine driven auxiliary feedwater
PTC	pump turbine driven centrifugal pump flow rate 240 kg/s; head 1.8 MPa

PTX	pump turbine driven emergency feedwater pump
PTS	pump turbine driven high pressure > 20 bar include CVCS,emergency charging system,aux.feedwater pumps
YSD	strainer service water (charging pump cooling system) duplex
YSF	strainer/filter
JTF	tank storage FWST
JTR	tank storage RWST
JUC	turbine combustion
JUP	turbine steam driven
JUS	turbine steam driven condensing, single stage, 500-999 HP
JUN	turbine steam driven non condensing 1000-5000 HP
JUM	turbine steam driven non condensing, multi stage, less than 500 HP
JUH	turbine turbine/HPCI assembly
VWO	valve ADS depressurization valve
VWA	valve angle valve
VWB	valve ball valve
VWT	valve butterfly valve
VWD	valve condenser steam discharge valve
VWP	valve diaphragm
VWF	valve flow control 1/2 inch, air fixed flow
VWG	valve gate
VWL	valve globe valve
VWE	valve high pressure shifting valve (steam dump)
VWN	valve needle valve
VWU	valve nozzle valve
VWJ	valve plug valve
VWX	valve pressure regulating
VWZ	valve pressure regulating 2-6 inches
VRB	valve primary relief valve BWR
VRA	valve relief
VRM	valve relief main steam atmosferic relief valve
VR6	valve relief & safety diameter between 2 and 6 inches
VR8	valve relief & safety diameter larger than 6 inches
VR2	valve relief & safety diameter less than 2 inches
VSA	valve safety
VWV	valve vent 3/4 inch, float operated,tank vent
VA1	valve air operated
VAR	valve air operated all systems except raw water return line
VAP	valve air operated purge isolation
VAQ	valve air operated raw water return line
VAZ	valve air operated turbine stop valve

VAI	valve air operated vent isolation
VAE	valve air operated PWR + BWR (ESF systems valves only)
VAT	valve air operated butterfly diameter larger than 24 inches
VAB	valve air operated general (BWR application)
VAW	valve air operated general (PWR application)
VAK	valve air operated globe diameter between 2 and 6 inches
VAL	valve air operated globe diameter less than 2 inches
VWH	valve air operated turbine governor valve
VWW	valve composite by design
VEA	valve explosive operated
VHA	valve hydraulic operated
VXA	valve manual
VXE	valve manual PWR + BWR (ESF systems valves only)
VXT	valve manual butterfly all systems except HVAC
VXG	valve manual gate diameter between 12 and 24 inches
VXH	valve manual gate diameter between 2 and 6 inches
VXI	valve manual gate diameter between 6 and 12 inches
VXS	valve manual gate diameter less than 2 inches
VMA	valve motor operated
VMC	valve motor operated Chemical and volume control system valves
VMB	valve motor operated all except condenser circulating water
VMJ	valve motor operated all except for use in CVCS and CCS systems
VMD	valve motor operated condenser circulating water valves
VME	valve motor operated containment spray system valves
VMI	valve motor operated main steam isolation valve
VM1	valve motor operated BWR (ESF systems valves only)
VMM	valve motor operated MSIV (FD-Schnellschlusschieber) gate
VMH	valve motor operated PWR (ESF system valves only)
VMS	valve motor operated butterfly diameter between 12 and 24 inches
VMU	valve motor operated butterfly diameter between 2 and 6 inches
VMT	valve motor operated butterfly diameter between 6 and 12 inches
VMF	valve motor operated control v
VMG	valve motor operated gate diameter between 12 and 24 inches
VML	valve motor operated globe diameter between 2 and 6 inches
VMO	valve motor operated isolation valve pipe dimension 100< DN < 200 mm
VMN	valve motor operated isolation valve pipe dimension > 200mm
VMK	valve motor operated isolation valve pipe dimension<=100 mm
VMR	valve motor operated regualting
VSO	valve pilot valve operated safety valve (pressurizer or main steam line) with one pilot valve
VST	valve pilot valve operated safety valve (pressurizer or main steam line) with two or three pilot valves

VPA	valve piston operated
VPT	valve piston operated butterfly used in HVAC
VAG	valve pneumatic operated isolation hydraulic scram system valve,pipe dimension <100 mm
VAH	valve pneumatic operated isolation pipe dimension <=100mm
VPR	valve power operated relief PORV
VWC	valve remote operated PORV block valve
VCA	valve self operated check
VCE	valve self operated check ECCS & RHR systems
VCF	valve self operated check ESF systems valves
VCS	valve self operated check diameter betweeen 2 nad 6 inches
VCL	valve self operated check diameter between 12 and 24 inches
VCT	valve self operated check diameter between 6 and 12 inches
VCH	valve self operated check diameter larger than 24 inches
VCB	valve self operated check diameter less than 2 inches
VCM	valve self operated check main steam check valve
VCJ	valve self operated check pipe dimension > 100mm
VWI	valve self operated check pipe dimension 500mm, 600 mm (main steam system)
VCI	valve self operated check pipe dimension <=100 mm
VCW	valve self operated check swing
VCN	valve self operated check testable
VCZ	valve self operated check tilting disc
VSC	valve self operated code safety valve
VWK	valve self operated pilot valve
VSD	valve self operated pressurizer safety valve short inlet piping
VSB	valve self operated primary safety valve
VSM	valve self operated safety main steam
VSP	valve self operated safety valves PWR
VVA	valve self operated vacuum valve
VCU	valve self operated (motor operated) stop check
VSR	valve self operated (pilot operated) safety valve (pressure relief system) pipe dimensions 125,150,300 mm
VRR	valve self operated (pilot or power operated) pressurizer relief
VWM	valve self operated, motor operated (redundant closure) stop chech pipe dimension 500mm, 600mm (main steam system valve)
VDA	valve solenoid operated
VDO	valve solenoid operated all systems, except HVAC
VDH	valve solenoid operated used in HVAC

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RELIABILITY DATA BASE

Electrical components types and codes

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BTA	battery
BTV	battery 125 V
BTL	battery lead acid
BTN	battery nickel cadmium
BTW	battery (power system) wet cell
BCA	battery charger
BC1	battery charger 120 V
BCR	battery charger rectifier
BCS	battery charger solid state
CBA	bus
CB5	bus <= 500V
CB2	bus 120 V AC , 220 V AC
CB1	bus 120 V DC
CB3	bus 380 V
CB6	bus 6 kV
CBD	bus DC
CBB	bus bare outdoor switchgear
CBH	bus high voltage,indoor voltage >= 4 kV
CBI	bus insulated switchgear bus 601-15 kV
CBL	bus low voltage indoor voltage <= 600 V
CBM	bus metal entclosed
CCC	cable control copper conductors
CCP	cable power
CCS	cable signal (supervisory)
KAA	circut breaker
KA4	circut breaker 4.16 kV
KA6	circut breaker 6 kV
KAL	circut breaker 600 V
KAM	circut breaker Voltage between 6 and 10 kV
KDC	circut breaker DC
KBF	circut breaker bus feed breaker AC
KFT	circut breaker fixed type including molden case
KGB	circut breaker generator Manufactured by BBC
KAH	circut breaker high power (leistungschalter)
KIA	circut breaker indoor AC application
KID	circut breaker indoor DC application
KIS	circut breaker isolation
KMT	circut breaker metal clad
KCT	circut breaker molded type
KM3	circut breaker motor operated 380 V
KOA	circut breaker outdoor AC application
KRP	circut breaker reactor protection
ECE	converter E/S
ECS	converter square root
KSF	feeder(ABZWEIG)
KTA	fuse all voltage levels
EGS	generator AC steam turbine driven
EGD	generator DC
EHT	heat tracing pipe heater
EHA	heater air heater
EHP	heater pressurizer heater
EIA	inverter
EII	inverter instrument
EIS	inverter solid state 120 volts AC
EIZ	inverter static single phase
EIX	inverter static three phase
MAA	motor
MPH	motor HP emergency coolant injection pump motor
MPL	motor LP emergency coolant injection pump motor
MPS	motor LP service water pump motor
MPF	motor auxiliary boiler feed pump motor
MPC	motor circulating water pump motor
MPE	motor condensate extraction pump motor
MPZ	motor emergency service water pump motor
MPX	motor end shield tank cooling pump motor
MPB	motor generator main lube oil pump motor
MPM	motor main moderator pump motor
MPQ	motor powerhouse upper level service water pump motor
MPP	motor primary heat transport feed circut pump motor
MPV	motor primary heat transport pump motor
MPW	motor shutdown cooling water pump motor
MAC	motor AC
MAI	motor AC induction
MAS	motor AC split phase

MAW	motor AC synchronous single phase
MPK	motor boiler feed pump
MSS	motor servo
MGX	motor generator
MGA	motor generator AC 220 V
MGD	motor generator D-C
MGR	motor generator D-C rotating converter
EB1	panelboard 120 V AC
EPA	power supply
ERE	rectifier excitation rectifier over 600 V
ERP	rectifier precipitator rectifier over 600 V
ERS	rectifier static
RWA	relay
RAA	relay auxiliary
RCL	relay control
RCA	relay control AC
RCD	relay control DC
RCE	relay control electromechanical
RPH	relay power 300-460 A
RPL	relay power 40-60 A
RRA	relay protective
RRO	relay protective overload protection
RRS	relay protective switchgear protection
RRV	relay protective voltage protection
RTA	relay time delay
RTB	relay time delay bimetallic
RTP	relay time delay pneumatic
RTS	relay time delay solid state
RYA	relay coil
RXA	relay contacts
ECM	static converter for reactor main coolant pumps
EBA	terminal board
TAA	transformer
TA2	transformer 220/120 V
TA5	transformer 50/6 kV
TA6	transformer 6kV/380 V
TA8	transformer 8 kV / 6 kV
TAD	transformer dry 4 kV/600 V
TAE	transformer dry 600 V/208 V
TTS	transformer auto liquid filled, single phase
TTT	transformer auto liquid filled, three phase
TIP	transformer instrument potential
TIC	transformer instrument transformer current transformer
TSA	transformer main power generator or unit liquid filled, single phase
TS4	transformer main power generator or unit liquid filled, single phase 146-242 kV
TS2	transformer main power generator or unit liquid filled, single phase 2-30 kV
TMA	transformer main power generator or unit liquid filled, three phase
TM2	transformer main power generator or unit liquid filled, three phase 2-30 kV
TM5	transformer main power generator or unit liquid filled, three phase 347-550 kV
TM4	transformer main power generator or unit liquid filled, three phase 46-242 kV
TS5	transformer main power generator or unit transformer liquid filled, single phase 347-550 kV
TVR	transformer regulating 120 V AC
TET	transformer station service including excitation dry type, three phase
TES	transformer station service including excitation dry type,single phase all voltage levels
TEG	transformer station service including excitation liquid filled, single phase <=40 kV
TEH	transformer station service including excitation liquid filled, three phase <=-40 kV
TXA	transformer station start and auxiliary Voltage levels: 130/6 kV, 70/6 kV, 20/6 kV
TUS	transformer substation liquid filled, single phase
TUT	transformer substation liquid filled, three phase
CWA	wire
CWC	wire control circut typical circut, several joints

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RELIABILITY DATA BASE

Instrumentation and control equipment types and codes

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UNA	annunciator
UNS	annunciator module solid state
NKA	computational module
UCA	controler
UCE	controler electronic
UCP	controler pneumatic
UCF	flow controler
UIE	indicating instrument electronic
UEY	isolating diode assembly
UMC	manual control device pushbutton
ARB	radiation monitors BWR main steam line
URS	reactor scram system
ACA	sensor core flux
AFA	sensor flow
ALA	sensor level
ALR	sensor level reactor water level
APA	sensor pressure
APR	sensor pressure reactor and containment sensor
APD	sensor pressure difference
ATA	sensor temperature
NCA	signal comparator bistable
NSA	signal conditioning system for core flux,level,flow,pressure,temperature general
NMA	signal modifier
NMT	signal modifier current-current transducer
NMP	signal modifier current-pneumatic transducer
NMV	signal modifier current-voltage transducer
NMS	signal modifier square root extractor
NMO	signal modifier voltage-pneumatic transducer
UEH	solid state devices high power application
UEL	solid state devices low power application
SDA	switch digital chanel pressure/vacuum, pressure,level
SFA	switch flow
SLA	switch level
SIA	switch limit
SIE	switch limit electronic
SMA	switch manual
SPA	switch pressure
STA	switch temperature
SQA	switch torque
SCC	switch contacts
LFF	transmitter flow
LAD	transmitter flow, level, pressure
LLL	transmitter level
LPP	transmitter pressure
LXR	transmitter presure difference
LTT	transmitter temperature

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RELIABILITY DATA BASE

Emergency power sources types and codes

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DEA	diesel engine
DEI	diesel engine No.2 fuel oil, 4 stroke, in-line
DEV	diesel engine no.2 fuel oil,4 stroke, V block
DGA	diesel generator emergency AC
DG4	diesel generator emergency AC 4160 V AC
DTG	gas turbine driven generator emergency AC

Appendix 5

COMPLETE LISTING OF THE IAEA DATA BASE

This Appendix provides complete listing of the IAEA Data Base. Records are listed in alphabetical order of component types.

Each record is listed in following format:

Record code Component type
Comp.boundary; Generic FM; Op. mode; Op.environment

Failure rate: Mid point; High; Low; Repair time; Error factor

Source; Ultimate source; Original FM
Comments

If some of the entries in the record are eather blank or indicated as not available (n/a), then they are deleted in the printout. For example, for 'UNSFE' (it is 'annunciator module solid state') only recommended value was available in the source. Since high and low bound, error factor and repair time are not available, single value with prefix 'rec' (abbreviation for recommended) is included in the printout.

QAAFB air cooler
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 6.0E-6/hr max: 4.0E-5/hr min: 3.0E-6/hr
Source: NUREG 2815 (table C.1.) Ultimate source: experts judgement and IREP data
Comment:

QAAFI air cooler
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 1.0E-5/hr ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: Not consensus data. ANO-1 IREP study plant specific

UNAFE annunciator general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail to operate on demand
FAILURE RATE OR PROBABILITY rec : 7.8E-7/hr high: 1.5E-5/hr low: 3.0E-8/hr REPAIR TIME: .2 hours
Source: IEEE 500 (1984) pg.41 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite of different kinds of annunciators and different sources including non-nuclear.
Principal reference:IEEE 500 (1977)

UNAKE annunciator general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: operates spourious or false response
FAILURE RATE OR PROBABILITY rec : 5.6E-7/hr high: 1.1E-5/hr low: 2.0E-8/hr REPAIR TIME: .2 hours
Source: IEEE 500 (1984) pg.41 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is coomposite value of different kinds of annunciators and different sources including non-nuclear.
Principal reference: IEEE 500 (1977)

UNSFE annunciator module solid state general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail to operate on demand
FAILURE RATE OR PROBABILITY rec : 1.1E-6/hr
Source: IEEE 500 (1984) pg.40 Ultimate source: operating experience
Comment: Reference : NUREG 2232 (1980)

UNSKE annunciator module solid state general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: operates spourious or false response
FAILURE RATE OR PROBABILITY rec : 1.7E-6/hr
Source: IEEE 500 (1984) pg.40 Ultimate source: operating experience
Comment: Reference : NUREG 2232 (1980)

BTABN battery
Component boundary: battery,container,terminal connections incl.1st breaker connect. Operating mode: all Operating environment: normal
Generic failure mode: degraded Original failure mode: inadequate output
FAILURE RATE OR PROBABILITY rec : 3.2E-6/hr high: 7.5E-6/hr low: 4.9E-7/hr REPAIR TIME: 4-7 hours
Source: NUREG 3831 (1985) (tbl.A6) Ultimate source: operating experience (plant records)
Comment: Operating experience:total pop. 51.Operational time 1.564.315 hrs No.of failures 5.
Repair time is range of medians.

BTAFN battery
Component boundary: battery,container,terminal connections incl.1st breaker connect. Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output
FAILURE RATE OR PROBABILITY rec : 6.4E-7/hr high: 3.0E-6/hr low: 3.0E-8/hr REPAIR TIME: 4-7 hours
Source: NUREG 3831 (1985) (tbl.A6) Ultimate source: operating experience (plant records)
Comment: Operating experience: total pop. 51.Operating time 1.564.315hours No of failures 1. High and low chi-square estimates.
Repair times range of median

BTAFO battery
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: operational failure
FAILURE RATE OR PROBABILITY mean : 8.2E-8/hr 95%: 2.5E-7/hr 5%: 8.E-10/hr REPAIR TIME: 11.2 hours
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:IEEE 500(1977)(pg104),rec=median; max=80% of distribution. Operating experience: 96.426 hours of operation, no failures.
Repair time is mean of updated component maintenance duration.

BTAFT battery
Component boundary: battery only Operating mode: standby Operating environment: normal
Generic failure mode: fail to function Original failure mode: failed effective output
FAILURE RATE OR PROBABILITY mean : 1.3E-2/d 95%: 6.8E-2/d REPAIR TIME: 2 hours
Source: Swedish Rel.data book, tbl.41 Ultimate source: plant operating experience (7 BWR plants), ATV reports, LERs
Comment: Demand failure rate is based on refueling outage testing interval Operating experience: Total pop.129.No of demands 531.Number of
failures 7. a=0.0346; b=2.59

BTAFZ battery
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 7.6E-8/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant specific experience
Comment: Prior:IEEE 500(1977)(pg.104) lead-acid batteries,stationary type Failure mode "catastrophic". Operating experience:2.0E+5 hours, no failures.

BTVFH battery 125 V
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail during opeartion
FAILURE RATE OR PROBABILITY mean : 5.2E-7/hr 95%: 1.7E-6/hr 5%: 5.0E-8/hr REPAIR TIME: 5 hours
Source: Old PWR Ultimate source: Generic data updated with plant operating experience
Comment: Generic mean 7.5E-7/hr. Operating experience 4.1E+5 hours of operation, no failures.

BTAAJ battery general
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: all modes Original failure mode: hardware failure
FAILURE RATE OR PROBABILITY mean : 4.0E-4/d ERROR FACTOR: 3
Source: NUREG 4550, Vol.1,tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: There is no specific failure mode assigned for this component in the source ASEP used IREP Procedure Guide value of 1.0E-6/hr assesed monthly system test.

BTLFE battery lead acid
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: catastrophic (no output given challenge)
FAILURE RATE OR PROBABILITY rec : 4.6E-6/cy high: 7.2E-6/cy low: 2.7E-6/cy
Source: IEEE 500 (1984) pg.85 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite of several sources.

BTLFE battery lead acid
Component boundary: detail n/a Operating mode: all Operating environment. normal
Generic failure mode: fail to function Original failure mode: catastrophic (no output given challenge)
FAILURE RATE OR PROBABILITY rec : 2.0E-8/hr high: 3.0E-8/hr low: 0.0E-0/hr
Source: IEEE 500 (1984) pg.85 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite of several sources. Tot.failure rate of batteries is estimated to be 1.6E-6/oper.hr,but 99.6% of failures were discovered through testing,what gives 6E-9/hr emergency oper

BTNAE battery nickel cadmium

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 2.6E-7/hr high: 9.9E-6/hr low: 1.1E-7/hr
Source: IEEE 500 (1984) pg.91 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite of IEEE 500 (1977) and NPRD-2. Catastrophic faulure rate is negligable, so all modes FR is dominated by degraded mode.

BTWFB battery (power system) wet cell

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to provide proper output
FAILURE RATE OR PROBABILITY mean : 2.0E-6/hr max: 1.0E-5/hr min: 8.0E-7/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment: Assumes out-of-specification cell replacement

BTWFI battery (power system) wet cell

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to provide proper output
FAILURE RATE OR PROBABILITY mean : 1.0E-6/hr ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: Assumes out-of-specification cell replacement

BTWFW battery (power system) wet cell

Component boundary: detail n/a Operating mode: emergency load condition Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to provide proper output
FAILURE RATE OR PROBABILITY median: 3.0E-6/hr 95%: 1.0E-5/hr 5%: 1.0E-6/hr ERROR FACTOR: 3
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from industrial,nuclear experience,expert opinion
Comment: Batteries are constantly charged and their open circut output vol tage is monitored, so failures like shorts to ground or internaly are detected quickly. Only significant failure mode is one listed

BCAFB battery charger

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode· fail to function Original failure mode· failure to operate
FAILURE RATE OR PROBABILITY mean : 6.0E-7/hr max: 4.0E-6/hr min: 3.0E 7/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment:

BCAFI battery charger
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 1.0E-6/hr ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

BCAFZ battery charger
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 5.5E-7/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant specific experience
Comment: Prior:IEEE 500(1977)(pg90) rectifiers,stationary type. Prior failure mode "all modes"
Operating experience: 2.0E+5 hours of operation,no failures

BC1FH battery charger 120 V
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 6.7E-6/hr 95%: 1.3E-5/hr 5%: 1.7E-6/hr REPAIR TIME: 5.6 hours
Source: Old PWR Ultimate source: Generic data updated with plant operating experience
Comment: Generic mean 1.9E-5/hr. Operating experience 2E+5 hours of operation, 1 failure.

BCSFO battery charger SCR type
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: operational failure
FAILURE RATE OR PROBABILITY mean : 5.0E-6/hr 95%: 1.3E-5/hr 5%: 3.0E-7/hr REPAIR TIME: 10.1 hours
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:IEEE 500 (1977)(pg93), rec=median; max=95% of distribution. Operating experience: 96.426 hours of operation, 1 failure.
Repair time is mean of updated component maintenance duration.

BCA battery charger general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: hardware failure
FAILURE RATE OR PROBABILITY mean : 4.0E-4/d ERROR FACTOR: 3
Source: NUREG 4550, Vol.1,tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: There is no specific failure mode assigned for this component in the source. ASEP used IREP Procedure Guide value of 1.0E-6/hr
assuming monthly system test.

BCRFE battery charger rectifier
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output
FAILURE RATE OR PROBABILITY rec : 4.9E-7/hr high: 1.2E-5/hr low: 6.0E-8/hr
Source: IEEE 500 (1984) pg.66 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite of different types and voltage levels.

BCSFN battery charger solid state general
Component boundary: charger, connecting breakers(feeder & output),protect.& controls Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output
FAILURE RATE OR PROBABILITY rec : 5.5E-6/hr high: 1.8E-5/hr low: 1.4E-6/hr REPAIR TIME: 5-10 hours
Source: NUREG 3831 (1985) (tbl.A12) Ultimate source: operating experience (plant records)
Comment: Operating experience:total pop.70. Operating time 2.183.975 hours No.of failures 12.
Repair time is range of medians.

QBFAE blower fan
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 2.5E-6/hr high: 2.8E-6/hr low: 2.3E-6/hr REPAIR TIME: 1.5 hours
Source: IEEE 500 (1984) pg.1249 Ultimate source: expert judgement and experience
Comment: Given value is composite of different sources, different types, designs and applications of fans. (non nucelar application)
reference:Corps of Engineers,R/M data base; NPRD-2

QBVAE blower ventilator air circulating fan
Component boundary: detail n/a Include driver Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 2.5E-6/hr high: 3.4E-6/hr low: 1.9E-6/hr
Source: IEEE 500 (1984) pg.1260 Ultimate source: expert opinion and experience
Comment: reference: A/E company "B"

CBAAB bus
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 3.0E-8/hr max: 2.0E-7/hr min: 6.E-10/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment:

CBAAI bus
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.0E-8/hr ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

CB2FH bus 120 V AC , 220 V AC
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 3.4E-7/hr 95%: 6.8E-7/hr 5%: 6.3E-8/hr
Source: Old PWR Ultimate source: Generic data updated with plant operating experiecne
Comment: Generic mean 5.0E-7/hr. Operating experience 1.4E+6 hours of opeartion, no failures.

CB1FH bus 120 V DC
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 4.2E-7/hr 95%: 9.2E-7/hr 5%: 6.9E-8/hr
Source: Old PWR Ultimate source: Generic data updated with plant operating experience
Comment: Generic mean 5.0E-7/hr. Operating experience 4.1E+5 hours of operation, no failures.

CB3FH bus 380 V
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 3.7E-7/hr 95%: 7.5E-7/hr 5%: 6.3E-8/hr
Source: Old PWR Ultimate source: Generic data updated with plant specific operating experience
Comment: Generic mean 5.0E-7/hr. Operating experience 9.5E+5 hours of operation, no failures.

CB6FH bus 6 kV
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 4.1E-7/hr 95%: 8.5E-7/hr 5%: 6.6E-8/hr
Source: Old PWR Ultimate source: Generic data updated with plant operating experience
Comment: Generic mean 5.0E-7/hr. Operating experience 5.4E+5 hours of operation, no failures.

CB5HT bus Voltage <= 500V

Component boundary: bus bar, measurement Operating mode: operating Operating environment: normal

Generic failure mode: short circut Original failure mode: short circut

FAILURE RATE OR PROBABILITY mean : 3.2E-7/hr REPAIR TIME: 8 hours

Source: Swedish Rel.data book, tbl.50 Ultimate source: plant operating experience (7 BWR plants), ATV reports, LERs

Comment: Op.exp.:total pop.254. Op. time 748E+4 hours, 2 failures. a=0.00952;b=29400. Critical failures ocuried at two plants only. This is only failmode experienced(no interruption or ground cnts.

CBDFO bus DC

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: fail to function Original failure mode: operational failure

FAILURE RATE OR PROBABILITY mean : 4.2E-7/hr 95%: 8.3E-7/hr 5%: 3.E-10/hr REPAIR TIME: 10.8 hours

Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience

Comment: Prior:IEEE 500(1977)(pg.185),rec=median;max=80%distribution Operating experince: 2.89E+5 hours of operation, no failures. Repair time is mean of updated maintenance duration(bus or panel)

CBBFE bus bare outdoor switchgear

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: fail to function Original failure mode: catastrophic

FAILURE RATE OR PROBABILITY rec : 2.3E-7/hr high: 2.0E-6/hr low: 4.0E-8/hr

Source: IEEE 500 (1984) pg.804 Ultimate source: expert opinion aggregation

Comment: Reference : IEEE 500 (1977) Failure mode "catastrophic" include open circut, short line to line and short to ground.

CBAAJ bus general

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: all modes Original failure mode: hardware failure

FAILURE RATE OR PROBABILITY mean : 9.0E-5/d ERROR FACTOR: 5

Source: NUREG 4550,Vol.1. tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources

Comment: There is no specific failure mode assigned for this component in the source. ASEP used IEEE value of 1.3E-7/hr assuming monthly system test.

CBHFO bus high voltage,indoor voltage >= 4 kV

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: fail to function Original failure mode: operational failure

FAILURE RATE OR PROBABILITY mean : 6.2E-7/hr 95%: 1.5E-6/hr 5%: 3.1E-9/hr REPAIR TIME: 10.8 hours

Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience

Comment: Prior:IEEE 500(1977)(pg.188),rec=median;max=80% of distribution Operating experience:4.34E+5 hours of operation, no failures. Repair time is mean of updated maintenance duration (4kV bus).

CBIAE bus insulated switchgear bus 601-15 kV
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.9E-7/hr high: 3.0E-7/hr low: 1.1E-7/hr
Source: IEEE 500 (1984) pg.810 Ultimate source: expert opinion aggregation
Comment: Reference IEEE 493 (1980)

CBLFO bus low voltage indoor voltage <= 600 V
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: operational failure
FAILURE RATE OR PROBABILITY mean : 1.8E-7/hr 95%: 8.3E-7/hr 5%: 1.8E-9/hr
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:IEEE 500 (1977)(pg.188),rec=median;max=80% of distribution Operating experience:2.17E+6 hours of operation, no failures.

CBMFE bus metal entclosed
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: catastrophic
FAILURE RATE OR PROBABILITY rec : 8.0E-8/hr high: 4.0E-7/hr low: 0.0E-0/hr
Source: IEEE 500 (1984) pg.811 Ultimate source: expert opinion aggreagtion
Comment: Reference: IEEE 500 (1977) Failure mode "catastrophic" include open circut,short line to
line and short to ground.

CBMIZ bus metal entclosed
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: open circut Original failure mode: open circut
FAILURE RATE OR PROBABILITY mean : 1.9E-8/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant operating experience
Comment: Prior: IEEE 500(1977)(pg188), metal entclosed bus.Prior failure mode "open circut"
Operating experience: 3.0E+6 hours of operation, no failures

CCCGE cable control cable copper conductors
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: short to ground Original failure mode: short line to ground
FAILURE RATE OR PROBABILITY rec : 2.4E-6/hr high: 4.4E-6/hr low: 2.0E-8/hr
Source: IEEE 500 (1984) pg.773 Ultimate source: expert opinion aggregation
Comment: Failure rate per 1000 circut feet Reference :IEEE 500 (1977)

CCCHE cable control cable copper conductors
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: short circut Original failure mode: short line to line
FAILURE RATE OR PROBABILITY rec : 1.1E-6/hr high: 1.9E-6/hr low: 1.0E-8/hr
Source: IEEE 500 (1984) pg.773 Ultimate source: expert opinion aggregation
Comment: Failure rate is per 1000 circut feet Reference: IEEE 500 (1977)

CCPIE cable power cable
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: open circut Original failure mode: open circut
FAILURE RATE OR PROBABILITY rec : 2.6E-7/hr high: 1.9E-6/hr low: 0.0E-0/hr
Source: IEEE 500 (1984) pg.747 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite of different types, isolation and voltage leves of power cables.
Failure rate per 1000 circut feet.

CCPGE cable power cable general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: short to ground Original failure mode: short line to ground
FAILURE RATE OR PROBABILITY rec : 1.2E-6/hr high: 8.8E-6/hr low: 0.0E-0/hr
Source: IEEE 500 (1984) pg.747 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite of different types,isolation and voltage levels of power cables.
Failure rate per 1000 circut feet.

CCPHE cable power cable general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: short circut Original failure mode: short line to line
FAILURE RATE OR PROBABILITY rec : 7.1E-7/hr high: 5.3E-6/hr low: 0.0E-0/hr
Source: IEEE 500 (1984) pg.747 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite of different types, isolation and voltage levels of power cables.
Failure rate is given per 1000 circut feet.

CCSGE cable signal (supervisory) general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: short to ground Original failure mode: short line to ground
FAILURE RATE OR PROBABILITY rec · 2.5E-6/hr high: 4.3E-6/hr low: 2.0E-8/hr
Source: IEEE 500 (1984) pg.778 Ultimate source: expert opinion aggregation
Comment: Failure rate per 1000 circut feet Reference : IEEE 500 (1977)

CCSHE cable signal (supervisory) general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: short circut Original failure mode: short line to line
FAILURE RATE OR PROBABILITY rec : 9.5E-7/hr high: 1.7E-6/hr low: 1.0E-8/hr
Source: IEEE 500 (1984) pg.778 Ultimate source: expert opinion aggregation
Comment: Failure rate per 1000 circut feet Reference: IEEE 500 (1977)

KA4AF circut breaker 4.16 kV
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 7.1E-7/hr 95%: 1.1E-6/hr 5%: 5.0E-7/hr ERROR FACTOR: 1.4 REPAIR TIME: 6 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.422. Cum.operating time 25.3E+6 hours. 18 failures."All modes incl:1)fails short circut,2)spurious operation,3)other. 2) & 3) about equal, 1)negligable(no failure recorded).

KA4CF circut breaker 4.16 kV
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate on demand
FAILURE RATE OR PROBABILITY mean : 5.0E-4/d
Source: HWR data Ultimate source: HWR assesment
Comment: Operating experience or some other basis for failure rate determination is not provided.

KA4DF circut breaker 4.16 kV
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: spurious operation
FAILURE RATE OR PROBABILITY mean : 4.0E-7/hr 95%: 6.9E-7/hr 5%: 2.4E-7/hr ERROR FACTOR: 1.6 REPAIR TIME: 6 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Pop.422. Cumulative operating time 25.3E+6 hours. 10 failures.

KA6CH circut breaker 6 kV
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate on demand
FAILURE RATE OR PROBABILITY mean : 2.9E-3/d 95%: 6.4E-3/d 5%: 1.0E-3/d
Source: Old PWR Ultimate source: Generic data updated with plant specific operating experience
Comment: Generic mean 2.3E-3/d. Operating experience 348 demands. 2 failures.

KA6DH circut breaker 6 kV
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: fail during operation(transfer open)
FAILURE RATE OR PROBABILITY mean : 3.5E-7/hr 95%: 8.1E-7/hr 5%: 3.4E-8/hr
Source: Old PWR Ultimate source: Generic data updated with plant operating experience
Comment: Generic mean 8.3E-7/hr. Operating experience 1.4E+6 hours of opeartion, no failures.

KALAF circut breaker 600 V
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.9E-7/hr 95%: 3.3E-7/hr 5%: 1.1E-7/hr ERROR FACTOR: 1.6 REPAIR TIME: 4 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.690. Cum.operating time 43E+6 hours. 8 failures." All modes" incl:1)fails short circut,2)spurius operation,3)other. 2) & 3) equal in value, 1) negligable (no failures occured)

KALCF circut breaker 600 V
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate on demand
FAILURE RATE OR PROBABILITY mean : 5.0E-4/d
Source: HWR data Ultimate source: HWR assesement
Comment: Operating experience or some other basis for failure rate determination is not provided.

KALDF circut breaker 600 V
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: spurious operation
FAILURE RATE OR PROBABILITY mean : 1.1E-7/hr 95%: 2.2E-7/hr 5%: 4.6E-8/hr ERROR FACTOR: 2.0 REPAIR TIME: 2 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.690. Cumulative operating time 43E+6 hours.4 failures.

KALCT circut breaker Voltage <= 660 V
Component boundary: breaker Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to change position
FAILURE RATE OR PROBABILITY mean : 1.8E-3/d 95%: 7.3E-3/d REPAIR TIME: 4 hours
Source: Swedish Rel.data book, tbl.53 Ultimate source: plant operating experience (7 BWR plants), ATV reports, LERs
Comment: Operating experience:total pop.730. No.of demands 11471. No.of failures 21.Critical failures reported at 5 plants. a=0.0299; b=16.3

KALDT circut breaker Voltage <= 660 V
Component boundary: breaker Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: spourious change of position
FAILURE RATE OR PROBABILITY mean : 3.6E-7/hr REPAIR TIME: 4 hours
Source: Swedish Rel.data book, tbl.53 Ultimate source: plant operating experience (7 BWR plants), ATV reports, LERs
Comment: Operating experience:total pop.730. Operational time 2250E+4 hours. No.of failures 8. Critical failures reported at 4 plants.
a=0.0117; b=32900

KAMCT circut breaker Voltage between 6 and 10 kV
Component boundary: breaker Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to change position
FAILURE RATE OR PROBABILITY mean : 1.7E-3/d 95%: 4.3E-3/d REPAIR TIME: 6 hours
Source: Swedish Rel.data book, tbl.52 Ultimate source: plant operating experience (7 BWR plants), ATV reports, LERs
Comment: Operating experience:total pop.278. No.of demands 1760.No.of failures 3. Critical failures occured at 3 plants.
a=0.0208; b=12.2

KAMDT circut breaker Voltage between 6 and 10 kV
Component boundary: breaker Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: spourious change of position
FAILURE RATE OR PROBABILITY mean : 3.2E-7/hr 95%: 3.8E-7/hr REPAIR TIME: 6 hours
Source: Swedish Rel.data book, tbl.52 Ultimate source: plant operating experience (7 BWR plants),ATV reports, LERs
Comment: Operating experience:total pop.278.Operational time 932E+4 hours No.of failures 3. Critical failures occured at 3 plants
a=0.0145; b=45200

KAMDU circut breaker low voltage (11 kV and below)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: spurious operation
FAILURE RATE OR PROBABILITY mean : 1.0E-6/hr
Source: Sizewell B (PWR/RX312 pg.14) Ultimate source: assesed from nuclear and industrial expereince nad data
Comment: Assesment based on W data item,literature source and 3 SRS data items.(3.5E-7/hr op.ex 357E+6 hrs-industrial use)(4.1E-7/hr,op.ex
185E+6hrs)(6.6E-7/hr,op.ex.1.5E+6hrs).

KAMEU circut breaker low voltage (11 kV and below)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close on demand
FAILURE RATE OR PROBABILITY mean : 1.0E-6/hr
Source: Sizewell B (PWR/RX312 pg.14) Ultimate source: assesed from nuclear nad industrial expereince and data
Comment: Data sources do not distinguish between failure modes, so the sources and data used to derive givenb value are the same as for
circut breaker spurious operation.

KAMOU circut breaker low voltage (11 kV and below)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open on demand
FAILURE RATE OR PROBABILITY mean : 1.0E-6/hr
Source: Sizewell B (PWR/RX312 pg.14) Ultimate source: assesed from nuclear and industrial experience and data
Comment: Data sources do not distinguish between failure modes, so the sources and data used to derive given value are the same as for circut breaker spurious operation.

KA4DO circut breaker AC 4 kV
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer open
FAILURE RATE OR PROBABILITY mean : 9.9E-8/hr 95%: 2.5E-7/hr 5%: 2.0E-9/hr
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:IEEE 500(1977)(pg.148).Failure mode"spourious operation" Component: Indoor design AC c/b.rec=50%;max=95% of distribution. Operating experience:8.88E+5 hours of operation, 2 failures.

KA4EO circut breaker AC 4 kV
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close
FAILURE RATE OR PROBABILITY mean : 8.9E-4/d 95%: 1.6E-3/d 5%: 5.4E-5/d
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant operating experience
Comment: Prior:IEEE 500(1977)(pg 148). rec=median;max=80% of distribution. Operating experience: 1193 demands, 2 failures.

KA4OO circut breaker AC 4 kV
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 3.0E-4/d 95%: 6.7E-4/d 5%: 1.5E-5/d
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:IEEE 500(1977)(pg.148)."Failure to open" includes combined IEEE modes"fail to open" and "fail to interrupt on opening".rec= median;max=95%of distrib(combined).Op.ex.1192 demands, no failur.

KALDO circut breaker AC voltage <= 600 V
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer open
FAILURE RATE OR PROBABILITY mean : 4.0E-7/hr 95%: 8.5E-7/hr 5%: 4.5E-8/hr
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:IEEE 500(1977)(pg.148),indoor AC c/b.rec=50%;max=80% of dis Failure mode "spourious operation".Same prior as for high volt.cb Operating experience:3.04E+6 operating hours, 2 failures.

KDCDO circut breaker DC
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer open
FAILURE RATE OR PROBABILITY mean : 1.8E-7/hr 95%: 4.2E-7/hr 5%: 2.E-10/hr
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:IEEE 500(1977)(pg150),rec=median; max=80% of distribution. Operating experience: 9.16E+5 hours of operation, no failures.

KBFDZ circut breaker bus feed breaker AC
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer open
FAILURE RATE OR PROBABILITY mean : 2.3E-7/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant operating experience
Comment: Prior:IEEE 500(1977)(pg.148) AC breaker interior design, spurious operation. Operating experience: 9.1E+5 hours of operation, no failures.

KBFEZ circut breaker bus feed breaker AC
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close on demand
FAILURE RATE OR PROBABILITY mean : 1.3E-3/d
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant operating experience
Comment: Prior:IEEE 500(1977)(pg.148) AC breaker interior design,fails to close. Operating experience: 3120 demands, 5 failures

KBFOZ circut breaker bus feed breaker AC
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open on demand
FAILURE RATE OR PROBABILITY mean : 5.3E-4/d
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant operating experience
Comment: Prior:IEEE 500(1977)(pg.148) AC breaker interior design,fail to open. Operating experience:3120 demands, 1 failure.

KFTAE circut breaker fixed type including molden case
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 5.9E-7/hr high: 3.6E-6/hr low: 2.5E-7/hr
Source: IEEE 500 (1984) pg.133 Ultimate source: expert opinion aggregation and operating experience
Comment: Given value is composite of breakers with differrent voltage and current levels

KAACB circut breaker general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to transfer
FAILURE RATE OR PROBABILITY mean : 1.0E-5/hr max: 5.0E-5/hr min: 2.0E-7/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment:

KAACW circut breaker general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to transfer
FAILURE RATE OR PROBABILITY median: 1.0E-3/d 95%: 3.0E-3/d 5%: 3.0E-4/d ERROR FACTOR: 3
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear,industrial and military expereince and data
Comment: Demand probability is based on presence of proper input signal.

KAADB circut breaker general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: spourious trip
FAILURE RATE OR PROBABILITY mean : 3.0E-5/hr max: 2.0E-4/hr min: 6.0E-7/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment:

KAADW circut breaker general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: premature transfer
FAILURE RATE OR PROBABILITY median: 1.0E-6/hr 95%: 3.0E-6/hr 5%: 3.0E-7/hr ERROR FACTOR: 3
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear,industrial and military experience and data
Comment:

KA4CI circut breaker general size 4 kV and smaller
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to transfer
FAILURE RATE OR PROBABILITY mean : 3.0E-3/d ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

KA4DI circut breaker general size 4 kV and smaller
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: spourious trip
FAILURE RATE OR PROBABILITY mean : 3.0E-5/d ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: For failure mode "spurious trip" rate is given in terms of probability(failures per demand)??

KGBOG circut breaker generator breaker Manufactured by BBC
Component boundary: detail n/a Operating mode: closed Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open
FAILURE RATE OR PROBABILITY median: 6.0E-7/hr ERROR FACTOR: 5
Source: German Risk Study (tb.F3,7-1) Ultimate source: operating experience (mainly conventional power plants)
Comment: Operating experience: total pop. 50. 166 years of operation, no failures. Time related rate derived from conventional plants is conservative,because there is much less demands in NPPs.

KGBOT circut breaker generator breaker Voltage = 20 kV
Component boundary: breaker,local control,central control,surrounding equipment Operating mode: operating (closed) Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 1.1E-2/d 95%· 3.6E-2/d REPAIR TIME: 15
Source: Swedish Rel.data book, tbl.51 Ultimate source: plant operating experience (5 BWR plants)
Comment: Operating experience: total pop.8.No.of demands 295. No.of failures 3. There is not reported any SPURIOUS FUNCTION of gener. breaker in 19E+4 operational hours. a=0.7; b=65

KAHEG circut breaker high power (leistungschalter)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close
FAILURE RATE OR PROBABILITY median: 3.0E-7/hr ERROR FACTOR: 6
Source: German Risk Study (tb.F3,7-1) Ultimate source: generic data
Comment: Failure rate is combination of several generic data sources. In original text this component is called"Leistungschalter ohne Abzweig", but 'Abzweig"seems to be obsolete.

KAHOG circut breaker high power (leistungschalter)
Component boundary: detail n/a Operating mode: all Operating environment. normal
Generic failure mode: fail to open Original failure mode: fail to open
FAILURE RATE OR PROBABILITY median: 2.0E-7/hr ERROR FACTOR: 11
Source· German Risk Study (tb.F3.7-1) Ultimate source: generic data
Comment: Failure rate is combination of several generic data sources. See comment at high power circut breaker fail to close

KIAAE circut breaker indoor AC application
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.4E-7/hr high: 6.5E-7/hr low: 2.0E-8/hr
Source: IEEE 500 (1984) pg.120 Ultimate source: expert opinion aggregation and operating experience
Comment: Reference:IEEE 500 (1977)

KIDAE circut breaker indoor DC application
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.4E-7/hr high: 4.0E-7/hr low: 2.0E-8/hr
Source: IEEE 500 (1984) pg.121 Ultimate source: expert opinion aggregation and experience
Comment: Reference:IEEE 500 (1977)

KISOH circut breaker isolation breaker
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open on demand
FAILURE RATE OR PROBABILITY mean : 7.5E-4/d 95%: 2.1E-3/d 5%: 4.0E-5/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 6.5E-4/d. Operating experience 72 demands, no failures.

KMTAE circut breaker metal clad
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 3.4E-7/hr high: 5.2E-7/hr low: 2.0E-7/hr
Source: IEEE 500 (1984) pg.141 Ultimate source: expert opinion aggregation and operating experience
Comment: Given value is composite of breakers with different voltage and current levels

KCTAE circut breaker molded type
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.1E-6/hr high: 2.9E-6/hr low: 3.1E-7/hr REPAIR TIME: 1.1 hours
Source: IEEE 500 (1984) pg.124 Ultimate source: expert opinion aggregation and operating experience
Comment: Given value is composite and include different numbers of poles (1,2,3) and current levels.

KM3DH circut breaker motor operated 380 V
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer open
FAILURE RATE OR PROBABILITY mean : 1.9E-7/hr 95%: 4.9E-7/hr 5%: 2.4E-8/hr
Source: Old PWR Ultimate source: generic datda updated with plant operating experience
Comment: Generic mean 8.3E-7/hr. Operating experience 4.5E+6 hours of opeartion, no failures.

KOAAE circut breaker outdoor AC application
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 3.2E-7/hr high: 1.3E-6/hr low: 6.0E-8/hr
Source: IEEE 500 (1984) pg.122 Ultimate source: expert opinion aggregation and operating experience
Comment: Reference: IEEE 500 (1977)

KRPOZ circut breaker reactor protection breakers
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open on demand
FAILURE RATE OR PROBABILITY mean : 9.8E-3/d
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant specific experience
Comment: Prior:IEEE 500(1977)(pg.148), AC breaker indoor design.Prior failure mode "catastrophic failure".
Operating experience:612 demands, 5 failures

JEMFW cluch mechanical
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY median: 3.0E-4/d 95%: 1.0E-3/d 5%: 1.0E-4/d ERROR FACTOR: 3
Source: WASH 1400 (table III 4-1) Ultimate source: assesed from nuclear,industrial and military expereince and data
Comment: Demand probability based on presence of proper input signal.

JEEDW clutch electrical
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: premature disengagement
FAILURE RATE OR PROBABILITY median: 1.0E-6/hr 95%: 1.0E-5/hr 5%: 1.0E-7/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from industrial and military experience
Comment:

JEEFW clutch electrical

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean: 3.0E-4/d 95%: 1.0E-3/d 5%: 1.0E-4/d ERROR FACTOR: 3
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear, industrial and military experience and data
Comment: Demand probability is based on presence of proper control signal

QCMRH compressor MSIV air compressor

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 4.3E-3/hr 95%: 5.9E-3/hr 5%: 2.7E-3/hr REPAIR TIME: 4.5 hours
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 9.8E-5/hr. Operating experience 3640 hours of operation, 18 failures. Repair time is mean of 42 maintenance events.

QCMSH compressor MSIV air compressor

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 2.5E-3/d 95%: 4.9E-3/d 5%: 5.9E-4/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 3.3E-3/d. Operating experience 756 demands, 2 failures.

QCCRH compressor containemnt air control

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 2.5E-3/hr 95%: 4.5E-3/hr 5%: 8.2E-4/hr REPAIR TIME: 39.7 hours
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 9.8E-5/hr. Operating expereince 1533 hours of operation, 5 failures. Rapair time is mean of 2 maintenance events.

QCCSH compressor containment air control

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 9.9E-3/d 95%: 2.0E-2/d 5%: 2.3E-3/d
Source: Old PWR Ultimate source: generic data upgraded with plant operating experience
Comment: Generic mean 3.3E-3/d. Operating experience 190 demands, 3 failures.

QCIRH compressor instrument air
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 3.0E-4/hr 95%: 4.5E-4/hr 5%: 2.8E-4/hr REPAIR TIME: 35.4 hours
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 9.8E-5/hr. Operating expereience 1.3E+5 hours of operation, 48 failures. Repair time is mean of 165 maintenance events(outage of 1).Outage of 2: 3 events, 4.5 hours repair time.

QCISH compressor instrument air
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 2.4E-2/d 95%: 3.1E-2/d 5%: 1.6E-2/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic eman 3.3E-3/d. Operating experience 948 demands, 24 failures.

QCPRA compressor pumpback (annulus ventilation)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 2.9E-5/hr 95%: 7.3E-5/hr 5%: 2.8E-6/hr
Source: Old PWR Ultimate source: generic data updated with plant operating expereince
Comment: Generic mean 3.4E-5/hr. Operating experience 2558 hours of operation, no failures.

QCPSH compressor pumpback (annulus ventilation)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 1.1E-2/d 95%: 1.5E-2/d 5%: 5.3E-3/d
Source: Old PWR Ultimate source: generic data updated with plant operating expereince
Comment: Generic mean 3.3E-3/d. Operating experience 560 demands, 8 failures.

NKAAE computational module
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.2E-6/hr high: 5.8E-4/hr low: 3.0E-8/hr
Source: IEEE 500 (1984) pg.705 Ultimate source: expert opinion and experience
Comment: Failure rate is composite value of 19 different types of computational modules. Reference NUREG 2232 (1980)

OCR2W control rod
Component boundary: detail n/a Operating mode: standby Operating environment: reactor
Generic failure mode: fail to insert Original failure mode: failure to insert
FAILURE RATE OR PROBABILITY median: 1.0E-4/d 95%: 3.0E-4/d 5%: 1.0E-5/d ERROR FACTOR: 3
Source: WASH 1400 (table III 4-1) Ultimate source: assesed from US nuclear operating expereince
Comment: Given value is for single scram rod.

OCSAE control rod clustered silver, indium, cadmium control rods
Component boundary: detail n/a Operating mode: all Operating environment:
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 2.3E-7/hr high: 4.0E-7/hr low: 1.1E-7/hr REPAIR TIME: 120 hours
Source: IEEE 500 (1984) pg.1267 Ultimate source: expert judgement and exeprience
Comment: reference: NUREG 2232

OCCAE control rod cruciform, boron carbide control rods
Component boundary: detail n/a Operating mode: all Operating environment:
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 2.3E-7/hr high: 4.0E-7/hr low: 1.1E-7/hr
Source: IEEE 500 (1984) pg.1268 Ultimate source: expert judgemenet and exeprience
Comment: reference: NUREG 2232 cruciform rods are found in Indian Point 1, Palisades,Yankee Rowe

OCB4T control rod BWR application
Component boundary: detail n/a Operating mode: alternating Operating environment:
Generic failure mode: control rod failure Original failure mode: control rod failure
FAILURE RATE OR PROBABILITY mean : 2.8E-5/d
Source: Swedish Rel.data book, tbl.26 Ultimate source: plant operating experience(7 BWR plants)
Comment: Total pop.918. No.of demands per operational time 36091. no.of failures 1. (at one plant only). a=0.00128; b=46.1

OCK2G control rod KWU PWR type
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to insert Original failure mode: failure to insert
FAILURE RATE OR PROBABILITY mean : 2.0E-7/hr ERROR FACTOR: 4
Source: German Risk Study (pg.F3-90) Ultimate source: german plants operating experience
Comment: Operating experience: 5.1E+6 control rod hours, no reported failures.Per demand probability is 7.0E-5/d (EF 4), calculated from about 14000 insertions without failures.

OCR2H control rod single control rod assembly
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to insert Original failure mode: fail to fully insert on demand
FAILURE RATE OR PROBABILITY mean : 3.0E-5/d 95%: 7.9E-5/d 5%: 2.8E-6/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 3.3E-5/d. Operating experience 1150 demands, no fasilures.

ODB1C control rod and drive mechanism BWR-s
Component boundary: control rod,drive mechanism,housing,all parts connecting CR & DM Operating mode: standby Operating environment:
Generic failure mode: dropped/uncoupled/overtraveled rod Original failure mode: uncoupled/overtraveled rod
FAILURE RATE OR PROBABILITY mean : 2.9E-7/hr 95%: 4.1E-7/hr 5%: 2.1E-7/hr
Source: NUREG 1331 (1980) (pg.268) Ultimate source: US plant LER reports evaluation
Comment: LERs from 01.72.to 04.78.

ODB3C control rod and drive mechanism BWR-s (GE)
Component boundary: control rod,drive mechanism,housing,all parts connecting CR & DM Operating mode: standby Operating environment:
Generic failure mode: inproper movement Original failure mode: improper rod movement
FAILURE RATE OR PROBABILITY mean : 9.7E-8/hr 95%: 1.6E-7/hr 5%: 5.1E-8/hr
Source: NUREG 1331 (1980) (pg.282) Ultimate source: US plant LER reports evaluation
Comment: failure rate is based on personnel errors only

ODB2C control rod and drive mechanism BWR-s (GE)
Component boundary: control rod,drive mechanism,housing,all parts connecting CR & DM Operating mode: standby Operating environment:
Generic failure mode: fail to insert Original failure mode: failure to insert during normal shutdown
FAILURE RATE OR PROBABILITY mean : 2.3E-5/d 95%: 7.1E-3/d 5%: 4.1E-6/d
Source: NUREG 1331 (1980) (pg.218) Ultimate source: US plant LER reports evaluation
Comment: standby hourly rate is 2.3E-8/hr

ODS2C control rod and drive mechanism BWR-s (GE)
Component boundary: control rod,drive mechanism,housing,all parts connecting CR & DM Operating mode: standby Operating environment:
Generic failure mode: fail to insert Original failure mode: failure to insert to at least 96% during scram
FAILURE RATE OR PROBABILITY mean : 5.4E-5/d 95%: 1.0E-4/d 5%: 2.6E-5/d
Source: NUREG 1331 (1980) (pg.202) Ultimate source: US plant LER reports evaluation
Comment: W/o command faults. With command faults 1.1E-4/d. Standby hourly rate w/o 7.5E-8, with command 1.5E-7.

ODT3C control rod and drive mechanism BWR-s (GE)
Component boundary: control rod,drive mechanism,housing,all parts connecting CR & DM Operating mode: standby Operating environment:
Generic failure mode: inproper movement Original failure mode: rod fails to move during power changes/testing
FAILURE RATE OR PROBABILITY mean : 1.8E-6/d 95%: 8.5E-6/d 5%: 9.2E-8/d
Source: NUREG 1331 (1980) (pg.234) Ultimate source: US plant LER reports evaluation
Comment: Standby hourly rate 1.1E-8/hr. LERs from 01.72 to 04.78.

ODE2C control rod and drive mechanism PWR-s
Component boundary: control rod,drive mechanism,housing,all parts connecting CR & DM Operating mode: standby Operating environment:
Generic failure mode: fail to insert Original failure mode: failure to insert to at least 96% during scram
FAILURE RATE OR PROBABILITY mean : 4.0E-5/d 95%: 1.2E-4/d 5%: 1.1E-5/d
Source: NUREG 1331 (1980) (pg.202) Ultimate source: US plant LER reports evaluation
Comment: LERs from 01.72 through 04.78. Standby hourly rate 6.6E-8/hr.

ODE3C control rod and drive mechanism PWR-s
Component boundary: control rod,drive mechanism,housing,all parts connecting CR & DM Operating mode: standby Operating environment:
Generic failure mode: inproper movement Original failure mode: rod fails to move during power changes/testing
FAILURE RATE OR PROBABILITY mean : 3.1E-5/d 95%: 9.6E-5/d 5%: 5.5E-6/d
Source: NUREG 1331 (1980) (pg.234) Ultimate source: US plant LER reports evaluation
Comment: W/o command faults. With command faults 7.6E-4/d. Standby hourly rate w/o 4.2E-8/hr, with command 1.0E-6/hr

ODP1C control rod and drive mechanism PWR-s
Component boundary: control rod,drive mechanism,housing,all parts connecting CR & DM Operating mode: standby Operating environment:
Generic failure mode: dropped/uncoupled/overtraveled rod Original failure mode: dropped rod
FAILURE RATE OR PROBABILITY mean : 3.2E-7/hr 95%: 4.8E-7/hr 5%: 2.0E-7/hr
Source: NUREG 1331 (1980) (pg.255) Ultimate source: US plant LER reports evaluation
Comment: W/o command faults. With command faults 2.2E-6/hr

ODP2C control rod and drive mechanism PWR-s
Component boundary: control rod,drive mechanism,housing,all parts connecting CR & DM Operating mode: standby Operating environment:
Generic failure mode: fail to insert Original failure mode: failure to insert during normal shutdown
FAILURE RATE OR PROBABILITY : n/a 95%: 6.4E-5/d
Source: NUREG 1331 (1980) (pg.218) Ultimate source: US plant LER reports evaluation
Comment: standby hourly rate 6.3E-8/hr (upper 95% confidence limit) no failures recorded

ODP3C control rod and drive mechanism PWR-s
Component boundary: control rod,drive mechanism,housing,all parts connecting CR & DM Operating mode: standby Operating environment:
Generic failure mode: inproper movement Original failure mode: improper rod movement
FAILURE RATE OR PROBABILITY mean : 2.8E-7/hr 95%: 4.5E-7/hr 5%: 1.6E-7/hr
Source: NUREG 1331 (1980) (pg.282) Ultimate source: US plant LER reports evaluation
Comment: failure rate is based on personnel errors only LERs from 01.72. to 04.78.

ORLAE control rod drive lead screw roller nut drive mechanism
Component boundary: detail n/a Operating mode: all Operating environment:
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 3.5E-6/hr high: 4.6E-6/hr low: 2.1E-6/hr
Source: IEEE 500 (1984) pg.1270 Ultimate source: exeprt judgement and experience
Comment: reference: NUREG 2232

ORMAE control rod drive magnetic jack latch drive mechanism
Component boundary: detail n/a Operating mode: all Operating environment:
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 7.8E-7/hr high: 1.7E-6/hr low: 3.9E-7/hr
Source: IEEE 500 (1984) pg.1271 Ultimate source: expert judgement and experience
Comment: reference: NUREG 2232

ORM2T control rod drive BWR appliaction mechanical insertion function
Component boundary: motor,drive nut,drive mechanism,logic,protection,controls Operating mode: alternating Operating environment:
Generic failure mode: fail to insert Original failure mode: failure of mechanical insertion function
FAILURE RATE OR PROBABILITY mean : 6.6E-4/d 95%: 3.9E-3/d
Source: Swedish Rel.data book, tbl.26 Ultimate source: plant operating experience(7 BWR plants), ATV reports, LERs
Comment: Total pop.918. No.of demands per operational time 126453. No.of failures 84.No failures reported of scram and insertion function (occuring simultaneously). a=0.0791; b=119

ORH2T control rod drive BWR application hydraulic scram function
Component boundary: drive mechanism, protection and logic, control equipment Operating mode: standby Operating environment:
Generic failure mode: fail to insert Original failure mode: failure of hydraulic scram function
FAILURE RATE OR PROBABILITY mean : 2.8E-5/d
Source: Swedish Rel.data book, tbl.26 Ultimate source: plant operating experience (7 BWR plants)
Comment: Total pop. 918. No.of demands per operational time: 36091 number of failures 1. Critical failure occured at one plant only a=0.00167; b=60.1

ORAAE control rod drive general
Component boundary: detail n/a Operating mode: all Operating environment:
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.6E-6/hr high: 4.3E-6/hr low: 1.1E-7/hr
Source: IEEE 500 (1984) pg.1265 Ultimate source: expert judgement and experience
Comment: references: NUREG 1331, NUREG 2232 Given value is composite of diffrerent sources and types of CR drives.

UCEAF controler electronic
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 4.9E-6/hr 95%: 8.6E-6/hr 5%: 3.0E-6/hr ERROR FACTOR: 1.6 REPAIR TIME: 8 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Population not known. Cum.operating time 1.8E+6 hours.9 failures. See failure mode comment controler pneumatic.

UCAAE controler general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 7.1E-7/hr high: 5.6E-4/hr low: 1.0E-8/hr
Source: IEEE 500 (1984) pg.725 Ultimate source: expert opinion aggregation and operating experience
Comment: Faliure rate is composite value of 10 controler types. Reference NUREG 2232 (1980).

UCPAF controler pneumatic
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 6.4E-7/hr 95%: 1.3E-6/hr 5%: 3.3E-7/hr ERROR FACTOR: 1.8 REPAIR TIME: 8 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Population not known.Cum.operating time 7.7E+6 hours. 5 failures. "All modes"to be used instead:1)fail.to operate,2)spurious,3) erratic operation. No data available for this failure modes.

ECEFS converter E/S general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fails to operate
FAILURE RATE OR PROBABILITY mean : 4.2E-6/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating experience
Comment:

ECSFS converter square root general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fails to operate
FAILURE RATE OR PROBABILITY mean : 4.2E-6/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating experience
Comment:

QDAFB damper
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 1.0E-6/hr max: 5.0E-5/hr min: 2.0E-7/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment:

QDAFI damper
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 3.0E-3/d ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

QDPAE damper Automatic backdraft, paralel blade
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.2E-6/hr REPAIR TIME: .6 hours
Source: IEEE 500 (1984) pg.1229 Ultimate source: expert judgement and experience
Comment: reference: Corps of engineers R/M data base

QDOAE damper Modulating, opposed blade, 36X48 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.8E-6/hr high: 2.7E-6/hr low: 1.2E-6/hr REPAIR TIME: .6 hours
Source: IEEE 500 (1984) pg.1228 Ultimate source: expert judgement and experience
Comment: reference: Corps of engineers R/M data base

QDTAE damper shut off, two position paralel blade
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.2E-6/hr REPAIR TIME: .6 hours
Source: IEEE 500 (1984) pg.1227 Ultimate source: expert judgement and experience
Comment: reference: Corps of Engineers R/M data base, Ground Stationary equipment, Report No 16, 04/12/73

QDCFZ damper containment fan coolers system
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate on demand
FAILURE RATE OR PROBABILITY mean : 1.9E-3/d
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant specific experience
Comment: Prior: NUREG 1363 air operated valves(PWR),failed to operate(mean and WASH 1400 air operated valves,fails to operate(distrib.).
Operating experience 1150 demands, 3 failures.

QDMDH damper manual (HVAC)
Component boundary: detail n/a Operating mode: normally open Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer closed
FAILURE RATE OR PROBABILITY mean : 3.6E-8/hr 95%: 1.1E-7/hr 5%: 1.6E-9/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 4.2E-8/hr. Operating experience 9.9E+5 hours of operation, no failures.

DEIAE diesel engine No.2 fuel oil, 4 stroke, in-line
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 6.5E-3/hr high: 6.5E-2/hr low: 6.5E-4/hr
Source: IEEE 500 (1984) pg.828 Ultimate source: exeprt judgement and experience
Comment: Reference: NUREG 2232

DEVAE diesel engine no.2 fuel oil,4 stroke, V block
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 4.7E-3/hr high: 1.0E-2/hr low: 2.0E-3/hr
Source: IEEE 500 (1984) pg.827 Ultimate source: expert judgement and experience
Comment: reference: NUREG 2232

DEARW diesel engine general
Component boundary: complete plant including starters pumps,fuel syst. Operating mode: emergency condition Operating environment: normal
Generic failure mode: fail to run Original failure mode: failure to run given start
FAILURE RATE OR PROBABILITY median: 3.0E-4/hr 95%: 3.0E-3/hr 5%: 3.0E-5/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from industrial experience and expert opinion
Comment: Diesel engine mentioned in this source is engine used to run emergency AC generator.Because of possible variance in redundancy of aux equipment,failrate is separated for engine and whole plant

DGARB diesel generator emergency AC
Component boundary: SEE IREP DG failure to start Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: failure to run, given start
FAILURE RATE OR PROBABILITY mean : 3.0E-3/hr max: 2.0E-2/hr min: 6.0E-5/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opnion aggregation and IREP data
Comment: Failure to run is failure to run for more than 1/2 hour, given start.
Failure rate is applicable to emergency condition.

DGARE diesel generator emergency AC
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: fails while running
FAILURE RATE OR PROBABILITY rec : 1.0E-4/hr high: 8.8E-3/hr low: 2.0E-5/hr REPAIR TIME: 11.5 hours
Source: IEEE 500 (1984) pg.1218 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite value of IEEE 500 (1977) and several nuclear sources including NUREG 1362 (1980).

DGARG diesel generator emergency AC
Component boundary: DG,governor,fuel system,starting system,cooling,controls Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: failure to run
FAILURE RATE OR PROBABILITY mean : 4.5E-3/hr ERROR FACTOR: 2
Source: German Risk Study (pg.F3-86) Ultimate source: German plants operating experience
Comment: Operating experience:35 units observed for 2.5 years.Exact time known for 11 units(avr.76 hr/y),50 hr/y considered for the rest.
Tot.op.time:3740 hr.No.of failures 17.SHORT OPERATING TIME RATE.

DGARH diesel generator emergency AC
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during first hour of operation
FAILURE RATE OR PROBABILITY mean · 2.7E-3/hr 95%: 3.7E-3/hr 5%: 1.3E-3/hr REPAIR TIME: 6.8 hours
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 1.7E-2/hr. Operating experience 1177 hours of operation, 2 failures.

DGARI diesel generator emergency AC
Component boundary: SEE failure to start, same source Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: failure to run given start
FAILURE RATE OR PROBABILITY mean : 3.0E-3/hr ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: Failure to run is failure to run more than 1/2 hour,given start.

DGARJ diesel generator emergency AC
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: failure to run
FAILURE RATE OR PROBABILITY mean : 2.0E-3/hr ERROR FACTOR: 10
Source: NUREG 4550, Vol.1,tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: ASEP used generic value from the Reliability of AC Power System Study (NUREG/CR-2989) which contain industry wide analysis.

DGARR diesel generator emergency AC
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: failure to continue to run
FAILURE RATE OR PROBABILITY mean : 1.4E-3/hr 95%: 2.9E-3/hr 5%: 5.4E-4/hr
Source: EPRI NP-2433(1982) (table 3-1) Ultimate source: operating experience(utility supplied data) Peach Bottom 2 & 3
Comment: Failure rate is calculated for Peach Bottom 2 & 3 plants only. Total expereince 32.9 years. No.of failures 5.

DGART diesel generator emergency AC
Component boundary: DG,control & protection equipment,service systems Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: spourious stop
FAILURE RATE OR PROBABILITY mean : 5.5E-3/hr 95%: 2.4E-2/hr REPAIR TIME: 20 hours
Source: Swedish Rel.data book, tbl.40 Ultimate source: plant operating experience (7 BWR plants),ATV reports,LERs,
Comment: Operating experience:total pop.20. Operational time 1440 hours No.of failures 8. a=0.338; b=60.8
Critical failures reported on 5 plants.

DGARU diesel generator emergency AC
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: failure to continue operation
FAILURE RATE OR PROBABILITY mean : 3.0E-3/hr
Source: Sizewell B (PWR/RX312 pg.13) Ultimate source: assesed from nuclear and industrial expereince and data
Comment: Assesment based on W data item,WASH 1400 and 3 SRS data items, (3.0E-3/hr)(1.3E-3/hr op.exp.8.7E+6hours) (1.4E-3/hr applicable
to average industrial use).

DGARW diesel generator emergency AC
Component boundary: complete diesel generator plant Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: failure to run given start
FAILURE RATE OR PROBABILITY median: 3.0E-3/hr 95%: 3.0E-2/hr 5%: 3.0E-4/hr ERROR FACTOR: 10 REPAIR TIME: 21 hours
Source: WASH 1400 (table III 4-2) Ultimate source: nuclear and non-nuclear experience
Comment: Repair time is mean maintenance duration. For plant with specific ation which limits the outage time to 24 hours, mean maintenance duration is 13 hours.

DGARZ diesel generator emergency AC
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 6.0E-3/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior: mean NUREG 1362, DG does not continue to run,w/o command, montly testing.Distribution WASH 1400, DG failure to run Operating experience: operating time 1340 hours, 6 failures.

DGASA diesel generator emergency AC
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start
FAILURE RATE OR PROBABILITY median: 7.1E-3/d ERROR FACTOR: 4.1
Source: NUREG 4550/Vol.3,tbl.IV.8-1 Ultimate source: Surry NPP operating expreince
Comment:

DGASB diesel generator emergency AC
Component boundary: SEE IREP DG failure to start Operating mode· standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean · 6.0E-5/hr max: 4.0E-4/hr min: 3.0E-5/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion aggregation and IREP data
Comment: Failure to start is failure to start, accept load and run for 1/2 hour.

DGASE diesel generator emergency AC
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: fails to start
FAILURE RATE OR PROBABILITY rec : 1.6E-2/cy high: 4.0E-1/cy low: 3.0E-4/hr REPAIR TIME: 11.5 hours
Source: IEEE 500 (1984) pg.1218 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite value of IEEE 500 (1977) and several nuclear sources including NUREG 1362 (1980).

DGASG diesel generator emergency AC
Component boundary: DG,governor,fuel system,starting system,cooling, controls Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 3.0E-2/hr ERROR FACTOR: 3
Source: German Risk Study (pg.F3-86) Ultimate source: German plants operating experience
Comment: Starting failure include failures which happed during initial running time.
Operating expereince: ca.810 demands, 24 failures.

DGASH diesel generator emergency AC
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 1.1E-2/d 95%: 1.5E-2/d 5%: 6.1E-3/d
Source: Old PWR Ultimate source: generic data updated with plant specific operating experience
Comment: Generic mean 2.1E-2/d. Operating experience 1068 demands, 11 failures.

DGASI diesel generator emergency AC
Component boundary: engine,gen.coupling,governor,out.breaker,exciter,lube & fuel oil Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 3.0E-2/d ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: BOUNDARY contd.starting system,intake and exaust air. Excluded: starting air compressor and accumulator,fuel storage & transfer load sequencer & synchroiser.Failmode incl. running for 1/2 hour.

DGASJ diesel generator emergency AC
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 3.0E-2/d ERROR FACTOR: 3
Source: NUREG 4550, Vol.1,tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: ASEP used generic value from the Reliability of AC Power System Study (NUREG/CR-2989) which contain industry wide data.

DGASR diesel generator emergency AC
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY pt.est: 1.7E-2/d
Source: EPRI NP-2433(1982) (table S-1) Ultimate source: operating experience (plant or utility supplied data,13 plants)
Comment: Failure per demand is based on 123.5 years of experience and 6910 diesel demands.

DGAST diesel generator emergency AC
Component boundary: DG,protection & control equipment,service systems Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 7.7E-3/d 95%: 2.9E-2/d REPAIR TIME: 20 hours
Source: Swedish Rel.data book, tbl.40 Ultimate source: plant operating experience (7 BWR plants),ATV reports, LERs
Comment: Operating experence:total pop.20. No.of demands 2090. No.of failures 16. a=0.552; b=67.7
Critical failures reported on 6 plants.

DGASU diesel generator emergency AC
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 3.0E-2/d
Source: Sizewell B (PWR/RX312 pg.13) Ultimate source: assesed from nuclear and industrial expereince and data
Comment: Assesment based on W data, WASH 1400,and SRS data,2.6E-2/d out of 1567 demands and 1.3E-2/d out of 5500 demands.

DGASW diesel generator emergency AC
Component boundary: complete plant,including starters,pumps and fueling system Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY median: 3.0E-2/d 95%: 1.0E-1/d 5%: 1.0E-2/d ERROR FACTOR: 3
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear and industrial experience and data
Comment:

DGASY diesel generator emergency AC
Component boundary: DG,control & protection equipment, service systems Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 1.2E-2/d REPAIR TIME: 8 hours
Source: Swedish Rel.data book, tbl.40 Ultimate source: plant operating experience (1 PWR plant-Ringhals 2),ATV reports
Comment: Operating experience:total pop.4. No.of demands 492. No.of failures 6.
No failures recorded out of 164 operating hours.

DGASZ diesel generator emergency AC
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start on demand
FAILURE RATE OR PROBABILITY mean : 1.8E-2/d
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data upgraded with plant operatig expereince
Comment: Prior:mean NUREG 1362,DG fails to start, w/o command. montly test Distribution WASH 1400,DG fail to start.
Operating expereince 1693 deamnds, 30 failures.

DG4RN diesel generator emergency AC 4160 V AC
Component boundary: DG,all local systems and components needed for start & operation Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail to run
FAILURE RATE OR PROBABILITY rec : 6.5E-3/hr high: 2.3E-2/hr low: 2.4E-3/hr REPAIR TIME: 3-8 hours
Source: NUREG 3831 (1985) (tbl.12) Ultimate source: operating experience (plant records)
Comment: Failure rate is combined failure modes "fail to run" and"inproper operation" because that way it is comparable with other data sources.

DGXRN* diesel generator emergency AC 4160 V AC
Component boundary: DG,all local systems and components needed for start & operation Operating mode: standby Operating environment: normal
Generic failure mode: fail to run* Original failure mode: fails to run once started
FAILURE RATE OR PROBABILITY rec : 3.6E-4/hr high: 1.8E-3/hr low: 1.6E-4/hr REPAIR TIME: 3-8 hours
Source: NUREG 3831 (1985) (tbl.A1) Ultimate source: operating experience (plant records)
Comment: Operating experience: total pop. 14.Operational time 2801. No.of failures 1.
Repair time is the range of median.

DGYRN* diesel generator emergency AC 4160 V AC
Component boundary: DG,all local systems and components needed for start & operation Operating mode: standby Operating environment: normal
Generic failure mode: fail to run* Original failure mode: inproper operation
FAILURE RATE OR PROBABILITY rec : 6.1E-3/hr high: 2.1E-2/hr low: 2.2E-3/hr REPAIR TIME: 3-8 hours
Source: NUREG 3831 (1985) (tbl.A1) Ultimate source: operating experience (plant records)
Comment: Op.experience:pop.17.Op.time 2801 hours.No.of failures 17.High & low represent range of plant spec.means.FMODE incl.fail to supply withinspec.time and autom.termination.Not consider.fail.in emerg.

DG4SN diesel generator emergency AC 4160 VAC
Component boundary: DG,all local systems and components needed for start & operation Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY rec : 2.9E-3/d high: 1.4E-2/d low: 4.0E-4/d REPAIR TIME: 3-8 hours
Source: NUREG 3831 (1985) (tbl.A1) Ultimate source: operating experience (plant records)
Comment: Operating experience:total pop.14. No.of 2801. No.of failures 8.
Repair time is range of medians.

QFVRH fan containment ventilation fan
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 6.0E-6/hr 95%: 1.1E-5/hr 5%: 1.9E-6/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience.
Comment: Generic mean 7.9E-6/hr. Operating experience 2.6E+5 hours of operation, 1 failure.

QFVSH fan containment ventilation fan
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 3.3E-4/d 95%: 7.8E-4/d 5%: 5.0E-5/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 4.8E-4/d. Operating experience 873 demands, no failures.

QFCRZ fan cooler containment fan cooler
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: failduring operation
FAILURE RATE OR PROBABILITY mean : 3.5E-6/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant specific experience
Comment: Prior: WASH 1400 electric motor failure to run,extreme enviroment Operating experience 1.52E+5 hours of operation, no failures.

QFCSZ fan cooler containment fan cooler
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start on demand
FAILURE RATE OR PROBABILITY mean : 1.2E-3/d
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant specific experience
Comment: Prior: WASH 1400 Electric motor failure to start Operating experience:1155 demands, 2 failures.
Given value includes motor failures only.

QFCRU fan cooler containment fan coolers
Component boundary: detail n/a Operating mode: standby Operating environment: post LOCA/SLB enviroment
Generic failure mode: fail to run Original failure mode: failure to continue operation
FAILURE RATE OR PROBABILITY mean : 3.7E-6/hr
Source: Sizewell B (PWR/RX312 pg.14) Ultimate source: assesed from nuclear expereince and data
Comment: The only source cited for the assesment of data is Westinghouse PWR data item.

QFCSU fan cooler containment fan coolers
Component boundary: detail n/a Operating mode: standby Operating environment: post LOCA/SLB enviroment
Generic failure mode: fail to start Original failure mode: failure to start (or change speed)
FAILURE RATE OR PROBABILITY mean : 2.0E-3/d
Source: Sizewell B (PWR/RX312 pg.14) Ultimate source: ultimate data source is not known
Comment: Since no data is available for fan coolers fail to start,low pressure motor driven pump data were used.Given value is a
stdby frate for fans to change from nrml to post fault oper.mode

QFCSO fan cooler reactor building cooling unit
Component boundary: low speed windings,detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 5.7E-3/d 95%: 1.2E-2/d 5%: 7.8E-4/d REPAIR TIME: 40.5 hours
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior: motor driven pump failure from NUREG 1205(1980).80%/20% ratio =10.Operating experience:237 demands, 3 failures.
Repair time is mean of plant spec.update of maintenance duration.

QFHRO fan cooler reactor building cooling units
Component boundary: high speed windings,detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: operational failure
FAILURE RATE OR PROBABILITY mean : 1.2E-5/hr 95%: 2.4E-5/hr 5%: 1.3E-6/hr REPAIR TIME: 40.5 hours
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:median from NUREG 1635 (1980).Only plants reporting coolers failure were B&W.Data for motors=5.3E-6/hr and for blower 1.7E-6
combined 7E-6 used as median.Op.experience 81.351 op.hrs,1 failur

QFLRO fan cooler reactor building cooling units
Component boundary: low speed windings, detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: operational failure
FAILURE RATE OR PROBABILITY mean : 9.5E-6/hr 95%: 2.4E-5/hr 5%: 4.4E-7/hr REPAIR TIME: 40.5 hours
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experince
Comment: Same prior as for high speed windings. Operating experience: 24.175 hours of operation, no failures.
Repair time is mean of plant spec.update of maintenance duration.

KSFCG feeder(ABZWEIG) general
Component boundary: circut breaker, fuse, connecting cable Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to open or to close
FAILURE RATE OR PROBABILITY median: 1.0E-6/hr ERROR FACTOR: 10
Source: German Risk Study (tb.F3,7-1) Ultimate source: expert opinion
Comment: ABZWEIG in German terminology indicate the path which is used to feed the electricity to final consumer(component-pump). It
usually consist of circut breaker,fuse and connecting cables.

YFMAE filter liquid, mechanical restriction
Component boundary: detail n/a Operating mode: all Operating environment· normal
Generic failure mode· all modes Original failure mode· all modes
FAILURE RATE OR PROBABILITY rec : 2 7E 6/hr high: 5.3E-6/hr low: 1 3E 6/hr
Source: IEEE 500 (1984) pg.1404 Ultimate source: expert judgement and experience
Comment· reference· NUREG 2232

UCFFS flow controler general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fails to operate
FAILURE RATE OR PROBABILITY mean : 4.2E-6/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating experience
Comment:

KTAAF fuse all voltage levels
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.1E-6/hr REPAIR TIME: 2 hours
Source: HWR data Ultimate source: not known
Comment: FM "all modes" sould be used instead of:1)premature open. 2)fails short circut,3)fails open circut.However, no operational data or other sources which were bases for fail.rate determ.are given.

KTAKB fuse general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: premature open
FAILURE RATE OR PROBABILITY mean : 3.0E-6/hr max: 2.0E-5/hr min: 6.0E-8/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment:

KTAKG fuse general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: premature opening
FAILURE RATE OR PROBABILITY median: 1.0E-6/hr ERROR FACTOR: 10
Source: German Risk Study (tb.F3,7-1) Ultimate source: generic data
Comment:

KTAKI fuse general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: premature open
FAILURE RATE OR PROBABILITY mean : 3.0E-6/hr ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

KTAKW fuse general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: premature open
FAILURE RATE OR PROBABILITY median: 1.0E-6/hr 95%: 3.0E-6/hr 5%: 3.0E-7/hr ERROR FACTOR: 3
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from industrial and military experience and data sources
Comment:

KTAOW fuse general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY median: 1.0E-5/d 95%: 3.0E-5/d 5%: 3.0E-6/d ERROR FACTOR: 3
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear, industrial and militay experience and data
Comment:

DTGAE gas turbine driven generator emergency AC
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 2.8E-3/cy
Source: IEEE 500 (1984) pg.1225 Ultimate source: expert opinion aggregation and experience
Comment: Source: Gas Turbine Manufacturer A. One cycle=one start attempt

FYAYG gasket
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: leakage
FAILURE RATE OR PROBABILITY median: 4.0E-7/hr ERROR FACTOR: 8
Source: German Risk Study (tb.F3,7-1) Ultimate source: generic data
Comment: Failure rate is combination of several generic data sources.

EGSRE generator AC steam turbine driven
Component boundary: detail n/a , does not include driver. Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail once started
FAILURE RATE OR PROBABILITY rec : 7.2E-7/hr high: 1.5E-6/hr low: 4.0E-8/hr
Source: IEEE 500 (1984) pg.257 Ultimate source: expert opinion aggregation and operating experience
Comment: Reference IEEE 500 (1977)

EGSSE generator AC steam turbine driven
Component boundary: detail n/a, does not include driver. Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start
FAILURE RATE OR PROBABILITY rec : 4.5E-7/hr high: 9.5E-7/hr low: 2.0E-8/hr
Source: IEEE 500 (1984) pg.257 Ultimate source: expert opinion aggregation and operating experience
Comment: Reference IEEE 500 (1977)

EGDRE generator DC general
Component boundary: detail n/a, does not include driver. Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail once started
FAILURE RATE OR PROBABILITY rec : 2.4E-7/hr high: 2.4E-5/hr low: 0.0E-0/hr
Source: IEEE 500 (1984) pg.272 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite of different sources.

EGDSE generator DC general
Component boundary: detail n/a, does not include driver Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start
FAILURE RATE OR PROBABILITY rec : 1.3E-7/hr high: 1.3E-5/hr low: 0.0E-0/hr
Source: IEEE 500 (1984) pg.272 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite of different sources.

HXCTH heat exchanger primary component cooling HX
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: rupture Original failure mode: rupture/excessive leakage during operation
FAILURE RATE OR PROBABILITY mean : 1.7E-6/hr 95%: 3.8E-6/hr 5%: 3.2E-7/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 2.0E-6/hr. Operating experience1.36E+5 hours of operation, no failures.

HXRTH heat exchanger residual heat removal HX
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: rupture Original failure mode: rupture/excessive leakege during operation
FAILURE RATE OR PROBABILITY mean : 1.9E-6/hr 95%: 5.0E-6/hr 5%: 3.2E-7/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 2.0E-6/hr. Operating expereince 1.43E+4 hours of operation, no failures.

HXSTH heat exchanger secondary component cooling HX
Component boundary: detail n.a Operating mode: all Operating environment: normal
Generic failure mode: rupture Original failure mode: rupture/excessive leakage during operation
FAILURE RATE OR PROBABILITY mean : 1.7E-6/hr 95%: 3.8E-6/hr 5%: 3.2E-7/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 2.0E-6/hr. Operating experience 1.36E+5 hours of operation, no failures.

HXHAE heat exchanger U tube horisontal shell and tube
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 4.8E-6/hr high: 7.6E-6/hr low: 2.9E-6/hr
Source: IEEE 500 (1984) pg.1359 Ultimate source: expert judgement and experience
Comment: reference: NUREG 2232

HXHAF heat exchanger U tube horisontal shell and tube
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.1E-5/hr 95%: 1.9E-5/hr 5%: 6.8E-6/hr ERROR FACTOR: 1.6 REPAIR TIME: 24 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Component population 107.Cumulative component operating time 90E+4 hours.No.of failures 10.Failure mode"all modes"include:
1)plugged,2)external,3)internal leak, 4)inadequate heat transfer

HXDAE heat exchanger U tube shell and tube plus steam drum
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 2.7E-6/hr high: 2.7E-4/hr low: 6.2E-7/hr
Source: IEEE 500 (1984) pg.1357 Ultimate source: expert judgement and experience
Comment: reference: NUREG 2232

HXVAE heat exchanger U tube veritcal shell and tube
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 9.3E-6/hr high: 1.4E-5/hr low: 6.5E-6/hr
Source: IEEE 500 (1984) pg.1358 Ultimate source: expert judgement and experience
Comment: reference: NUREG 2232

HXVAF heat exchanger U tube vertical shell and tube
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 4.0E-5/hr 95%: 5.2E-5/hr 5%: 3.1E-5/hr ERROR FACTOR: 1.3 REPAIR TIME: 24 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Componet population 98.Cumulative componet operating time 105E+4 hours.No.of failures 42.Failure mode "all modes" include:
1)external.2)internal leak,3)plugged,4)inadequate heat transfer

HXA6B heat exchanger general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage(shell) Original failure mode: shell leak
FAILURE RATE OR PROBABILITY mean : 3.0E-6/hr max: 2.0E-5/hr min: 6.0E-8/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment:

HXA6I heat exchanger general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage(shell) Original failure mode: shell leak
FAILURE RATE OR PROBABILITY mean : 3.0E-6/hr ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert judgement
Comment:

HXA6J heat exchanger general
Component boundary: deatil n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage (shell) Original failure mode: Rupture (Leakage)
FAILURE RATE OR PROBABILITY mean : 3.0E-6/hr ERROR FACTOR: 10
Source: NUREG 4550, Vol.1,tbl.VIII.1-2 Ultimate source: assesed form several nuclear data sources
Comment: ASEP used the generic value from IREP Procedure Guide.

HXA7B heat exchanger general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage (tube) Original failure mode: tube leak(per tube)
FAILURE RATE OR PROBABILITY mean : 3.0E-9/hr max: 2.0E-8/hr min: 6.E-11/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment:

HXA7I heat exchanger general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage (tube) Original failure mode: tube leak (per tube)
FAILURE RATE OR PROBABILITY mean : 3.0E-9/hr ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert judgement
Comment:

HXAQJ heat exchanger general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: plug Original failure mode: blockage
FAILURE RATE OR PROBABILITY mean : 5.7E-6/hr ERROR FACTOR: 10
Source: NUREG 4550,Vol.1,tbl.VIII.1-2 Ultimate source: value taken from single plant PSA study.
Comment: ASEP used generic value from GE's LaSalle's PSA.

HXAYS heat exchanger general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: leakage
FAILURE RATE OR PROBABILITY mean : 5.7E-6/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating experience
Comment:

HXAYZ heat exchanger general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: leakage
FAILURE RATE OR PROBABILITY mean : 7.1E-7/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data upgraded with plant operating experience
Comment: Prior NPRDS page 34. (mean4.6E-6/hr, distribution engn.judgement) Operating experience 2.36E+5 hours, no failures.Plugged shell and /or tube side=negligible(engn.judgement).8.35E+4 hrs,no failures.

HXCAE heat exchanger helical coil general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 8.7E-6/hr high: 5.6E-4/hr low: 1.4E-6/hr
Source: IEEE 500 (1984) pg.1352 Ultimate source: expert judgement and operating experience
Comment: reference: NUREG 2232 Given value is composite of different helical coil heat exchangers

HXBAF heat exchanger straight tube horisontal shell and tube
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 2.0E-5/hr 95%: 2.8E-5/hr 5%: 1.4E-5/hr ERROR FACTOR: 1.4 REPAIR TIME: 24 hours
Source: HWR data Ultimate source: HWR operating exprience
Comment: Component population 120. Cumulative component operating time 119E+4 hours.No.of failures 24. Failure mode "all modes"include:
1)plugged,2)external,3)internal leak, 4) inadequate heat transfer

HXBAE heat exchanger straight tube horizontal shell and tube
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 4.2E-6/hr high: 7.3E-6/hr low: 2.1E-6/hr
Source: IEEE 500 (1984) pg.1363 Ultimate source: expert judgement and operating experience
Comment: reference :NUREG 2232

HXZAF heat exchanger straight tube radiation type
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 4.3E-6/hr 95%: 1.1E-5/hr 5%: 1.9E-6/hr ERROR FACTOR: 2.1 REPAIR TIME: 24 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Component population 46.Cumulative component operating time 69.8E+4 hours.No.of failures 3. Failure mode "all modes" include:
1)pluged,2)external,3)internal leakage,4)inadequate heat transfer

HXZAE heat exchanger straight tube radiator type
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 3.2E-6/hr high: 7.2E-6/hr low: 1.6E-6/hr
Source: IEEE 500 (1984) pg.1361 Ultimate source: expert judgement and experience
Comment: reference: NUREG 2232

HXMAE heat exchanger straight tube vertical shell and tube
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 2.3E-5/hr high: 3.7E-5/hr low: 1.4E-5/hr
Source: IEEE 500 (1984) pg.1362 Ultimate source: expert judgement and operating experience
Comment: reference : NUREG 2232

HXMAF heat exchanger straight tubes vertical shell and tube
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.1E-4/hr 95%: 1.5E-4/hr 5%: 8.3E-5/hr ERROR FACTOR: 1.3 REPAIR TIME: 24
Source: HWR data Ultimate source: HWR operating expereince
Comment: Component population 38.Cumulative component operating time 31E+4 hours.No.of failures 34. Failure mode "all modes" include:
1)plugged,2)external,3)nternal leak, 4)inadequate heat transfer

EHTFE heat tracing pipe heater
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failed to heat
FAILURE RATE OR PROBABILITY rec : 5.6E-7/hr high: 1.6E-6/hr low: 2.0E-7/hr
Source: IEEE 500 (1984) pg.310 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite of two sources. Reference: IEEE 500(1977) and NUREG 2232 (1980)

EHA5E heater air heater general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: overheated Original failure mode: overheated
FAILURE RATE OR PROBABILITY rec : 2.5E-7/hr high: 3.6E-6/hr low: 1.0E-8/hr REPAIR TIME: 1.5 hours
Source: IEEE 500 (1984) pg.288 Ultimate source: expert opinion aggreagtion and operating experience
Comment: Failure rate is comosite of different types and sizes of heaters and different sources including non-nuclear sources.

EHAFE heater air heater general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failed to heat
FAILURE RATE OR PROBABILITY rec · 1.1E-6/hr high: 1.6E-5/hr low: 7.0E-8/hr REPAIR TIME: 1.5 hours
Source: IEEE 500 (1984) pg.288 Ultimate source: expert opinion aggreagtion and operating experience
Comment: Failure rate is composite of different types and sizes of heaters and different sources including non-nuclear application.

JHFAE heater feedwater heater
Component boundary: detail n/a Operating mode: operating Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.3E-5/hr REPAIR TIME: 54 hours
Source: IEEE 500 (1984) pg.1387 Ultimate source: expert judgement and experience
Comment: reference: Nuclear unit productivity analysis, EPRI report No 46

EHPFE heater pressurizer heater
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: catastrophic
FAILURE RATE OR PROBABILITY rec : 2.2E-6/hr
Source: IEEE 500 (1984) pg.286 Ultimate source: operating experience
Comment: Catastropic failure mode include "Won't heat" and "Other" failure modes.
Reference:NUREG 2232 (1980)

QVARH hvac unit annulus ventilation
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 6.2E-5/hr 95%: 7.9E-5/hr 5%: 4.4E-5/hr REPAIR TIME: 21.6 hours
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 7.9E-6/hr. Operating experience 4.2E+5 hours of operation, 31 failure. Repair time is mean of 59 maintenance events.

QVXRH hvac unit auxiliary building
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 6.1E-5/hr 95%: 7.4E-5/hr 5%: 4.5E-5/hr REPAIR TIME: 10 hours
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 7.9E-6/hr. Operating experience 3.5E+5 hours of operation, 22 failures. Repair time is mean of 77 maintenance events.

QVXSH hvac unit auxiliary building
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 1.9E-3/d 95%: 3.7E-3/d 5%: 4.2E-4/d
Source: Old PWR Ultimate source: generic data updated with plant specific operating expereince
Comment: Generic mean 4.8E-4/d. Operating experience 635 demands, 3 failures.

QVBRH hvac unit battery room ventilation
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 7.2E-6/hr 95%: 1.2E-5/hr 5%: 2.9E-6/hr REPAIR TIME: 5.1 hours
Source: Old PWR Ultimate source: generic data updated with plant opearting experience
Comment: Generic mean 7.9E-6/hr. Operaing experience 2.7E+5 hours of operation, 2 failures. Repair time is mean of maintenace events.

QVBSH hvac unit battery room ventilation
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 4.0E-4/d 95%: 8.7E-4/d 5%: 5.0E-5/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 4.8E-4/d. Operating experience 376 demands, no failures.

QVCRH hvac unit cable spreading room
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 9.3E-6/hr 95%: 1.7E-5/hr 5%: 3.4E-6/hr REPAIR TIME: 5.1 hours
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 7.9E-6/hr. Operating experience 1.4E+5 hours of operation, 2 failures.Repair time is mean of 6 maintenance events

QVCSH hvac unit cable spreading room
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 4.3E-4/d 95%: 1.0E-3/d 5%: 5.0E-5/d
Source: Old PWR Ultimate source: generic data updated with plant operating expereince
Comment: Generic mean 4.8E-4/d. Operating experience 189 demands, no failures.

QVRRH hvac unit control room ventilation
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 3.5E-5/hr 95%: 4.7E-5/hr 5%: 1.5E-5/hr REPAIR TIME: 46.9 hours
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 9.4E-5/hr. Operating experience 1.7E+5 hours of operation, 4 failures. Repair time is mean of 7 maintenance events.

QVRSH hvac unit control room ventilation
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 5.5E-3/d 95%: 9.6E-3/d 5%: 1.4E-3/d
Source: Old PWR Ultimate source: generic data updated with plant specific operating experince
Comment: Generic mean 8.1E-3/d. Operating experience 394 demands, 2 failures.

QVERH hvac unit electric eqiupment area ventilation
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 7.4E-5/hr 95%: 9.6E-5/hr 5%: 4.9E-5/hr REPAIR TIME: 28.6 hours
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 7.9E-6/hr. Operating experience 2.6E+5 hours of operation, 21 failures. Repair time is mean of 50 maintenance events.

QVESH hvac unit electrical equipment area ventilaton
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 3.1E-4/d 95%: 7.8E-4/d 5%: 5.0E-5/d
Source: Old PWR Ultimate source: generic data updated with plant operating experince
Comment: Generic mean 4.8E-4/d. Operating experience 1174 demands, no failures.

QVIRH hvac unit intermediate building
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 1.6E-5/hr 95%: 3.0E-5/hr 5%: 4.5E-6/hr REPAIR TIME: 25 hours
Source: Old PWR Ultimate source: generic data updated with plant operating expereince
Comment: Generic mean 7.9E-6/hr. Operating experience 1.4E+5 hours of operation, 4 failures. Repair time is mean of maintenance events

QVISH hvac unit intermediate building
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 4.3E-4/d 95%: 1.0E-3/d 5%: 5.0E-5/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 4.8E-4/d. Operating experience 207 demands,no failures

QVASH hvacunit annulus ventilation
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 2.2E-4/d 95%: 4.5E-4/d 5%: 4.4E-5/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 4.8E-4/d. Operating experience 3189 demands,no failures.

UIEFT indicating instrument electronic general

Component boundary: not clear Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: faulty measurement
FAILURE RATE OR PROBABILITY mean : 7.7E-7/hr 95%: 3.1E-6/hr REPAIR TIME: 2 hours
Source: Swedish Rel.data book, tbl.39 Ultimate source: plant operating experience (7 BWR plants),ATv reports, LERs
Comment: Operating experience:total pop. 280. Operational time 1040E+4 hours. No.of failures 8. a=0.0315; b=41100
Critical failures reported on 5 plants.

IAABW instrumentation general

Component boundary: includes transmitter, amplifier and output device Operating mode: all Operating environment: normal
Generic failure mode: degraded Original failure mode: shift in calibration
FAILURE RATE OR PROBABILITY median: 1.0E-5/hr 95%: 1.0E-4/hr 5%: 1.0E-6/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from military experience and data and testing facilities
Comment: The data for shift in calibration incorporate a variation of drift magnitude, an may be very pessimistic if used for instrumen
tarion with wide tolerance bands.

IAAFI instrumentation general

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 3.0E-6/hr ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

IAAFW instrumentation general

Component boundary: includes transmitter, amplifier and output device Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY median: 1.0E-6/hr 95%: 1.0E-5/hr 5%: 1.0E-7/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear,industrial and military experience and data
Comment: The relatively large error factor associated with instrumentation reflects wide variation in configuration from application to
application.

ICCBM instrumentation channel analog core flux

Component boundary: Complete instr.channel(sensor,transmitter,cond.system,bistable) Operating mode: operating Operating environment: normal
Generic failure mode: degraded Original failure mode: reduced capability
FAILURE RATE OR PROBABILITY mean : 5.8E-6/hr 95%: 6.4E-6/hr 5%: 5.3E-6/hr
Source: NUREG 1740 (1984) (table 19) Ultimate source: US plants LER reports evaluation
Comment: Overall rate,with command faults. W/o command faults 5.3E-6/hr

ICCFM instrumentation channel analog core flux

Component boundary: Complete instr.channel(sensor,transmitter,cond.system,bistable) Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: inoperable
FAILURE RATE OR PROBABILITY mean : 8.2E-6/hr 95%: 9.0E-6/hr 5%: 7.5E-6/hr
Source: NUREG 1740 (1984) (table 19) Ultimate source: US plants LER reports evaluation
Comment: Overall rate with command faults. W/o command faults 7.5E-6/hr.

ICFBM instrumentation channel analog flow

Component boundary: comlete instr.channel(sensor,trensmitter,cond.system,bistable) Operating mode: operating Operating environment: normal
Generic failure mode: degraded Original failure mode: reduced capability
FAILURE RATE OR PROBABILITY mean : 5.2E-6/hr 95%: 6.2E-6/hr 5%: 4.3E-6/hr
Source: NUREG 1740 (1984) (table 19) Ultimate source: US plants LER reports evaluation
Comment: Overall rate with command faults. W/o command faults 4.9E-6/hr.

ICFFM instrumentation channel analog flow

Component boundary: complete instr.channel(sensor,transmitter,cond.system,bistable) Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: inoperable
FAILURE RATE OR PROBABILITY mean : 4.5E-6/hr 95%: 5.4E-6/hr 5%: 3.8E-6/hr
Source: NUREG 1740 (1984) (table 19) Ultimate source: US plants LER reports evaluation
Comment: Overall rate with command faults.W/o command faults 4.2E-6/hr. PWR rate about 4 times higher than BWR.

ICLBM instrumentation channel analog level

Component boundary: complete instr.channel(sensor,transmitter,cond.system,bistable) Operating mode: operating Operating environment: normal
Generic failure mode: degraded Original failure mode: reduced capability
FAILURE RATE OR PROBABILITY mean : 6.7E-6/hr 95%: 8.0E-6/hr 5%: 5.6E-6/hr
Source: NUREG 1740 (1984) (table 19) Ultimate source: US plants LER reports evaluation
Comment: Not applicable to BWR. Overall PWR rate with command faults. W/o command faults 6.2E-6/hr.

ICLFM instrumentation channel analog level

Component boundary: complete instr.channel(sensor,transmitter,cond.system,bistable) Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: inoperable
FAILURE RATE OR PROBABILITY mean : 4.5E-6/hr 95%: 5.4E-6/hr 5%: 3.8E-6/hr
Source: NUREG 1740 (1984) (table 19) Ultimate source: US plants LER reports evaluation
Comment: Not applicable to BWR.Overall PWR rate with command faults. W/o command faults 4.1E-6/hr.

ICPBM instrumentation channel analog pressure
Component boundary: complete instr.channel(sensor,transmitter,cond.system,bistable) Operating mode: operating Operating environment: normal
Generic failure mode: degraded Original failure mode: reduced capacity
FAILURE RATE OR PROBABILITY mean : 8.2E-6/hr 95%: 9.8E-6/hr 5%: 6.8E-6/hr
Source: NUREG 1740 (1984) (table 19) Ultimate source: US plants LER reports evaluation
Comment: Not applicable to BWR. Overall PWR rate with command faults. W/o command faults 7.8E-6/hr.

ICPFM instrumentation channel analog pressure
Component boundary: complete instr.channel(sensor,transmitter,cond.system,bistable) Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: inoperable
FAILURE RATE OR PROBABILITY mean : 4.6E-6/hr 95%: 6.0E-6/hr 5%: 3.5E-6/hr
Source: NUREG 1740 (1984) (table 19) Ultimate source: US plants LER reports evaluation
Comment: Not applicable to BWR. Overall PWR rate with command faults. W/o command faults 3.8E-6/hr.

ICTBM instrumentation channel analog temperature
Component boundary: complete instr.channel(sensor,transmitter,cond.system,bistable) Operating mode: operating Operating environment: normal
Generic failure mode: degraded Original failure mode: reduced capability
FAILURE RATE OR PROBABILITY mean : 6.8E-6/hr 95%: 8.8E-6/hr 5%: 5.2E-6/hr
Source: NUREG 1740 (1984) (table 19) Ultimate source: US plants LER reports evaluation
Comment: Not applicable to BWR. Overall PWR rate with command faults. W/o command faults 6.7E-6/hr.

ICTFM instrumentation channel analog temperature
Component boundary: complete instr.channnel(sensor,transmitter,cond. system,bistable) Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: inoperable
FAILURE RATE OR PROBABILITY mean : 1.4E-5/hr 95%: 1.7E-5/hr 5%: 1.2E-5/hr
Source: NUREG 1740 (1984) (table 19) Ultimate source: US plants LER reports evaluation
Comment: Not applicable to BWR. Overall PWR rate with command faults. W/o command faults 1.3E-5/hr.

IDLBM instrumentation channel digital level
Component boundary: level switch Operating mode: operating Operating environment: normal
Generic failure mode: degraded Original failure mode: reduced capability
FAILURE RATE OR PROBABILITY mean : 8.3E-6/hr 95%: 1.0E-5/hr 5%: 6.9E-6/hr
Source: NUREG 1740 (1984) (table 19) Ultimate source: US plants LER reports evaluation
Comment: Level switch is considered a channel.Not applicable to PWR. BWR rate with command faults. W/o commad faults 6.8E-6/hr

IDLFM instrumentation channel digital level
Component boundary: level switch Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: inoperable
FAILURE RATE OR PROBABILITY mean : 2.7E-6/hr 95%: 3.8E-6/hr 5%: 1.9E-6/hr
Source: NUREG 1740 (1984) (table 19) Ultimate source: US plants LER reports evaluation
Comment: Level switch is considered a channel. Not applicable to PWR. BWR rate with command faults. W/o command faults 2.4E-6/hr.

IDPBM instrumentation channel digital pressure
Component boundary: pressure switch Operating mode: operating Operating environment: normal
Generic failure mode: degraded Original failure mode: reduced capability
FAILURE RATE OR PROBABILITY mean : 7.3E-6/hr 95%: 8.0E-6/hr 5%: 6.6E-6/hr
Source: NUREG 1740 (1984) (table 19) Ultimate source: US plants LER reports evaluation
Comment: Pressure switch is considered a channel.Overall rate with command fault. W/o command faults 7.1E-6/hr.
BWR rate about 5 times higher than PWR.

IDPFM instrumentation channel digital pressure
Component boundary: pressure switch Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: inoperable
FAILURE RATE OR PROBABILITY mean : 4.1E-7/hr 95%: 7.0E-7/hr 5%: 2.3E-7/hr
Source: NUREG 1740 (1984) (table 19) Ultimate source: US plants LER reports evaluation
Comment: Pressure switch is considered a channel.Overall rate with command faults. W/o command faults 3.7E-7/hr.
BWR rate is tvice PWR rate.

YTSQH intake screen service water system
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: plug Original failure mode: plugged during operation
FAILURE RATE OR PROBABILITY mean : 3.7E-6/hr 95%: 9.0E-6/hr 5%: 6.5E-7/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 6.2E-6/hr. Operating expereince 1.36E+5 hours of operation, no failres.

EIAAJ inverter general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: hardware failure
FAILURE RATE OR PROBABILITY mean : 4.0E-2/d ERROR FACTOR: 3
Source: NUREG 4550, Vol.1,tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: There is no specific failure mode assigned for this component in the source. ASEP used IPRD (NUREG 3831) value of 1.0E-4/hr
assuming montly system test.

EIAFB inverter general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 6.0E-5/hr max: 4.0E-4/hr min: 3.0E-5/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment:

EIAFI inverter general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 1.0E-4/hr ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

EIAFZ inverter general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 1.1E-5/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant operating experience
Comment: Prior: WASH 1400, solid state devices, high power application failure mode "fails to function".Operating experience:
3.04E+5 hours of operation, 3 failures.

EIIFO inverter instrument inverter
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: operational failure
FAILURE RATE OR PROBABILITY mean : 4.3E-5/hr 95%: 4.8E-5/hr 5%: 4.9E-6/hr REPAIR TIME:
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Not possible to identify prior source. Prior mean 1.3E-4/hr. Oper exp:3.37E+5 hours of operation,9 failures.

EISFN inverter solid state 120 volts AC
Component boundary: inverter,transfer switch,rectifier,feeder breaker,prot.& control Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output
FAILURE RATE OR PROBABILITY rec : 2.1E-5/hr high: 1.9E-4/hr low: 8.5E-6/hr REPAIR TIME: 4-8 hours
Source: NUREG 3831 (1985) (tbl.A18) Ultimate source: operating experience (plant records)
Comment: Operating experience:total pop.31. Operating time 985.505 hours No.of failures 21.
Repair time is range of medians.

EISFT inverter static
Component boundary: inverter,reversing switch,associated cables, transformer,breaker Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: loss of effective output
FAILURE RATE OR PROBABILITY mean : 5.2E-6/hr 95%: 2.6E-5/hr REPAIR TIME: 13 hours
Source: Swedish Rel.data book, tbl.43 Ultimate source: plant operating experience (4 BWR plants), ATV reports, LERs
Comment: Operating experience: Total pop.10. Operational time 38.5E+4. No.of failures 2. Only one critical failure; a=0.224; b=43100

EISFY inverter static
Component boundary: inverter, reversing switch, associated cables,transformer,breaker Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: loss of effective output
FAILURE RATE OR PROBABILITY mean : 1.2E-5/hr REPAIR TIME: 11 hours
Source: Swedish Rel.data book, tbl.43 Ultimate source: plant operating experience (Ringhals 2 PWR)
Comment: operating experience: Total pop. 4. Total operational time 17.29E+4 hours.No.of failures 2.

EIZFE inverter static single phase
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output
FAILURE RATE OR PROBABILITY rec : 1.0E-6/hr high: 1.2E-5/hr low: 3.0E-7/hr
Source: IEEE 500 (1984) pg.276 Ultimate source: expert opinion aggregation and operating experience
Comment: Reference IEEE 500(1977)

EIXFE inverter static three phase
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output
FAILURE RATE OR PROBABILITY rec : 3.0E-6/hr high: 3.0E-5/hr low: 1.9E-7/hr
Source: IEEE 500 (1984) pg.277 Ultimate source: expert opinion aggregation and operating experience
Comment: Reference IEEE 500 (1977)

UEYFO isolating diode assembly
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: operational failure
FAILURE RATE OR PROBABILITY mean : 3.7E-6/hr 95%: 6.8E-6/hr 5%: 4.1E-7/hr
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:Diode,high power application, MIL-HDBK 217C, all failure modes. High power value =20Xlow power value.Operating experience:
3.86E+5 hours of operation, 1 failure.

JLCFS lube oil cooler
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fails to operate
FAILURE RATE OR PROBABILITY mean : 1.5E-6/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating experience
Comment:

UMCFF manual control device pushbutton
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY mean : 2.3E-7/hr REPAIR TIME: 3 hours
Source: HWR data Ultimate source: HWR assesment
Comment: Ultimate data source not known. Number of demands in time not known.
Repair time conservatevly estimated to be 3 hours.

UMCKF manual control device pushbutton
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: spurious operation
FAILURE RATE OR PROBABILITY mean : 1.1E-7/hr
Source: HWR data Ultimate source: HWR assesment
Comment: Ultimate data source not known.

MPHAF motor HP emergency coolant injection pump motor
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.7E-5/hr 95%: 2.9E-5/hr 5%: 1.1E-5/hr ERROR FACTOR: 1.6 REPAIR TIME: 223 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Population not known. Cumulative component operating time 63.9E4 hours. 11 failures.

MPLAF motor LP emergency coolant injection pump motor
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.0E-5/hr 95%: 2.1E-5/hr 5%: 5.7E-6/hr ERROR FACTOR: 1.8 REPAIR TIME: 210 hours
Source: HWR data Ultimate source: HWR operating experince
Comment: Population not known. Cumulative component operating time 57.5E+4 hours. 6 failures.

MPSAF motor LP service water pump motor
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 9.8E-6/hr 95%: 2.1E-5/hr 5%: 5.1E-6/hr ERROR FACTOR: 1.9 REPAIR TIME: 200 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Population not known. Cumulative component operating time 51.1E+4 hours. 5 failures.

MPFAF motor auxiliary boiler feed pump motor
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.1E-5/hr 95%: 1.5E-5/hr 5%: 8.6E-6/hr ERROR FACTOR: 1.3 REPAIR TIME: 274 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Population not known. Cum.operating time 2.7E+6 hours. 31 failures.

MPCAF motor circulating water pump motor
Component boundary: detail n/a Operating mode: running Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 7.7E-6/hr 95%: 1.8E-5/hr 5%: 3.8E-6/hr ERROR FACTOR: 2.0 REPAIR TIME: 452 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Population not known. Cum.operating time 51.9E+4 hours. 4 failures.

MPEAF motor condensate extraction pump motor
Component boundary: detail n/a Operating mode: running Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 2.5E-6/hr 95%: 3.6E-6/hr 5%: 1.7E-6/hr ERROR FACTOR: 1.4 REPAIR TIME: 161 hour
Source: HWR data Ultimate source: HWR operating experience
Comment: Population not known. Cumulative component operating time 7.7E+6 hours. 19 failures.

MPZAF motor emergency service water pump motor
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 8.0E-6/hr 95%: 1.2E-5/hr 5%: 5.5E-6/hr ERROR FACTOR: 1.4 REPAIR TIME: 150 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Population not known. Cumulative component operating time 2.3E+6 hours. 18 failures.

MPXAF motor end shield tank cooling pump motor
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.3E-5/hr 95%: 2.7E-5/hr 5%: 6.8E-6/hr ERROR FACTOR: 1.9 REPAIR TIME: 211 hours
Source: HWR data Ultimate source: HWR operating experiecne
Comment: Population not known. Cumulative operating time 38E+4 hours. 5 failures.

MPBAF motor generator main lube oil pump motor
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.3E-5/hr 95%: 2.8E-5/hr 5%: 6.8E-6/hr ERROR FACTOR: 1.9 REPAIR TIME: 211 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Populaton not known. Cum.operating time 38E+4 hours.5 failures.

MPMAF motor main moderator pump motor
Component boundary: detail n/a Operating mode: running Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.5E-5/hr 95%: 3.4E-5/hr 5%: 7.3E-6/hr ERROR FACTOR: 2.0 REPAIR TIME: 227 hours
Source: HWR data Ultimate source: WRU operating experience
Comment: Population not known. Cumulative component operating time 27E+4 hours. 4 failures.

MPQAF motor powerhouse upper level service water pump motor
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.1E-5/hr 95%: 2.4E-5/hr 5%: 5.2E-6/hr ERROR FACTOR: 2.0 REPAIR TIME: 263 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Population not known. Cum.operating time 38E+4 hours.4 failures

MPPAF motor primary heat transport feed circut pump motor
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.1E-5/hr 95%: 2.3E-5/hr 5%: 5.7E-6/hr ERROR FACTOR: 1.9 REPAIR TIME: 154 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Population not known. Cum.operating time 45.7E+4 hours. 5 failure

MPVAF motor primary heat transport pump motor
Component boundary: detail n/a Operating mode: running Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.5E-5/hr 95%: 2.9E-5/hr 5%: 8.7E-6/hr ERROR FACTOR: 1.7 REPAIR TIME: 170 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Population not known. Cum.operating time 45.6E+4 hours. 7 failures.

MPWAF motor shutdown cooling water pump motor
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.6E-5/hr 95%: 3.1E-5/hr 5%: 8.6E-6/hr ERROR FACTOR: 1.8 REPAIR TIME: 184 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Population not known. Cumulative component operating time 38E+4 hours. 6 failures.

MACRE motor AC general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail to run once started
FAILURE RATE OR PROBABILITY rec : 3.2E-6/hr high: 3.0E-3/hr low: 0.0E-0/hr REPAIR TIME: 1.8 hours
Source: IEEE 500 (1984) pg.220 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite of different types and voltage levels.

MAIRE motor AC induction
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail to run once started
FAILURE RATE OR PROBABILITY rec : 1.2E-6/hr high: 1.6E-3/hr low: 1.0E-8/hr
Source: IEEE 500 (1984) pg.229 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite of different voltage and power levels.

MASAE motor AC split phase
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.6E-6/hr high: 1.5E-3/hr low: 1.0E-8/hr
Source: IEEE 500 (1984) pg.242 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite of two voltage levels

MAWAE motor AC synchronous single phase
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail to run once started
FAILURE RATE OR PROBABILITY rec : 7.0E-7/hr high: 8.4E-7/hr low: 5.6E-7/hr
Source: IEEE 500 (1984) pg.241 Ultimate source: expert opinion aggregation and operating experience
Comment:

MAWSE motor AC synchronous single phase
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start
FAILURE RATE OR PROBABILITY rec : 5.5E-7/hr high: 6.6E-7/hr low: 4.4E-7/hr
Source: IEEE 500 (1984) pg.241 Ultimate source: expert opinion aggregation and operating experience
Comment: Number of starts in time not known.

MDAAE motor DC general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.5E-5/hr high: 3.7E-4/hr low: 1.0E-8/hr
Source: IEEE 500 (1984) pg.245 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure mode is compsite of two types of DC motors

MPKAF motor boiler feed pump motor
Component boundary: detail n/a Operating mode: running Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.5E-5/hr 95%: 2.6E-5/hr 5%: 9.5E-6/hr ERROR FACTOR: 1.6 REPAIR TIME: 194 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Population not known. Cumulative operating time 65E+4 hours. 10 failures

MAARG motor general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail to run
FAILURE RATE OR PROBABILITY median: 2.0E-6/hr ERROR FACTOR: 8
Source: German Risk Study (tb.F3,7-1) Ultimate source: generic data
Comment: Failure rate is combination of number of generic data sources including non-nuclear.

MAARS motor general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: fails to run given start
FAILURE RATE OR PROBABILITY mean : 1.0E-6/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating experience
Comment:

MAARW motor general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: failure to run, given start
FAILURE RATE OR PROBABILITY median: 1.0E-5/hr 95%: 3.0E-5/hr 5%: 3.0E-6/hr ERROR FACTOR: 3
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear, industrial and military expereince and data
Comment: Applicable only to motors that function independently of pumps and valves.

MAASG motor general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start
FAILURE RATE OR PROBABILITY median: 1.0E-6/hr ERROR FACTOR: 8
Source: German Risk Study (tb.F3,7-1) Ultimate source: generic data
Comment: Failure rate is combination of number of generic data sources, including non nuclear.

MAASW motor general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY median: 3.0E-4/d 95%: 1.0E-3/d 5%: 1.0E-4/d ERROR FACTOR: 3
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear, industrial and military expereince and data
Comment: Demand probability is based on presence of proper input signal Applicable only to motors that function independently of pumps and valves

MAXRW motor general
Component boundary: detail n/a Operating mode: all Operating environment: extreme (post accident)
Generic failure mode: fail to run Original failure mode: failure to run, given start
FAILURE RATE OR PROBABILITY median: 1.0E-3/hr 95%: 1.0E-2/hr 5%: 1.0E-4/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from military,research & test reactor and limited NPP
Comment: Applicable only to motors that function independently of pumps and valves

MSSFE motor servo general

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail to position
FAILURE RATE OR PROBABILITY rec : 2.6E-7/hr high: 5.5E-7/hr low: 8.0E-8/hr
Source: IEEE 500 (1984) pg.248 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite.

MSSFE motor servo general

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail to operate on demand
FAILURE RATE OR PROBABILITY rec : 2.5E-7/hr high: 5.5E-7/hr low: 8.0E-8/hr
Source: IEEE 500 (1984) pg.248 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite. Number of demands in time not known.

MGXAE motor generator

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 4.0E-5/hr high: 5.6E-5/hr low: 2.8E-5/hr REPAIR TIME: 2.5 hours
Source: IEEE 500 (1984) pg.278 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite of two non-nuclear sources. References: Corps of engineers R/M data base and NPRD-2

MGAFH motor generator AC 220 V

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 6.3E-6/hr 95%: 1.4E-5/hr 5%: 2.5E-6/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 3.6E-5/hr. Operating experience 5.4E+5 hours of operation, 3 failures.

MGDFB motor generator D-C

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 3.0E-6/hr max: 2.0E-5/hr min: 6.0E-8/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment:

MGDFI motor generator D-C
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 3.0E-6/hr ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

MGRFT motor generator D-C rotating converter
Component boundary: DC motor, generator,excitation,rotation regulator,fuse,cables. Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: loss of effective output
FAILURE RATE OR PROBABILITY mean : 2.1E-5/hr 95%: 7.2E-5/hr REPAIR TIME: 14 hours
Source: Swedish Rel.data book, tbl.44 Ultimate source: plant operating experience (7 BWR plants),ATV reports, LERs
Comment: operating experience:total pop.42.Operational time 147E+4 hours No.of failures 31.a=0.711; b=33700. 2 groups of rot. converters: regulation of main coolant pumps(NNS);supply batt.secured AC net

FXAQB orifice
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: plug Original failure mode: plug
FAILURE RATE OR PROBABILITY mean : 6.0E-7/hr max: 4.0E-6/hr min: 3.0E-7/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion and IREP data
Comment: Given data are WASH 1400 data as alternate data are not available. WASH data are per demand. Calculated number of demands per unit time is not known.

FXTQW orifice, test valve, flow meter
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: plug Original failure mode: failure to remain open (plug)
FAILURE RATE OR PROBABILITY median: 3.0E-4/d 95%: 1.0E-3/d 5%: 1.0E-4/d ERROR FACTOR: 3
Source: WASH 1400 (table III 4-1) Ultimate source: ultimate data source not known
Comment:

FXTTW orifice, test valve, flow meter
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: rupture Original failure mode: rupture
FAILURE RATE OR PROBABILITY median: 1.0E-8/hr 95%: 1.0E-7/hr 5%: 1.0E-9/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-1) Ultimate source: assesed from reports and experts opinion
Comment:

EB1FO panelboard 120 V AC

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: operational failure
FAILURE RATE OR PROBABILITY mean : 3.8E-7/hr 95%: 8.3E-7/hr 5%: 3.E-10/hr REPAIR TIME: 10.8 hours
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Pricr:IEEE 500(1977)(pg.185) DC buswork, failmode"failure during operation". Operating experience:3.86E+5 hours,no failures.
Repair time is mean of updated maintenance duration(bus or panel)

JPEAE penetration electrical

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.0E-7/hr
Source: IEEE 500 (1984) pg.1342 Ultimate source: expert opinion and experience
Comment: reference : NUREG 1730

JPPAE penetration piping

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 8.0E-8/hr
Source: IEEE 500 (1984) pg.1343 Ultimate source: expert judgement and experience
Comment: reference NUREG 1730

FSSTF pipe (nuclear grade) straight section diameter size less than 1 inch

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: rupture Original failure mode: rupture
FAILURE RATE OR PROBABILITY mean : 1.2E-9/hr 95%: 2.0E-9/hr 5%: 7.E-10/hr ERROR FACTOR: 1.6
Source: HWR data Ultimate source: HWR operating experience
Comment: Population 7.3E+4 meters.Operating time 8.5E+9 meter-hours.No.of failures 10. Data include contribution from all pressure boundary components(nozzle,fittings,valve bodies).

FSMTF pipe (nuclear grade) straight section diameter sizes between 1 and 6 inches

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: rupture Original failure mode: rupture
FAILURE RATE OR PROBABILITY mean : 7.E-11/hr 95%: 3.E-10/hr 5%: 2.E-11/hr ERROR FACTOR: 2.8
Source: HWR data Ultimate source: HWR operating expreince
Comment: Population:13E+4 meters.Operating time 1.5E+10 meter-hrs. 1 failure. Data include contribution from all pressure boundary components(nozzle,fittings,valve bodies).

FS3JW piping <= 3" diameter
Component boundary: pipe section(average lenght between two discontinuities-valves) Operating mode: all Operating environment: normal
Generic failure mode: rupture/plug Original failure mode: rupture/plug
FAILURE RATE OR PROBABILITY median: 1.0E-9/hr 95%: 3.0E-8/hr 5%: 3.E-11/hr ERROR FACTOR: 30
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear,industrial experience and expert opinion
Comment: Given value is per pipe section. Given value applicable to standby and actve pipes.
Assesment based on rupture only.

FSMJW piping > 3" diameter
Component boundary: Pipe section(average lenght between two discontinuities-valves) Operating mode: all Operating environment: normal
Generic failure mode: rupture/plug Original failure mode: rupture/plug
FAILURE RATE OR PROBABILITY median: 1.E-10/hr 95%: 3.0E-9/hr 5%: 3.E-12/hr ERROR FACTOR: 30
Source: WASH 1400 (table III 4-1) Ultimate source: assesed from nuclear,industrial expereince and expert opinion
Comment: Given value is per pipe section. Applicable to high quality piping. Given value applies to standby
and active pipes. Assesment based on rupture only.

FE5AE piping elbow 4-6 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.9E-5/hr high: 1.9E-3/hr low: 6.3E-7/hr
Source: IEEE 500 (1984) pg.1319 Ultimate source: expert judgement and experience
Comment: reference NUREG 2232

FEATH piping expansion joint
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: rupture Original failure mode: rupture/excessive leakage during operation
FAILURE RATE OR PROBABILITY mean : 5.9E-8/hr 95%: 1.7E-7/hr 5%: 1.0E-8/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 1.6E-6/hr. Operating experience 6.83E+6 hours of operation, no failures.

FE3AE piping expansion joint 3 " 400 PSI corrugated steel
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.2E-6/hr
Source: IEEE 500 (1984) pg.1325 Ultimate source: expert judgement and experience
Comment: reference:NUREG 2232

FNAAE piping nozzle
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.8E-5/hr high: 2.2E-3/hr low: 1.8E-6/hr
Source: IEEE 500 (1984) pg.1328 Ultimate source: expert judgement and experience
Comment: Given value is composite of diffrerent sizes. reference :NUREG 2232

FNSQO piping nozzle spray nozzle
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: plug Original failure mode: plugged (50%)
FAILURE RATE OR PROBABILITY mean : 2.4E-4/d 95%: 9.0E-4/d 5%: 9.5E-6/d
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: engineering judgement,extrapolation ofdata of small pipe plugging
Comment: Applicable to the plugging of approximately 50% of the spray nozzles of the single header. It was assumed that no water flow test are performed to verify that spray nozzles are open.

FRLAE piping rupture diaphragm 10-16 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 3.3E-6/hr
Source: IEEE 500 (1984) pg.1327 Ultimate source: expert judgement and experience
Comment: reference :NUREG 2232

FSAAE piping straight section general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 9.4E-6/hr high: 1.8E-3/hr low: 4.5E-7/hr
Source: IEEE 500 (1984) pg.1314 Ultimate source: expert judgement and experience
Comment: Given value is composite of different piping sizes. reference NUREG 2232

FTAAE piping tees general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.9E-5/hr high: 2.2E-3/hr low: 1.7E-6/hr
Source: IEEE 500 (1984) pg.1321 Ultimate source: expert judgement and experience
Comment: G9ven value is composite of diferent sizes of. reference: NUREG 2232

FTLAE piping thermowell 6-10 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.8E-5/hr high: 7.3E-5/hr low: 1.8E-6/hr
Source: IEEE 500 (1984) pg.1324 Ultimate source: expert judgement and experience
Comment: reference :NUREG 2232

FWSAE piping welds less than 4" conecting weld
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 2.2E-5/hr high: 2.3E-3/hr low: 7.6E-6/hr
Source: IEEE 500 (1984) pg.1326 Ultimate source: expert judgement and experience
Comment: reference:NUREG 2232

EPAFE power supply general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output
FAILURE RATE OR PROBABILITY rec : 1.4E-6/hr high: 2.0E-6/hr low: 3.0E-8/hr
Source: IEEE 500 (1984) pg.660 Ultimate source: expert opinion aggregation
Comment: Reference IEEE 500 (1977)

EPAFS power supply general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fails to operate
FAILURE RATE OR PROBABILITY mean : 4.2E-6/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating experience
Comment:

PWAAF pump auxiliary boiler feed pump
Component boundary: detail n/a Operating mode: standby? Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 7.6E-5/hr 95%: 1.3E-4/hr 5%: 4.8E-5/hr ERROR FACTOR: 1.6 REPAIR TIME: 11 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Population: unknown.Cumulative component operating time 14.5E+4 hours. No.of failures 11. FM "all modes" is not defined,but prob.
incl:1)external leak,2)start,3)run failure,4)less than rated outp

PWCRE pump centrifugal
Component boundary: detail n/a. Sometimes include driver. Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: fails while running
FAILURE RATE OR PROBABILITY rec : 7.1E-6/hr high: 5.8E-4/hr low: 0.0E-0/hr
Source: IEEE 500 (1984) pg.890 Ultimate source: expert opinion, selected plant data
Comment: Given value is composite of several sources, different pump types and sizes and operating modes.More specific data included elswere

PWCSE pump centrifugal
Component boundary: Detail n/a.Sometimes include driver Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: fails to start
FAILURE RATE OR PROBABILITY rec : 4.7E-3/cy high: 2.5E-1/cy low: 0.0E-0/cy
Source: IEEE 500 (1984) pg.893 Ultimate source: expert opinion,selected plant data,NUREG 2886,1205,2232,NPRD-2
Comment: This value is composite of several sources, different pump types and operating modes.More detailed data are included elswere.

PWDBF pump centrifugal horisontal flow 22-820 l/s
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: degraded Original failure mode: less than rated output
FAILURE RATE OR PROBABILITY mean : 1.5E-5/hr 95%: 2.1E-5/hr 5%: 1.2E-5/hr ERROR FACTOR: 1.3 REPAIR TIME: 18
Source: HWR data Ultimate source: HWR operating expereince
Comment: Population 44.Cumulative component operating time 226E+4 hours. 35 failures.

PWDSF pump centrifugal horisontal flow 22-820 l/s
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: start failure
FAILURE RATE OR PROBABILITY mean : 1.0E-6/hr 95%: 2.7E-6/hr 5%: 3.4E-7/hr ERROR FACTOR: 2.4 REPAIR TIME: 21 hour
Source: HWR data Ultimate source: HWR operating expreince
Comment: Number of starts per operational time is not known. Population 44.Component cumulative operational time 226E+4 hours.
no.of failures 2.

PWBRF pump centrifugal horizontal flow 22-820 l/s
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: running failure
FAILURE RATE OR PROBABILITY mean : 6.2E-6/hr 95%: 9.7E-6/hr 5%: 4.1E-6/hr ERROR FACTOR: 1.5 REPAIR TIME: 10 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Population 44. Component cumulative operating time 226E+4 hours. No.of failures 14.

PWBYF pump centrifugal horizontal flow 22-820 l/s
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leak
FAILURE RATE OR PROBABILITY mean : 2.4E-5/hr 95%: 3.0E-5/hr 5%: 1.9E-5/hr ERROR FACTOR: 1.2 REPAIR TIME: 8 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Population 44. Cumulative component operating time 226E+4 hours. 54 failures

PWEBF pump centrifugal vertical flow 70-1900 l/s
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: degraded Original failure mode: less than rated output
FAILURE RATE OR PROBABILITY mean : 1.4E-5/hr 95%: 1.8E-5/hr 5%: 1.1E-5/hr ERROR FACTOR: 1.3 REPAIR TIME: 12
Source: HWR data Ultimate source: HWR operating expereince
Comment: Population 62. Cumulative component operating time 296E+4 hours. 110 failures.

PWERF pump centrifugal vertical flow 70-1900 l/s
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: running failure
FAILURE RATE OR PROBABILITY mean : 4.0E-6/hr 95%: 7.0E-6/hr 5%: 2.9E-6/hr ERROR FACTOR: 1.5 REPAIR TIME: 15 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Population 62.Cumulative component operating time 296E+4 hours. 13 failures.

PWESF pump centrifugal vertical flow 70-1900 l/s
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: start failure
FAILURE RATE OR PROBABILITY mean : 1.0E-6/hr 95%: 1.5E-6/hr 5%: 1.1E-7/hr ERROR FACTOR: 2.8 REPAIR TIME: 9 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Number of starts per operational time is not known. Population 62. Cumulative component operating time 296E+4 hours.
No.of failures 1.

PWEYF pump centrifugal vertical flow 70-1900 l/s
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leak
FAILURE RATE OR PROBABILITY mean : 3.6E-5/hr 95%: 4.3E-5/hr 5%: 3.1E-5/hr ERROR FACTOR: 1.2 REPAIR TIME: 5 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Population 62. Cumulative component operating time 296E+4 hours. No.of failures 110.

PWFAF pump condensate extraction pump
Component boundary: detail n/a Operating mode: running Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 5.5E-5/hr 95%: 6.8E-5/hr 5%: 4.4E-5/hr ERROR FACTOR: 1.2 REPAIR TIME: 16.3
Source: HWR data Ultimate source: HWR operating experience
Comment: Population: unknown.Cumulative component operating time 100E+4 hr No.of failures 55.FM"all modes" is not defined,but probbably incl 1)external leak,2)start,3)run failure,4)less than rated output.

PWPRE pump positive displacement
Component boundary: Variable. Sometimes includes driver. Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: fails while running
FAILURE RATE OR PROBABILITY rec : 1.9E-6/hr high: 2.4E-4/hr low: 0.00
Source: IEEE 500 (1984) pg.855 Ultimate source: expert opinion,selected plant data,NUREG 2886,2232
Comment: Given value is composite of several sources,different pump types and sizes and operating modes.More specific data included elswere

PWPSE pump positive displacement
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: fails to start
FAILURE RATE OR PROBABILITY rec : 1.9E-2/d high: 1.6E-1/d low: 0.0 REPAIR TIME: 7.3 hours
Source: IEEE 500 (1984) pg.855 Ultimate source: expert opinion,selected plant data
Comment: Given value is composite of several sources, diferent pump types, and operating modes.More detailed data which are given in IEEE500 regarding pumps are included in NUREG 2886 data.

PDAFP pump diesel driven
Component boundary: incl.mech.control,governor,emergency tripping,blower,lube oil sys Operating mode: standby Operating environment: normal
Generic failure mode: fail to function Original failure mode: does not operate
FAILURE RATE OR PROBABILITY mean : 1.2E-2/d 95%: 3.5E-2/d 5%: 4.3E-3/d
Source: NUREG 1205 (1982) (pg.403) Ultimate source: US plant LER report evaluation
Comment: Pop.4.No of failures 4.W/o command faults.With command faults 4.8E-2.Failmode"does not operate"incl:leakage/rupt,loss of funct. failure to start and does not continue to run.Stdby hr.rate 3E-5.

PDARI pump diesel driven
Component boundary: pump,diesel,lube oil system,fuel oil,suction and exhaust,starting Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: failure to run given start
FAILURE RATE OR PROBABILITY mean : 8.0E-4/hr ERROR FACTOR: 30
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

PDASB pump diesel driven
Component boundary: Pump,diesel,lube oil system,fuel oil,suction and exhaust,starting Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 1.0E-6/hr max: 5.0E-5/hr min: 2.0E-7/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion agregation and IREP data
Comment:

PDASD pump diesel driven
Component boundary: pump,shaft,diesel,local instrumentation and control circutry Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: fails to start
FAILURE RATE OR PROBABILITY mean : 2.1E-2/d : 3.0E-1/d : 4.0E-3/d
Source: NUREG 2886 (1982) (tbl.19) Ultimate source: plant operating experience-maintenance records(2PWR & 4BWR)
Comment: Pop.24. 9 catastrophic demand related failures of 427 demands. Upbound and lowbound are largest and smallest rate of the functional aggregates of selected pumps classified by driver

PDASI pump diesel driven
Component boundary: pump,diesel,lube oil system,fuel oil,suction and exhaust,starting Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 1.0E-3/d ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

PDASP pump diesel driven
Component boundary: incl.mech.control,governor,emergency tripping,blower,lube oil sys Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: does not start
FAILURE RATE OR PROBABILITY mean : 3.0E-3/d
Source: NUREG 1205 (1982) (table 15) Ultimate source: US plant LER report evaluation
Comment: Pop.4 (PWR & BWR). 1 failure. W/o command faults.W command faults 3.0E-2/d. Standby hourly rate with command faults 6.5E-5/hr

PDCRZ pump diesel driven containment spray pump
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 2.9E-2/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant experience
Comment: Prior:WASH 1400 pumps (w/o motor),failure to run, normal environ. WASH 1400, Diesel(engine only),failure to run. Operating experience: 33 hours of operation, 2 failures.

PDCSZ pump diesel driven containment spray pump
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start on demand
FAILURE RATE OR PROBABILITY mean : 4.2E-3/d
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data upgraded with plant specific experience
Comment: Prior:NUREG 1205(diesel pump,stdby)(M),WASH 1400(diesel plant??). (D).Op.exp.183 demands,1 failure. N-1205 population of 4 include 2 ZION diesel pumps and only 1 failure occuring.Failrate too low?

PDASJ pump diesel driven general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: fails to start
FAILURE RATE OR PROBABILITY mean : 1.0E-3/d ERROR FACTOR: 3
Source: NUREG 4550, Vol.1,tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: ASEP used the generic value from LERs. Failure to start incl.two types of failure:circut breaker command faults (3.0E-2) and pump hardware faults(3.0E-3).

PWWRG pump general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: failure to run
FAILURE RATE OR PROBABILITY mean : 2.9E-5/hr ERROR FACTOR: 3.7
Source: German Risk Study (pg.F3-72) Ultimate source: generic data,including non nuclear application and experience
Comment:

PWWSG pump general
Component boundary: pump with driver Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 1.6E-5/hr ERROR FACTOR: 7
Source: German Risk Study (pg.F3-71) Ultimate source: generic data including non-nuclear application
Comment: Assuming 4 weeks test interval, failure rate is about twice the recorded operational experience.

PMAFP pump motor driven
Component boundary: pumping unit,motor,coupling,mech.control.Excl.MCC,breakers,ect Operating mode: standby Operating environment: normal
Generic failure mode: fail to function Original failure mode: does not operate
FAILURE RATE OR PROBABILITY median: 2.4E-3/d 95%: 1.9E-3/d 5%: 2.8E-3/d
Source: NUREG 1205 (1982) (pg.387) Ultimate source: US plant LER report evaluation
Comment: Failmode incl.:does not start,leak/rupt.,loss of funct.,does not continue to run.Pop:596;No.of failures:76.W/o command fail.W.com. faults 6.2E-3.Stdby hourly rate w/o 4.7E-6,w 1.2E-5.per stdby hr.

PMASP pump motor driven
Component boundary: pumping unit,motor,coupling,mech.controlExcl.MCC,breakers,ect Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: does not start
FAILURE RATE OR PROBABILITY median: 5.1E-4/d 95%: 7.1E-4/d 5%: 3.4E-4/d
Source: NUREG 1205 (1982) (pg.362) Ultimate source: US plant LER report evaluation
Comment: Overall data, includes all types of reactors,LER-s from 1972 to 1980.Ttl.pop.596. No.of failures 91.W/o command faults.
W command faults 3.0E-3. Stdby hourly rate 1.0E-6

PMASZ pump motor driven
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start on demand
FAILURE RATE OR PROBABILITY mean : 7.2E-4/d
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data upgraded with plant specific experience
Comment: Priors:NUREG 1205(tbl.14)standby system does not start,w/o comman (mean),and WASH 1400 table III 2-1,electric motor failure to strt
for distribution. Experience:3138 demands,3 failures

PMBRP pump motor driven
Component boundary: pumping unit,coupling,motor,mech.control.Excl.MCC,breakers Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: does not operate given start
FAILURE RATE OR PROBABILITY median: 1.8E-5/hr 95%: 2.0E-5/hr 5%: 1.6E-5/hr
Source: NUREG 1205 (1982) (pg.340) Ultimate source: US plant LER report evaluation
Comment: Overall data (PWR&BWR)LER from72 to 80.Ttl pop.720,no.of fail 110 W/o command faults(w.command faults 2.1E-5).F.mode does not
operate incl:leakage/rupt.ls.of function,does not cont.to run

PMBSP pump motor driven
Component boundary: pumping unit,motor,coupling,mech.control.excl.MCC,breacker ect. Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: does not start
FAILURE RATE OR PROBABILITY median: 3.4E-4/d 95%: 5.1E-4/d 5%: 2.3E-4/d
Source: NUREG 1205 (1982) (pg.305) Ultimate source: US plant LER report evaluation
Comment: Overall data,include all types of reactors, LER-s from 1972 to 1980. Total pop.720 pumps.Total No.of failures 18.W/o command flt
W.command faults 1.4E-3/d.Stdby hourly rate 1.4E-6/hr.

PMRRP pump motor driven
Component boundary: pumping unit,motor,coupling,mech,control.Excl.MCC,breakers ect Operating mode: running Operating environment: normal
Generic failure mode: fail to run Original failure mode: does not operate given start
FAILURE RATE OR PROBABILITY median: 5.3E-6/hr 95%: 6.9E-6/hr 5%: 4.1E-6/hr
Source: NUREG 1205 (1982) (pg.292) Ultimate source: US plant LER report evaluation
Comment: Overall data(PWR&BWR)LER from 72 to 80.Ttl.pop.209,no of fail.12 W/o command faults(w.command faults 1.4E-5).Fmode"does not
operate"incl:leakage/rupt,ls of function,does not cont.to run

PMURB pump motor driven
Component boundary: pump and motor,exclusdes control circuts Operating mode: all Operating environment: extreme
Generic failure mode: fail to run Original failure mode: failure to run, given start
FAILURE RATE OR PROBABILITY mean : 3.0E-3/hr max: 2.0E-2/hr min: 6.0E-5/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion agregation and IREP data
Comment: Extreme operating environment caracterise interface with heavy chemical environment-boric acid.

PMURI pump motor driven
Component boundary: pump and motor excludes control circuts Operating mode: all Operating environment: extreme
Generic failure mode: fail to run Original failure mode: failure to run given start
FAILURE RATE OR PROBABILITY mean : 3.0E-3/hr ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: Extreme operating environment is caracterised with interface with heavy chemical environment-boric acid.

PMURW pump motor driven
Component boundary: detail n/e, including motor Operating mode: all Operating environment: extreme, post accident inside containment
Generic failure mode: fail to run Original failure mode: failure to run given start
FAILURE RATE OR PROBABILITY median: 1.0E-3/hr 95%: 1.0E-2/hr 5%: 1.0E-4/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-1) Ultimate source: assesed from test & resesarch reactors and military experience
Comment:

PMYRB pump motor driven
Component boundary: pump and motor, excludes control circuts Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: failure to run, given start
FAILURE RATE OR PROBABILITY mean : 1.0E-4/hr max: 5.0E-4/hr min: 2.0E-6/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion agregation and IREP data
Comment:

PMYRI pump motor driven
Component boundary: pump and motor, exclude control circuts Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: failure to run given start
FAILURE RATE OR PROBABILITY mean : 3.0E-5/hr ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

PMYRS pump motor driven
Component boundary: pump and motor Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: failure to run
FAILURE RATE OR PROBABILITY mean : 7.9E-6/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating experience
Comment: From the data tables it is assumed that the given value include failure fot pump to start and to continue running.

PMYRW pump motor driven
Component boundary: detail n/a, include motor Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: failure to run given start
FAILURE RATE OR PROBABILITY median: 3.0E-5/hr 95%: 3.0E-4/hr 5%: 3.0E-6/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-1) Ultimate source: assesed from nuclear, industrial and military experience and data
Comment:

PMYSB pump motor driven
Component boundary: including motor,excluding control circutry Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 1.0E-5/hr max: 5.0E-5/hr min: 2.0E-7/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion agregation & IREP data
Comment:

PMYSI pump motor driven
Component boundary: including motor, excluding control circutry Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start on demand
FAILURE RATE OR PROBABILITY mean : 3.0E-3/d ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

PMYSW pump motor driven
Component boundary: detail n/a, including motor Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start on demand
FAILURE RATE OR PROBABILITY median: 1.0E-3/d : 3.0E-3/d : 3.0E-4/d ERROR FACTOR: 3
Source: WASH 1400 (table III 4-1) Ultimate source: assesed from nuclear, industrial end military expereince and data
Comment:

PMXRZ pump motor driven auxiliary feedwater
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 9.9E-5/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant specific operating experience
Comment: Priors:NUREG 1205 alternating system,does not operate given start (mean) and WASH 1400 pump(w/o motor)failure to run(distrib). Opearting experience:3800 hours of operation, 1 failure.

PMXSA pump motor driven auxiliary feedwater
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start/run
FAILURE RATE OR PROBABILITY median: 5.6E-3/d ERROR FACTOR: 2.2
Source: NUREG 4550/Vol.3,tbl.IV.8-1 Ultimate source: Surry NPP operating experience (test data??)
Comment: It was not possible to identify failure mode as appear in table. It seems to cover starting failure and initial running failure.

PMXSZ pump motor driven auxiliary feedwater
Component boundary: DETAIL n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start on demand
FAILURE RATE OR PROBABILITY mean : 5.0E-3/d
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant specific experience
Comment: Priors: NUREG 1205(tb.14) standby system,does not start, w/o comm (mean)and WASH 1400(tbl.III 2-1)electric motor failure to start (distribution)Experience: 462 demands,4 failures

PMXRH pump motor driven auxiliary feedwater pump
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean · 5.9E-5/hr 95%: 1.7E-4/hr 5%: 8.9E-6/hr REPAIR TIME: 5.5 hours
Source: Old PWR Ultimate source· generic data updated with plant operating experience
Comment: Generic mean 3.4E-5/hr. Operating experience 5641 hour of operation, 1 failure. Repair time is mean of 27 maintenance events.

PMXSH pump motor driven auxiliary feedwater pump
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 5 4E-3/d 95%: 1.1E-2/d 5%: 1.5E-3/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 3.3E-3/d. Operating experience 424 demands, 3 failures.

PMHRZ pump motor driven centrifugal charging pump
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 1.8E-6/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant specific experience
Comment: Priors:NUREG 1205,Alternating sys.,motor driven,does not operate given strt(M); WASH 1400,pumps,fail to run,extreme environment(D)
Operating experience:7.6E+4 hours of operation, no failures

PMDRT pump motor driven centrifugal horisontal flow rate 130-200 kg/s;head .7 MPa
Component boundary: pump,transmission,motor,breaker,fuse,protection,controls Operating mode: runing Operating environment: normal
Generic failure mode: fail to run Original failure mode: spourious stop
FAILURE RATE OR PROBABILITY mean : 2.3E-5/hr 95%: 1.0E-4/hr REPAIR TIME: 18 hr
Source: Swedish Rel.data book, tbl.2 Ultimate source: plant experience,(6 BWR plants), ATV reports, LERs, plant inform.
Comment: Operating expereince: total pop. 16. Operating time 18.1E+4 hours 5 failures. a=0.315; b=13800. Critical failures occured at 3 plan
ts.

PMOST pump motor driven centrifugal horisontal and vertical flow rate 30 kg/s; head 2.2-6.7 MPa
Component boundary: pump,transmission,motor,swich,fuses,protection,controls Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 1.4E-3/d 95%: 8.3E-3/d REPAIR TIME: 2 hr
Source: Swedish Rel.data book, tbl.7 Ultimate source: operating experience (7 BWR plants),ATV reports,LERs,plant infor.
Comment: Data derived from observation of 12 components,696 demands(per op.time),1 failure occuring(critical)
Critical failures occured at one plant only. a=0.116;b=80.3

PMMRT pump motor driven centrifugal horisontal and vertical flow rate 75-250 kg/s; head .3-.9 MPa
Component boundary: pump,transmission,motor,breaker,fuse protection,controls Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: spourious stop
FAILURE RATE OR PROBABILITY mean · 1.7E-5/hr 95%: 8.4E-5/hr REPAIR TIME: 10 hr
Source: Swedish Rel.data book, tbl.5 Ultimate source: plant operating experience (7 BWR plants),ATV reports,LERs
Comment: Operating experience:Total pop.66. Operational time 78.6E+4 hours 13 faulures. a=0.21; b=12700. Critical failures occured at 6
plants.

PMMST pump motor driven centrifugal horisontal and vertical flow rate 75-250 kg/s; head .3-.9 MPa
Component boundary: pump,transmission,motor,breaker,fuse,protection,controls Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: faliure to start
FAILURE RATE OR PROBABILITY mean : 3.9E-3/d 95%: 2.1E-2/d REPAIR TIME: 10 hr
Source: Swedish Rel.data book, tbl.5 Ultimate source: plant operating experience (7 BWR plants),ATV reports, LERs
Comment: Operating experience: total pop 66.Other data not known. Critical failures occured at 6 plants.

PMNRT pump motor driven centrifugal horizontal flow rate: 40-60kg/s; head .5-.7MPa
Component boundary: pump,transmission,motor,breaker,fuses,protection,controls Operating mode: running Operating environment: normal
Generic failure mode: fail to run Original failure mode: spourious stop
FAILURE RATE OR PROBABILITY mean : 2.8E-5/hr 95%: 1.1E-4/hr REPAIR TIME: 11 hr
Source: Swedish Rel.data book, tbl.1 Ultimate source: plant operating experience (7 BWR plants), ATV reports, LERs
Comment: Operating experience:total pop.14. operating time 28,8E+4 hours 8 failures. a=0.0527; b=19000. Critical failures occured at 4 plants.

PMMSY pump motor driven centrifugal horizontal and vertical flow rate 75-250 kg/s; head .3-.9 MPa
Component boundary: pump,transmision,motor,breaker,fuses,protection,controls Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 1.4E-3/d REPAIR TIME: 24 hr
Source: Swedish Rel.data book, tbl.5 Ultimate source: plant operating experience Ringhals 2 PWR
Comment: 10 components observed, other information not avaliable

PMPRT pump motor driven centrifugal reactor coolant pump flow rate 1036-2347 kg/s; head .3-.4 MPa
Component boundary: pump,transmission,motor,breaker,fuses,protection,controls Operating mode: running Operating environment: normal
Generic failure mode: fail to run Original failure mode: spourious stop
FAILURE RATE OR PROBABILITY mean : 2.7E-6/hr 95%: 1.5E-5/hr REPAIR TIME: 5 hr
Source: Swedish Rel.data book, tbl.4 Ultimate source: plant operating experience (7 BWR plants), ATV reports, LERs
Comment: Operating experoence: total pop. 38.Operating time 112E+4 hours. No.of failures 3. a=0.0671; b=25100. Critical failures occured at 3 plants.

PMWRT pump motor driven centrifugal wet flow rate 75-150 kg/s; head 1.3-1.8 MPa
Component boundary: pump.trasmission,motor,breakers,fuses,protection,controls Operating mode: running Operating environment: normal
Generic failure mode: fail to run Original failure mode: spourious stop
FAILURE RATE OR PROBABILITY mean : 7.8E-5/hr 95%: 1.9E-4/hr REPAIR TIME: 18 hr
Source: Swedish Rel.data book, tbl.3 Ultimate source: plant operating experience (7 BWR plants), ATV reports, LERs
Comment: Operating experience: total pop 14. Operating time 27.2E+4 hours 19 failures. a=1.93; b=24900. Critical failures occured at 6 plants.

PMWRY pump motor driven centrifugal wet flow rate 75-150 kg/s; head 1.3-1.8 MPa
Component boundary: pump,transmission,motor,breaker,fuse,protection,controls Operating mode: running Operating environment: normal
Generic failure mode: fail to run Original failure mode: spurious stop
FAILURE RATE OR PROBABILITY mean : 1.2E-4/hr REPAIR TIME: 24 hr
Source: Swedish Rel.data book, tbl.3 Ultimate source: plant operating experience,Ringhals 2 PWR
Comment: Operating experience: total pop 2. Operating time 2.56E+4 hours 3 failures.

PMMRY pump motor driven centrifugal, horisontal and vertical flow rate 75-250 kg/s; head .3-.9 MPa
Component boundary: pump,transmission,motor,breaker,fuses,protection,controls Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: spurious stop
FAILURE RATE OR PROBABILITY mean : 8.1E-5/hr REPAIR TIME: 24 hr
Source: Swedish Rel.data book, tbl.5 Ultimate source: plant operating experience(Ringhals 2 PWR)
Comment: Operating experience:total pop.10. Operating time 8.67E+4 hours 7 failures.

PMNRY pump motor driven centrifugal,horisontal flow rate 40-60 kg/s;head .5-.7 Mpa
Component boundary: pump,transmission,motor,breaker,fuse,protection,controls Operating mode: running Operating environment: normal
Generic failure mode: fail to run Original failure mode: spourious stop
FAILURE RATE OR PROBABILITY mean : 6.9E-5/hr REPAIR TIME: 3 hr
Source: Swedish Rel.data book, tbl.1 Ultimate source: plant operating experience, Ringhals 2 PWR
Comment: Operating experience: total pop.2 Operational time 4.32E+4 hours 3 failures.

PMQST pump motor driven centrifugal,horisontal and vertical flow rate 120-240 kg/s;head 1.2-1.8 MPa
Component boundary: pump,motor,transmission,swich,fuse,prtection,controls Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 5.1E-3/d 95%: 2.1E-2/d REPAIR TIME: 3 hr
Source: Swedish Rel.data book, tbl.8 Ultimate source: plant operating experience (7 BWR plants),ATV reports, LERs
Comment: Operating experience:total pop.18. No.of demands 784. 4 failures. a=0.387; b=75.4 Critical failures occured at 2 plants.

PMHRH pump motor driven charging pump
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 2.7E-4/hr 95%: 3.4E-4/hr 5%: 2.0E-4/hr REPAIR TIME: 16 hours
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 3.4E-5/hr.Operating experience 1.3E+5 hours of operation, 38 failures. Repair time is mean of 168 recorded maintenance events(short single pump outage).Long outage=667 hrs.

PMHSH pump motor driven charging pump
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 1.2E-3/d 95%: 2.6E-3/d 5%: 1.4E-4/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 2.4E-3/d. Operating experience 559 demands, no failures.

PMHRA pump motor driven charging/high pressure injection
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail to run
FAILURE RATE OR PROBABILITY median: 5.5E-5/hr ERROR FACTOR: 2.9
Source: NUREG 4550/Vol.3,tbl.IV.8-1 Ultimate source: Surry NPP operating experience
Comment: Charging pump provide RCS makeup and RPS seal cooling flow in normal operation and serve as a high pressure injection/ recirculation pump following accident.

PMHSA pump motor driven charging/high pressure injection
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start
FAILURE RATE OR PROBABILITY median: 3.1E-3/d ERROR FACTOR: 3.5
Source: NUREG 4550/Vol.3,tbl.IV.8-1 Ultimate source: Surry NPP operating experience
Comment: Charging pumps provide normal RCS makeup and RCP cooling flow in normal operation and serve as a high pressure injection recirculation following accident.

PMERZ pump motor driven component cooling
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 1.8E-6/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data upgraded with plant specific experience
Comment: Priors:NUREG 1205,alternaing system,does not operate given start, (Mean) and WASH 1400 pump(w/o motor) failure to run (Distrib). Operating experience:7.6E+4 hrs of operation,no failures.

PMCRH pump motor driven containment spray
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 3.4E-5/hr 95%: 7.8E-5/hr 5%: 2.8E-6/hr REPAIR TIME: 6.6 hours
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 3.4E-5/hr. Operating experience 209 hours of operation, no failures. Repair time is mean of 16 maintenance events.

PMCRZ pump motor driven containment spray
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 1.5E-5/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant specific experience
Comment: Priors:NUREG 1205,alternating system,does not operate given start (mean) and WASH 1400, pump(w/o motor),failure to run(distrib.) Operating expereince:66 hours of operation,no failures

PMCSH pump motor driven containment spray
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 5.1E-3/d 95%: 9.0E-3/d 5%: 1.7E-3/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 3.3E-3/d. Operating experience 634 demands, 4 failures.

PMGSH pump motor driven electric equipment area ventilation cooling pump
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 1.4E-3/d 95%: 3.2E-3/d 5%: 2.0E-4/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 2.4E-3/d. Operating experience 329 demands, no failures.

PMGRH pump motor driven electrical equipment area ventilation cooling pump
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 4.7E-5/hr 95%: 7.4E-5/hr 5%: 2.2E-5/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 3.4E-5/hr. Operating experience 1.3E+5 hours of operation, 7 failures.

PMFRO pump motor driven emergency feedwater pump
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: operational failure
FAILURE RATE OR PROBABILITY mean : 2.0E-5/hr 95%: 6.0E-5/hr 5%: 5.9E-7/hr REPAIR TIME: 20.9 hours
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source· generic data updated with plant specific operating experience
Comment: Prior:mean NUREG 1205(1980),alternating pump,80%/20% based on RSS distribution.Same prior as injection pumps.Op.exper:15 op.hrs, no failures.Repair time is mean generic maintenance duration.

PMFSO pump motor driven emergency feedwater pump
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode· fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean . 4.8E-4/d 95%: 1.4E-3/d 5%: 1.4E-5/d REPAIR TIME: 20.9 hours
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source. generic data updated with plant specific operating experience
Comment: Prior:mean NUREG 1205(1980),standby pump,80%/20% ratio based on RSS distrib.Op.expereince:18 demands, no failures. Repair time is mean generic component maintenance duration.

PMARJ pump motor driven general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: fails to run
FAILURE RATE OR PROBABILITY mean : 3.0E-5/hr ERROR FACTOR: 10
Source: NUREG 4550, Vol.1,tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: ASEP used the generic values developed in the Station Blackout Study (NUREG/CR 3226).

PMASJ pump motor driven general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: fails to start
FAILURE RATE OR PROBABILITY mean : 3.0E-3/d ERROR FACTOR: 10
Source: NUREG 4550, Vol.1,tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: ASEP used geenric values developed in Station Blackout Study (NUREG/CR-3226). Value for fails to start included two types of failures:Pump hardware (4.0E-4/d) and circut br.command(2.5E-3).

PMISU pump motor driven high pressure (>20 bar) applicable to HHSI,CVCS and auxiliary feedwater pumps
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start on demand
FAILURE RATE OR PROBABILITY mean : 4.0E-3/d
Source: Sizewell B (PWR/RX312 pg.9) Ultimate source: assesed from nuclear and industrial experience and data
Comment: Assesment based on W data,WASH 1400,EDF data and 2 SRS data items one applies to HHSI,RHR and auxfeed(4.0E-3/d) and other to CVCS and CCWS (2.0E-3/d).

PMVRO pump motor driven high pressure injection
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: operational failure
FAILURE RATE OR PROBABILITY mean : 8.4E-6/hr 95%: 2.0E-5/hr 5%: 4.4E-7/hr REPAIR TIME: 21.5 hours
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:Mean NUREG 1205(1980),alteranting pump,80%/20% ratio based on RSS.Op.experience: 38.787 hours of operation, no failures. Repair time is mean of updated component maintenance duration.

PMVSO pump motor driven high pressure injection
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 8.4E-4/d 95%: 2.1E-3/d 5%: 6.0E-5/d REPAIR TIME: 21.5 hours
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:Mean NUREG 1205(1980),standby pump,80%/20% ratio based on RSS distribution.Operating experience: 530 demands,1 failure. Repair time is mean of updated component maintenance duration.

PMIRU pump motor driven high pressure(> 20 bar) applicable to HHSI,CVCS and auxiliary feedwater pumps
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: failure to continue operation
FAILURE RATE OR PROBABILITY mean : 6.0E-5/hr
Source: Sizewell B (PWR/RX312 pg.10) Ultimate source: assesed from nuclear and industrial experience and data
Comment: Assesement based on W data and 3 SRS data items. Two of them applies to RHR,HHSI and auxfeed (5.0E-5/hr and 1.0E-5/hr) and one to CVCS and CCWS (2.0E-5/hr).

PMZSD pump motor driven include CCW,SW,RHR, boric acid transfer,boron injection recirc
Component boundary: pump,shaft,motor,swiches,local control & instrumentation Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: fails to start
FAILURE RATE OR PROBABILITY mean : 5.3E-3/d : 6.0E-4/d : 5.0E-2/d
Source: NUREG 2886 (1982) (tbl.19) Ultimate source: plant operating experience-maintenance records(2PWR & 4BWR)
Comment: Pop.102. 22 catastophic demand related failures of 4148 demand Upbound & lowbound are largest and smallest rate of func.aggreg. of the pumps class.by driver type.Include altern.and stdby pumps

PMZRD pump motor driven include CCW,SW,RHR,boric acid transfer,boron injection recirc.
Component boundary: pump,shaft motor swiches,local control and instrumentation Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fails while running
FAILURE RATE OR PROBABILITY mean : 2.7E-5/hr : 3.0E-4/hr : 1.0E-6/hr
Source: NUREG 2886 (1982)(tbl.18 & 19) Ultimate source: plant operating experience-maintenance records(2PWR & 4BWR)
Comment: Pop.102.33 catastrofic failures of 1.24E+6 population hours Upbound and lowbound identical as running pumps(see comment).

PMTSD pump motor driven include containment spray,standby liquid control
Component boundary: pump,shaft,motor,swiches,local control and instrumentation Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failsre to start
FAILURE RATE OR PROBABILITY mean : 5.5E-3/d : 6.0E-4/d : 5.0E-2/d
Source: NUREG 2886 (1982)(tbl.18 & 19) Ultimate source: plant operating experience-maintenance records(2PWR & 4BWR)
Comment: Pop.95.31 catastrophic demand related failures of 5456 demands Up & lowbound derived from funct.aggregation.Failrate is based on 1 demand/month.(actual 2-3 times higher)very conservative

PMJRD pump motor driven includes reactor coolant,reactor recirculating,CW,feedwater,cond.
Component boundary: pump,shaft,motor,swiches,local control & instrumentation Operating mode: running Operating environment: normal
Generic failure mode: fail to run Original failure mode: fails while running
FAILURE RATE OR PROBABILITY mean : 2.2E-5/hr : 3.0E-4/hr : 1.0E-6/hr
Source: NUREG 2886 (1982)(tbl.18 & 19) Ultimate source: plant operating experience-maintenance records(2PWR & 4BWR)
Comment: Pop.79. 35 catastrofic time related failures of 1.6E+6 operating hours.Upbound and lowbound are the largest and smallest rate of funct.aggregation by driver.

PMCSA pump motor driven inside spray recirculation
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start/run
FAILURE RATE OR PROBABILITY median: 3.6E-2/d ERROR FACTOR: 1.8
Source: NUREG 4550/Vol.3,tbl.IV.8-1 Ultimate source: Surry NPP operating experience (test data)
Comment: It was not possible to identify failure mode in table. It seems to cover starting failure and initial running failure (during test)

PULRU pump motor driven low pressure <20 bar applicable to ESWS, CCWS,LHSI/RHR, CSS, boric acid transfer pumps
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: failure to continue operation
FAILURE RATE OR PROBABILITY mean : 1.5E-5/hr
Source: Sizewell B (PWR/RX312 pg.11) Ultimate source: assesed from nuclear and industrial experience and data
Comment: Assesment based on W data,4 EDF data items(1.2E-4/hr ESW pumps) (6.8E-6/hr CCW),(5.6E-6/hr cond.extraction),(3.5E-6/hr cond.cool.),2 SRS items(industrial use)(2.1E-4{1E5hrs} and 1.8E-5{5E5hrs}).

PULSU pump motor driven low pressure <20bar applicable to ESWS, CCWS, LHSI/RHR, CSS, boric acid transfer
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 2.0E-3/d
Source: Sizewell B (PWR/RX312 pg.11) Ultimate source: assesed from nuclear and industrial experience and data
Comment: Assesement based on W data,WASH 1400, EDF data item(1.8E-4/d out of 16800 demands) and two SRS data items (4.0E-3/d for HHSI,RHR and auxfeed) and (2.0E-3/d for CVCS and CCWS).

PMLRO pump motor driven low pressure injection
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: operational failure
FAILURE RATE OR PROBABILITY mean : 3.7E-5/hr 95%: 9.5E-5/hr 5%: 2.5E-6/hr REPAIR TIME: 10.8 hours
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:mean NUREG 1205(1980),alternating pump.80%/20% ratio based on RSS.Same prior as for HPI pump.Op.experience:11.287 op.hrs, 1 failure.Repair time is mean of generic maintenance duration.

PMLSO pump motor driven low pressure injection
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 3.7E-4/d 95%: 1.0E-3/d 5%: 1.4E-5/d REPAIR TIME: 10.8 hours
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operational experience
Comment: Prior:mean NUREG 1205(1980),standby pump,80%/20% ratio based on RSS distrib.Same prior as for HPI pump.Op.exp.223 demands,no fail Repair time is mean generic component maintenance duration.

PMKRO pump motor driven low pressure service water
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: operational failure
FAILURE RATE OR PROBABILITY mean : 2.8E-5/hr 95%: 5.6E-5/hr 5%: 4.1E-6/hr REPAIR TIME: 10.5 hours
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior: mean NUREG 1205(1980),alternating pump,80%/20% ratio based on RSS. Op.experience:47.991 hours of operation,2 failures. Repair time is mean of plant spec.update of maintenance duration.

PMKSO pump motor driven low pressure service water
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 4.5E-4/d 95%: 1.3E-3/d 5%: 1.4E-5/d REPAIR TIME: 10.5 hours
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior: mean NUREG 1205(1980), standby pump,80%/20%ratio based on RSS. Op.expereince: 61 demands, no failures. Repair time is mean of plant spec.update of maintenance duration.

PUMRU pump motor driven main feed pumps
Component boundary: detail n/a Operating mode: running Operating environment: normal
Generic failure mode: fail to run Original failure mode: failure to continue operation
FAILURE RATE OR PROBABILITY mean : 8.0E-4/hr
Source: Sizewell B (PWR/RX312 pg.8) Ultimate source: assesed from nuclear and industrial experience and data
Comment: Assesment based on W data, CEGB data item,EDF PWRdata(3.1E-4/hr out of 4.2E+6 hrs) and 2 SRS data items(7.4E-4/hr)and(1.7E-3/hr based on operating experience 2.5E+5 hr).

PURSH pump motor driven main steam relief hydraulic pump
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 6.9E-4/d 95%: 1.2E-3/d 5%: 2.6E-4/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 3.3E-3/d. Operating experience 5636 demands, 3 failures.

PUERH pump motor driven primary component cooling water pump
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 1.4E-5/hr 95%: 2.5E-5/hr 5%: 3.9E-6/hr REPAIR TIME: 8 hours
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 3.4E-5/hr. Operating experience 1.7E+5 hours of operation, 2 failures. Repair time is mean of 14 maintenance events.

PUESH pump motor driven primary component cooling water pump
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 3.4E-3/d 95%: 5.2E-3/d 5%: 1.7E-3/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 2.4E-3/d. Operating experience 1840 demands, 7 failures.

PUBRH pump motor driven primary service water booster pump
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 6.4E-5/hr 95%: 1.0E-4/hr 5%: 2.8E-5/hr REPAIR TIME: 12.1
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 3.4E-5/hr. Operating experience 9.2E+4 hours of operation, 7 failures. Repair time is mean of 17 maintenance events.

PUBSH pump motor driven primary service water booster pump
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 1.6E-3/d 95%: 3.7E-3/d 5%: 2.2E-4/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 2.4E-3/d. Operating experience 222 demands,no failures.

PUKRU pump motor driven primary service water pump
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fails during operation
FAILURE RATE OR PROBABILITY mean : 5.5E-5/hr 95%: 9.2E-5/hr 5%: 2.7E-5/hr REPAIR TIME: 17.4 hours
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 3.4E-5/hr. Operating experience 1.6E+5 hours of operation,10 failures. Repair time is mean of 46 maintenance events.

PUKSU pump motor driven primary service water pump
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 1.3E-3/d 95%: 2.3E-3/d 5%: 3.9E-4/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 2.4E-3/d. Operating experience 1909 demands, 2 failures.

PMCRO pump motor driven reactor building spray
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: operational failure
FAILURE RATE OR PROBABILITY mean : 2.0E-5/hr 95%: 6.0E-5/hr 5%: 5.9E-7/hr REPAIR TIME: 28.6 hours
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:mean NUREG 1205(1980),alternating pump,ratio of 80%/20% is based on RSS distrib.Same as for injection pumps.Op.exp.40 hrs of operation,no failures.Repair time is mean maintenance duration

PMCSO pump motor driven reactor building spray
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 8.1E-3/d 95%: 1.8E-2/d 5%: 1.1E-3/d REPAIR TIME: 28.6 hours
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:Mean NUREG 1205(1980),80%/20% is based on RSS distribution. Same prior as for injecton pumps.Op.experience:140 dem.3 failures Repair time is mean of plant spec.update of maintenance duration.

PUPST pump motor driven reciprocating(positive displacement) flow rate 2.5-3.9kg/s; head 8.7 MPa;
Component boundary: pump,transmission,motor,swich,fuse,protection,control Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 4.0E-3/d 95%: 2.1E-2/d REPAIR TIME: 7 hr
Source: Swedish Rel.data book, tbl.10 Ultimate source: plant operating exeperience (7 BWR plants)
Comment: Operating experience:total pop 22. No.of demands 1238. 5 failures a=0.186; b=46. Critical failures occured at 3 plants.

PUZRH pump motor driven recirculation pump
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 3.4E-5/hr 95%: 8 1E-5/hr 5%: 2.8E-6/hr REPAIR TIME: 4.2 hours
Source: Old PWR Ultimate source· generic data updated with plant operating experience
Comment: Generic mean 3.4E-5/hr Operating experience 56 hours of operation, no failures. Repair time is mean of 14 maintenance events.

PUZSH pump motor driven recirculation pump
Component boundary. detail n/a Operating mode· all Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean . 1.0E-3/d 95%: 2.5E-3/d 5%: 1.3E-4/d
Source: Old PWR Ultimate source· generic data updated with plant operating experience
Comment: Generic mean 3.3E-3/d. Operating experience 684 demands, no failures.

PUWRH pump motor driven residual heat removal pump
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 1.1E-4/hr 95%: 2.4E-4/hr 5%: 2.5E-5/hr REPAIR TIME: 4.8 hours
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 3.4E-5/hr. Operating experience 1.4E+4 hours of operation, 3 failures. Repair time is mean of 2 maintenance event (short duration). Long duration maintenance 6.1E+3 hours??

PUWRZ pump motor driven residual heat removal pump
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 2.5E-6/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant specific experience
Comment: Priors:NUREG 1205 alternating system,does not operate given start (mean) and WASH 1400,pump(w/o motor),failure to run(distrib.). Operating experience:3.25E+4 hrs of operation, no failures.

PUWSH pump motor driven residual heat removal pump
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 6.5E-3/d 95%: 1.7E-2/d 5%: 7.1E-4/d
Source: Old PWR Ultimate source: generic data updated with plant specific operating experience
Comment: Generic mean 3.3E-3/d. Operating experience 58 demands, 1 failure

PMSRH pump motor driven safety injection pump
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 3.6E-5/hr 95%: 7.8E-5/hr 5%: 2.8E-6/hr REPAIR TIME: 4.8 hours
Source: Old PWR Ultimate source: generic data updated with plant specific operating experience
Comment: Generic mean 3.4E-5/hr. Operating experience 272 hours of operation, no failures. Repair time is mean of 21 recorded maintenance events.

PMSRZ pump motor driven safety injection pump
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 1.6E-5/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant specific experience
Comment: Prior: NUREG 1205,alternating system,does not operate given start (M) and WASH 1400,pump (w/o motor),fail to run(distrib.) Operating experience: 46 hours of operation, no failures.

PMSSH pump motor driven safety injection pump
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 8.4E-3/d 95%: 1.3E-2/d 5%: 3.7E-3/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 3.3E-3/d. Operating experience 719 demands,7 failures.

PUSRY pump motor driven screw flow rate 550 kg/s; head 0.3 MPa
Component boundary: pump,transmission,motor,breaker,fuse,protection,control Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: spourious stop
FAILURE RATE OR PROBABILITY mean : 3.1E-5/hr REPAIR TIME: 32 hr
Source: Swedish Rel.data book, tbl.6 Ultimate source: plant operating experience Ringhals 2 PWR
Comment: Operating experience: total pop. 6 Operating time 12.97E+4 hours 4 failures.
No failure to start recorded on this component.

PUSST pump motor driven screw flow rate 750kg/s;0.2MPa;
Component boundary: pump,transmission,motor,swich,fuses,protection,controls Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 2.5E-3/d 95%: 1.4E-2/d REPAIR TIME: 8 hours
Source: Swedish Rel.data book, tbl.6 Ultimate source: plant operating experience (1 BWR plant), ATV reports, LERs
Comment: Operating experience: total pop.7. No.of demands 399. 1 failure. a=0.164; b=65.2

PUFRH pump motor driven secondary component cooling water
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 7.3E-6/hr 95%: 1.6E-5/hr 5%: 1.3E-6/hr REPAIR TIME: 73.8 hours
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 3.4E-5/hr. Operating experience 1.4E+5 hours of operation, no failures. Repair time is mean of 7 maintenance events.

PUFSH pump motor driven secondary component cooling water
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 1.7E-3/d 95%: 3.9E-3/d 5%: 2.3E-4/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 2.4E-3/d. Operating experience 193 demands, no failures.

PMKRH pump motor driven secondary service water
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 5.5E-5/hr 95%: 8.6E-5/hr 5%: 2.5E-5/hr REPAIR TIME: 32.5 hours
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 3.4E-5/hr. Operating experience 1.4E+5 hours of operation, 9 failures. Repair time is mean of 17 maintenance evens.

PMKSH pump motor driven secondary service water pump
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 1.7E-3/d 95%: 3.8E-3/d 5%: 2.3E-4/d
Source: Old PWR Ultimate source: generic data updated with palnt operating experience
Comment: Generic mean 2.4E-3/d. Operating experience 203 demands, no failures.

PMKRZ pump motor driven service water
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 1.3E-6/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant specific experience
Comment: Priors:NUREG 1205,alternating system,does not operate given start (mean) and WASH 1400, pump(w/o motor),failure to run(distrib). Operating expreince:1.52E+5 hours of operation,no failures

PUCRA pump motor driven service water pump used in charging pump cooling system
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail to run
FAILURE RATE OR PROBABILITY median: 1.6E-4/hr ERROR FACTOR: 1.6
Source: NUREG 4550/Vol 3,tbl.IV.8-1 Ultimate source: Surry NPP operating experience
Comment:

PUCSA pump motor driven service water pump used in charging pump cooling system
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start
FAILURE RATE OR PROBABILITY median: 5.9E-3/d ERROR FACTOR: 3.5
Source: NUREG 4550/Vol 3,tbl.IV.8-1 Ultimate source: Surry NPP operating expereince
Comment:

PUVRH pump motor driven well water pump
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 3.4E-5/hr 95%: 8.0E-5/hr 5%: 2.8E-6/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 3.4E-5/hr. Operating experience 108 hours, no failures.

PUVSH pump motor driven well water pump
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start on demand
FAILURE RATE OR PROBABILITY mean : 3.7E-3/d 95%: 8.4E-3/d 5%: 5.3E-4/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 3.3E-3/d. Operating experience 192 demands, 1 failure.

PTAFP pump turbine driven
Component boundary: incl.mech.contol,governor,trip-throt.vlv,lube oil sys,bearing lb Operating mode: standby Operating environment: normal
Generic failure mode: fail to function Original failure mode: does not operate
FAILURE RATE OR PROBABILITY median: 2.1E-2/d 95%: 2.3E-2/d 5%: 1.8E-2/d
Source: NUREG 1205 (1982) (pg.397) Ultimate source: US plant LER report evaluation
Comment: Overall data,includes all types of reactors,LER 72-80. Ttl.pop. 92.W/o command faults.With command faults 5.0E-2.Failmode include fail to start,leak/rupt,loss of function,does not cont. to run

PTASD pump turbine driven
Component boundary: pump,shaft,turbine,local instrumentaion and control Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: fails to start
FAILURE RATE OR PROBABILITY mean : 1.1E-2/d : 3.0E-2/d : 2.0E-3/d
Source: NUREG 2886 (1982) (tbl.19) Ultimate source: plant operating experience-maintenance records(2PWR & 4BWR)
Comment: Pop.11. 5 catastrofic demand related falures in 469 demands. Upbound and lowbound are the largest and smallest failure rate of the functional aggregate of selected pumps classified by driver

PTASP pump turbine driven
Component boundary: Incl.mech.control,governor,trip-throt.vlv,lube oil sys,bearing lb Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: does not start
FAILURE RATE OR PROBABILITY median: 9.6E-3/d 95%: 1.2E-2/d 5%: 8.0E-3/d
Source: NUREG 1205 (1982) (pg.372) Ultimate source: US plant LER report evaluation
Comment: Overall data,including all types of reactors,LER 72-80. Ttl.pop. 92. W/o command faults.With command faults 2.5E-2. Standby hour rate w/o command 1.9E-5/hr, with command faults 5.1E-5/hr.

PTRRD pump turbine driven

Component boundary: pump,shaft.turbine,local control and instrumentation Operating mode: running Operating environment: normal

Generic failure mode: fail to run Original failure mode: fails while running

FAILURE RATE OR PROBABILITY mean : 1.0E-4/hr : 2.0E-4/hr : 8.0E-5/hr

Source: NUREG 2886 (1982) (tbl.19) Ultimate source: plant operating experience-maintenance records(2PWR & 4BWR)

Comment: Pop.11.21 catastrofic time related failures in 2.08E-5 op.hours. Upbound and lowbound are the largest and smalest rate of the functional aggregates of the selected pumps classified by driver

PTYRB pump turbine driven

Component boundary: pump, turbine,steam and throttle valve, governor Operating mode: all Operating environment: normal

Generic failure mode: fail to run Original failure mode: failure to run given start

FAILURE RATE OR PROBABILITY mean : 2.0E-5/hr max: 1.0E-4/hr min: 8.0E-6/hr

Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion aggregation and IREP data

Comment:

PTYR1 pump turbine driven

Component boundary: pump,turbine,steam and throttle valves, governor Operating mode: all Operating environment: normal

Generic failure mode: fail to run Original failure mode: failure to run given start

FAILURE RATE OR PROBABILITY mean : 1.0E-5/hr ERROR FACTOR: 3

Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion

Comment:

PTYSB pump turbine driven

Component boundary: pump,turbine,steam and throttle valves, governor Operating mode: all Operating environment: normal

Generic failure mode: fail to start Original failure mode: failure to start

FAILURE RATE OR PROBABILITY mean : 1.0E-4/hr max: 5.0E-4/hr min: 2.0E-6/hr

Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion aggregation and IREP data

Comment: Failure mode includes under and over speed

PTYSI pump turbine driven

Component boundary: pump,turbine,steam and throttle valves,governor Operating mode: all Operating environment: normal

Generic failure mode: fail to start Original failure mode: failure to start

FAILURE RATE OR PROBABILITY mean : 3.0E-2/d ERROR FACTOR: 10

Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion

Comment: Failure mode includes under and overspeed

PTFRZ pump turbine driven auxiliary feedwater
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 7.6E-6/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant specific experience
Comment: Prior:NUREG 1205("turbine driven pump failure during operation is similar to motor driven).
Operating experience:1900 hours of operation, no failures.

PTFSA pump turbine driven auxiliary feedwater
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: fail to start/run
FAILURE RATE OR PROBABILITY median: 7.1E-3/d ERROR FACTOR: 4.6
Source: NUREG 4550/Vol.3,tbl.IV.8-1 Ultimate source: Surry NPP operating experience
Comment: It was not possible to identify failure mode as appear in table.

PTFSZ pump turbine driven auxiliary feedwater
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: faliure to start on demand
FAILURE RATE OR PROBABILITY mean : 2.3E-2/d
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant specific experience
Comment: Prior:NUREG 1205,standby system(w/o command) does not start(Mean) DIstribution based on engineering judgement.
Operating experience: 231 demands, 6 failures.

PTCSY pump turbine driven centrifugal pump flow rate 240 kg/s; head 1.8 MPa
Component boundary: auxiliary equipment not included Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 3.3E-2/d REPAIR TIME: 8 hr
Source: Swedish Rel.data book, tbl.9 Ultimate source: plant operating experience Ringhals 2 PWR
Comment: One observed component, 30 demands per operational time, one failure recorded.

PTXSO pump turbine driven emergency feedwater
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 3.8E-2/d 95%: 5.8E-2/d 5%: 1.2E-2/d REPAIR TIME: 24.5 hours
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:mean NUREG 1205(1980),standby pump.80%/20% ratio based on RSS distribution.Op.experience: 113 demands,6 failures.
Repair time is mean of plant spec.update of maintenance duration.

PTXRO pump turbine driven emergency feedwater pump
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to run Original failure mode: operational failure
FAILURE RATE OR PROBABILITY mean : 9.9E-4/hr 95%: 4.0E-3/hr 5%: 4.1E-6/hr REPAIR TIME: 24.5 hours
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating expreience
Comment: Prior:mean NUREG 1205(1980),alternating pump.80%/20% ratio =100 Operating experience:94 hours of operation,1 failure.
Repair time is mean of plant spec.update of maintenance duration.

PTARJ pump turbine driven general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: fails to run
FAILURE RATE OR PROBABILITY mean : 5.0E-3/hr ERROR FACTOR: 10
Source: NUERG 4550, Vol.1,tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: ASEP value is taken from IREP Procedure Guide.

PTASJ pump turbine driven general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: fails to run
FAILURE RATE OR PROBABILITY mean : 3.0E-2/d ERROR FACTOR: 10
Source: NUREG 4550, Vol.1,tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: ASEP used generic value from IREP Procedure Guide.The value for fails to start incl.two types of failures:circut breaker command
faults(2.0E-2) and pump hardware(1.0E-2).

PTSRU pump turbine driven high pressure > 20 bar include CVCS,emergency charging system,aux.feedwater pumps
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: failure to continue operation
FAILURE RATE OR PROBABILITY mean : 6.0E-5/hr
Source: Sizewell B (PWR/RX312 pg.12) Ultimate source: assesed from nuclear and industrial experience
Comment: Assesment based on W data and SRS data item relevant for PWR (5.0E-5/hr).

PTSSU pump turbine driven high pressure > 20 bar include CVCS,emergency charging system and aux.feedwater pumps
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to start Original failure mode: failure to start
FAILURE RATE OR PROBABILITY mean : 2.0E-2/d
Source: Sizewell B (PWR/RX312 pg.12) Ultimate source: assesed from nuclear and industrial experience and data
Comment: Assesment based on W data and SRS data item relevant for PWR (1.0E-2/d)

PDARJ pupm diesel driven general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to run Original failure mode: fails to run
FAILURE RATE OR PROBABILITY mean : 8.0E-4/hr ERROR FACTOR: 10
Source: NUREG 4550, Vol.1,tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: ASEP used generic values from LERs.

ARBBM radiation monitors BWR main steam line
Component boundary: radiation channel Operating mode: operating Operating environment: normal
Generic failure mode: degraded Original failure mode: reduced capability
FAILURE RATE OR PROBABILITY mean : 9.6E-6/hr 95%: 1.2E-5/hr 5%: 7.4E-6/hr
Source: NUREG 1740 (1984) (table 18) Ultimate source: US plants LER reports evaluation
Comment: BWR rate with command faults. W/o command faults 9.1E-6/hr.

ARBFM radiation monitors BWR main steam line
Component boundary: radiation channel Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: inoperable
FAILURE RATE OR PROBABILITY mean : 6.0E-6/hr 95%: 8.4E-6/hr 5%: 4.3E-6/hr
Source: NUREG 1740 (1984) (table 18) Ultimate source: US plants LER reports evaluation
Comment: BWR rate with command faults. W/o command faults 5.6E-6/hr.

URSFI reactor scram system
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to scram
FAILURE RATE OR PROBABILITY mean : 3.0E-5/d ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert judgement
Comment:

EREFE rectifier excitation rectifier over 600 V
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output(catastrophic)
FAILURE RATE OR PROBABILITY rec : 1.3E-6/hr high: 3.6E-6/hr low: 3.2E-7/hr
Source: IEEE 500 (1984) pg.421 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure node "no output" consist of:1)automatic removal by protective circutry; 2)manual removal; 3)open circut

ERPFE rectifier precipitator rectifier over 600 V

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output(catastrophic)
FAILURE RATE OR PROBABILITY rec : 1.4E-6/hr high: 4.1E-6/hr low: 3.6E-7/hr
Source: IEEE 500 (1984) pg.422 Ultimate source: expert opinion aggregation and operating experience
Comment: Falure mode "no output" consist of:1)automatic removal by protective circutry; 2)manual removal; 3)open circut.

ERSFT rectifier static

Component boundary: rectifier, fuse(380V side), tap. Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: loss of effective output
FAILURE RATE OR PROBABILITY mean : 1.4E-6/hr 95%: 5.8E-6/hr REPAIR TIME: 16 hours
Source: Swedish Rel.data book, tbl.42 Ultimate source: plant operating experience (7 BWR plants), ATV reports, LERs
Comment: Critical failures are: burned connections,failed fans,unstable electronics.Op.experience: total pop.140.Op.time 427E+4 hours.
No.of failures 6. a=0.0324; b=23000 Critical failures at 3 plants

RAADE relay auxiliary all types

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: spourious operation
FAILURE RATE OR PROBABILITY high : n/a : 1.5E-5/cy
Source: IEEE 500 (1984) pg.195 Ultimate source: expert opinion aggregation and operating experience
Comment: Given value is composite of different voltage levels of switchgear auxiliary relays.

RAAEE relay auxiliary all types

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close
FAILURE RATE OR PROBABILITY high : n/a : 7.0E-6/cy
Source: IEEE 500 (1984) pg.195 Ultimate source: expert opinion aggregation and operating experience
Comment: Given value is composite of different voltage levels of switchgear auxiliary relays

RAAOE relay auxiliary all types

Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open
FAILURE RATE OR PROBABILITY high : n/a : 8.9E-6/cy
Source: IEEE 500 (1984) pg.195 Ultimate source: expert opinion aggregation and operating experience
Comment: Given value is composite of different voltage levels of switchgear auxiliary relays

RCAAE relay control AC control relay
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 3.0E-7/hr high: 4.3E-4/hr low: 4.0E-8/hr
Source: IEEE 500 (1984) pg.186 Ultimate source: expert opinion aggregation and operating experience
Comment: Given value is composite of 4 AC control relays voltage levels.

RCDAE relay control DC control relay
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 3.6E-7/hr high: 2.1E-4/hr low: 2.0E-8/hr
Source: IEEE 500 (1984) pg.191 Ultimate source: expert opinion aggregation and operating experience
Comment: GIven value is composite of 3 DC control relays voltage levels.

RCLDE relay control all types
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: spourious operation
FAILURE RATE OR PROBABILITY rec : 4.0E-8/hr high: 2.5E-4/hr low: 1.0E-8/hr
Source: IEEE 500 (1984) pg.183 Ultimate source: expert opinion aggregation and operating experience
Comment: Given value is composite of AC and DC control relays and diffrerent voltage leves in both groups.Reference IEEE 500(1977)

RCLEE relay control all types
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close
FAILURE RATE OR PROBABILITY rec : 3.9E-6/cy high: 5.6E-6/cy low: 0.0E-0/cy
Source: IEEE 500 (1984) pg.183 Ultimate source: expert opinion aggergation and operating experience
Comment: Given value is composite of AC and DC control relays and different voltage levels in both groups.

RCLOE relay control all types
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open
FAILURE RATE OR PROBABILITY rec : 3.1E-6/cy high: 4.4E-6/cy low: 0.0E-0/cy
Source: IEEE 500 (1984) pg.183 Ultimate source: expert opinion aggregation and operating experience
Comment: Given value is composite of AC and DC control relays and different voltage levels in both groups. Reference IEEE 500(1977)

RCEAF relay control electromechanical

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: all modes Original failure mode: all modes

FAILURE RATE OR PROBABILITY mean : 3.4E-7/hr 95%: 4.2E-7/hr 5%: 2.7E-7/hr ERROR FACTOR: 1.2 REPAIR TIME: 3 hours

Source: HWR data Ultimate source: HWR operating experience

Comment: Population not known.Cumulative operating time 172.2E+6 hours. 59 failures.
Repair time is conservatively estimeted to be 3 hours.

RCECF relay control electromechanical

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: fail to change position Original failure mode: failure to energise

FAILURE RATE OR PROBABILITY mean : 1.0E-4/d 95%: 3.0E-4/d REPAIR TIME: 3 hours

Source: HWR data Ultimate source: HWR assesment

Comment: Ultimate data source is not known.

RCEEF relay control electromechanical

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: fail to close Original failure mode: failure of NO contacts to close when energised

FAILURE RATE OR PROBABILITY mean : 3.4E-7/hr 95%: 1.0E-6/hr REPAIR TIME: 3 hours

Source: HWR data Ultimate source: HWR assesment

Comment: Data based on 48 V DC relays commonly used in control circuts. Ultimate source is not known(oper.exper. or expert).No.of demands in time is not known. Same failure rate for "NC contacts to open"

RCEOF relay control electromechanical

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: fail to open Original failure mode: failure of NO contacts to open when de-energised

FAILURE RATE OR PROBABILITY mean : 1.0E-7/hr 95%: 3.4E-7/hr REPAIR TIME: 3 hours

Source: HWR data Ultimate source: HWR assesment

Comment: Data based on 48 V DC relays used in control circuts. Ultimate data source not known(op.exper. or expert). No of demands in time is not known. Same failure rate for "NC to close".

RWAFW relay general

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: fail to function Original failure mode: failure to energize

FAILURE RATE OR PROBABILITY median: 1.0E-4/d 95%: 3.0E-4/d 5%: 3.0E-5/d ERROR FACTOR: 3

Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear,industrial and military experience and data

Comment: Due to available data,failure rates of "failure to energise" include failure of normaly open contacts to close. Generally, relay and contacts failure rates should not be combined together.

RWCDW relay general
Component boundary: detail n/a Operating mode: normally closed Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: failure of NC cnts by opening,given not energised
FAILURE RATE OR PROBABILITY median: 1.0E-7/hr 95%: 3.0E-7/hr 5%: 3.0E-8/hr ERROR FACTOR: 3
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear expereince
Comment:

RWOEW relay general
Component boundary: detail n/a Operating mode: normaly open Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure of NO contacts to close,given energised
FAILURE RATE OR PROBABILITY median: 3.0E-7/hr 95%: 1.0E-6/hr 5%: 1.0E-7/hr ERROR FACTOR: 3
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear, industrial and military experiecne and data
Comment: Available data do not completely sepaarte causes of failures,so failure modes are not necessary independent.Fail to energise incl
ude this failure mode.Relay & contacts rates should not be added.

RPHFG relay power 300-460 A
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: loss of main function
FAILURE RATE OR PROBABILITY median: 1.0E-6/hr ERROR FACTOR: 15
Source: German Risk Study (tb.F3,7-1) Ultimate source: generic data
Comment: Failure rate is combination of several generic data sources

RPLFG relay power 40-60 A
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: loss of main function
FAILURE RATE OR PROBABILITY median: 9.0E-7/hr ERROR FACTOR: 10
Source: German Risk Study (tb.F3,7-1) Ultimate source: generic data
Comment: Filure rate is combination of several generic data sources.

RRADE relay protective all types
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: spourious operation
FAILURE RATE OR PROBABILITY rec : 3.0E-8/hr high: 2.4E-4/hr low: 0.0 REPAIR TIME: .55 hours
Source: IEEE 500 (1984) pg.164 Ultimate source: expert opinion aggregation and operating experience
Comment: Given value is composite of all types and voltage levels of protective relays.References IEEE 500 (1977) and
IEEE 493 (1980)

RRAEE relay protective all types

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: fail to close Original failure mode: fails to close

FAILURE RATE OR PROBABILITY rec : 3.0E-6/cy high: 6.0E-6/cy low: 8.5E-7/cy REPAIR TIME: .55 hours

Source: IEEE 500 (1984) pg.164 Ultimate source: expert opinion aggregation and operating experience

Comment: Given value is composite of all types and voltage levels of protective relays.

RRAOE relay protective all types

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: fail to open Original failure mode: fail to open

FAILURE RATE OR PROBABILITY rec : 5.3E-7/cy high: 1.1E-6/cy low: 1.2E-7/cy REPAIR TIME: .55 hours

Source: IEEE 500 (1984) pg.164 Ultimate source: expert opinion aggregation and operating experience

Comment: Given value is composite of all types and voltage levels of protective relays. References IEEE 500 (1977) and IEEE 493(1980)

RROAE relay protective overload protection

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: all modes Original failure mode: all modes

FAILURE RATE OR PROBABILITY rec : 7.3E-7/hr high: 1.8E-6/hr low: 1.1E-7/hr REPAIR TIME: .5 hours

Source: IEEE 500 (1984) pg.168 Ultimate source: expert opinion aggregation and operating experience

Comment: Given value is composite of current and temperature protection relays

RRSAE relay protective switchgear protection

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: all modes Original failure mode: all modes

FAILURE RATE OR PROBABILITY rec : 2.5E-7/hr high: 6.0E-4/hr low: 1.0E-8/hr REPAIR TIME: 61 hours

Source: IEEE 500 (1984) pg.179 Ultimate source: expert opinion aggregation and operating experience

Comment: Given value is composite of two AC voltage level and one DC voltage level

RRVAE relay protective voltage protection

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: all modes Original failure mode: all modes

FAILURE RATE OR PROBABILITY rec : 9.9E-7/hr high: 2.2E-6/hr low: 5.5E-7/hr REPAIR TIME: .6 hours

Source: IEEE 500 (1984) pg.172 Ultimate source: expert opinion aggregation and operating experience

Comment: Given value is composite of over and undervoltage protective relays.

RTAAF relay time delay
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.9E-6/hr 95%: 2.9E-6/hr 5%: 1.4E-6/hr REPAIR TIME: 3 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Populaton not known. Cumulative operating time 9.2E+6 hours. 18 failures. Reapir time is conservatively estimated to be 3 hrs.

RTBCB relay time delay bimetallic
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fails to transfer
FAILURE RATE OR PROBABILITY mean : 1.0E-5/hr max: 1.0E-5/hr min: 2.0E-7/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment:

RTBCI relay time delay bimetallic
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fails to transfer
FAILURE RATE OR PROBABILITY mean : 5.0E-6/hr ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion and non nuclear experience
Comment: Data source is MIL-HDBK 217B. Fail to transfer rates are not available for non-bimetallic time delay relays.

RTADB relay time delay general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: premature transfer
FAILURE RATE OR PROBABILITY mean : 1.0E-6/hr max: 5.0E-6/hr min: 2.0E-8/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment:

RTADI relay time delay general
Component boundary: detali n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: premature transfer
FAILURE RATE OR PROBABILITY mean : 3.0E-4/d ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

RTPAE relay time delay pneumatic
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 3.9E-7/hr high: 6.0E-4/hr low: 1.0E-8/hr
Source: IEEE 500 (1984) pg.206 Ultimate source: expert opinion aggregation and operating experience
Comment: Given value is composite of AC an DC category of time delay pneumatic relays

RTSAE relay time delay solid state
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.6E-6/hr high: 1.0E-3/hr low: 1.0E-8/hr
Source: IEEE 500 (1984) pg.201 Ultimate source: expert opinion aggreagtion and operating experience
Comment: Given value is composite of 3 AC relays voltage levels and 1 DC relay voltage category.

RYAFB relay coil
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failed open or short
FAILURE RATE OR PROBABILITY mean : 3.0E-6/hr max: 2.0E-5/hr min: 6.0E-8/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment:

RYAFI relay coil
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failed open or short
FAILURE RATE OR PROBABILITY mean : 1.0E-6/hr ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

RYAHF relay coil
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: short circut Original failure mode: short circut
FAILURE RATE OR PROBABILITY mean : 1.0E-8/hr 95%: 1.0E-7/hr REPAIR TIME: 3 hours
Source: HWR data Ultimate source: HWR assesment
Comment: Data based on 48 V DC relays used in control circuts. Ultimate data source(operating experience or expert) not known.

RYAHW relay coil
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: short circut Original failure mode: short to power
FAILURE RATE OR PROBABILITY mean: 1.0E-8/hr 95%: 1.0E-7/hr 5%: 1.0E-9/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-2) Ultimate source: ultimate data source not known
Comment:

RYAIF relay coil
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: open circut Original failure mode: open circut
FAILURE RATE OR PROBABILITY mean : 1.0E-7/hr 95%: 1.0E-6/hr REPAIR TIME: 3 hours
Source: HWR data Ultimate source: HWR assesment
Comment: Data based on 48 V DC relays used in control circuts Ultimate data source (operating experience or expert) is not known.

RYAIW relay coil
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: open circut Original failure mode: coil open
FAILURE RATE OR PROBABILITY median: 1.0E-7/hr 95%: 1.0E-6/hr 5%: 1.0E-8/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-2) Ultimate source: ultimate data source not known
Comment:

RXAHF relay contacts
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: short circut Original failure mode: short circuted
FAILURE RATE OR PROBABILITY mean : 1.0E-8/hr 95%: 1.0E-7/hr REPAIR TIME: 3 hours
Source: HWR data Ultimate source: HWR assesment
Comment: Data based on 48V DC relays used in control circuts. Ultimate data source(operating experience or expert opinion) is not known.

RXACB relay contacts general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to transfer
FAILURE RATE OR PROBABILITY mean : 1.0E-6/hr max: 5.0E-6/hr min: 2.0E-8/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment:

RXACI relay contacts general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to transfer
FAILURE RATE OR PROBABILITY mean : 3.0E-4/d ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: failure mode include failure to transfer open or close

RXAHW relay contacts general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: short circut Original failure mode: short across NO/NC contact
FAILURE RATE OR PROBABILITY median: 1.0E-8/hr 95%: 1.0E-7/hr 5%: 1.0E-9/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-2) Ultimate source: assesed form nuclear and military expereince and data
Comment:

ACABM sensor core flux general
Component boundary: sensor only Operating mode: operating Operating environment: normal
Generic failure mode: degraded Original failure mode: reduced capability
FAILURE RATE OR PROBABILITY mean : 1.6E-7/hr 95%: 2.1E-7/hr 5%: 1.1E-7/hr
Source: NUREG 1740 (1984) (table 18) Ultimate source: US plants LER reports evaluation
Comment: Overall rate, with command faults. W/o command faults 1.4E-7/hr. PWR rate is 6 times higher than BWR.

ACAFM sensor core flux general
Component boundary: sensor only Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: inoperable
FAILURE RATE OR PROBABILITY mean : 2.9E-7/hr 95%: 3.5E-7/hr 5%: 2.2E-7/hr
Source: NUREG 1740 (1984) (table 18) Ultimate source: US plants LER reports evaluation
Comment: Overall rate(BWR + PWR) with command faults. W/o command faults 2.5E-7/hr. PWR rate is order of magnitude higher.

AFAFT sensor flow general
Component boundary: sensor only (not clear) Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to function
FAILURE RATE OR PROBABILITY mean : 3.3E-3/d 95%: 7.6E-3/d REPAIR TIME: 2 hours
Source: Swedish Rel.data book, tbl.32 Ultimate source: plant operating experience (3 BWR plants),ATV reports, LERs
Comment: Operating experience:total pop 34.No.of demands 990. No.of failures 1.a=0.0192; b=5.83
Critical failures reported at one plant.

AFAKT sensor flow general
Component boundary: not clear Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: spurious function
FAILURE RATE OR PROBABILITY mean : 4.3E-6/hr 95%: 2.3E-5/hr REPAIR TIME: 2 hours
Source: Swedish Rel.data book, tbl.32 Ultimate source: plant operating experience (7 BWR plants),ATV reports,LERs
Comment: Operating experience:total pop.134.Operational time 500E+4 hours No.of failures 22. a=0.18; b=41900
Critcal failures reported on 4 plants.

AFAXT sensor flow general
Component boundary: sensor only Operating mode: all Operating environment: normal
Generic failure mode: other critical faults Original failure mode: other critical faults
FAILURE RATE OR PROBABILITY mean : 4.0E-7/hr 95%: 4.9E-7/hr REPAIR TIME: 2 hours
Source: Swedish Rel.data book, tbl.32 Ultimate source: plant operating experience (7 BWR plants),ATV reports, LERs
Comment: Operating experience:total pop. 134.Operational time 500E+4 hours No.of failures 2. a=0.0148; b=37000
Critical failures reported on 2 plants.

ALAFT sensor level general
Component boundary: sensor only Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to function
FAILURE RATE OR PROBABILITY mean : 2.1E-4/d REPAIR TIME: 3 hours
Source: Swedish Rel.data book, tbl.34 Ultimate source: plant operating expereince (7 BWR plants),ATV reports,LERs
Comment: Operating experience:total pop. 552.No.of demands 38.904. No.of failures 4. a=0.00191; b=9.24
Critical failures reported on 3 plants.

ALAKT sensor level general
Component boundary: sensor only Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: spourious function
FAILURE RATE OR PROBABILITY mean : 8.2E-7/hr 95%: 4.6E-6/hr REPAIR TIME: 3 hours
Source: Swedish Rel.data book, tbl.34 Ultimate source: plant operating experience (7 BWR plants),ATV reports, LERs
Comment: Operating experience:total pop.478. Operating time 1500E+4 hours No.of failures 13. a=0.0648; b=79400.
Critical faliures reported on 4 plants.

ALAXT sensor level general
Component boundary: sensor only Operating mode: all Operating environment: normal
Generic failure mode: other critical faults Original failure mode: other critical faults
FAILURE RATE OR PROBABILITY mean : 6.7E-7/hr 95%: 1.6E-6/hr REPAIR TIME: 3 hours
Source: Swedish Rel.data book, tbl.34 Ultimate source: plant operating experience(7 BWR plants),ATV reports, LERs
Comment: Operating experience:total pop. 571. Operational time 1940E+4 hours. No.of failures 13. a=0.0205; b=30600
Critical failures reported on 5 plants.

ALRFS sensor level reactor water level
Component boundary: detail n/a Operating mode: all Operating environment: reactor
Generic failure mode: fail to function Original failure mode: fails to operate
FAILURE RATE OR PROBABILITY mean : 3.9E-6/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating experience
Comment:

APAFT sensor pressure general
Component boundary: pressure sensor, excuding valves,piping ect. Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to function
FAILURE RATE OR PROBABILITY mean : 7.0E-4/d REPAIR TIME: 2 hours
Source: Swedish Rel.data book, tbl.28 Ultimate source: plant operating experience (7 BWR plants),ATV reports,LERs
Comment: Operating experience:total pop.294. No.of demands 14.305, no.of failures 6. a=0.0124; b=17.8
Critical failures reported by 4 plants.

APAKT sensor pressure general
Component boundary: pressure sensor only, excluding piping, valves ect. Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: spourious function
FAILURE RATE OR PROBABILITY mean : 8.7E-7/hr 95%: 2.2E-6/hr REPAIR TIME: 2 hours
Source: Swedish Rel.data book, tbl.28 Ultimate source: plant operating experience(7 BWR plants),ATV reports, LERs
Comment: Operating exprience:total pop.720. Operational time:2750E+4 hours no.of failures 24. a=0.0215; b=24600

APAKY sensor pressure general
Component boundary: pressure sensor only, excluding piping,valves ect. Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: spourious function
FAILURE RATE OR PROBABILITY mean : 8.8E-7/hr REPAIR TIME: 2 hours
Source: Swedish Rel.data book, tbl.28 Ultimate source: plant operating experience(1 PWR plant-Ringhals 2)
Comment: Operating experience:total pop.34.Operational time 113.1E+4 hours 1 failure recorded.

APAXT sensor pressure general
Component boundary: pressure sensor only, excluding piping, valves ect. Operating mode: all Operating environment: normal
Generic failure mode: other critical faults Original failure mode: other critical faults
FAILURE RATE OR PROBABILITY mean : 1.8E-7/hr REPAIR TIME: 2 hours
Source: Swedish Rel.data book, tbl.28 Ultimate source: plant operating experience (7 BWR plants),ATv reports, LERs
Comment: Operating experience:total pop.720.Operational time:2750E+4 hours no.of failures 5. a=0.00595; b=32700
Critical failures reported by 3 plants.

APAXY sensor pressure general
Component boundary: pressure sensor only, excluding piping,valves ect. Operating mode: all Operating environment: normal
Generic failure mode: other critical faults Original failure mode: other critical faults
FAILURE RATE OR PROBABILITY mean : 8.8E-7/hr REPAIR TIME: 2 hours
Source: Swedish Rel.data book, tbl.28 Ultimate source: plant operating experience(1 PWR plant-Ringhals 2)
Comment: Operating experience:total pop.34.Operational time 113.1E+4 hours 1 failure recorded.

APRFS sensor pressure reactor and containment sensor
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fails to operate
FAILURE RATE OR PROBABILITY mean : 1.1E-6/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating experience
Comment: In the failure rate data comparison (table A.2-1),under this component category and failure mode,pressure switch failure to operate from WASH 1400 is included.

APDFT sensor pressure difference general
Component boundary: pressure difference sensor, excluding all piping,valves ect. Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to function
FAILURE RATE OR PROBABILITY mean : 5.1E-3/d 95%: 2.6E-2/d REPAIR TIME: 3 hours
Source: Swedish Rel.data book, tbl.30 Ultimate source: plant operating experience(2 BWR plants),ATV reports, LERs
Comment: Operating experience: total pop. 4.No.of demands 198. No.of failures 1. a=0.216; b=42.6
Critical failures reported on one plant only.

APDKT sensor pressure difference general
Component boundary: pressure difference sensor, excluding all piping, valves ect. Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: spurious function
FAILURE RATE OR PROBABILITY mean : 3.2E-7/hr REPAIR TIME: 3 hours
Source: Swedish Rel.data book, tbl.30 Ultimate source: plant operating experience(7 BWR plants),ATV reports, LERs
Comment: Operating experience:total pop.206. Operational time 313E+4 hours 1 failure. a=0.00467; b=14600
Critical failure reportred only on one plant.

APDKY sensor pressure difference general
Component boundary: pressure diference sensor, excluding all piping,valves ect. Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: spurious function
FAILURE RATE OR PROBABILITY mean : 2.5E-6/hr REPAIR TIME: 2 hours
Source: Swedish Rel.data book, tbl.30 Ultimate source: plant operating experience(1 PWR plant-Ringhals 2)
Comment: Operating experience: total pop.12. Operational time 39.91E+4 hours. 1 failure.

ATABM sensor temperature general
Component boundary: sensor only Operating mode: operating Operating environment: normal
Generic failure mode: degraded Original failure mode: reduced capability
FAILURE RATE OR PROBABILITY mean : 7.4E-7/hr 95%: 1.2E-6/hr 5%: 4.4E-7/hr
Source: NUREG 1740 (1984) (table 18) Ultimate source: US plants LER reports evaluation
Comment: Not applicable to BWR. Overall PWR data . Same value with and w/o command faults.

ATAFM sensor temperature general
Component boundary: sensor only Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: inoperable
FAILURE RATE OR PROBABILITY mean : 1.7E-6/hr 95%: 2.4E-6/hr 5%: 1.2E-6/hr
Source: NUREG 1740 (1984) (table 18) Ultimate source: US plants LER reports evaluation
Comment: Not applicable to BWR.Overall PWR data. Same value with and w/o command faults.

ATAFT sensor temperature general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to function
FAILURE RATE OR PROBABILITY mean : 1.9E-3/d 95%: 1.1E-2/d REPAIR TIME: 3 hours
Source: Swedish Rel.data book, tbl.36 Ultimate source: plant operating experience (5 BWR plants), ATV reports, LERs
Comment: Operating experience: total pop.57. Number of demands 2160. No.of failures 4. a=0.061; b=32.9
Critical failures reported on 1 plant.

ATAKT sensor temperature general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: spurious function
FAILURE RATE OR PROBABILITY mean : 7.1E-7/hr 95%: 1.8E-6/hr REPAIR TIME: 3 hours
Source: Swedish Rel.data book, tbl.36 Ultimate source: plant operating experence (7 BWR plants)
Comment: Operating experience: total pop.728. Operational time 2250E+4 hours. No.of failures 16. a=0.0210; b=29500
Critical failures reported on 6 plants.

NCABM signal comparator bistabile for core flux,flow,level,pressure,temperature
Component boundary: bistabile only Operating mode: operating Operating environment: normal
Generic failure mode: degraded Original failure mode: reduced capability
FAILURE RATE OR PROBABILITY mean : 1.2E-6/hr 95%: 1.4E-6/hr 5%: 1.1E-6/hr
Source: NUREG 1740 (1984) (table 18) Ultimate source: US plants LER reports evaluation
Comment: Comparators/bistables recive output from the conditioning systems in turn provide inputs to logic matrices.BWR core flux and flow
only. Overall rate with command faults. W/o command 1.1E-6/hr.

NCAFM signal comparator bistable for core flux,level,flow,pressure,temperature
Component boundary: bistable only Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: inoperable
FAILURE RATE OR PROBABILITY mean : 5.2E-7/hr 95%: 6.8E-7/hr 5%: 4.0E-7/hr
Source: NUREG 1740 (1984) (table 18) Ultimate source: US plants LER reports evaluation
Comment: Comparators/bistables recive input from the conditioning systems in turn provide input to logic matrices.BWR core flux nad flow only. Overall rate with command faults. W/o command 4.3E-7/hr.

NCABE signal comparator bistable general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: degraded Original failure mode: degraded
FAILURE RATE OR PROBABILITY rec : 3.4E-7/hr high: 1.1E-6/hr low: 4.0E-8/hr
Source: IEEE 500 (1984) pg.628 Ultimate source: expert opinion aggregation
Comment: Reference IEEE 500 (1977) Failure mode "degraded" include:1)functioned at improper signal l level; 2)premature or delayed action

NCAFE signal comparator bistable general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: catastrophic
FAILURE RATE OR PROBABILITY rec : 1.0E-6/hr high: 3.5E-6/hr low: 1.0E-7/hr
Source: IEEE 500 (1984) pg.628 Ultimate source: expert opinion aggregation
Comment: Reference IEEE 500 (1977) Failure mode "catastrophic" include 1)functioned without signal; 2)no function with signal.

NCAFI signal comparator bistable general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 3.0E-7/d ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: IREP data base do not define failure mode for this component. Failure to operate is the most logical one and is in accordance with other sources. Reference: MIL-HDBK 217C

NSABM signal conditioning system for core flux,level,flow,pressure,temperature general
Component boundary: computational modules,summation amplifiers,power supply ect. Operating mode: operating Operating environment: normal
Generic failure mode: degraded Original failure mode: reduced capacity
FAILURE RATE OR PROBABILITY mean : 1.8E-6/hr 95%: 2.0E-6/hr 5%: 1.6E-6/hr
Source: NUREG 1740 (1984) (table 18) Ultimate source: US plants LER reports evaluation
Comment: Conditioning system is defined as conglomeration of components that recive output from sensing device and develop input for comparator.Overall rate,with command faults.W/o command 1.7E-6/hr

NSAFM signal conditioning system for core flux,level,flow,pressure,temperature general
Component boundary: computational modules,summation amplifiers,power supply Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: inoperable
FAILURE RATE OR PROBABILITY mean : 3.4E-6/hr 95%: 3.7E-6/hr 5%: 3.1E-6/hr
Source: NUREG 1740 (1984) (table 18) Ultimate source: US plants LER reports evaluation
Comment: Conditioning system is defined as conglomeration of components that recive output from sensing device and develop input for comparator.Overall rate,with command faults.W/o command 3.2E-6/hr

NMTAF signal modifier current-current transducer
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 4.7E-6/hr 95%: 6.3E-6/hr 5%: 3.5E-6/hr ERROR FACTOR: 1.3 REPAIR TIME: 3 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Population not known. Cumulative component operating time 6.6E+6 hours. 31 failures."All modes" should be used instead 1)no output 2)high,3)low output,4)no change in output with change of input.

NMPAF signal modifier current-pneumatic transducer
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY median: 7.3E-6/hr 95%: 3.1E-5/hr 5%: 5.7E-7/hr ERROR FACTOR: 4.3 REPAIR TIME: 3 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Population not known. Cum.operating time 9.5E+4 hours.No failures Repair time is estimated. "All modes" include:1)no output,2)high 3)low output,4)no change in output with change of input.

NMVAF signal modifier current-voltage transducer
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 2.3E-5/hr 95%: 2.9E-5/hr 5%: 1.8E-5/hr ERROR FACTOR: 1.2 REPAIR TIME: 3 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Population not known. Cumualtive component operating time 2.3E+6 hours. 52 failures."All modes include:1)no output,2)high,3)low output,4) no change in output with change in input.

NMABE signal modifier general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: degraded Original failure mode: degraded
FAILURE RATE OR PROBABILITY rec : 8.4E-7/hr high: 1.6E-6/hr low: 3.5E-7/hr
Source: IEEE 500 (1984) pg.627 Ultimate source: expert opinion aggregation
Comment: Reference IEEE 500 (1977)

NMAFE signal modifier general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: catastrophic
FAILURE RATE OR PROBABILITY rec : 3.0E-7/hr high: 5.7E-7/hr low: 1.3E-7/hr
Source: IEEE 500 (1984) pg.627 Ultimate source: expert opinion aggregation
Comment: Referenfce IEEE 500 (1977) Failure mode "catastrophic" include 1)zero or maximum output; 2)no change in output with change in input.

NMSAF signal modifier square root extractor
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 5.1E-6/hr 95%: 6.8E-6/hr 5%: 3.9E-6/hr ERROR FACTOR: 1.3 REPAIR TIME: 3 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Population not known.Cum.operating time 6.2E+6 hours. 32 failures "All modes"include following:1)no output,2)high,3)low output,4)no change in output with change input.Data not available fot this FM

NMOAF signal modifier voltage-pneumatic transducer
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.5E-6/hr 95%: 7.1E-6/hr 5%: 5.7E-7/hr ERROR FACTOR: 2.8 REPAIR TIME: 3 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Poulation not known. Cum.operating time 67.5E+4 hours. 1 failure. "All modes" include following failure modes:1)no output,2)high, 3)low output,4)no change in output with change of input.

UEHFB solid state devices high power application
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 3.0E-6/hr max: 2.0E-5/hr min: 6.0E-8/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment: NUREG 2815 do not define failure mode for this component. Failure to operate is the most logical one, and it is in accordance with other sources

UEHFI solid state devices high power application
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 3.0E-6/hr ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: IREP data base do not define failure mode for this component. Failure to operate is the most logical one and is in accordance with other sources.

UEHFW solid state devices high power application (current >=1 A or voltage >=28 V)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fails to function
FAILURE RATE OR PROBABILITY median: 3.0E-6/hr 95%: 3.0E-5/hr 5%: 3.0E-7/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear experience and from military data
Comment: The available data do not permit separation of the causes of fail ures in all cases, hence solid state devices failure modes are not independent.Large errorfctor due to differece in application.

UEHHW solid state devices high power application (current >=1A or voltage >=28 V)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: short circut Original failure mode: fails shorted
FAILURE RATE OR PROBABILITY median: 1.0E-6/hr 95%: 1.0E-5/hr 5%: 1.0E-7/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear experience and military data
Comment: The available data do not permit separation of causes of failure hence failure modes are not independent and should not be combine d.Large error factor due to difference in application.

UELFB solid state devices low power application general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 3.0E-6/hr max: 2.0E-5/hr min: 6.0E-8/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment: NUREG 2815 do not define failure mode for this component. Failure to operate is the most logical one, and is in accordance with other sources.

UELFI solid state devices low power application general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 3.0E-6/hr ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: IREP data base do not define failure mode for this component. FAilure to operate is the most logical one and is in accordance with other sources. Reference: MIL-HDBK 217C

UELFW solid state devices low power application general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY median: 1.0E-6/hr 95%: 1.0E-5/hr 5%: 1.0E-7/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear and military expereince and data
Comment: Failure modes are not independent. The relativly large error factor reflect variation form aapplication to application.

UELHW solid state devices low power application general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: short circut Original failure mode: fails short
FAILURE RATE OR PROBABILITY median: 1.0E-7/hr 95%: 1.0E-6/hr 5%: 1.0E-8/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from military expereince and expert opinion
Comment: Failure modes are not independent. The relativly large error factor reflects variation from application to application.

ECMFT static converter for reactor main coolant pumps
Component boundary: rectifier,inverter,contiuous voltage equipment,transformer Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: loss of effective output
FAILURE RATE OR PROBABILITY mean : 4.1E-5/hr 95%: 1.4E-4/hr REPAIR TIME: 28 hours
Source: Swedish Rel.data book, tbl.54 Ultimate source: plant operating exeprience(2 BWR plants),ATV reports, LERs
Comment: Operating experience:total pop. 16.Operational time 19.7E+4 hours No.of failures 8. a=0.67; b=16500

YSDQA *strainer service water strainer (charging pump cooling system) duplex strainer*
Component boundary: detail n/a Operating mode: alternating Operating environment: normal
Generic failure mode: plug Original failure mode: plugged
FAILURE RATE OR PROBABILITY median: 2.0E-5/hr ERROR FACTOR: 3
Source: NUREG 4550/Vol.3,tbl.IV.8-1 Ultimate source: Surry NPP operating expreince
Comment: Normal environment in this case incude raw water environment.

YSFQB strainer/filter general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: plug Original failure mode: plugged
FAILURE RATE OR PROBABILITY mean : 3.0E-5/hr max: 2.0E-4/hr min: 6.0E-7/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion and IREP data
Comment: For clear fluids. Contaminated fluids and fluids with heavy chemical buren should be considered on plant specific bases.

YSFQI strainer/filter general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: plug Original failure mode: plugged
FAILURE RATE OR PROBABILITY mean : 3.0E-5/hr ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: Given value is for clear fluids only. Contaminated fluids or fluids with a heavy chemical burden should be considered on plant specific bases.

SDABM switch digital chanel pressure/vacuum, pressure,level
Component boundary: digital channel Operating mode: operating Operating environment: normal
Generic failure mode: degraded Original failure mode: reduced capability
FAILURE RATE OR PROBABILITY mean : 7.5E-6/hr 95%: 8.3E-6/hr 5%: 6.8E-6/hr
Source: NUREG 1740 (1984) (table 18) Ultimate source: US plants LER reports evaluation
Comment: Overall rate with command faults. W/o command 7.1E-6/hr Pressure/vacuum and level applicable to BWR, and pressure applicable to PWR. BWR rate 5 times higher than PWR.

SDAFM switch digital channel pressure/vacuum, pressure, level
Component boundary: digital channel Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: inoperable
FAILURE RATE OR PROBABILITY mean : 1.0E-6/hr 95%: 1.3E-6/hr 5%: 7.7E-7/hr
Source: NUREG 1740 (1984) (table 18) Ultimate source: US plants LER reports evaluation
Comment: Overall rate with command faults. W/o command 8.9E-7/hr. Pressure/vacuum and level switches applicable to BWR, pressure applicable to PWR.BWR rate is order of magnitude higher than PWR.

SFABF switch flow
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: degraded Original failure mode: erratic operation
FAILURE RATE OR PROBABILITY mean : 3.4E-7/hr REPAIR TIME: 4 hours
Source: HWR data Ultimate source: HWR assesment
Comment: Ultimate data source is not known.

SFAFF switch flow
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY mean : 1.7E-6/hr REPAIR TIME: 4 hours
Source: HWR data Ultimate source: HWR assesment
Comment: Ultimate source of data is not clear.

SFAKF switch flow
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: spurious operation
FAILURE RATE OR PROBABILITY mean : 1.6E-6/hr REPAIR TIME: 4 hours
Source: HWR data Ultimate source: HWR assesment
Comment: Ultiamte source of data is not known.

SFAFE switch flow general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no function with signal
FAILURE RATE OR PROBABILITY rec : 9.8E-7/hr high: 1.8E-6/hr low: 8.0E-8/hr REPAIR TIME: .6 hours
Source: IEEE 500 (1984) pg.578 Ultimate source: expert opinion aggreagtion and operating experience
Comment: Failure rate is composite and include some non-nuclear suorces

SFAFS switch flow general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fails to operate
FAILURE RATE OR PROBABILITY mean : 2.6E-7/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating experience
Comment:

SFAKE switch flow general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: functioned without signal
FAILURE RATE OR PROBABILITY rec : 8.6E-7/hr high: 1.6E-6/hr low: 8.0E-8/hr REPAIR TIME: .6 hours
Source: IEEE 500 (1984) pg.578 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite and include some non-nuclear sources.

SFXFE switch flow general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no function with signal
FAILURE RATE OR PROBABILITY rec; h: 1.0E-8/cy gh;: 4.0E-8/cy ow:: 0.0E-0/cy REPAIR TIME: .6 hours
Source: IEEE 500 (1984) pg.578 Ultimate source: expert opinion aggreagtion and operating experience
Comment: Failure rate is composite.

SFXKE switch flow general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: functioned without signal
FAILURE RATE OR PROBABILITY rec : 1.0E-8/cy high: 5.0E-8/cy low: 0.0E-0/cy REPAIR TIME: .6 hours
Source: IEEE 500 (1984) pg.578 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite.

SLABF switch level
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: degraded Original failure mode: erratic operation
FAILURE RATE OR PROBABILITY mean : 7.2E-7/hr
Source: HWR data Ultimate source: HWR assesment
Comment: Ultimate data source is not known.

SLAFF switch level
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY mean : 1.4E-6/hr REPAIR TIME: 4 hours
Source: HWR data Ultimate source: HWR assesment
Comment: Ultimate data source is not known.

SLAKF switch level
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: spurious operation
FAILURE RATE OR PROBABILITY mean : 3.2E-6/hr REPAIR TIME: 4 hours
Source: HWR data Ultimate source: HWR assesment
Comment: Ultimate data source is not known.

SLAKE switch level general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: functioned without signal
FAILURE RATE OR PROBABILITY rec : 1.6E-6/hr high: 3.0E-6/hr low: 7.7E-7/hr REPAIR TIME: 1.5 hours
Source: IEEE 500 (1984) pg.589 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite.

SLXFE switch level general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no change of output with change of input
FAILURE RATE OR PROBABILITY rec : 3.0E-8/cy high: 6.0E-8/cy low: 0.0E-0/cy REPAIR TIME: 1.5 hours
Source: IEEE 500 (1984) pg.589 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure rate is composite.

SIAAF switch limit
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 3.3E-6/hr 95%: 4.0E-6/hr 5%: 2.9E-6/hr ERROR FACTOR: 1.4 REPAIR TIME: 4 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Population not known. Cumulative component operating time 29.8E+6 hours. 100 failures. "All modes" include:1)failure to operate,2) spurious,3)erratic operation. No data for other FM are given.

SIEKT switch limit electronic
Component boundary: limit switch only Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: spourious operation
FAILURE RATE OR PROBABILITY mean : 7.7E-7/hr 95%: 4.0E-6/hr REPAIR TIME: 2 hours
Source: Swedish Rel.data book, tbl.38 Ultimate source: plant operating experience (7 BWR plants),ATV reports, LERs
Comment: Operating experience: total pop. 249. Operational time 816E+4 hours. No.of failures 7.a=0.0481; b=62700. Critical failures at 3 plants. No critical failures for "failure to operate on demand".

SIAFB switch limit general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 6.0E-6/hr max: 4.0E-6/hr min: 8.0E-7/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment: Where limit switch is uses as a part of pump/valve, switch failure rate is included in pump/valve rate

SIAFI switch limit general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 1.0E-4/d ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: Where limit switch is used as part of pump/valve,switch failure rate is included in pump/valve failure rate

SIAFW switch limit general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY median: 3.0E-4/d 95%: 1.0E-3/d 5%: 1.0E-4/d ERROR FACTOR: 3
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear, industrial and military experience and data
Comment: The data do not uniquely separate the causes of failure, hence failure modes are not necessary independent. Failure to operate includes failures of contacts.

SMACF switch manual
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY mean : 4.6E-7/hr REPAIR TIME: 3 hours
Source: HWR data Ultimate source: HWR assesment
Comment: Ultimate data source is not known. Number of demands in time is not known.
Repair time consevatively estimated to be 3 hours.

SMAKF switch manual
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: spurious operation
FAILURE RATE OR PROBABILITY mean : 3.4E-7/hr
Source: HWR data Ultimate source: HWR assesment
Comment: Ultimate data source is not known.

SMACB switch manual general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to transfer
FAILURE RATE OR PROBABILITY mean : 1.0E-6/hr max: 5.0E-6/hr min: 2.0E-8/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment:

SMACI switch manual general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to transfer
FAILURE RATE OR PROBABILITY mean : 3.0E-5/d ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

SMACW switch manual general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to transfer
FAILURE RATE OR PROBABILITY median: 1.0E-5/d 95%: 3.0E-5/d 5%: 3.0E-6/d ERROR FACTOR: 3
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear, industrial and military expereince and data
Comment:

SPAAF switch pressure
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 5.7E-6/hr 95%: 8.1E-6/hr 5%: 4.1E-6/hr ERROR FACTOR: 1.4 REPAIR TIME: 4 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Population not known. Cumualtive component operating time 3.9E+6 hours. 22 failures. "All modes" incl:1)spurious,2)erratic oper., 3)failure to operate.Contrib.of 2)is negligable,1)&3) about equal

SPAFB switch pressure
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 2.0E-7/hr max: 1.0E-6/hr min: 8.0E-8/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment:

SPAFF switch pressure
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 3.1E-6/hr 95%: 5.0E-6/hr 5%: 2.0E-6/hr ERROR FACTOR: 1.5
Source: HWR data Ultimate source: HWR operating experience
Comment: Operational data for this failure mode are not given, but probbably included in "all modes".

SPAKF switch pressure
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: spurious operation
FAILURE RATE OR PROBABILITY mean : 2.2E-6/hr 95%: 4.0E-6/hr 5%: 1.4E-6/hr ERROR FACTOR: 1.6
Source: HWR data Ultimate source: HWR operating experience
Comment: Operational data for this failure mode are not given. probbably are included in "all modes" .

SPAFE switch pressure general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no function with signal
FAILURE RATE OR PROBABILITY rec : 4.0E-7/hr high: 1.9E-6/hr low: 1.0E-8/hr REPAIR TIME: .6 hours
Source: IEEE 500 (1984) pg.556 Ultimate source: expert opinion aggregation and operating experience
Comment: Value is composite and include some non-nuclear sources For this component failure rate per hour and per cycle is given.

SPAFI switch pressure general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 1.0E-4/d ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

SPAFW switch pressure general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY median: 1.0E-4/d 95%: 3.0E-4/d 5%: 3.0E-5/d ERROR FACTOR: 3
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear, industrial and military experience and data
Comment: Data do not uniquely separate causes of failures, hence failure modes are not necessary independent. Failure to operate includes failure of contacts.

SPAKE switch pressure general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: functioned without signal
FAILURE RATE OR PROBABILITY rec : 7.0E-8/hr high: 3.1E-7/hr low: 0.0E-0/hr REPAIR TIME: .6 hours
Source: IEEE 500 (1984) pg.556 Ultimate source: expert opinion aggregation and operating experience
Comment: Value is composite and include some non-nuclear sources. For this component failure rate per hour and per cycle is given.

SPXFE switch pressure general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no function with signal
FAILURE RATE OR PROBABILITY rec : 1.4E-7/cy high: 3.0E-7/cy low: 3.0E-8/cy REPAIR TIME: .6 hours
Source: IEEE 500 (1984) pg.556 Ultimate source: expert opinion aggregation and operating experience
Comment: Value is composite and include some non-nuclear sources. For this component failure rate per hour and per cycle is given.

SPXKE switch pressure general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: functioned without signal
FAILURE RATE OR PROBABILITY rec : 1.4E-7/cy high: 8.0E-7/cy low: 1.0E-8/cy REPAIR TIME: .6 hours
Source: IEEE 500 (1984) pg.556 Ultimate source: expert opinion aggregation and operating experience
Comment: Value is composite and include some non-nuclear sources. For this component failure rate per hour and per cycle is given.

STABF switch temperature
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: degraded Original failure mode: erratic operation
FAILURE RATE OR PROBABILITY mean : 1.8E-7/hr
Source: HWR data Ultimate source: HWR assesment
Comment: Ultimate data source is not known.

STAFF switch temperature
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 5.3E-7/hr
Source: HWR data Ultimate source: HWR assesment
Comment: Ultimate data source is not known.

STAKF switch temperature
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: spurious operation
FAILURE RATE OR PROBABILITY mean : 5.5E-7/hr
Source: HWR data Ultimate source: HWR assesment
Comment: Ultimate data source is not known.

STAOS switch temperature
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fails to open
FAILURE RATE OR PROBABILITY mean : 3.3E-7/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating experience
Comment:

STAFE switch temperature general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no function with signal
FAILURE RATE OR PROBABILITY rec : 1.2E-7/cy high: 2.4E-7/cy low: 2.0E-8/cy REPAIR TIME: .5 hours
Source: IEEE 500 (1984) pg.534 Ultimate source: expert opinion aggregation and operating experience
Comment: Composite value For this component failure rate per hour and per cycle is given.

STAFE switch temperature general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no function with signal
FAILURE RATE OR PROBABILITY rec : 2.0E-7/hr high: 3.9E-7/hr low: 5.0E-8/hr REPAIR TIME: .5 hours
Source: IEEE 500 (1984) pg.534 Ultimate source: expert opinion aggregation and operating experience
Comment: Given value is composite. For this component failure rate per hour and per cycle is given.

STAFS switch temperature general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fails to operate
FAILURE RATE OR PROBABILITY mean : 2.3E-6/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating experience
Comment:

STAKE switch temperature general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: functioned without signal
FAILURE RATE OR PROBABILITY rec : 2.3E-7/hr high: 4.5E-7/hr low: 6.0E-8/hr REPAIR TIME: .5 hours
Source: IEEE 500 (1984) pg.534 Ultimate source: expert opinion aggregation and operating experience
Comment: Given value is composite of different types and data sources for temperatre switches.
For this component failure rate per hour and per cycle is given.

STXKE switch temperature general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: spurious function Original failure mode: functioned without signal
FAILURE RATE OR PROBABILITY rec : 1.4E-7/cy high: 2.9E-7/cy low: 2.0E-8/cy REPAIR TIME: .5 hours
Source: IEEE 500 (1984) pg.534 Ultimate source: expert opinion aggregation and operating experience
Comment: Given value is composite. For this component failure rate per hour and per cycle is given.

SQAFB switch torque general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 2.0E-7/hr max: 1.0E-6/hr min: 6.0E-8/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment: Where torque switch is used as a part of pump/valve, switch failure rate is included in pump/valve rate

SQAFI switch torque general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 1.0E-4/d ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: Where torque switch is used as part of pump/valve, switch failure rate is included in pump/valve failure rate

SQAFW switch torque general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY meidan: 1.0E-4/d 95%: 3.0E-4/d 5%: 3.0E-5/d ERROR FACTOR: 3
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear and military experience and data sources
Comment: Data do not uniquely separate the causes of failure,hence failure modes are not necessary independent. Failure to operate include failures of contacts.

SCAHW switch contacts general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: short circut Original failure mode: short across NO/NC switches
FAILURE RATE OR PROBABILITY median: 1.0E-8/hr 95%: 1.0E-7/hr 5%: 1.0E-9/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear and military experience and data
Comment: Data do not uniquely separate causes of failures, hence failure modes are not necessary independent.

SCCDW switch contacts general
Component boundary: detail n/a Operating mode: normally closed Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: failure of NC cnts by opening,given no sw.operat.
FAILURE RATE OR PROBABILITY median: 3.0E-8/hr 95%: 3.0E-7/hr 5%: 3.0E-9/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-2) Ultimate source: ultimate data source is not known
Comment: The data do not uniquely separate the causes of failure,hence failure modes are not necessary independent.

SCOCW switch contacts general
Component boundary: detail n/a Operating mode: normally open Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure of NO cnts to close,given switch operation
FAILURE RATE OR PROBABILITY median: 1.0E-7/hr 95%: 1.0E-6/hr 5%: 1.0E-8/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-2) Ultimate source: ultimate data source is not known
Comment: Data do not uniqely separaet causes of failure, hence failure modes are not necessary independent.

SCACS switch contacts {relay HFA}
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: coil fails to operate
FAILURE RATE OR PROBABILITY mean : 4.0E-7/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating expereince
Comment: It was not possible to identify this component and failure mode in other sources.

SCAOS switch contacts {relay HFA}
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open* Original failure mode: coil fails to open
FAILURE RATE OR PROBABILITY mean : 8.0E-8/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating experience
Comment: It was not possible to identify this component and failure mode in other sources.

JTFTH tank storage FWST
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: rupture Original failure mode: rupture during operation
FAILURE RATE OR PROBABILITY mean : 2.6E-8/hr 95%: 7.4E-8/hr 5%: 7.E-10/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 2.7E-8/hr. Operating expereince 1.36E+5 hours of operation, no failures.

JTRTH tank storage RWST
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: rupture Original failure mode: rupture during operation
FAILURE RATE OR PROBABILITY mean : 2.7E-8/hr 95%: 7.6E-8/hr 5%: 7.E-10/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 2.7E-8/hr. Operating experience 1.36E+5 hours of operation, no failures.

EBAHB terminal board general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: short circut Original failure mode: short to adjacent circut
FAILURE RATE OR PROBABILITY mean : 3.0E-7/hr max: 2.0E-6/hr min: 6.0E-9/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment: Given value is per terminal

EBAHI terminal board general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: short circut Original failure mode: short to adjacent circut
FAILURE RATE OR PROBABILITY mean : 3.0E-7/hr ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: Given value is per terminal

EBAHW terminal board general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: short circut Original failure mode: short to adjacent circut
FAILURE RATE OR PROBABILITY median: 1.0E-8/hr 95%: 1.0E-7/hr 5%: 1.0E-9/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-2) Ultimate source: ultimate source not known
Comment: Data do not permit unique separation of failure modes between wires and terminal boards, so should not be combined. Data for terminal boards are given for cases where unique effects exsist.

EBAIB terminal board general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: open circut Original failure mode: open circut
FAILURE RATE OR PROBABILITY mean : 3.0E-7/hr max: 2.0E-6/hr min: 6.0E-9/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment: Given value is per terminal

EBAII terminal board general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: open circut Original failure mode: open circut
FAILURE RATE OR PROBABILITY mean : 3.0E-7/hr ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: Given value is per terminal

EBAIW terminal board general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: open circut Original failure mode: open connection
FAILURE RATE OR PROBABILITY median: 1.0E-7/hr 95%: 1.0E-6/hr 5%: 1.0E-8/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-2) Ultimate source: ultimate data source not known
Comment: Data do not permit unique separation of failure modes between wires and terminal boards, so should not be combined.Data for terminal boards are given for cases where unique effects exsist.

TA2FH transformer 220/120 V
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 2.5E-6/hr 95%: 5.2E-6/hr 5%: 5.1E-7/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 1.6E-6/hr. Operating experience 5.4E+5 hours of operation, 2 failures.

TA5FH transformer 50/6 kV
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 1.3E-6/hr 95%: 2.5E-6/hr 5%: 2.8E-7/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 1.6E-6/hr. Operating experience 1.4E+5 hours of operation, no failures.

TA6FH transformer 6kV/380 V
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 4.9E-7/hr 95%: 1.1E-6/hr 5%: 8.6E-8/hr
Source: Old PWR Ultimate source: generic data updated with plant specific operating experience
Comment: Generic mean 6.9E-7/hr. Operating expereince 8.2E+5 hours of operation, no failures.

TA8FH transformer 8 kV / 6 kV
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 1.3E-6/hr 95%: 2.5E-6/hr 5%: 2.8E-7/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 1.6E-6/hr. Operating experience 1.4E+5 hours of operation, no failures.

TADFO transformer dry 4 kV/600 V
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: operational failure
FAILURE RATE OR PROBABILITY mean : 4.8E-7/hr 95%: 1.2E-6/hr 5%: 2.1E-8/hr REPAIR TIME: 10.8 hours
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:IEEE 500(1977)(pg.300), rec=median;max=80% of distribution Operating experience: 4.34E+5 hours of operation, no failures.
Repair time is mean generic maintenance duration.

TAEFO transformer dry 600 V/208 V
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: operational failure
FAILURE RATE OR PROBABILITY mean : 3.1E-7/hr 95%: 7.8E-7/hr 5%: 5.7E-9/hr REPAIR TIME: 10.8 hours
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operational experience
Comment: Prior:IEEE 500 (1977) pg.299.rec=median; max=80% of distribution. Operating experience:8.2E+5 hours of operation, no failures. Repair time is mean generic maintenance duration.

TTSFE transformer auto transformer liquid filled, single phase all voltage levels
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output(catastrophic)
FAILURE RATE OR PROBABILITY rec : 4.5E-7/hr high: 2.0E-6/hr low: 1.3E/7/hr
Source: IEEE 500 (1984) pg.397 Ultimate source: expert opinion aggregation and operating exeprience
Comment: Given value is composite of 7 diffrerent voltage levels See failure mode comment IEEE main transformer composite

TTTFE transformer auto transformer liquid filled, three phase all voltage levels
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output(catastrophic)
FAILURE RATE OR PROBABILITY rec : 1.5E-6/hr high: 2.7E-6/hr low: 4.0E-7/hr
Source: IEEE 500 (1984) pg.405 Ultimate source: expert opinion aggregation and operating experience
Comment: given value is composite of 7 diffrerent voltage levels Failure mode"no output" include 1)automatic removal by protective circutry;2)manual removal;3)open circut.Dominant contrib. #1)

TAAAB transformer general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 6.0E-7/hr max: 4.0E-6/hr min: 3.0E-7/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment:

TAAAI transformer general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.0E-6/hr ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

TAAFG transformer general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY median: 1.5E-6/hr ERROR FACTOR: 5
Source: German Risk Study (tb.F3,7-1) Ultimate source: generic data
Comment: In the table F3,7-1 failure mode is missing. Failure mode "failure to operate" was assumed on the bases of generic sources included."Failure to operate" include "open" and "short" circut.

TAAHW transformer general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: short circut Original failure mode: short primary to secondary
FAILURE RATE OR PROBABILITY median: 1.0E-6/hr 95%: 3.0E-6/hr 5%: 3.0E-7/hr ERROR FACTOR: 3
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear,industrial and military expereince and data
Comment:

TAAIW transformer general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: open circut Original failure mode: open circut, primary to secondary
FAILURE RATE OR PROBABILITY median: 1.0E-6/hr 95%: 3.0E-6/hr 5%: 3.0E-7/hr ERROR FACTOR: 3
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from nuclear,industrial nad military experience and data
Comment:

TABFZ transformer general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: fail during operation
FAILURE RATE OR PROBABILITY mean : 1.7E-6/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant specific experience
Comment: Prior:IEEE 500(1977)(pg.300) transformer 601V-15kV, prior failure mode="all modes"
Operating experience:3.0E+5 hours of operation,1 failure.

TA6FT transformer general Voltage <= 6 kV
Component boundary: transformer,relay protection,coolers,supervision,monitors Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: interruption
FAILURE RATE OR PROBABILITY mean : 7.9E-7/hr 95%: 3.5E-6/hr REPAIR TIME: 10 hours
Source: Swedish Rel.data book, tbl.47 Ultimate source: plant operating experience (7 BWR plants),ATV reports, LERs
Comment: Operating experience: total pop. 129.Opertional time 379E+4 hours No.of failures 3. Critical failures occured at two plants only.
a=0.0345; b=43600

TM2FO transformer high voltage outdoor
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: operational failure
FAILURE RATE OR PROBABILITY mean : 1.4E-6/hr 95%: 3.5E-6/hr 5%: 1.5E-7/hr REPAIR TIME: 10.8 hours
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data upgraded with plant operating experience
Comment: Prior:IEEE 500 (1977)(pg.315),rec=median;max=80%.FM"catastrophic' "seems to include load side protection).Op.exp. 81.900 hours of operation,no failures. Repair time is generic maintn.duration.

TICFE transformer instrument transformer current transformer all voltage levels
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output (catastrophic)
FAILURE RATE OR PROBABILITY rec : 2.6E-7/hr high: 4.9E-7/hr low: 1.1E-7/hr
Source: IEEE 500 (1984) pg.417 Ultimate source: expert opinion aggregation and opertiong experience
Comment: Given value is composite of two diffrerent voltage levels Failure mode "no output"include no output due to: 1) open circut 2)shorts.

TIPFE transformer instrument transformer potential transformer all voltage levels
Component boundary: detil n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output(catastrophic)
FAILURE RATE OR PROBABILITY rec : 4.2E-7/hr high: 1.0E-6/hr low: 2.7E-7/hr
Source: IEEE 500 (1984) pg.414 Ultimate source: expert opinion aggreagtion and operating experience
Comment: Given value is composite of two diffrerent voltage levels. Failure mode no output include no output due to:1) open circut 2)short.

TSAFE transformer main power generator or unit transformer liquid filled, single phase all volatge levels
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output(catastrophic)
FAILURE RATE OR PROBABILITY rec : 2.8E-7/hr high: 1.8E-6/hr low: 3.0E-8/hr
Source: IEEE 500 (1984) pg.348 Ultimate source: expert opinion aggregation and operating experience
Comment: This is a composite value of all voltage levels of main, liquid filled single phase transformers. Failure mode include:1)autom. removal; 2)manual removal; 3)open circut. #1) is dominant.

TS2FE transformer main power generator or unit transformer liquid filled, single phase voltage 2-30 kV
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output(catastrofic)
FAILURE RATE OR PROBABILITY rec : 2.2E-7/hr high: 3.9E-7/hr low: 9.5E-8/hr
Source: IEEE 500 (1984) pg.347 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure mode includes no output due to:1) automatic removal by protective circutry; 2)manual removal; 3) open circut.

TS4FE transformer main power generator or unit transformer liquid filled, single phase voltage 146-242 kV
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output(catastrophic)
FAILURE RATE OR PROBABILITY rec : 3.2E-7/hr high: 6.2E-7/hr low: 2.5E-7/hr
Source: IEEE 500 (1984) pg.350 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure mode "no output" include: 1)automatic removal by protect. circutry 2)manual removal; 3)open circut.
#1) is order of magnitude higher than #2) and #3).

TS5FE. transformer main power generator or unit transformer liquid filled, single phase voltage 347-550 kV
Component boundary: detil n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output(catastrophic)
FAILURE RATE OR PROBABILITY rec : 1.2E-6/hr high: 1.9E-6/hr low: 5.3E-7/hr
Source: IEEE 500 (1984) pg.352 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure mode "no output" include: 1) automatic removal by protec. circutry; 2)manual removal; 3)open circut.
#1) is order of magnitude higher than #2) and #3).

TMAFE transformer main power generator or unit transformer liquid filled, three phase all voltage levels
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output(catastrophic)
FAILURE RATE OR PROBABILITY rec : 5.8E-7/hr high: 1.6E-6/hr low: 1.0E-7/hr
Source: IEEE 500 (1984) pg.354 Ultimate source: expert opinion aggregation and operating experience
Comment: Given value is composite of all voltage levels. Failure mode include:1)automatic; 2)manual removal; 3)open circut
#1) is order of magnitude higher than #2) and #3).

TM4FE transformer main power generator or unit transformer liquid filled, three phase voltage 146-242 kV
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output(catastrophic)
FAILURE RATE OR PROBABILITY rec : 1.1E-6/hr high: 1.5E-6/hr low: 5.0E-7/hr
Source: IEEE 500 (1984) pg.358 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure mode "no output" include: 1) automatic removal; 2)manual removal; 3) open circut.
Dominant contributor is #1) (more than order-of-magnitude)

TM2FE transformer main power generator or unit transformer liquid filled, three phase voltage 2-30 kV
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output(catastrophic)
FAILURE RATE OR PROBABILITY rec : 3.4E-7/hr high: 5.1E-7/hr low: 1.8E-7/hr
Source: IEEE 500 (1984) pg.355 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure mode "no output" include: 1)automatic removal; 2)manual removal; 3) open circut.
Dominalnt contributor is #1).

TM5FE transformer main power generator or unit transformer liquid filled, three phase voltage 347-550 kV
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output(catastrophic)
FAILURE RATE OR PROBABILITY rec : 7.4E-7/hr high: 1.4E-6/hr low: 4.3E-7/hr
Source: IEEE 500 (1984) pg.360 Ultimate source: expert opinion aggregation and operating experience
Comment: Failure mode "no output" include: 1) automatic removal; 2) manual removal; 3) open circut. #1) is order of magnitude higher than #2) and #3).

TM5FT transformer main transformer Voltage= 400kV,130kV
Component boundary: transformer,coolers,relay protection,supervision,monitors Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: interruption
FAILURE RATE OR PROBABILITY mean : 3.5E-6/hr 95%: 1.8E-5/hr REPAIR TIME: 38 hours
Source: Swedish Rel.data book, tbl.45 Ultimate source: plant operating experience (7 BWR plants), ATV reports, LERs
Comment: Operating experience:total pop. 10.Operating time 28.8E+4 hours. No.of failures 1. Most frequent failures are cooling fan failures which are not critical failures of the transform.a=0.195;b=56200

TVRFO transformer regulating 120 V AC
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: operational failure
FAILURE RATE OR PROBABILITY mean : 2.0E-6/hr 95%: 4.2E-6/hr 5%: 4.4E-9/hr
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior: IEEE 500 (1977)(pg.298)Failure mode "catastrophic failure" Operating experience: 48.213 hours of operation, no failures rec=median; max=80% of distribution

TETFE transformer station service including excitation dry type, three phase all voltage levels
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output(catastrophic)
FAILURE RATE OR PROBABILITY rec : 4.0E-7/hr high: 1.4E-6/hr low: 1.1E-7/hr
Source: IEEE 500 (1984) pg.330 Ultimate source: expert opinion aggregation and operating experience
Comment: Given value is composite of three different voltage levels Failure mode include: 1) automatic removal; 2) manual removal; 3) open circut. Dominant contributor is #1).

TESFE transformer station service including excitation dry type,single phase all voltage levels
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output(catastrophic)
FAILURE RATE OR PROBABILITY rec : 2.7E-7/hr high: 2.3E-6/hr low: 8.0E-8/hr
Source: IEEE 500 (1984) pg.326 Ultimate source: expert opinion aggregation and operating experience
Comment: Given value is composite of three diffrerent voltage levels. Failure mode include: 1)automatic removal; 2) manual removal; 3)open circut. Dominant contributor is #1).

TEGFE transformer station service including excitation liquid filled, single phase all voltage level (0-40 kV)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output(catastrophic)
FAILURE RATE OR PROBABILITY rec : 2.2E-7/hr high: 1.1E-6/hr low: 8.6E-8/hr
Source: IEEE 500 (1984) pg.318 Ultimate source: expert opinion aggregation and operating experience
Comment: Given value is composite of three diffrerent voltage levels. Falure mode include: 1)automatic removal; 2)manual removal 3)open circut. dominant contributor is #1).

TEHFE transformer station service including excitation liquid filled, three phase all voltage levels (0-40 kV)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output(catastrophic)
FAILURE RATE OR PROBABILITY rec : 1.1E-7/hr high: 8.1E-7/hr low: 5.4E-8/hr
Source: IEEE 500 (1984) pg.322 Ultimate source: expert opinion aggregation and operating experience
Comment: Given value is composite of threr diffrerent voltage levels. Failure mode include: 1)automatic removal; 2)manual removal: 3)open circut. Dominant contributor is #1).

TXAFT transformer station start and auxiliary transformer Voltage levels: 130/6 kV, 70/6 kV, 20/6 kV
Component boundary: tramsformer,coolers,relay protection,supervisions, monitors Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: interruption
FAILURE RATE OR PROBABILITY mean : 2.0E-6/hr 95%: 1.1E-5/hr REPAIR TIME: 5 hours
Source: Swedish Rel.data book, tbl.46 Ultimate source: plant operating experience (7 BWR plants), ATV reports, LERs
Comment: Operating experience:total pop. 17.Operational time 51.2E+4 hours No.of failures 1.
a=0.101; b=51800

TUSFE transformer substation liquid filled, single phase all voltage levels
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output(catastrophic)
FAILURE RATE OR PROBABILITY rec : 5.1E-7/hr high: 2.6E-6/hr low: 9.0E-8/hr
Source: IEEE 500 (1984) pg.380 Ultimate source: expert opinion aggregation and operating experience
Comment: see failure mode comment IEEE 500 main transformer composite Failure mode "no output" include:1)automatic removal; 2)manual removal; 3)open circut. Dominant contributor is #1).

TUTFE transformer substation liquid filled, three phase all voltage levels
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output(catastrophic)
FAILURE RATE OR PROBABILITY rec : 8.0E-7/hr high: 1.9E-6/hr low: 3.1E-7/hr
Source: IEEE 500 (1984) pg.388 Ultimate source: expert opinion aggregation and operating experience
Comment: Given value is composite of all voltage level Failure mode "no output' include: 1)automatic removal; 2)manual removal; 3)open circut. Dominant contributor is #1).

LFFBE transmitter flow general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: degraded Original failure mode: degraded
FAILURE RATE OR PROBABILITY rec : 1.5E-6/hr high: 2.8E-6/hr low: 6.3E-7/hr
Source: IEEE 500 (1984) pg.577 Ultimate source: expert opinion aggregation
Comment: Reference IEEE 500 (1977) Failure mode "degraded" include: 1)erratic; 2)high; 3)low output

LFFFE transmitter flow general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: catastrophic
FAILURE RATE OR PROBABILITY rec : 1.5E-6/hr high: 2.8E-6/hr low: 6.2E-7/hr
Source: IEEE 500 (1984) pg.577 Ultimate source: expert opinion aggregation
Comment: Reference IEEE 500 (1977) Failure mode "catastrophic" include:1) zero or maximum output;
2)no change in output whit change in input. Dominant #1).

LFFFT transmitter flow general
Component boundary: transmitter only Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: signal failure
FAILURE RATE OR PROBABILITY mean : 3.4E-6/hr 95%: 1.9E-5/hr REPAIR TIME: 3 hours
Source: Swedish Rel.data book, tbl.33 Ultimate source: plant operating experience (5 BWR plants),ATV reports, LERs
Comment: Operating experience: total pop.97. Operational time 358E+4 hours. No.of failures 12. a=0.101; b=30200
Critical failures reported on 5 plants.

LADBF transmitter flow, level, pressure (DP cells)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: degraded Original failure mode: erratic output
FAILURE RATE OR PROBABILITY mean : 7.3E-7/hr 95%: 1.1E-6/hr 5%: 2.3E-7/hr ERROR FACTOR: 1.4 REPAIR TIME: 3 hours
Source: HWR data Ultimate source: HWR assesment
Comment: Operational data for this FM are not given,but probbably included in"all modes".Degraded failure rate should incl.this,high and low
output. Combined failure rate mean=2.0E-6/hr,95%=3.0E-6/hr.

LADFF transmitter flow, level, pressure (DP cells)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: no output
FAILURE RATE OR PROBABILITY mean : 1.2E-6/hr 95%: 1.6E-6/hr 5%: 9.0E-7/hr ERROR FACTOR: 1.3 REPAIR TIME: 3 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Operational data for this failure mode are not given,but probbably included in "all modes".Catastrophic failures are this
and "no chng in output with ch.." summed together mean=1.9E-6/hr.

LADAF transmitter flow, level, pressure (DP cells)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 4.1E-6/hr 95%: 4.8E-6/hr 5%: 3.5E-6/hr ERROR FACTOR: 1.2 REPAIR TIME: 3 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Population not known.Cum.component operating time 28.5E+6 hours. 116 failures. "All modes"incl:1)no output,2)high,3)low output,4) no chng in out.with chng in.,5)errratic. All equally contribute.

LADBM transmitter flow, level, pressure general
Component boundary: transmitter only Operating mode: operating Operating environment: normal
Generic failure mode: degraded Original failure mode: reduced capability
FAILURE RATE OR PROBABILITY mean : 3.3E-6/hr 95%: 3.6E-6/hr 5%: 3.0E-6/hr
Source: NUREG 1740 (1984) (table 18) Ultimate source: US plants LER reports evaluation
Comment: Overall rate, w command faults. W/o command faults 3.2E-6/hr. Only the flow transmitters from BWRs are included. PWR rate is two orders of magnitude higher than BWR.

LADFM transmitter flow, level, pressure general
Component boundary: transmitter only Operating mode: operating Operating environment: normal
Generic failure mode: fail to function Original failure mode: inoperable
FAILURE RATE OR PROBABILITY mean : 1.9E-6/hr 95%: 2.3E-6/hr 5%: 1.6E-6/hr
Source: NUREG 1740 (1984) (table 18) Ultimate source: US plants LER reports evaluation
Comment: Overall rate, with command faults. W/o command faults 1.7E-6/hr. Only the flow transmitter for BWR. PWR rate is almost two orders of magnitude higher than BWR.

LLLBE transmitter level general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: degraded Original failure mode: degraded
FAILURE RATE OR PROBABILITY rec : 1.1E-6/hr high: 2.4E-6/hr low: 6.0E-6/hr
Source: IEEE 500 (1984) pg.588 Ultimate source: expert opinion aggregation
Comment: Reference IEEE 500 (1977) Failure mode "degraded" include 1)erratic; 2)high; 3) low output all contribute about equal to given rate.

LLLFE transmitter level general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: catastrophic
FAILURE RATE OR PROBABILITY rec · 1.4E-6/hr high: 3.0E-6/hr low· 7 1E-7/hr
Source: IEEE 500 (1984) pg.588 Ultimate source: expert opinion aggregation
Comment: Reference IEEE 500 (1977) Failure mode"catastrophic" include: 1)zero or max output; 2)no change in output whit change in input Both about equal.

LLLFT transmitter level general
Component boundary: level transmitter only Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: signal failure
FAILURE RATE OR PROBABILITY mean : 3.8E-6/hr 95%: 2.0E-5/hr REPAIR TIME: 2 hours
Source: Swedish Rel.data book, tbl.35 Ultimate source: plant operating experience(5 BWR plants), ATV reports, LERs
Comment: Operating experience:total pop.72. Operational time 289E+4 hours No.of failures 11.
a=0.188; b=49500

LPPBE transmitter pressure general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: degraded Original failure mode: degraded
FAILURE RATE OR PROBABILITY rec : 6.4E-7/hr high: 1.2E-6/hr low: 1.5E-7/hr
Source: IEEE 500 (1984) pg.552 Ultimate source: expert opinion aggregation
Comment: Reference IEEE 500 (1977) Failure mode include: 1)erratic; 2)high; 3) low output.
About equal contribution.

LPPFE transmitter pressure general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: catastrophic
FAILURE RATE OR PROBABILITY rec : 8.8E-7/hr high: 1.7E-6/hr low: 2.0E-7/hr
Source: IEEE 500 (1984) pg.552 Ultimate source: expert opinion aggregation
Comment: Reference IEEE 500 (1977) Faliure mode "catastrophic" include: 1)zero or max.output; 2)no
change in output with change in input. About equal contribution.

LPPFT transmitter pressure general
Component boundary: pressure transmitter only Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: signal failure
FAILURE RATE OR PROBABILITY mean : 1.8E-6/he 95%: 1.0E-5/hr REPAIR TIME: 2 hours
Source: Swedish Rel.data book, tbl.29 Ultimate source: plant operating experience (5 BWR plants), ATV reports, LERs
Comment: Operating experience:total pop.203.Operational time 820E+4 hours no.of failures 15.
a=0.0558; b=30500

LPPFY transmitter pressure general
Component boundary: pressure transmitter only Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: signal failure
FAILURE RATE OR PROBABILITY mean : 2.5E-6/hr REPAIR TIME: 5 hours
Source: Swedish Rel.data book, tbl.29 Ultimate source: plant operating exprience (1 PWR plant-Ringhals 2) ,ATV reports
Comment: Operating experience:total pop.12.Operational time 39.91E+4 hours 1 failure

LXRFY transmitter pressure difference general

Component boundary: pressure difference transmitter only Operating mode: all Operating environment: normal

Generic failure mode: fail to function Original failure mode: signal failure

FAILURE RATE OR PROBABILITY mean : 8.4E-7/hr REPAIR TIME: 2 hours

Source: Swedish Rel.data book, tbl.31 Ultimate source: plant operating experience (1 PWR plant-Ringhals 2), ATV reports

Comment: Operating experience:total pop.72.Operational time 239.5E+4 hours No.of failure 2.

LXRFT transmitter presure difference general

Component boundary: pressure differernce transmitter only Operating mode: all Operating environment: normal

Generic failure mode: fail to function Original failure mode: signal failure

FAILURE RATE OR PROBABILITY mean : 1.4E-6/hr 95%: 8.3E-6/hr REPAIR TIME: 3 hours

Source: Swedish Rel.data book, tbl.31 Ultimate source: plant operating experience(7 BWR plants), ATV reports, LERs

Comment: Operating experience:total pop 132. Operational time 558E+4 hours No.of failures 8. a=0.0942; b=66200
Critical failures reported on 4 plants

LTTAF transmitter temperature

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: all modes Original failure mode: all modes

FAILURE RATE OR PROBABILITY mean : 4.9E-6/hr 95%: 9.2E-6/hr 5%: 2.7E-6/hr ERROR FACTOR: 1.7 REPAIR TIME: 3 hours

Source: HWR data Ultimate source: HWR operating experience

Comment: Population not known.Cum.component operating time 1.4E+6 hours. 7 failures.

LTTBE transmitter temperature general

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: degraded Original failure mode: degraded

FAILURE RATE OR PROBABILITY rec : 3.7E-7/hr high: 3.2E-6/hr low: 1.8E-7/hr

Source: IEEE 500 (1984) pg.531 Ultimate source: expert opinion aggregation

Comment: Reference IEEE 500(1977) Failure mode "degraded" include: 1)erratic; 2)high; 3)low output.
#1) and #2) order of magnitude higher than #3).

LTTFE transmitter temperature general

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: fail to function Original failure mode: catastrophic

FAILURE RATE OR PROBABILITY rec : 3.7E-7/hr high: 3.3E-6/hr low: 1.9E-7/hr

Source: IEEE 500 (1984) pg.531 Ultimate source: expert opinion aggregation

Comment: Reference IEEE 500 (1977) Failure mode include: 1)zero or max.output 2)no change of output
with change of input. Dominant contributor is #1).

LTTFT transmitter temperature general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to function Original failure mode: signal failure
FAILURE RATE OR PROBABILITY mean : 2.8E-6/hr 95%: 1.5E-5/hr REPAIR TIME: 3 hours
Source: Swedish Rel.data book, tbl.37 Ultimate source: plant operating experience(6 BWR plants), ATV reports, LERs
Comment: Operating experience: total pop. 132. Operational time 289E+4 hours. No.of failures 8. a=0.0579; b=20900
Critical failures reported on 5 plants.

JUCAE turbine combustion general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 5.7E-4/hr high: 2.0E-3/hr low: 2.0E-5/hr
Source: IEEE 500 (1984) pg.840 Ultimate source: expert judgement and experience
Comment: Given value is composite of different sources, NUREG 2232, EPRI report No.AP 2321 Mar.82, EPRI Journal Mar.82 pp 37.
Include gas and oil combustion

JUSAE turbine steam driven condensing, single stage, 500-999 HP
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 4.0E-4/hr high: 1.6E-3/hr low: 1.0E-4/hr
Source: IEEE 500 (1984) pg.834 Ultimate source: expert judgement and experience
Comment: reference: NUREG 2232

JUPAE turbine steam driven general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 2.1E-4/hr REPAIR TIME: 81 hours
Source: IEEE 500 (1984) pg.835 Ultimate source: expert judgement and experience
Comment: Given value is composite of several different sources,EPRI report No.46,Aug.76,EPRI report No.2205,Feb.82, EPRI Journal,Mar.82,pp37
Value is composite of different application as well.

JUNAE turbine steam driven non condensing 1000-5000 HP
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.0E-4/hr high: 1.0E-2/hr low: 1.0E-6/hr
Source: IEEE 500 (1984) pg.832 Ultimate source: expert judgement and exeprience
Comment: reference: NUREG 2232 (?)

JUMAE turbine steam driven non condensing, multi stage, less than 500 HP
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 2.0E-4/hr high: 2.0E-3/hr low: 2.0E-5/hr
Source: IEEE 500 (1984) pg.833 Ultimate source: expert judgement and experience
Comment: reference :NUREG 2232

JUHFS turbine turbine/HPCI assembly
Component boundary: detail n/a Operating mode: n/a Operating environment: normal
Generic failure mode: fail to function Original failure mode: fails to operate
FAILURE RATE OR PROBABILITY mean : 1.0E-5/hr
Source: Shoreham PRA,GE data(tb.A.2.1) Ultimate source: evaluation of BWR operating experience
Comment:

VWOCS valve ADS depressurization valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fails to operate
FAILURE RATE OR PROBABILITY mean : 7.0E-6/hr
Source: Shoreham,PRA GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating experience
Comment:

VWAAE valve angle valve
Component boundary: detail n/a (generally excludes driver) Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 3.3E-6/hr high: 2.3E-3/hr low: 2.5E-7/hr
Source: IEEE 500 (1984) pg.1203 Ultimate source: expert judgement and experience
Comment: Reference:NUREG 2232. Given value is composite of different sizes and operators of angle valves.FM"all modes"is sum of catastrophic (failed to operate,plugged,ext.leakage),degraded and incipient.

VWBAE valve ball valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 2.4E-6/hr high: 8.8E-4/hr low: 4.4E-7/hr REPAIR TIME: 1.3 hours
Source: IEEE 500 (1984) pg.1042 Ultimate source: expert judgement and experience
Comment: References:NUREG 2232,Corps of engineers,R/M data base,NPRD-2. Given value is composite of different sources,sizes and operators of ball valves.Per cycle value 6.0E-5/cy.FM see comment angle vlv

VWTAE valve butterfly valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.2E-6/hr high: 3.5E-4/hr low: 3.0E-8/hr REPAIR TIME: 1.9 hours
Source: IEEE 500 (1984) pg.1050 Ultimate source: expert judgement and experience
Comment: references:see ball valve. FM see comment angle valve Given value is composite of diffrerent sources and differrent sizes and operators of butterfly valves.

VWDAF valve condenser steam discharge valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 2.3E-5/hr 95%: 3.1E-5/hr 5%: 1.7E-5/hr ERROR FACTOR: 1.3 REPAIR TIME: 12 hours
Source: HWR data Ultimate source: HWR operating exeprience
Comment: Pop.24.Operating time 126E+4 hours.29 failures. "all modes" incl; 1)external,2)internal leak,3)fail to close,4)fail to open,5)limit switch,6)faulty indication,7)out of calibration,8)unspecified

VWDEF valve condenser steam discharge valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close
FAILURE RATE OR PROBABILITY mean : 3.2E-6/hr 95%: 7.3E-6/hr 5%: 1.6E-6/hr ERROR FACTOR: 2.0 REPAIR TIME: 5 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.24. Cumulative operating time 126E+4 hours.4 failures. Number of demands per operating time is not known.

VWDOF valve condenser steam discharge valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open
FAILURE RATE OR PROBABILITY mean : 6.3E-6/hr 95%: 1.1E-5/hr 5%: 3.7E-6/hr ERROR FACTOR: 1.7 REPAIR TIME: 5 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.24.Cumulative operating time 126E+4 hours. 8 failures. Number of demands per operating time is not known.

VWDYF valve condenser steam discharge valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leak
FAILURE RATE OR PROBABILITY mean : 4.8E-6/hr 95%: 9.4E-6/hr 5%: 2.6E-6/hr ERROR FACTOR: 1.8 REPAIR TIME: 42 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.24. Cumulative component operating time 126E+4 hours. No.of failures 6.

VWPAE valve diaphragm
Component boundary: detail n/a (generally exclude driver) Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 2.8E-6/hr high: 6.2E-5/hr low: 1.2E-6/hr REPAIR TIME: .9 hours
Source: IEEE 500 (1984) pg.1099 Ultimate source: expert judgement and experience
Comment: ref:Corps of Engineers R/M data base,NPRD-2,NUREG 0666 Given value is composite of different sources,operators, sizes and applications of diaphragm valves. FM see comment angle valve.

VWFAE valve flow control 1/2 inch, air fixed flow
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 5.5E-6/hr high: 1.0E-5/hr low: 2.0E-6/hr REPAIR TIME: 1 hour
Source: IEEE 500 (1984) pg.1039 Ultimate source: expert judgement(delphi procedure) & experience
Comment: reference: R/m data base FM see comment angle valve.

VWGAE valve gate
Component boundary: detail n/a (generally exclude driver) Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.9E-6/hr high: 4.6E-5/hr low: 1.7E-7/hr REPAIR TIME: 3.3 hours
Source: IEEE 500 (1984) pg.1109 Ultimate source: expert judgement and exprience
Comment: ref:Corps of Engineers R/M data base,NPRD-2,NUREG 2232 Given value is composite of different sources,operators, sizes and applications of gate valves.FM see comment angle valve.

VWLAE valve globe valve
Component boundary: detail n/a (generelly exclude driver) Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 3.5E-6/hr high: 1.7E-4/hr low: 1.8E-7/hr REPAIR TIME: 1.7 hours
Source: IEEE 500 (1984) pg.1138 Ultimate source: expert judgement and experience
Comment: references:same as gate valve Given value is composite of differerent sources,application,sizes and operators of globe valves. FM see comment angle valve.

VWECG valve high pressure shifting valve (steam dump)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: not functioning
FAILURE RATE OR PROBABILITY median: 4.0E-2/d ERROR FACTOR: 10
Source: German Risk Study (tb.F3,7-1) Ultimate source: operating experience
Comment: This type of valve should switch over 30 seconds. In 126 trials it did not swich properly in 12 cases.That gives even higher rate but given value is assesed to be adequate for emergency cases.

VWNAE valve needle valve
Component boundary: detail n/a (generaly exclude driver) Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 1.2E-6/hr high: 4.2E-4/hr low: 9.0E-8/hr REPAIR TIME: .8 hours
Source: IEEE 500 (1984) pg.1164 Ultimate source: expert judgement and experience
Comment: ref:see globe valve Given value is composite of different sources,applications,sizes and operators of needle valves. FM see comment angle valve.

VWUAE valve nozzle valve
Component boundary: detail n/a (generally exclude operator) Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 5.4E-6/hr high: 6.5E-4/hr low: 3.2E-7/hr
Source: IEEE 500 (1984) pg.1195 Ultimate source: expert judgement and experience
Comment: reference:NUREG 2232 Given value is composite of different sizes and operators of nozzle valves. FM see comment angle valve.

VWKET valve pilot valve pressure relief system pilot valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to reclose
FAILURE RATE OR PROBABILITY mean : 1.2E-3/d 95%: 6.8E-3/d
Source: Swedish Rel.data book, tbl.22 Ultimate source: operating experience(7 BWR plants),ATV reports,LERs,plant inform.
Comment: Population 55. Number of demands 845. 1 failure. Critical failure at one plant. a=0.0684;b=57.7

VWKOT valve pilot valve pressure relief system pilot valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 8.3E-3/d 95%: 4.7E-2/d
Source: Swedish Rel.data book, tbl.22 Ultimate source: operating experience (7 BWR plants)
Comment: Total population 55. 845 demands per operational time. 7 failures Critical failures reported on 4 plants. a=0.13;b=15.6

VWJAE valve plug valve
Component boundary: detail n/a (generally excludes operator) Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 2.6E-6/hr high: 3.2E-3/hr low: 1.4E-7/hr REPAIR TIME: 1.2 hours
Source: IEEE 500 (1984) pg.1175 Ultimate source: expert judgement and experience
Comment: reference:see needle valve. Given value is composite of different sources,applications,sizes, and operators of plug valves. FM see comment angle valve

VWXAF valve pressure regulating
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.3E-6/hr 95%: 1.6E-6/hr 5%: 1.1E-6/hr ERROR FACTOR: 1.2 REPAIR TIME: 10 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Pop.1064.Cum.oper.time 73.7E+6 hours.98 failures."All modes" incl 1)external leak,2)fail to operate,3)fail to open,4)fail closed, 5)out of calibration,6)unspec.6) dominant,3)&4)negligable(1 fail)

VWZAE valve pressure regulating 2-6 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 2.9E-6/hr REPAIR TIME: 1.3 hours
Source: IEEE 500 (1984) pg.1037 Ultimate source: expert judgement(delphi procedure) & experience
Comment: reference: R/M data base FM see comment angle valve.

VWXCF valve pressure regulating valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY mean : 1.1E-7/hr 95%: 1.9E-7/hr 5%: 6.8E-8/hr ERROR FACTOR: 1.7 REPAIR TIME: 5 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.1064. Cum.operating time 73.7E+6 hours. 8 failures. Number of demands in operating time is not known. Failure rate for this FM is order of magnitude higher than for "fail to open".

VWXYF valve pressure regulating valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leak
FAILURE RATE OR PROBABILITY mean : 2.7E-7/hr 95%: 3.9E-7/hr 5%: 1.9E-7/hr ERROR FACTOR: 1.4 REPAIR TIME: 8 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.1064. Cum.operating experience 73.7E+6 hours.20 failures.

VRBDV valve primary relief valve BWR
Component boundary: valve body and internals,operating mechanism Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: premature open
FAILURE RATE OR PROBABILITY mean : 3.5E-6/hr 95%: 4.9E-6/hr 5%: 2.3E-6/hr
Source: NUREG 1363 (1982) (pg.478) Ultimate source: US plants LER reports evaluation
Comment: W/o command faults. With command faults 3.9E-6/hr Includes all BWR safety relief valves (ADS and ordinary relief valves)

VRBEV valve primary relief valve BWR
Component boundary: valve body and internals, operating mechanism Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to reseat
FAILURE RATE OR PROBABILITY mean : 3.1E-3/d 95%: 4.7E-3/d 5%: 2.1E-3/d
Source: NUREG 1363 (1982) (pg.482) Ultimate source: US plants LER reports evaluation
Comment: See comment relief failure to open.Standby hourly rate 3.0E-6/hr. W/o command faults. With command faults 3.2E-3/d.Standby hourly rate with command faults 3.2E-6/hr.

VRBOV valve primary relief valve BWR
Component boundary: valve body and internals,operating mechanism Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 8.9E-3/d 95%: 1.1E-2/d 5%: 6.8E-3/d
Source: NUREG 1363 (1982) (pg.474) Ultimate source: US plants LER reports evaluation
Comment: Incl.all BWR safety-relief vlv(ADS and ordinary relief).W/o comm. W command 1.1E-2/d.No.of demands is 1 test and operational demand equal to tot.no.of forced and manual scrams.Rate 8.7E-6/hr stdby.

VRAAE valve relief
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 2.3E-6/hr high: 2.4E-6/hr low: 1.2E-6/hr REPAIR TIME: .6 hours
Source: IEEE 500 (1984) pg.1029 Ultimate source: expert judgement(delphi procedure) & exeprience
Comment: This values are composite of diffrerent sources and different types and sizes of relief valves. Valve operators (if any) are not identified.

VRADW valve relief
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: premature open
FAILURE RATE OR PROBABILITY median: 1.0E-5/hr 95%: 3.0E-5/hr 5%: 3.0E-6/hr ERROR FACTOR: 3
Source: WASH 1400 (table III 4-1) Ultimate source: assesed from nuclear, industrial(SRS) and mil.expereince and data
Comment:

VRAOW valve relief
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY median: 1.0E-5/d 95%: 3.0E-5/d 5%: 3.0E-6/d ERROR FACTOR: 3
Source: WASH 1400 (table III 4-1) Ultimate source: assesed from nuclear,industrial(SRS) and mil.experience and data
Comment:

VRMOH valve relief main steam atmosferic relief valve
Component boundary: detail n/a Operating mode: closed Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open on demand
FAILURE RATE OR PROBABILITY mean : 3.0E-3/d 95%: 7.0E-3/d 5%: 3.6E-4/d
Source: Old PWR Ultimate source: genric data updated with palnt opearting experience
Comment: Generic mean 2.4E-3/d. Operating experience 199 demands, 1 failure.

VR68F valve relief & safety diameter between 2 and 6 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: internal leak Original failure mode: internal leak
FAILURE RATE OR PROBABILITY mean : 1.5E-7/hr 95%: 4.6E-7/hr 5%: 5.7E-8/hr ERROR FACTOR: 2.4 REPAIR TIME: 26 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Pop.242. Cumulative operating time 13.8E+6 hours. 2 failures.

VR6EF valve relief & safety diameter between 2 and 6 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to reseat
FAILURE RATE OR PROBABILITY mean : 1.5E-7/hr 95%: 4.6E-7/hr 5%: 5.7E-8/hr ERROR FACTOR: 2.4 REPAIR TIME: 4 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Pop.242. Cumulative operating time 13.8E+6 hours. 2 failures. Number of opening in cumulative operating time is not known.

VR6AF valve relief & safety diameter between 2 nad 6 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 2.6E-6/hr 95%: 3.4E-6/hr 5%: 2.0E-6/hr ERROR FACTOR: 1.3 REPAIR TIME: 14 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Pop.242.Cum.operating time 13.8E+6 hours.36 failures."All modes" incl:1)fail to reseat,2)external,3)internal leak,4)out of calibr.
5)unspecified.5)is dominant, all other about equal.

VR88F valve relief & safety diameter larger than 6 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: internal leak Original failure mode: internal leak
FAILURE RATE OR PROBABILITY mean : 3.7E-7/hr 95%: 1.2E-6/hr 5%: 1.5E-7/hr ERROR FACTOR: 2.4 REPAIR TIME: 8 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Pop.96. Cumulative operating time 5.5E+6 hours. 2 failures.

VR8AF valve relief & safety diameter larger than 6 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.8E-6/hr 95%: 3.1E-6/hr 5%: 1.1E-6/hr ERROR FACTOR: 1.6 REPAIR TIME: 8 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.96. Cum.operating time 5.5E+6 hours.10 failures."All modes" incl:1)internal leak,2)out of calibration, 3)unspecified.
1) & 2) identical, 3) 3 times larger.

VR28F valve relief & safety diameter less than 2 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: internal leak Original failure mode: internal leak
FAILURE RATE OR PROBABILITY mean : 2.4E-7/hr 95%: 3.3E-7/hr 5%: 1.7E-7/hr ERROR FACTOR: 1.4 REPAIR TIME: 7 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.1667. Cumulative component operating time 109E+6 hours. 26 failures.

VR2EF valve relief & safety diameter less than 2 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to reseat
FAILURE RATE OR PROBABILITY mean : 3.4E-8/hr 95%: 8.0E-8/hr 5%: 2.3E-8/hr ERROR FACTOR: 1.8 REPAIR TIME: 7 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.1667. Cumulative component opearting time 109E+6 hours. No.of failures 4. Number of opening in cumulative time is not known.

VR2AF valve relief & safety diameter less than 2 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 9.5E-7/hr 95%: 1.1E-6/hr 5%: 8.1E-7/hr ERROR FACTOR: 1.2 REPAIR TIME: 7 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Pop.1667. Cum.operating time 109E+6 hours 103 failures."All modes incl:1)fail to reseat, 2)external,3)internal leak,4)out of calibr
5)unspecified. 5)dominant, 1),2) and 4) significantly lower.

VRAEI valve relief valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close, given open
FAILURE RATE OR PROBABILITY mean : 2.0E-2/d ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

VRAOI valve relief valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 3.0E-4/d ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

VSADE valve safety
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: premature open
FAILURE RATE OR PROBABILITY rec : 3.0E-6/hr
Source: IEEE 500 (1984) pg.1040 Ultimate source: expert judgement(delphi procedure) & experience
Comment: reference EGG-EA-5816 1982.

VSAOE valve safety
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open
FAILURE RATE OR PROBABILITY rec : 4.0E-3/cy
Source: IEEE 500 (1984) pg.1040 Ultimate source: expert judgement(delphi procedure) & experience
Comment: reference EGG-EA -5816 1982.

VSADU valve safety valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: spourious opening
FAILURE RATE OR PROBABILITY mean : 2.0E-6/hr 95%: 1.2E-5/hr REPAIR TIME: 4 hours
Source: Swedish Rel.data book, tbl.21 Ultimate source: plant operating experience(7 BWR plants), ATV reports, LERs
Comment: Total pop.139. Operational time 404E+4.No of failures 7. Critical failures reported on 4 plants. a=0.102; b=50300
Leakage generally equals spurious opening (conservative approach)

VWVAE valve vent 3/4 inch, float operated,tank vent
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 3.1E-6/hr REPAIR TIME: 1.2 hours
Source: IEEE 500 (1984) pg.1035 Ultimate source: expert judgement, operating experience
Comment: reference:Corps of Engineers(HND) R/M Data Base, Ground Stationary Equipment,Re.No.16,04/12/73.

VARDH valve air operated all systems except raw water return line
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer closed
FAILURE RATE OR PROBABILITY mean : 1.2E-7/hr 95%: 2.7E-7/hr 5%: 1.4E-8/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 2.7E-7/hr. Operating experience 3E+6 hours of operation,no failures.

VAPDH valve air operated purge isolation valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer open
FAILURE RATE OR PROBABILITY mean : 2.0E-7/hr 95%: 5.0E-7/hr 5%: 1.5E-8/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 2.7E-7/hr. Operating experience 4.7E+5 hours of operation, no failures.

VAPEH valve air operated purge isolation valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close on demand
FAILURE RATE OR PROBABILITY mean : 2.3E-3/d 95%: 4.4E-3/d 5%: 8.4E-4/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 1.5E-3/d. Operating experience 756 demands, 3 failures.

VAPOH valve air operated purge isolation valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open on demand
FAILURE RATE OR PROBABILITY mean : 1.3E-3/d 95%: 2.4E-3/d 5%: 4.6E-4/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 1.5E-3/d. Operating experience 756 demands, 1 failure.

VAQDH valve air operated raw water return line
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer closed
FAILURE RATE OR PROBABILITY mean : 5.5E-6/hr 95%: 1.2E-5/hr 5%: 7.7E-7/hr
Source: Old PWR Ultimate source: generic data updated with plant specific operating experience
Comment: Generic mean 2.7E-7/hr. Operating expereince 1.4E+5 hours of operation, 3 failures.

VAZEH valve air operated turbine stop valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close on demand
FAILURE RATE OR PROBABILITY mean : 1.1E-4/d 95%: 2.2E-4/d 5%: 3.0E-5/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 1.3E-4/d. Operating experience 1680 demands, no failures.

VAIDH valve air operated vent isolation valve (annulus ventilation)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer open
FAILURE RATE OR PROBABILITY mean : 2.2E-7/hr 95%: 5.5E-7/hr 5%: 1.6E-8/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 2.7E-7/hr. Operating experience 2.4E+5 hours of operation, no failures.

VAIEH valve air operated vent isolation valve (annulus ventilation)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close on demand
FAILURE RATE OR PROBABILITY mean : 1.2E-3/d 95%: 2.2E-3/d 5%: 2.8E-4/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 1.5E-3/d. Operating experience 362 demands, no failures

VAIOH valve air operated vent isolation valve (annulus ventilation)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open on demand
FAILURE RATE OR PROBABILITY mean : 1.1E-2/d 95%: 2.0E-2/d 5%: 4.0E-3/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 1.5E-3/d. Operating experience 362 demands, 6 failures.

VABCV valve air operated BWR (ESF systems valves only)
Component boundary: valve body & internals,operator,funct.accesories(limit,torque sw) Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY mean : 2.6E-3/d 95%: 5.2E-3/d 5%: 1.1E-3/d
Source: NUREG 1363 (1982) (pg.426) Ultimate source: US plants LER reports evaluation
Comment: With command faults. No failures recorded in w/o comand faults category, 95% confidence bound is 1.3E-3/d. Standby hourly rate with command 1.2E-6/hr, w/o command (95%) 5.9E-7/hr.

VAWCV valve air operated PWR (ESF systems valves only)
Component boundary: valve body & interiors,operator,functional accesories(eg.limit sw Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY mean : 1.2E-3/d 95%: 2.2E-3/d 5%: 6.0E-4/d
Source: NUREG 1363 (1982) (pg.422) Ultimate source: US plants LER reports evaluation
Comment: W/o command faults. With command faults 2.1E-3/d. Standby hourly failure rate w/o command 5.6E-7/hr, with command 9.8E-7/hr.

VAEYV valve air operated PWR + BWR (ESF systems valves only)
Component boundary: valve body & internals,operator,funct.access(limit,torque sw) Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: leak externally
FAILURE RATE OR PROBABILITY mean : 1.0E-7/hr 95%: 3.1E-7/hr 5%: 1.8E-8/hr
Source: NUREG 1363 (1982) (pg.430) Ultimate source: US plants LER reports evaluation
Comment: Overall rate. BWR rate is twice larger than PWR rate.

VAAEH valve air operated all systems
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close on demand
FAILURE RATE OR PROBABILITY mean : 1.2E-3/d 95%: 1.8E-3/d 5%: 6.9E-4/d
Source: Old PWR Ultimate source: generic data updated with plant specific operating experience
Comment: Generic mean 1.5E-3/d. Operating experience 4970 demands, 6 failures.

VAAOH valve air operated all systems
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open on demand
FAILURE RATE OR PROBABILITY mean : 8.4E-4/d 95%: 1.4E-3/d 5%: 3.5E-4/d
Source: Old PWR Ultimate source: generic data updated with plant operating expereince
Comment: Generic mean 1.5E-3/d. Operating experience 4970 demands, 3 failures.

VAT8F valve air operated butterfly diameter larger than 24 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: internal leak Original failure mode: internal leak
FAILURE RATE OR PROBABILITY mean : 1.6E-7/hr 95%: 7.6E-7/hr 5%: 5.7E-8/hr ERROR FACTOR: 2.8 REPAIR TIME: 4 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.70.Cum.operating time 632E+4 hours. No.of failures 1. Data based on experience with control valves.

VATAF valve air operated butterfly diameter larger than 24 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 3.2E-5/hr 95%: 3.6E-5/hr 5%: 2.8E-5/hr ERROR FACTOR: 1.1 REPAIR TIME: 4 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Pop.70.Cum.operating time 623E+4 hours.No of failures 199.Failure mode include:1)fail to operate,2)external,3)internal leak,4)fault indication,5)plugged,6)unspecified.Contrib.of 3)&5) negligable.

VATCF valve air operated butterfly diameter larger than 24 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY mean : 7.2E-6/hr 95%: 9.3E-6/hr 5%: 5.7E-6/hr ERROR FACTOR: 1.3 REPAIR TIME: 6 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.70.Cum.operating time 623E+4 hours.No.of failures 45.No.of demands not known.Data based on expereince with control valves.FM include actuator failures but not air supply to acuator.

VATQF valve air operated butterfly diameter larger than 24 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: plug Original failure mode: plugged
FAILURE RATE OR PROBABILITY mean · 1.6E-7/hr 95%: 7.6E-7/hr 5%: 5.7E-8/hr ERROR FACTOR: 2.8 REPAIR TIME: 12 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Pop.70.Cum.operating time 623E+4 hours.No.of failures 1. Data based on experience with control valves.

VATYF valve air operated butterfly diameter larger than 24 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leak
FAILURE RATE OR PROBABILITY mean . 1.1E-5/hr 95%: 1.3E-5/hr 5%: 8.7E-6/hr ERROR FACTOR: 1.2 REPAIR TIME: 2 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.70.Cum.operating time 623E+4 hours.No.of failures 66. Data based on experience with control valves.

VA1DW valve air operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: failure to remain open(plug)
FAILURE RATE OR PROBABILITY median: 3.0E-7/hr 95%: 1.0E-6/hr 5%: 1.0E-7/hr ERROR FACTOR: 3
Source: WASH 1400 (table III 4-1) Ultimate source: ultimate source not known(sources presenting plug per demand)
Comment: Plug probabilities are given per demand and per hour since phenomena is generally time dependant,but plugged conditions may be discovered only upon demand. See FM comment air valve/demand.

VAACB valve air operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 1.0E-5/hr max: 5.0E-5/hr min: 2.0E-7/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion and IREP data
Comment:

VAACG valve air operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to open or to close
FAILURE RATE OR PROBABILITY mean : 4.3E-5/hr ERROR FACTOR: 23
Source: German Risk Study (pg.P3-76) Ultimate source: generic data
Comment: Failure rate is combination of several generic data sources. Compared with other valve types failure rate seems to be too high

VAACI valve air operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 3.0E-3/d ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

VAACJ valve air operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fails to operate
FAILURE RATE OR PROBABILITY mean : 1.0E-3/d ERROR FACTOR: 3
Source: NUREG 4550,Vol 1,Tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: Generic value developed in Station Blackout Study(NUREG/CR-3226). Two types of failures are included in the failure rate: valve hardware faults(1.0E-3) and command circut fault(1.0E-4).

VAACO valve air operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 1.6E-3/d 95%: 3.1E-3/d 5%: 3.2E-4/d
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:NUREG 1363, PWR air-op valves,failure on demand,w/o command 80%/20% ratio=10.Operating experience; 1349 demands, 3 failures.

VAACU valve air operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 6.0E-6/hr
Source: Sizewell B (PWR/RX312 pg.8) Ultimate source: assesed from nucelar experience and generic data
Comment: Assesment based on W data item and WASH 1400 data(failrate cited is not one which appears in WASH 1400).For montly testing, peak probability is 4.3E-3/d, what is pessimistic compared to W-1400.

VAACW valve air operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY median: 3.0E-4/d 95%: 1.0E-3/d 5%: 1.0E-4/d ERROR FACTOR: 3
Source: WASH 1400 (table III 4-1) Ultimate source: assesed from nuclear,industrial and military expereince and data
Comment: Failure to operate includes changing state from open to closed or closed to open.

VAACZ valve air operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to operate on demand
FAILURE RATE OR PROBABILITY mean : 1.4E-3/d
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant operating experience
Comment: Priors: NUREG 1363 air operated valve(PWR),fail to operate(mean) and WASH 1400 air operated valve, fails to operate (distrib.) Operating experience: 1540 demands, 3 failures.

VAADO valve air operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer closed
FAILURE RATE OR PROBABILITY mean : 8.0E-7/hr 95%: 2.3E-6/hr 5%: 3.9E-8/hr
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:WASH 1400,air-op valves,f.to remain open.5%=20%;95%=80%. Per demand rate converted to hrly rate assuming 1 d.in 45 days. Operating experience:1.94E+5 hours of operation,1 failure.

VAADW valve air operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: failure to remain open (plug)
FAILURE RATE OR PROBABILITY median: 1.0E-4/d 95%: 3.0E-4/d 5%: 3.0E-5/d ERROR FACTOR: 3
Source: WASH 1400 (table III 4-1) Ultimate source: assesed from nuclear experience (incl.test & research reactors)
Comment: Failure to remain open refers to reduction of flow to unusable level due to foreign material or gate failure. Not included in data is inadvertent or false signal driving valve closed.

VAADZ valve air operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer closed,plugged
FAILURE RATE OR PROBABILITY mean : 1.1E-7/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant operating exprience
Comment: Prior:WASH 1400,air operated valve,failure to remain open(plug). 1 demand in 45 daysused to convert to hourly rate.
Operating experience: 2.13E+6 hours of operation, no failures.

VAATW valve air operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: rupture Original failure mode: rupture
FAILURE RATE OR PROBABILITY median: 1.0E-8/hr 95%: 1.0E-7/hr 5%: 1.0E-9/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-1) Ultimate source: assesed from US nucelar experience
Comment:

VAAYJ valve air operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: fails from plugging
FAILURE RATE OR PROBABILITY mean : 4.0E-5/d ERROR FACTOR: 3
Source: NUREG 4550, Vol.1,tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: Value is based on NRC LER data summary (1.0E-7/hr) and assuming monthly system test (720 hrs).

VABCE valve air operated general (BWR application)
Component boundary: detail n/a(generally excludes operator) Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY rec : 3.0E-3/cy
Source: IEEE 500 (1984) pg.1027 Ultimate source: expert judgement (delphi procedure) & experience
Comment: reference EGG-EA-5B16 1982.

VABYE valve air operated general (BWR application)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leakage
FAILURE RATE OR PROBABILITY rec : 2.0E-7/hr
Source: IEEE 500 (1984) pg.1027 Ultimate source: expert judgement (delphi procedure) & experience
Comment: reference EGG-EA-5B16 1982.

VAWCE valve air operated general (PWR application)
Component boundary: detail n/a (generally excludes driver) Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY rec : 2.0E-3/cy
Source: IEEE 500 (1984) pg.1026 Ultimate source: expert judgement (delphi procedure) & experience
Comment: Reference EGG-EA-5B16 1984.

VAWYE valve air operated general (PWR application)
Component boundary: detail n/a (generally exclude driver) Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leakage
FAILURE RATE OR PROBABILITY rec : 7.0E-8/hr
Source: IEEE 500 (1984) pg.1026 Ultimate source: expert judgement (delphi procedure) & exeprience
Comment: reference EGG-EA-5B16 1982.

VAKAF valve air operated globe diameter between 2 and 6 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 4.0E-6/hr 95%: 4.8E-6/hr 5%: 3.4E-6/hr ERROR FACTOR: 1.2 REPAIR TIME: 10 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Pop.343. Cum.oper.time 22.4E+6 hours.91 failure."All modes" incl: 1)fail to operate,2)external,3)internal leak,4)faulty indication, 5)spurious opeartion,6)limit switch,7)unspec.1)&7)dominant cntrib

VAKCF valve air operated globe diameter between 2 and 6 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY mean : 1.5E-6/hr 95%: 2.0E-6/hr 5%: 1.1E-6/hr ERROR FACTOR: 1.3 REPAIR TIME: 11 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Pop.343. Cum.operating time 22.4E+6 hours. 34 failures.Number of demands in operational time is not known.FM include actuator failures,but not air supply.Based on expereince with control v.

VAKYF valve air operated globe diameter between 2 nad 6 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leak
FAILURE RATE OR PROBABILITY mean : 6.7E-7/hr 95%: 1.0E-6/hr 5%: 4.5E-7/hr ERROR FACTOR: 1.5 REPAIR TIME: 11 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.343. Cum. operating time 22.4E+6 hours. 15 failures. Based on experience with control valves.

VAL8F valve air operated globe diameter less than 2 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: internal leak Original failure mode: internal leak
FAILURE RATE OR PROBABILITY mean : 3.4E-7/hr 95%: 5.7E-7/hr 5%: 2.6E-7/hr ERROR FACTOR: 1.6 REPAIR TIME: 27 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Pop.420. Cum.operating time 32.1E+6 hours. 11 failures. Data based on experience with control valves.

VALAF valve air operated globe diameter less than 2 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 2.4E-6/hr 95%: 3.3E-6/hr 5%: 2.3E-6/hr ERROR FACTOR: 1.2 REPAIR TIME: 10 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Pop.420. Cum.operating time 32.1E+7 hours.78 failures."All modes" incl:1)fail to operate,2)external,3)internal leak.4)unspecified.
About equal contribution.Data based on expereince with control v.

VALCF valve air operated globe diameter less than 2 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY mean : 9.9E-7/hr 95%: 1.3E-6/hr 5%: 7.5E-7/hr ERROR FACTOR: 1.3 REPAIR TIME: 5 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.420.Cum.operating time 32.1E+6 hours. 31 failure.No.of demand in operational time is not known.FM include actuator failures,but
not power suppy to actuator.Data based on control valves.

VALYF valve air operated globe diameter less than 2 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leak
FAILURE RATE OR PROBABILITY mean : 4.0E-7/hr 95%: 6.4E-7/hr 5%: 2.6E-7/hr ERROR FACTOR: 1.5 REPAIR TIME: 11 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.420. Cum.operating time 32.1E+6 hours.13 failures. Data based on experince with control valves.

VAHEH valve air operated turbine governor valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close on demand
FAILURE RATE OR PROBABILITY mean : 1.1E-4/d 95%: 2.2E-4/d 5%: 3.0E-5/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 1.3E-4/d. Opearting experience 1680 demands, no failures.

VWWAE valve composite by design
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 2.8E-6/hr high: 3.2E-3/hr low: 3.0E-8/hr REPAIR TIME: 1.4 hours
Source: IEEE 500 (1984) pg.1041 Ultimate source: expert judgement(delphi procedure) and experience
Comment: This value is composite of all data on valves, grouped by design caracteristic. It is given for illustrative purposes. Per cycle(demand)rate it 7.6E-5/cy. FM see comment angle valve.

VEACJ valve explosive operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fails to operate
FAILURE RATE OR PROBABILITY mean : 3.0E-3/d ERROR FACTOR: 10
Source: NUREG 4550, Vol.1,tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources.
Comment: The same value as for motor operated valves. Values dveloped in Station Blackout Study were used. Two types of failure are incl.: valve hardware (5.0E-4) and command circuts faults (2.5E-4).

VEAYJ valve explosive operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: fails from plugging
FAILURE RATE OR PROBABILITY mean : 4.0E-5/d ERROR FACTOR: 3
Source: NUREG 4550, Vol.1,tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: Same value as for motor operated valves. Value based on NRC LER data summary (1.0E-7/hr) and assuming monthly test interval.

VHACJ valve hydraulic operated general
Component boundary. detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fails to operate
FAILURE RATE OR PROBABILITY mean : 1.0E-3/d ERROR FACTOR: 3
Source: NUREG 4550,Vol.1,tbl VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: The same values as for air operated were assumed. Two types of failure included: valve hardware faults (1.0E-3/d) and command circut faults (1.0E-4).

VHAYJ valve hydraulic operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode· leakage/external leak Original failure mode: fail from plugging
FAILURE RATE OR PROBABILITY mean : 4.0E-5/d ERROR FACTOR: 3
Source: NUREG 4550,Vol.1, tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: Values assumed to be the same as for air operated valves. Value is based on NRC LER data summary (1.0E-7/hr) assuming monthly test interval

VXADH valve manual
Component boundary: deatil n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer closed
FAILURE RATE OR PROBABILITY mean : 1.7E-8/hr 95%: 4.3E-8/hr 5%: 1.4E-9/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 4.2E-8/hr. Operating experience 1.8E+7 hours of operation, no failures.

VXEYV valve manual PWR + BWR (ESF systems valves only)
Component boundary: valve body and interiors,operating mechanism Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leakage
FAILURE RATE OR PROBABILITY mean : 2.2E-8/hr 95%: 5.7E-8/hr 5%: 5.9E-9/hr
Source: NUREG 1363 (1982) (pg.458) Ultimate source: US plants LER reports evaluation
Comment: Overall data PWR and BWR about equal.

VXECV valve manual PWR + BWR (ESF systems valves only)
Component boundary: valve body and interiors, operating mechanism Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY mean : 6.3E-5/d 95%: 1.6E-4/d 5%: 2.1E-5/d
Source: NUREG 1363 (1982) (pg.454) Ultimate source: US plants LER reports evaluation
Comment: Overall data PWr and BWR about equal. Standby hourly rate 2.9E-8/hr.

VXTDH valve manual butterfly all systems except HVAC
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer closed
FAILURE RATE OR PROBABILITY mean : 3.1E-8/hr 95%: 9.8E-8/hr 5%: 1.5E-9/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 4.2E-8/hr. Opearting experience 2.2E+6 hours, no failures.

VXGAF valve manual gate diameter between 12 and 24 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 2.4E-6/hr 95%: 2.9E-6/hr 5%: 2.0E-6/hr ERROR FACTOR: 1.2 REPAIR TIME: 10 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.520.Cum.operating time 34.6E+6 hours.84 failures."All modes" incl:1)fail to operate,2)external,3)internal leak,4)faulty indic.
5)plugged,6)unspecified. 2)is dominant,5) 40 times lower.

VXGCF valve manual gate diameter between 12 and 24 inches

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: fail to change position Original failure mode: fail to operate

FAILURE RATE OR PROBABILITY mean : 4.3E-7/hr 95%: 6.7E-7/hr 5%: 2.9E-7/hr ERROR FACTOR: 1.5 REPAIR TIME: 14 hours

Source: HWR data Ultimate source: HWR operating experience

Comment: Pop.520. Cumulative operating time 34.6E+6 hours.15 failures. Number of demand per operational time is not known.

VXGYF valve manual gate diameter between 12 and 24 inches

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: leakage/external leak Original failure mode: external leak

FAILURE RATE OR PROBABILITY mean : 1.4E-6/hr 95%: 1.8E-6/hr 5%: 1.1E-6/hr ERROR FACTOR: 1.3 REPAIR TIME: 6 hours

Source: HWR data Ultimate source: HWR operating expereince

Comment: Pop.520. Cumulative operating time 34.6E+6 hours.49 failures.

VXH8F valve manual gate diameter between 2 and 6 inches

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: internal leak Original failure mode: internal leak

FAILURE RATE OR PROBABILITY mean : 1.0E-7/hr 95%: 1.5E-7/hr 5%: 8.0E-8/hr ERROR FACTOR: 1.3 REPAIR TIME: 8 hours

Source: HWR data Ultimate source: HWR operating experience

Comment: Pop. 3546. Cum.operating experience 2.5E+8 hours. 26 failures.

VXHAF valve manual gate diameter between 2 and 6 inches

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: all modes Original failure mode: all modes

FAILURE RATE OR PROBABILITY mean : 1.2E-6/hr 95%: 1.3E-6/hr 5%: 1.0E-6/hr ERROR FACTOR: 1.1 REPAIR TIME: 6 hours

Source: HWR data Ultimate source: HWR operating experience

Comment: Pop 3546.Cum.operating time 2.5E+8 hours.278 failures."All modes" incl:1)external,2)internal leak,3)fail to operate,4)plugged,5) unspecified. 1) is dominant, 4) is negligable(1 failure only)

VXHCF valve manual gate diameter between 2 nad 6 inches

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: fail to change position Original failure mode: fail to operate

FAILURE RATE OR PROBABILITY mean : 1.3E-7/hr 95%: 1.6E-7/hr 5%: 9.1E-8/hr ERROR FACTOR: 1.3 REPAIR TIME: 4 hours

Source: HWR data Ultimate source: HWR operating experience

Comment: Pop.3546. Cum.operating time 2.5E+8 hours. 30 failures. Number of demands per operating time is not known.

VXHYF valve manual gate diameter between 2 nad 6 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leak
FAILURE RATE OR PROBABILITY mean : 6.4E-7/hr 95%: 7.3E-7/hr 5%: 5.6E-7/hr ERROR FACTOR: 1.1 REPAIR TIME: 4 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.3546. Cumulative component opearting time 2.5E+8 hours. No.of failures 160.

VXIAF valve manual gate diameter between 6 and 12 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all mode Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 2.4E-6/hr 95%: 2.6E-6/hr 5%: 2.1E-6/hr ERROR FACTOR: 1.1 REPAIR TIME: 7 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Pop.1179.Cum.operating time 84.2E+6 hours.199 failures."All modes incl:1)external,2)internal leak,3)fail to operate,4)faulty indic. 5)plugged,6)unspecified.1)is dominant,3),4) and 5) 25 times lower

VXICF valve manual gate diameter between 6 and 12 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY mean : 2.2E-7/hr 95%: 3.2E-7/hr 5%: 1.5E-7/hr ERROR FACTOR: 1.4 REPAIR TIME: 9 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Pop.1179. Cum.operating time 84.2E+6 hours.18 failures. Number of demands per operational time in not known.

VXIYF valve manual gate diameter between 6 and 12 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leak
FAILURE RATE OR PROBABILITY mean : 1.5E-6/hr 95%: 2.1E-6/hr 5%: 1.3E-6/hr ERROR FACTOR: 1.2 REPAIR TIME: 5 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.1179. Cumulative component operating time 84.2E+6 hours. No.of failures 122.

VXSAF valve manual gate diameter less than 2 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 5.4E-7/hr 95%: 5.7E-7/hr 5%: 5.1E-7/hr ERROR FACTOR: 1.1 REPAIR TIME: 6 hurs
Source: HWR data Ultimate source: HWR operating expereince
Comment: Pop.19351. Cumulative operating time 1.3E9 hours. 707 failures. "All modes" incl:1)external,2)internal leak,3)fail to operate, 4)plugged,5)unspecified.1) and 5) dominant,4) negligable.

VXSCF valve manual gate diameter less than 2 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY mean : 3.3E-8/hr 95%: 4.2E-8/hr 5%: 2.6E-8/hr ERROR FACTOR: 1.3 REPAIR TIME: 2 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.19351. Cum.operating time 1.3E+9 hours. 43 failures. Number of demands per operating time is not known.

VXSYF valve manual gate diameter less than 2 inches
Component boundary: detail n/a Operating mode: aall Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leak
FAILURE RATE OR PROBABILITY mean : 2.2E-7/hr 95%: 2.4E-7/hr 5%: 1.9E-7/hr ERROR FACTOR: 1.1 REPAIR TIME: 3 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.19351 .Cum.operating time 1.3E+9 hours. 286 failures.

VXACB valve manual general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 2.0E-7/hr max: 1.0E-6/hr min: 8.0E-8/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion and IREP data
Comment: Failure to operate is dominated by human error. Rate is based on one actuaton per month

VXACG valve manual general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to open or to close
FAILURE RATE OR PROBABILITY mean : 4.7E-6/hr ERROR FACTOR: 12
Source: German Risk Study (pg.F3-79) Ultimate source: generic data and operating experience
Comment: Both generic and specific sources were combined for this failure rate.

VXACI valve manual general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 1.0E-4/d ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: Failure to operate is dominated by human error Hourly rate 3.0E-7 (EF 10) is based on one actuation per month

VXADO valve manual general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer closed
FAILURE RATE OR PROBABILITY mean : 8.9E-8/hr 95%: 2.4E-7/hr 5%: 4.8E-9/hr
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior: NUREG 1363,failure of internals of manual valves. Operating experience: 3.09E+6 hours of operation, 1 failure.
95%/5% ratio is 100, indicating high degree of uncertanty.

VXADW valve manual general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: failure to remain open(plug)
FAILURE RATE OR PROBABILITY median: 1.0E-4/d 95%: 3.0E-4/d 5%: 3.0E-5/d ERROR FACTOR: 3
Source: WASH 1400 (table III 4-1) Ultimate source: assesed from US nuclear expereince (including test & research R)
Comment: Failure to remain open refers to reduction of flov to unusable level due to foreign material or agte failure.

VXAYJ valve manual general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: fails from plugging
FAILURE RATE OR PROBABILITY mean : 4.0E-5/d ERROR FACTOR: 3
Source: NUREG 4550, Vol.1.tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: Value based on NRC LER data summaries (1.0E-7/hr) assuming monthly test interval (720 hrs).

VXBCE valve manual general (BWR application)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failed to operate
FAILURE RATE OR PROBABILITY rec : 6.0E-5/cy
Source: IEEE 500 (1984) pg.1019 Ultimate source: expert opinion aggregation (delphi method) & operating exeprience
Comment: Reference EGG-EA-5816 82.Data Summaries of LER of Valves at US Commercial NPP

VXBYE valve manual general (BWR application)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leakage
FAILURE RATE OR PROBABILITY rec : 3.0E-8/hr
Source: IEEE 500 (1984) pg.1019 Ultimate source: expert opinion aggregation(delphi procedure)&operating experience
Comment: Reference EGG-EA-5816 82.Data Summaries of LER of Valves at US Commercial NPP.

VXPCE valve manual general (PWR application)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failed to operate
FAILURE RATE OR PROBABILITY rec : 7.0E-5/cy
Source: IEEE 500 (1984) pg.1018 Ultimate source: expert judgement aggregation (delphi method)
Comment:

VXPYE valve manual general (PWR application)
Component boundary: detail n/a (generally excludes operator) Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leakage
FAILURE RATE OR PROBABILITY rec : 2.0E-8/hr
Source: IEEE 500 (1984) pg.1018 Ultimate source: expert judgement aggregation (delphi method) and experience
Comment:

VMCCZ valve motor operated Chemical and volume control system valves
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to operate on demand
FAILURE RATE OR PROBABILITY mean : 3.7E-3/d
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant operating experience
Comment: Priors: NUREG 1363,MOV+remote(PWR)(w/o command)fail to operate(M) and WASH 1400 MOV, fails to operate (distrib).
Operating experience:1720 demands, 7 failures.

VMBCO valve motor operated all except condenser circulating water
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 6.4E-3/d 95%: 7.7E-3/d 5%: 4.5E-3/d
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experince
Comment: Prior: NUREG 1363, failure of MOV and remote operated on demand. Operating experience: 6725 demands, 42 failures.

VMJCZ valve motor operated all except for use in CVCS and CCS systems
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to operate on demand
FAILURE RATE OR PROBABILITY mean : 1.6E-3/d
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant operating experience
Comment: Priors:NUREG 1363 MOV+ remote(PWR)(w/o command)fail to operate(M) and WASH 1400 failed to operate (distrib.).
Operating experience: 11310 demands, 14 failures.

VMDCO valve motor operated condenser circulating water valves
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 1.0E-1/d 95%: 1.6E-1/d 5%: 2.7E-2/d
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior: NUREG 1363,failure of MOV and remote operated on demand. Operating experience: 30 demands, 5 failures.

VMECZ valve motor operated containment spray system valves
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to operate on demand
FAILURE RATE OR PROBABILITY mean : 5.7E-3/d
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant operating experience
Comment: Priors:NUREG 1363 MOV+remote (PWR)(w/o command),fail to operate (M) and WASH 1400 MOV, fails to operate (distrib.).
Operating experience: 1647 deamnds, 10 failures.

VMIEH valve motor operated main steam isolation valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close on demand
FAILURE RATE OR PROBABILITY mean . 2.4E-3/d 95%: 4.5E-3/d 5%: 6.9E-4/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 4.3E-3/d. Operating experience 714 demands, no failures.

VM1CV valve motor operated BWR (ESF systems valves only)
Component boundary: valve body and its internal parts,motor,functional accesories Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY mean : 6.8E-3/d 95%: 7.4E-3/d 5%: 6.2E-3/d
Source: NUREG 1363 (1982) (pg.398) Ultimate source: US plants LER reports evaluation
Comment: W/o command faults. With command 9.6E-3/d.Standby hourly failure rate:w/o 3.1E-6/hr; with 4.4E-6/hr.LEr rates from 'unknovn remote and MOV' what better represent MOV population.

VMMCG valve motor operated MSIV (FD-Schnellschlusschieber) gate
Component boundary: main valve without pilot valve Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to open or to close
FAILURE RATE OR PROBABILITY median: 6.0E-3/d ERROR FACTOR: 4
Source: German Risk Study (tb.F3,7-1) Ultimate source: operating experience
Comment: Bases for failure rate is 112 operating demands without failure.

VMHCV valve motor operated PWR (ESF system valves only)
Component boundary: valve body & internals,motor,functional assecories(limit swich) Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY mean : 4.1E-3/d 95%: 4.9E-3/d 5%: 3.4E-3/d
Source: NUREG 1363 (1982) (pg.398) Ultimate source: US plants LER reports evaluation
Comment: W/o command faults. With command faults 6.2E-3/d.Standby rate 1.9E-6/hr. LER rate from 'unknown remote and motor operated' what better represent MOV population.

VMHQV valve motor operated PWR + BWR (ESF systems valves only)
Component boundary: valve body & internals,motor,functional assecories(limit swich) Operating mode: all Operating environment: normal
Generic failure mode: plug Original failure mode: plugged
FAILURE RATE OR PROBABILITY mean : 8.1E-9/hr 95%: 3.8E-8/hr 5%: 4.E-10/hr
Source: NUREG 1363 (1982) (pg.406) Ultimate source: US plants LER reports evaluation
Comment: Overall rate. LER rate from 'unknown remote and MOV' what better represent MOV population. W/o command faults. With command faults 7.3E-8/hr.

VMHYV valve motor operated PWR + BWR (ESF systems valves only)
Component boundary: valve body & interiors,motor,functional assecories(limit switch) Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: leak externally
FAILURE RATE OR PROBABILITY mean : 1.4E-7/hr 95%: 2.1E-7/hr 5%: 8.7E-8/hr
Source: NUREG 1363 (1982) (pg.414) Ultimate source: US plants LER reports evaluation
Comment: LER rate from 'unknown remore and MOV what better represent MOV population.P WR and BWR rates identical.

VMS8F valve motor operated butterfly diameter between 12 and 24 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: internal leak Original failure mode: internal leak
FAILURE RATE OR PROBABILITY mean : 2.5E-7/hr 95%: 7.8E-7/hr 5%: 1.0E-7/hr ERROR FACTOR: 2.3 REPAIR TIME: 14 hours
Source: HWR data Ultimate source: HWR opearting experience
Comment: Pop.95.Cum.operating time 8E+6 hours.No.of failures 2.Data based on expereince with isolating valves vith either electric or pneumatic opeartor.

VMSAF valve motor operated butterfly diameter between 12 and 24 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 4.9E-6/hr 95%: 6.3E-6/hr 5%: 3.8E-6/hr ERROR FACTOR: 1.3 REPAIR TIME: 30 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.95.Cum.operating time 8E+6 hours.No.of failures 39 Failure mo incl:1)fail to operate,2)external leak,3)internal leak,4)faulty indication,5)unspecified. Failure rate dominated by 1) and 5).

VMSCF valve motor operated butterfly diameter between 12 and 24 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY mean : 2.6E-6/hr 95%: 3.8E-6/hr 5%: 1.9E-6/hr ERROR FACTOR: 1.4 REPAIR TIME: 10 hours
Source: HWR data Ultimate source: WRU operating experience
Comment: Pop.95.Cum.operating time 8E+6 hours.No.of failures 21.No.of demands not known.Failure mode "fail to operate" include actuator failure but not loss of power.Data from isolation valves.

VMSYF valve motor operated butterfly diameter between 12 and 24 inches
Component boundary: deatil n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leak
FAILURE RATE OR PROBABILITY mean : 1.2E-7/hr 95%: 6.4E-7/hr 5%: 4.6E-8/hr ERROR FACTOR: 3.1 REPAIR TIME: 4 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.95.Cum.operating time 8E+6 hours.No.of failures 1.Data based on experience with isolating valves with either pneumatic or electric valve operator.

VMUAF valve motor operated butterfly diameter between 2 and 6 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 7.4E-7/hr 95%: 1.3E-7/hr 5%: 4.3E-7/hr ERROR FACTOR: 1.7 REPAIR TIME: 15 hours
Source: HWR data Ultimate source: HWR operataing expeience
Comment: Failure mode "all modes" include 1)fail to operate.2)external leak,3)faulty indication,4)unspecified. Failure rate is dominated by 3) and 4).Total pop.157. Oper.time 10.8E+6hrs.8 failures.

VMUCF valve motor operated butterfly diameter between 2 and 6 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY mean : 9.1E-8/hr 95%: 4.3E-7/hr 5%: 3.4E-8/hr ERROR FACTOR: 2.7 REPAIR TIME: 1 hour
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.157.Cum.operating time 1080E+4 hours.1 failure.No.of demands in time not known.Data based on expereince with isolating valves (electr.or pneum.operator).FM.incl.failure of actuator, w/o comm.

VMUYF valve motor operated butterfly diameter between 2 and 6 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leak
FAILURE RATE OR PROBABILITY mean : 9.1E-8/hr 95%: 4.3E-7/hr 5%: 3.4E-8/hr ERROR FACTOR: 2.7 REPAIR TIME: 1 hour
Source: HWR data Ultimate source: HWR operating experience
Comment: Data based on experience with isolating valves with either electric or pneumatic operator. Pop.157.Cum.operating time 10.80E+6 hours. No.of failures 1.

VMT8F valve motor operated butterfly diameter between 6 and 12 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: internal leak Original failure mode: internal leak
FAILURE RATE OR PROBABILITY mean : 7.0E-7/hr 95%: 1.2E-6/hr 5%: 4.2E-7/hr ERROR FACTOR: 1.6 REPAIR TIME: 5 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.165.Cum.operating time.12.95E+6 hours.No.of failures 9. Data based on experience with isolating valves with either electr or pneumatic operator.

VMTAF valve motor operated butterfly diameter between 6 and 12 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 6.8E-6/hr 95%: 8.2E-6/hr 5%: 5.8E-6/hr ERROR FACTOR: 1.2 REPAIR TIME: 4 hours
Source: HWR data Ultimate source: WRU operating experience
Comment: failure mode"all modes" include:1)fail to operate,2)external leak 3)internal leak,3)faulty identification,4)unspecified.Failure rate is dominated by 1) and 5).Tot.pop.165.12.9E+6op.hrs.89 fail.

VMTCF valve motor operated butterfly diameter between 6 and 12 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY mean : 3.6E-6/hr 95%: 4.6E-6/hr 5%: 2.9E-6/hr ERROR FACTOR: 1.3 REPAIR TIME: 3 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.165.Cum.opearting time 12.95E+6 hours.No.of failures 47. No.of demands not known.Failure mode include actuator failure,but not loss of power.Data based on experience with isolation valves.

VMTYF valve motor operated butterfly diameter between 6 and 12 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leak
FAILURE RATE OR PROBABILITY mean : 4.7E-7/hr 95%: 9.1E-7/hr 5%: 2.5E-7/hr ERROR FACTOR: 1.8 REPAIR TIME: 5 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.165.Cum.operating expeirence 12.95E+6 hours.No.of failures 6. Data based on experience with isolating valves with either electr or pneumatic operator.

VMFCT valve motor operated control valve
Component boundary: valve,motor,protection,controls,relays,logic and automation Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to change position
FAILURE RATE OR PROBABILITY mean : 2.5E-2/d 95%: 1.6E-1/d REPAIR TIME: 4 hours
Source: Swedish Rel.data book, tbl.20 Ultimate source: plant operating experience(7 BWR plants), ATV reports
Comment: Total pop.69.No.of demands per operational time 2012.No of failures 22. a=0.0971; b=3.75 Critical failures reported at 5 plants.

VMGAF valve motor operated gate diameter between 12 and 24 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 4.1E-6/hr 95%: 4.8E-6/hr 5%: 3.6E-6/hr ERROR FACTOR: 1.2 REPAIR TIME: 15 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Pop.356.Cum.operating time 29.1E+6 hours. 120 failures."All modes incl:1)fail to operate,2))external,3)internal leak,4)faulty indi. 5)unspecified. 1),2) and 5) dominant, 3)significantly lower.

VMGCF valve motor operated gate diameter between 12 and 24 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY mean : 2.2E-6/hr 95%: 2.7E-6/hr 5%: 1.6E-6/hr ERROR FACTOR: 1.2 REPAIR TIME: 21 hour
Source: HWR data Ultimate source: HWR operating expereince
Comment: Pop.356. Cum.operating time 29.1E+6 hours.63 failures. Number of demands in operational time is not known. "Fail to operate" incl. actuator failure,but not power supply to actuator.

VMGYF valve motor operated gate diameter between 12 and 24 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leak
FAILURE RATE OR PROBABILITY mean : 1.2E-6/hr 95%: 1.6E-6/hr 5%: 9.1E-7/hr ERROR FACTOR: 1.3 REPAIR TIME: 2 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Pop.356. Cum.operating time 29.1E+6 hours.35 failures.

VM1DW valve motor operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: failure to remain open (plug)
FAILURE RATE OR PROBABILITY median: 1.0E-4/d 95%: 3.0E-4/d 5%: 3.0E-5/d ERROR FACTOR: 3
Source: WASH 1400 (table III 4-1) Ultimate source: assesed from nuclear expereince (incl. test & research reactors)
Comment: This failure mode is given per demand and time related since phenomena is time related,but may be deceted only upon a demand

VMA8B valve motor operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: internal leak* Original failure mode: internal leakage(catastrophic)
FAILURE RATE OR PROBABILITY mean : 1.0E-7/hr max: 7.0E-7/hr min: 1.E-10/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion and IREP data
Comment: Catastrophic leakage or"rupture" is assigned by enginering judgement. Catastrophic leakage assumes the valve to be in a closed state, then the valve fails

VMA8I valve motor operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: internal leak* Original failure mode: internal leakege (catastrophic)
FAILURE RATE OR PROBABILITY mean : 5.0E-7/hr ERROR FACTOR: 100
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: Catastrophic leakage or "rupture" assigned by engineering judgement. It assumes the valve to be in a closed state, then the valve fails.

VMACG valve motor operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to open or to close
FAILURE RATE OR PROBABILITY mean : 1.7E-5/hr ERROR FACTOR: 3
Source: German Risk Study (pg.F3-74) Ultimate source: generic data and operating expereince
Comment: The same value is used in FTs for fail to open or close mode. For the standby operating mode,assuming montly test interval failure per demand is 5.4E-3.

VMACJ valve motor operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fails to operate
FAILURE RATE OR PROBABILITY mean : 3.0E-3/d ERROR FACTOR: 10
Source: NUREG 4550, Vol.1,tbl VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: Valuse used is from Station Blachout Study (NUREG/CR-3226). Two types of failures are included: valve hardware faults(5.0E-4) and command circut faults (2.5E-4)

VMACW valve motor operated general
Component boundary: detail n/a, include driver. Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY median: 1.0E-3/d 95%: 3.0E-3/d 5%: 3.0E-4/d ERROR FACTOR: 3
Source: WASH 1400 (table III 4-1) Ultimate source: assesed from nuclear,industrial and military experience and data
Comment: Demand probabilities are based on presence of proper input signal Failure to operate include changing state from closed to open or from open to closed position.

VMADB valve motor operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: failure to remain open
FAILURE RATE OR PROBABILITY mean : 2.0E-7/hr max: 1.0E-6/hr min: 8.0E-8/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion and IREP data
Comment:

VMADH valve motor operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer closed
FAILURE RATE OR PROBABILITY mean : 7.3E-8/hr 95%: 1.6E-7/hr 5%: 9.1E-9/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 9.3E-8/hr. Operating experience 1.6E+6 hours of operation, no failures.

VMADI valve motor operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: failure to remain open
FAILURE RATE OR PROBABILITY mean : 1.0E-7/hr ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

VMADO valve motor operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer closed
FAILURE RATE OR PROBABILITY mean : 1.2E-7/hr 95%: 3.0E-7/hr 5%: 5.8E-9/hr
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior: WASH 1400,MOV fail to remain open. 5%=20%; 95%=80%. Per demand rate converted to hrly rate assuming 1 demand in 45 days.
Operating experience: 1.89E+6 hours of operation, no failures.

VMADW valve motor operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: failure to remain open (plug)
FAILURE RATE OR PROBABILITY median: 3.0E-7/hr 95%: 1.0E-6/hr 5%: 1.0E-6/hr ERROR FACTOR: 3
Source: WASH 1400 (table III 4-1) Ultimate source: ultimate data source not known(sources presents plug per demand)
Comment: Failure to remain open refers to reduction of flow to unusable level due to foreign particles or gate failure. Not included
in value inadvertant or false signal driving valve closed.

VMADZ valve motor operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer closed
FAILURE RATE OR PROBABILITY mean : 5.3E-8/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant specific experience
Comment: Also applicable to manual valves. Prior:WASH 1400, fail to remain open,plugged. 1 demand in 45 days used to convert to hourly rate.
Operating experience:1.11E+7 hours of operation, no failures.

VMADZ valve motor operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer open /excessive leakage through valve
FAILURE RATE OR PROBABILITY mean : 3.1E-8/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant operating experience
Comment: Priors:NUREG 1363 MOV+remote(PWR),external leakage (mean)and WASH 1400, MOV, external elakage/rupture (distribution).
Opearting experience:6.95E+5 hours of operation, no failures.

VMAEB valve motor operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close
FAILURE RATE OR PROBABILITY mean : 1.0E-5/hr max: 5.0E-5/hr min: 2.0E-7/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion and IREP data
Comment:

VMAEH valve motor operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close on demand
FAILURE RATE OR PROBABILITY mean : 9.2E-4/d 95%: 1.6E-3/d 5%: 2.8E-4/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 4.3E-3/d. Operating experience 5315 demands, 3 failures.

VMAEI valve motor operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close
FAILURE RATE OR PROBABILITY mean : 3.0E-3/d ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

VMAOB valve motor operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 1.0E-5/hr max: 5.0E-5/hr min: 2.0E-7/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion and IREP data
Comment:

VMAOH valve motor operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open on demand
FAILURE RATE OR PROBABILITY mean : 2.9E-3/d 95%: 3.8E-3/d 5%: 1.7E-3/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 4.3E-3/d. Operating experience 5315 demands, 15 failures.

VMAOI valve motor operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 3.0E-3/d ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

VMATU valve motor operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: rupture Original failure mode: internal leakage
FAILURE RATE OR PROBABILITY mean : 2.0E-6/hr
Source: Sizewell B (PWR/RX312 pg.7) Ultimate source: assesed from nuclear experience and generic data
Comment: Assesement based on W data item nad WASH 1400.Generic failure mod is based on FM assigned to W-1400,because it is not clearly defin ed here. Assesed failure rate is said to be very pessimistic.

VMATW valve motor operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: rupture Original failure mode: rupture
FAILURE RATE OR PROBABILITY median: 1.0E-8/hr 95%: 1.0E-7/hr 5%: 1.0E-9/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-1) Ultimate source: assesed from US nuclear experience
Comment: Failure mode comparable with external leak.

VMAYJ valve motor operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: fails from plugging
FAILURE RATE OR PROBABILITY mean : 4.0E-5/d ERROR FACTOR: 3
Source: NUREG 4550, Vol.1,tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: Value based on NRC LER data summary (1.0E-7/hr) assuming monthly system test (720 hrs).

VMVDS valve motor operated general
Component boundary: detail n/a Operating mode: normally closed Operating environment: normal
Generic failure mode: fail to remain in position* Original failure mode: failed closed
FAILURE RATE OR PROBABILITY mean : 1.5E-6/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating experience
Comment:

VMWDS valve motor operated general
Component boundary: detail n/a Operating mode: normally open Operating environment: normal
Generic failure mode: fail to remain in position* Original failure mode: failed open
FAILURE RATE OR PROBABILITY mean : 1.6E-6/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating exprience
Comment:

VMXDS valve motor operated general
Component boundary: detail n/a Operating mode: normally open Operating environment: normal
Generic failure mode: fail to remain in position* Original failure mode: failed closed
FAILURE RATE OR PROBABILITY mean : 1.5E-7/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluatiopn of BWR operating experience
Comment:

VMYDS valve motor operated general
Component boundary: detail n/a Operating mode: normally closed Operating environment: normal
Generic failure mode: fail to remain in position* Original failure mode: failed open
FAILURE RATE OR PROBABILITY mean : 1.6E-7/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating experience
Comment:

VMQCE valve motor operated general (BWR application)
Component boundary: detail n/a(generaly exclude driver) Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY rec : 8.0E-3/cy
Source: IEEE 500 (1984) pg.1023 Ultimate source: expert judgement aggregation (delphi procedure) & experience
Comment: Reference EGG-EA 5B16 1982.

VMQQE valve motor operated general (BWR application)
Component boundary: detail n/a(generally exclude operator) Operating mode: all Operating environment: normal
Generic failure mode: plug Original failure mode: plugged
FAILURE RATE OR PROBABILITY rec : 6.0E-8/hr
Source: IEEE 500 (1984) pg.1023 Ultimate source: expert judgement aggregation (delphi procedure) & experience
Comment: Reference EGHG-EA-5B16 1982.

VMQYE valve motor operated general (BWR application)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leakage
FAILURE RATE OR PROBABILITY rec : 8.0E-8/hr
Source: IEEE 500 (1984) pg.1023 Ultimate source: expert judgement aggregation (delphi procedure) & experience
Comment: reference EGG-EA-5B16 1982.

VMPCE valve motor operated general (PWR application)
Component boundary: detail n/a(generally excludes operator) Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to operate
FAILURE RATE OR PROBABILITY rec : 4.0E-3/cy
Source: IEEE 500 (1984) pg.1022 Ultimate source: expert opinion aggregation (delphi procedure) & plant experiexce
Comment: Reference EGG-EA-5B16 1982.

VMPQE valve motor operated general (PWR application)
Component boundary: detail n/a (generally excludes driver) Operating mode: all Operating environment: normal
Generic failure mode: plug Original failure mode: plugged
FAILURE RATE OR PROBABILITY rec : 6.0E-8/hr
Source: IEEE 500 (1984) pg.1022 Ultimate source: expert judgement aggregation (delphi procedure) and expreience
Comment: Reference EGG-EA-5B16

VMPYE valve motor operated general(PWR application)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leakage
FAILURE RATE OR PROBABILITY rec : 1.0E-7/hr
Source: IEEE 500 (1984) pg.1022 Ultimate source: expert judgement aggregation(delphi procedure) and experience
Comment: Reference EGG-EA-5B169

VML8F valve motor operated globe diameter between 2 and 6 inches

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: internal leak Original failure mode: internal leak

FAILURE RATE OR PROBABILITY mean : 2.3E-6/hr 95%: 3.1E-6/hr 5%: 1.8E-6/hr ERROR FACTOR: 1.3 REPAIR TIME: 4 hours

Source: HWR data Ultimate source: HWR operating experience

Comment: Pop.220.Cum.operating time 14E+6 hours.33 failures. Data based on experience with isolating valves.

VMLCF valve motor operated globe diameter between 2 and 6 inches

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: fail to change position Original failure mode: fail to operate

FAILURE RATE OR PROBABILITY mean : 1.3E-6/hr 95%: 1.9E-6/hr 5%: 9.0E-7/hr ERROR FACTOR: 1.1 REPAIR TIME: 5 hours

Source: HWR data Ultimate source: HWR operating experience

Comment: Pop.220.Cum.operating time 14E+6 hours.18 failures.No.of demands in operational time is not known. Data based on experience with isolating valves.FM incl.actuator failure,but not power supply.

VMLYF valve motor operated globe diameter between 2 and 6 inches

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: leakage/external leak Original failure mode: external leak

FAILURE RATE OR PROBABILITY mean : 6.3E-6/hr 95%: 7.5E-6/hr 5%: 5.3E-6/hr ERROR FACTOR: 1.2 REPAIR TIME: 6 hours

Source: HWR data Ultimate source: HWR operating experience

Comment: Pop.220 Cum.operating time 14E+6 hours.89 failures. Data based on experience with isolating valves with either electric or pneumatic operator.

VMLAF valve motor operated globe diameter between 2 nad 6 inches

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: all modes Original failure mode: all modes

FAILURE RATE OR PROBABILITY mean : 1.3E-5/hr 95%: 1.5E-5/hr 5%: 1.1E-5/hr ERROR FACTOR: 1.1 REPAIR TIME: 9 hours

Source: HWR data Ultimate source: HWR operating experience

Comment: Pop.220. Cum.operating time 14E+6 hours.187 failures."All modes" incl:1)fail to operate,2)external,3)internal leak,4)faulty indic. 5)spurius operation,6)unspecified.1),2),3) and 6) dominat,5)minor

VMOCY valve motor operated isolation valve pipe dimension 100 < DN < 200 mm

Component boundary: valve,motor,protection,control,switch,fuse,indications Operating mode: all Operating environment: normal

Generic failure mode: fail to change position Original failure mode: failure to change position

FAILURE RATE OR PROBABILITY mean : 1.7E-3/d

Source: Swedish Rel.data book, tbl.12 Ultimate source: plant operating exprience (Ringhals 2 PWR),ATV reports

Comment: Total pop. 12.Number of demands per operational time 600.Number of failures 1.FAILMODE regarded open/close operation as one demand

VMOCT valve motor operated isolation valve pipe dimension 100< DN < 200 mm
Component boundary: valve,motor,protection,controls,switch,fuse,indications Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to change position
FAILURE RATE OR PROBABILITY mean : 6.3E-3/d 95%: 3.7E-2/d REPAIR TIME: 4 hours
Source: Swedish Rel.data book, tbl.12 Ultimate source: plant operating experience(7 BWR plants), ATV reports, LERs
Comment: Total pop.180.Number of demads per operational time 6181.Number of failures:30. a=0.114; b=18 Critical failures occured at 6 plants.

VMNCY valve motor operated isolation valve pipe dimension > 200 mm
Component boundary: valve,motor,protection,controls,switch,fuse,indications Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to change position
FAILURE RATE OR PROBABILITY mean : 3.3E-3/d REPAIR TIME: 8 hours
Source: Swedish Rel.data book, tbl.13 Ultimate source: plant operating experience(Ringhals 2 PWR) ATV reports
Comment: Total pop. 23.Number of demands per operational time 1486.Number of failures 5.

VMNCT valve motor operated isolation valve pipe dimension > 200mm
Component boundary: valve,motor,protection,controls,switch,fuse,indications Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to change position
FAILURE RATE OR PROBABILITY mean : 7.2E-3/d 95%: 4.2E-2/d REPAIR TIME: 5 hours
Source: Swedish Rel.data book, tbl.13 Ultimate source: plant operating experience (7 BWR plants), ATV reports, LERs
Comment: Total pop.95.Number of demands per operational time 3059.Number of failures 22. a= 0.11; b=15.2 Critical failures occured at 4 plants.

VMKCT valve motor operated isolation valve pipe dimension<=100 mm
Component boundary: valve,motor,protection,controls,switch,fuse,indications Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to change position
FAILURE RATE OR PROBABILITY mean : 7.9E-3/d 95%: 3.6E-2/d REPAIR TIME: 4 hours
Source: Swedish Rel.data book, tbl.11 Ultimate source: plant operating experience (7 BWR plants), ATV reports, LERs
Comment: Total pop.71.Number of demands per operational time 2512.Number of failures observed: 18. a=0.307; b=38.5. Critical failures occured at 6 plants.

VMKCY valve motor operated isolation valve pipe dimension<=100mm
Component boundary: valve,motor,protection,controls,switch,fuse,indications Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to change position
FAILURE RATE OR PROBABILITY mean : 5.3E-3/d REPAIR TIME: 3 hours
Source: Swedish Rel.data book, tbl.11 Ultimate source: plant operating experience (Ringhals 2 PWR)
Comment: Total pop.22.Number of demands per operational time 983.Number of failures:5.

VMRCG valve motor operated regualting
Component boundary: valve with operator Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to close (in terms of regulating)
FAILURE RATE OR PROBABILITY mean : 1.0E-5/hr ERROR FACTOR: 7
Source: German Risk Study (pg.F3-79) Ultimate source: generic data
Comment: Failure rate is combination of generic data sources

VMACU valve motor oprated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 2.0E-6/hr
Source: Sizewell B (PWR/RX312 pg.6) Ultimate source: asesed from nuclear experience and generic sources
Comment: Assesment based on W data item and WASH 1400 data.If valves are tested montly,given failure rate gives the peak probability of 1.4E-3/d, what is in agreement with WASH 1400.

VSROT valve pilot valve operated safety valve pipe dimension 125,150,300 mm
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 7.8E-4/d 95%: 1.4E-3/d REPAIR TIME: 9 hours
Source: Swedish Rel.data book, tbl.22 Ultimate source: plant operating experience(7 BWR plants),ATV reports,LERs
Comment: Total pop.126.No.of demands 1281.No of failures 1.a=0.0167;b=21.4 Pilot valve see "vwkot". Safety valve+pilot valve=pressure relief system.Critical failure on one plant only.

VSOCG valve pilot valve operated safety valve (pressurizer or main steam line) with one pilot valve
Component boundary: detail n/a Operating mode: closed Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to open or to close
FAILURE RATE OR PROBABILITY median: 7.0E-3/d ERROR FACTOR: 4
Source: German Risk Study (tb.F3,7-1) Ultimate source: operating experience
Comment: Operating experience: 20 test and 80 operational demands, no failures.
Not applicable to water relief safety valves.

VSTEG valve pilot valve operated safety valve (pressurizer or main steam line) with two or three pilot valves
Component boundary: detail n/a Operating mode: closed Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close
FAILURE RATE OR PROBABILITY median: 7.0E-3/d ERROR FACTOR: 4
Source: German Risk Study (tb.F3,7-1) Ultimate source: operating expereince
Comment: Operating experience: 20 test and 80 operational demands, no failures. Failure rate is not influenced by number of pilot valves. Not applicable to water relief safety valves.

VSTOG valve pilot valve operated safety valve (pressurizer or main steam line) with two or three pilot valves
Component boundary: detail n/a Operating mode: closed Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open
FAILURE RATE OR PROBABILITY median: 4.0E-3/d ERROR FACTOR: 6
Source: German Risk Study (tb.F3,7-1) Ultimate source: operating experience
Comment: Operating experience: 20 test and 80 operational demands, no failures reported. It is assumed that having more than one pilot valve lower actual valve opening failure rate.N/a to water relief

VPTDH valve piston operated butterfly used in HVAC
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer closed
FAILURE RATE OR PROBABILITY mean : 1.7E-7/hr 95%: 4.3E-7/hr 5%: 1.4E-8/hr
Source: Old PWR Ultimate source: generic data updated with plant operating expereince
Comment: Generic mean 2.7E-7/hr. Operating experience 9.3E+5 hours of operation, no failures.

VPTEH valve piston operated butterfly used in HVAC
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close on demand
FAILURE RATE OR PROBABILITY mean : 1.2E-3/d 95%: 1.4E-3/d 5%: 8.3E-4/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 1.5E-3/d. Operating experience 24713 demands, 30 failures.

VPTOH valve piston operated butterfly used in HVAC
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open on demand
FAILURE RATE OR PROBABILITY mean : 1.9E-3/d 95%: 2.2E-3/d 5%: 1.4E-3/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 1.5E-3/d. Operating expereince 24713 demands, 49 failures.

VPACO valve piston operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 3.5E-3/d 95%: 4.9E-3/d 5%: 1.4E-3/d
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:NUREG 1363,PWR air-op valves,failure on demand,w/o command. Operating experience:2564 demands, 10 failures

VPADO valve piston operated general

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: fail to remain in position Original failure mode: transfer closed

FAILURE RATE OR PROBABILITY mean : 1.9E-7/hr 95%: 5.5E-7/hr 5%: 6.8E-9/hr

Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience

Comment: Prior:WASH 1400,air-op,failure to remain open.5%=20%; 95%=80% Per demand rate converted to hourly rate assuming 1 dem. in 45 days. Operating experience:2.74E+5 hours of operation,no failures.

VAGOT valve pneumatic operated isolation valve hydraulic scram system valve,pipe dimension <100 mm

Component boundary: valve, operator,control eqiupment,relays,logic and automation Operating mode: all Operating environment: normal

Generic failure mode: fail to open Original failure mode: failure to open

FAILURE RATE OR PROBABILITY mean : 1.4E-4/d 95%: 3.3E-4/d REPAIR TIME: 4 hours

Source: Swedish Rel.data book, tbl.17 Ultimate source: plant operating experience(7 BWR plants), ATV reports, LERs

Comment: Total pop.278.No.of demands per operational time 27816. No.of failures 4. a=0.0203; b=141. Critical failures occured at one plant

VAHCT valve pneumatic operated isolation valve pipe dimension <=100mm

Component boundary: valve,operator,control equipment,relays,logic and automation Operating mode: all Operating environment: normal

Generic failure mode: fail to change position Original failure mode: failure to change position

FAILURE RATE OR PROBABILITY mean : 5.9E-3/d 95%: 3.4E-2/d REPAIR TIME: 6 hours

Source: Swedish Rel.data book, tbl.16 Ultimate source: plant operating experience(7 BWR plants),ATV reports, LERs

Comment: Total pop.86.No.of demands per operational time 2366, 14 failures a=0.129; b=21.7 Critical failures occured at 4 plants.

VAHCY valve pneumatic operated isolation valve pipe dimension <=100mm

Component boundary: valve,operator,control equipment,relays,logic and automation Operating mode: all Operating environment: normal

Generic failure mode: fail to change position Original failure mode: failure to change position

FAILURE RATE OR PROBABILITY mean : 6.5E-3/d REPAIR TIME: 5 hours

Source: Swedish Rel.data book, tbl.16 Ultimate source: plant operating experience(Ringhals 2 PWR)

Comment: total pop.33.No.of demand per operational time 1236, no.of failures 8.

VRPOU valve power operated relief PORV

Component boundary: detail n/a Operating mode: standby Operating environment: normal

Generic failure mode: fail to open Original failure mode: failure to open

FAILURE RATE OR PROBABILITY mean : 2.6E-6/hr

Source: Sizewell B (PWR/RX312 pg.5) Ultimate source: assesed from nuclear expereince and data

Comment: The same failure rate applicable for safety valves.Assesment bsd on W data,WASH 1400 adn SRS data item(7.0E-3/d).For yearly testin stdby failrate(2.6E-6/hr)gives peak rate 2.3E-2/d(pessimistic).

VRPEH valve power operated relief PORV
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close on demand
FAILURE RATE OR PROBABILITY mean : 3.3E-2/d 95%: 6.7E-2/d 5%: 1.0E-2/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 2.5E-2/d. Operating experience 8 demands, 1 failure.

VRPEO valve power operated relief PORV
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close
FAILURE RATE OR PROBABILITY mean : 1.1E-2/d 95%: 3.0E-2/d 5%: 6.9E-4/d
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior: NUREG 1363. Failure to reclose after water or steam relief has the same distribution, based on EPRI valve test program. Operating experience:31 demands. 1 failure.

VRPOH valve power operated relief PORV
Component boundary: detail n/a Operating mode: closed Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open on demand
FAILURE RATE OR PROBABILITY mean : 4.2E-3/d 95%: 8.6E-3/d 5%: 1.0E-3/d
Source: Old PWR Ultimate source: generic data updated with plant operatng experience
Comment: Generic mean 4.3E-3/d . Operating expereince 8 demands, no failures.

VRPOO valve power operated relief PORV
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 4.9E-3/d 95%: 1.1E-2/d 5%: 2.1E-4/d
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior: NUREG 1363 (1980),BWR relief open on demand. BWR used because lack of PWR PORV data, and similarities between PORV and AD function.Op.experience 31 demand, no failures.

VRPEJ valve power operated relief valve PORV
Component boundary: detail n/a Operating mode: all Operating environment· normal
Generic failure mode: fail to close Original failure mode: fails to reclose
FAILURE RATE OR PROBABILITY mean : 3.0E-2/d ERROR FACTOR: 10
Source: NUREG 4550, Vol.1,tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: This value is also applicable to Safety Relief Valves. ASEP used generic value from IREP procedure guide, but it also falls into the range indicated by LERs.

VRPEU valve power operated relief valve POVR
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close
FAILURE RATE OR PROBABILITY mean : 5.0E-6/d
Source: Sizewell B (PWR/RX312 pg.5) Ultimate source: assesed from nuclear experience and data
Comment: Assesment based on W data item and SRS data item applicable to PORV's(4.0E-2/d) If PORVs are tested yearly,stdby failrate(5E-6/h r)gives peak probability of 4.4E-2/d, what is consistent with SRS

VWCCA valve remote operated PORV block valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fails to transfer on demand
FAILURE RATE OR PROBABILITY median: 3.6E-2/d ERROR FACTOR: 2.4
Source: NUREG 4550/Vol.3,tbl.IV.8-1 Ultimate source: Surry NPP operating expreince
Comment:

VCA8B valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: internal leak Original failure mode: internal leakage minor
FAILURE RATE OR PROBABILITY mean : 3.0E-6/hr max: 2.0E-5/hr min: 6.0E-8/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion and IREP data
Comment:

VCA8B valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: internal leak Original failure mode: internal leakage catastrophic
FAILURE RATE OR PROBABILITY mean : 1.0E-7/hr max: 7.0E-7/hr min: 1.E-10/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion and IREP data
Comment: Valve initialy closed, then failed

VCA8G valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: internal leak Original failure mode: internal leakage
FAILURE RATE OR PROBABILITY mean : 3.9E-5/hr ERROR FACTOR: 10
Source: German Risk Study (pg.P3-78) Ultimate source: generic data
Comment: Failure rate is combination of several data sources. Operating experience revealed two values, 2.6E-5/hr and 4.2E-6/hr with 2 and 5 recorded events,respectively

VCA8I valve self operated check
Component boundary: detail n/a Operating mode: al Operating environment: normal
Generic failure mode: internal leak Original failure mode: internal leakage(catastrophic)
FAILURE RATE OR PROBABILITY mean : 5.0E-7/hr ERROR FACTOR: 100
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: This failure mode assume that valve initialy closed than failed

VCA8W valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: internal leak Original failure mode: internal leak (severe)
FAILURE RATE OR PROBABILITY median: 3.0E-7/hr 95%: 1.0E-6/hr 5%: 1.0E-7/hr ERROR FACTOR: 3
Source: WASH 1400 (table III 4-1) Ultimate source: assesed from industrial, military and other experiecne and data
Comment: Internal leak is failure mode comparable to fail to close.

VCA9I valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: internal leak Original failure mode: internal leakage(minor)
FAILURE RATE OR PROBABILITY mean : 3.0E-5/hr ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opnion
Comment:

VCAAE valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY rec : 2.1E-6/hr high: 3.3E-4/hr low: 8.0E-8/hr REPAIR TIME: 1.8 hours
Source: IEEE 500 (1984) pg.1065 Ultimate source: expert judgement and experience
Comment: ref:Corps of Engineers R/M data base,NPRD-2,NERS 80-02,NUREG 2232 Given value is composite of diffrerent sources,constructions and sizes of check vlvs.Per cycle val.9.6E-5/cy.FM comment angle vlv.

VCADH valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer closed
FAILURE RATE OR PROBABILITY mean : 1.0E-8/hr 95%: 2.1E-8/hr 5%: 2.4E-9/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experince
Comment: Generic mean 1.0E-8/hr. Operating experience 2.2E+6 hours of operation, no failures.

VCAEB valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close
FAILURE RATE OR PROBABILITY mean : 2.0E-6/hr max: 1.0E-5/hr min: 6.0E-7/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion and IREP datda
Comment:

VCAEG valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close
FAILURE RATE OR PROBABILITY mean : 3.1E-6/hr ERROR FACTOR: 3
Source: German Risk Study (pg.P3-77) Ultimate source: generic data
Comment: Failure rate used is combination of several generic data sources. Regarding operating experience, there was 1 recorded failure in 2.6E+6 hours,what is comparable to generic,so it was used.

VCAEH valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close on demand
FAILURE RATE OR PROBABILITY mean : 2.8E-4/d 95%: 4.5E-4/d 5%: 1.4E-4/d
Source: Old PWR Ultimate source: generic data updated with plant operating experince
Comment: Generic mean 2.7E-4/d. Operating experience 14262 demands, 5 failures.

VCAEI valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close
FAILURE RATE OR PROBABILITY mean : 1.0E-3/d ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: Hourly rate 3.0E-6(EF 10) based on one actuation per month

VCAEJ valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fails to close (causing back leakage)
FAILURE RATE OR PROBABILITY mean : 1.0E-3/d ERROR FACTOR: 3
Source: NUREG 4550, Vol.1,tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: Value used in from IREP Procedure Guide.

VCAES valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fails to prevent flow
FAILURE RATE OR PROBABILITY mean : 1.6E-6/hr
Source: Shoreham PRA,GE data(tb.A.2.1) Ultimate source: evaluation ofBWR operating experience
Comment:

VCAEZ valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to seat/excessive leakage
FAILURE RATE OR PROBABILITY mean : 8.4E-7/d
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant operating experience
Comment: Priors:NUREG 1363 check valve(PWR),internal leakage (mean) and WASH 1400, check valves, reverse leakage (distrib).
Operating experience:6.08E+5 hours of operation, no failures.

VCAOB valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean · 2.0E-7/hr max: 1.0E-6/hr min: 8.0E-8/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion and IREP data
Comment:

VCAOH valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open on demand
FAILURE RATE OR PROBABILITY mean : 1.8E-4/d 95%: 2.8E-4/d 5%: 6.9E-5/d
Source: Old PWR Ultimate source: generic data updater with plant operating expereince
Comment. Generic mean 2.7E-4/d. Operating experience 14262 demands, 2 failures.

VCAOI valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 1.0E-4/d ERROR FACTOR· 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: Hourly rate is 3.0E-7 (EF 10), based on one actuation per month

VCAOJ valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fails to open
FAILURE RATE OR PROBABILITY mean : 1.0E-4/d ERROR FACTOR: 3
Source: NUREG 4550, Vol.1,tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: Generic value developed in Station Blackout Study was used.

VCAOS valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fails to permit flow
FAILURE RATE OR PROBABILITY mean : 1.5E-7/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating experience
Comment:

VCAOW valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY median: 1.0E-4/d 95%: 3.0E-4/d 5%: 3.0E-5/d ERROR FACTOR: 3
Source: WASH 1400 (table III 4-1) Ultimate source: assesed from nuclear, industrial and military expereince and data
Comment:

VCAOZ valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open on demand
FAILURE RATE OR PROBABILITY mean : 4.3E-5/d
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant operating experience
Comment: Prior:NUREG 1363 check valves(PWR),fail to open (mean) and WASH 1400 check valves, fail to oepn (distrib.).
Operating experience:6968 demands, no failures.

VCATW valve self operated check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: rupture Original failure mode: rupture
FAILURE RATE OR PROBABILITY median: 1.0E-8/hr 95%: 1.0E-7/hr 5%: 1.0E-9/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-1) Ultimate source: assesed from nuclear and industrial experience and data
Comment: Rupture is failure mode comparable to external leak.

VCEOG valve self operated check ECCS & RHR systems
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open
FAILURE RATE OR PROBABILITY mean : 7.1E-7/hr ERROR FACTOR: 4
Source: German Risk Study (pg.P3-76) Ultimate source: operating experience
Comment: Operating experience: 1.5E+6 operating hours, no failures. For other check valves combination of generic data sources with failure rate of 2.1E-6/hr (EF 10) was used in FTs.

VCFOV valve self operated check ESF system valves
Component boundary: valve, body and interiors Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 6.4E-5/d 95%: 1.7E-4/d 5%: 1.7E-5/d
Source: NUREG 1363 (1982) (pg.438) Ultimate source: US plants LER reports
Comment: Overall standy hourly failure rate 3.0E-8/hr.

VCF8V valve self operated check ESF systems valves
Component boundary: valve body and interiors Operating mode: all Operating environment: normal
Generic failure mode: internal leak Original failure mode: reverse leakage
FAILURE RATE OR PROBABILITY mean : 5.4E-7/hr 95%: 7.0E-7/hr 5%: 4.1E-7/hr
Source: NUREG 1363 (1982) (pg.442) Ultimate source: US plants LER reports evaluation
Comment: Overall rate. BWR 2 times higher than PWR.

VCFYV valve self operated check ESF systems valves
Component boundary: valve body and interiors Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: leak externally
FAILURE RATE OR PROBABILITY mean : 4.9E-8/hr 95%: 1.0E-7/hr 5%: 1.9E-8/hr
Source: NUREG 1363 (1982) (pg.446) Ultimate source: US plants LER reports
Comment: Overall rate. BWR higher than PWR.

VCAEU valve self operated check applicable to all check valves in safeguard systems and main feed
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close
FAILURE RATE OR PROBABILITY mean : 2.0E-6/hr
Source: Sizewell B (PWR/RX312 pg.4) Ultimate source: assesed from nuclear experience and data
Comment: Assesment based on W data item,literature data, and SRS data item (2.0E-4/d).For monthly tested valves stdby prob. of 2.0E-6/hr gives peak failure prob.of1.4E-3/d what is pessimistic.

VCAOU valve self operated check applicable to all check valves in safeguards system and main feed
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 1.0E-7/hr
Source: Sizewell B (PWR/RX312 pg.4) Ultimate source: assesed from nuclear expereince and data
Comment: Assesment based on 2 W data item,WASH 1400,and SRS data item(PWR) (5.0E-5/d).For monthly tested valves stdby failrate of 1.0E-7/hr gives peak failure rate of 7.2E-5/d.Consistent with other sources

VCS8F valve self operated check diameter betweeen 2 nad 6 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: internal leak Original failure mode: internal leak
FAILURE RATE OR PROBABILITY mean : 5.3E-7/hr 95%: 7.3E-7/hr 5%: 3.9E-7/hr ERROR FACTOR: 1.3 REPAIR TIME: 9 hours
Source: HWR data Ultimate source: HWR operating expreince
Comment: Pop.662. Cum.operating time 51E+6 hours. No.of failures 27.

VCL8F valve self operated check diameter between 12 and 24 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: internal leak Original failure mode: internal leak
FAILURE RATE OR PROBABILITY mean : 6.2E-7/hr 95%: 9.5E-7/hr 5%: 4.1E-7/hr ERROR FACTOR: 1.5 REPAIR TIME: 12 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Pop.343. Cum.operational time 24.4E+6 hours. No.of failures 15.

VCLAF valve self operated check diameter between 12 and 24 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 2.2E-6/hr 95%: 2.8E-6/hr 5%: 1.8E-6/hr ERROR FACTOR: 1.2 REPAIR TIME: 12 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.343.Cum.operating time 24.4E+6 hours.No of failures 54."All modes"include: 1)fail to open,2)fail to close,3)external,4)intern leak,5)unspecified.1)completely negligable(no failures occuring)

VCLEF valve self operated check diameter between 12 and 24 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close
FAILURE RATE OR PROBABILITY mean : 1.2E-7/hr 95%: 3.2E-7/hr 5%: 5.7E-8/hr ERROR FACTOR: 2.1 REPAIR TIME: 19 hours
Source: HWR data Ultimate source: HHW operating experiece
Comment: Pop.343.Cum.operating time 24.4E+6 hours.No.of failures 3.No.of demands in cumulative component operating time is not known.

VCLYF valve self operated check diameter between 12 and 24 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leak
FAILURE RATE OR PROBABILITY mean : 9.8E-7/hr 95%: 1.4E-6/hr 5%: 7.1E-7/hr ERROR FACTOR: 1.4 REPAIR TIME: 8 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.343.Cum.operating time 24.4E+6 hours. No.of failures 24.

VCSAF valve self operated check diameter between 2 and 6 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.3E-6/hr 95%: 1.6E-6/hr 5%: 1.0E-6/hr ERROR FACTOR: 1.2 REPAIR TIME: 8 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.662. Cum.operating time 51E+6 hours. 67 failures. "All modes" include:1)fail to open,2)fail to close,3)external leak,4)internal leak,5)unspecified.1)is negligable(no failures recorded)

VCSEF valve self operated check diameter between 2 and 6 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close
FAILURE RATE OR PROBABILITY mean : 1.1E-7/hr 95%: 2.2E-7/hr 5%: 6.8E-8/hr ERROR FACTOR: 1.8 REPAIR TIME: 6 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.662.Cum.operating time 51E+6 hours.6 failures. No.of demands in cumulative opearting time is not known.

VCSOF valve self operated check diameter between 2 and 6 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open
FAILURE RATE OR PROBABILITY mean : 1.9E-8/hr 95%: 9.2E-8/hr 5%: 6.8E-9/hr ERROR FACTOR: 2.8 REPAIR TIME: 6 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.662.Cum.operating time 51E+6 hours. 1 failure. No.of demands in cumulative operational time not known.

VCSYF valve self operated check diameter between 2 and 6 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leak
FAILURE RATE OR PROBABILITY mean : 2.1E-7/hr 95%: 3.5E-7/hr 5%: 1.3E-7/hr ERROR FACTOR: 1.6 REPAIR TIME: 8 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.662.Cum.operating time 51E+6 hours.No.of failures 11.

VCT8F valve self operated check diameter between 6 and 12 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: internal leak Original failure mode: internal leak
FAILURE RATE OR PROBABILITY mean : 4.5E-7/hr 95%: 7.1E-7/hr 5%: 3.0E-7/hr ERROR FACTOR: 1.5 REPAIR TIME: 13 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.390. Cumulative component operating time 29E+6 hours. No.of failures 13.

VCTAF valve self operated check diameter between 6 and 12 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 1.8E-6/hr 95%: 2.3E-6/hr 5%: 1.5E-6/hr ERROR FACTOR: 1.2 REPAIR TIME: 12 hours
Source: HWR data Ultimate source: HWR operating expreince
Comment: Pop.390.Cum.operating time 29E+6 hours. No.of failures 53. "All modes" include:1)fail to open,2)fail to close,3)external leak, 4)internal leak,5)unspecified.1)completely negligable(no failure)

VCTEF valve self operated check diameter between 6 and 12 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close
FAILURE RATE OR PROBABILITY mean : 1.4E-7/hr 95%: 3.2E-7/hr 5%: 6.8E-8/hr ERROR FACTOR: 2 REPAIR TIME: 6 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.390. Cumulative component operating time 29E+6 hours. No.of failures 4.Number of demands per operational time is not known.

VCTYF valve self operated check diameter between 6 nad 12 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leak
FAILURE RATE OR PROBABILITY mean : 7.2E-7/hr 95%: 1.2E-6/hr 5%: 5.9E-7/hr ERROR FACTOR: 1.4 REPAIR TIME: 12 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.390. Cumulative component operational time 29E+6 hours. No.of failures 24.

VCHAF valve self operated check diameter larger than 24 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 3.6E-6/hr 95%: 6.2E-6/hr 5%: 2.1E-6/hr ERROR FACTOR: 1.6 REPAIR TIME: 10 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.48. Cumulative component operating time 2.52E+6 hours.9 failures. "all modes" include 1)external leak, 2)unspecified.

VCHYF valve self operated check diameter larger than 24 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leak
FAILURE RATE OR PROBABILITY mean : 2.0E-6/hr 95%: 4.2E-6/hr 5%: 1.0E-6/hr ERROR FACTOR: 1.9 REPAIR TIME: 13 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.48. Cumulative component operating time 2.52E+6 hours. 5 failures.

VCB8F valve self operated check diameter less than 2 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: internal leak Original failure mode: internal leak
FAILURE RATE OR PROBABILITY mean : 1.3E-7/hr 95%: 1.8E-7/hr 5%: 8.0E-8/hr ERROR FACTOR: 1.4 REPAIR TIME: 5 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.1907.Cum.operating time 1.4E+8 hours.No.of failures 17.

VCBAF valve self operated check diameter less than 2 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 3.7E-7/hr 95%: 4.6E-7/hr 5%: 2.9E-7/hr ERROR FACTOR: 1.2 REPAIR TIME: 6 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.1907.Cum.operating time 1.4E+8 hours. 51 failures. Failure mode include:1)fail to open,2)fail to close,3)external leak,4) internal leak,5)unspecified.Contribution of 1)extremly low.

VCBEF valve self operated check diameter less than 2 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close
FAILURE RATE OR PROBABILITY mean : 3.4E-8/hr 95%: 6.8E-8/hr 5%: 1.1E-8/hr ERROR FACTOR: 2 REPAIR TIME: 4 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.1907.Cum.operating time 1.4E+8 hours. No.of failures 4. No.of demands not known.

VCBOF valve self operated check diameter less than 2 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open
FAILURE RATE OR PROBABILITY mean : 6.8E-9/hr 95%: 3.4E-8/hr 5%: 2.3E-9/hr ERROR FACTOR: 3.0 REPAIR TIME: 4 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.1907.Cum.operating time 1.4E+8 hours.No.of failure 1. No.of demands not known.

VCBYF valve self operated check diameter less than 2 inches
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: leakage/external leak Original failure mode: external leak
FAILURE RATE OR PROBABILITY mean : 4.6E-8/hr 95%: 8.0E-8/hr 5%: 2.3E-8/hr ERROR FACTOR: 1.8 REPAIR TIME: 4 hours
Source: HWR data Ultimate source: HWR operating experience
Comment: Pop.1907.Cum.operating time 1.4E+8 hours. No.of failures 6.

VCMEH valve self operated check main steam check valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close on demand
FAILURE RATE OR PROBABILITY mean : 2.4E-4/d 95%: 4.7E-4/d 5%: 5.2E-5/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 2.7E-4/d. Operating experience 378 demands, no failures.

VCJET valve self operated check pipe dimension > 100mm
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close
FAILURE RATE OR PROBABILITY mean : 3.4E-3/d 95%: 1.9E-2/d REPAIR TIME: 9 hours
Source: Swedish Rel.data book, tbl.19 Ultimate source: plant operating experience(7 BWR plants), ATV reports, LERs
Comment: Total pop.168.No.of demands per operational time 3211.No.of failures 11. a=0.0568; b=16.5 Critical falures reportd at 5 plants.

VCSCT valve self operated check pipe dimension 500mm, 600 mm (main steam system)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to change position
FAILURE RATE OR PROBABILITY mean : 3.2E-3/d 95%: 1.9E-2/d
Source: Swedish Rel.data book, tbl.15 Ultimate source: plant operating experience(6 BWR plants), ATV reports, LERs
Comment: Total pop.24.Number of demands per operational time 632. No. of failures 2. a=0.09; b=28.3
Critical failures reported on one plant only.

VCIET valve self operated check pipe dimension <=100 mm
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close
FAILURE RATE OR PROBABILITY mean : 5.5E-4/d REPAIR TIME: 12 hours
Source: Swedish Rel.data book, tbl.18 Ultimate source: plant operating experience (7 BWR plants), ATV reports, LERs
Comment: Total pop.417.No.of demands per operational time 3628.No of failures 2.a=0.0129; b=23.3 Critical failures at one plant only.
No failure to open observed out of 3628 demands.

VCJOT valve self operated check pipe dimension > 100 mm
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 6.3E-4/d REPAIR TIME: 9 hours
Source: Swedish Rel.data book, tbl.19 Ultimate source: plant operating experience (7 BWR plants), ATV reports, LERs
Comment: Total pop.168. No.of demands per operational time 3211. No of failures 1.a=0.071; b=11.2 Critical failure at one plant only.
Ringhals 2 PWR- no failure to open out of 1844 demands.

VCUDO valve self operated check stop check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer closed
FAILURE RATE OR PROBABILITY mean : 1.8E-7/hr 95%: 5.2E-7/hr 5%: 6.7E-9/hr
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience.
Comment: Prior: WASH 1400 failure of MOV to remain open.5%=20%;95%=80%.Per demand rate converted to hrly rate assuming 1 demand in 45 days
Operating experience:3.42E+5 hours of operation, no failures.

VCUEO valve self operated check stop check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close
FAILURE RATE OR PROBABILITY mean : 1.6E-4/d 95%: 3.4E-4/d 5%: 3.3E-5/d
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior: NUREG 1363,check valve failure to close on demand Operating experience: 321 demand, 1 failure.
95%/5% ratio is 10, indicating moderate degree of uncertanty.

VCUOI valve self operated check stop check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 1.0E-4/d ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

VCUOO valve self operated check stop check
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 9.9E-5/d 95%: 2.2E-4/d 5%: 2.1E-5/d
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior: NUREG 1363 check valve failure to open on demand Operating experience: 251 demand, no failures.
95%5% ratio is 10, indicating moderate degree of unceratnty

VCWDO valve self operated check swing
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer closed
FAILURE RATE OR PROBABILITY mean : 2.0E-7/hr 95%: 6.0E-7/hr 5%: 6.9E-9/hr
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating expeirience
Comment: Prior:WASH 1400 failure of MOV to remain open.5%=20%; 95%=80%.Per demand rate converted to hrly rate assuming 1 demand in 45 days
Operating experience:1.48E+5 hours of operation, no failuires.

VCWEO valve self operated check swing
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close
FAILURE RATE OR PROBABILITY mean : 9.8E-5/d 95%: 2.1E-4/d 5%: 2.0E-5/d
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:NUREG 1363, check valve failure to close on demand. Operating experience: 426 demands, no failures
95%/5% ratio is 10 indicating moderate degree of uncertanty.

VCWOO valve self operated check swing
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 9.8E-5/d 95%: 2.1E-4/d 5%: 2.0E-5/d
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:NUREG 1363, check valve failure to open on demand. Operating experience: 427 demands, no failures.
95%/5% ratio is 10 indicating moderate degree of unceratnty.

VCNES valve self operated check testable check valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fails to prevent flow
FAILURE RATE OR PROBABILITY mean : 2.2E-6/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating experience
Comment:

VCZDO valve self operated check tilting disc check valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer closed
FAILURE RATE OR PROBABILITY mean : 1.9E-7/hr 95%: 5.7E-7/hr 5%: 6.8E-9/hr
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior: WASH 1400,failure of MOV to remain open.5%=20%;95%=80%.Per demand rate converted to hrly rate assuming 1 demand in 45 days
Operating experience: 2.39E+5 hours of operation, no failures.

VCZEO valve self operated check tilting disc check valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close
FAILURE RATE OR PROBABILITY mean : 1.3E-4/d 95%: 2.7E-4/d 5%: 3.0E-5/d
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior: NUREG 1363, check valve failure to close on demand. Operating experience: 2719 demands, 1 failure.
95%/5% ratio is 10 indicating moderate degree of unceratnty.

VCZOO valve self operated check tilting disc check valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 8.7E-5/d 95%: 1.7E-4/d 5%: 1.9E-5/d
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior: NUREG 1363,check valve failure to open on demand Operating experience: 2707 demands, no failures.
95%/5% ratio is 10 indicating moderate degree of uncertanty.

VCNOS valve self operated check valve testable check valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fails to permit flow
FAILURE RATE OR PROBABILITY mean : 2.2E-7/hr
Source: Shoreham PRA,GE data(tb.A.2-1) Ultimate source: evaluation of BWR operating experience
Comment:

VSCEB valve self operated code safety valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close, given open
FAILURE RATE OR PROBABILITY mean : 2.0E-5/hr max: 2.0E-4/hr min: 8.0E-6/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion and IREP data
Comment: Aplies to PWR only

VSCEI valve self operated code safety valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close, given open
FAILURE RATE OR PROBABILITY mean : 1.0E-2/d ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: applies to PWR only

VSCOB valve self operated code safety valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 6.0E-7/hr max: 4.0E-5/hr min: 3.0E-6/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion and IREP data
Comment: applies to PWR only. Premature opening covered under initiating events

VSCOI valve self operated code safety valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 1.0E-5/d ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: Applies to PWR only. Premature opening is treated as an initiating event.

VWKCG valve self operated pilot valve
Component boundary: detail n/a Operating mode: closed Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to open or to close
FAILURE RATE OR PROBABILITY median: 4.0E-3/d ERROR FACTOR: 6
Source: German Risk Study (tb.F3,7-1) Ultimate source: operating experience
Comment: Operating experience: 60 test and 80 operational demands no failures .

VSDEO valve self operated pressurizer safety valve short inlet piping
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close
FAILURE RATE OR PROBABILITY mean : 4.8E-3/d 95%: 1.0E-2/d 5%: 1.1E-3/d
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:Median,failure to reclose(steam relief) Babcock&Wilcox Co. Distribution based on EPRI test.
Operating experience: 10 deamnds, no failure. ONLY STEAM RELIEF

VSDOO valve self operated pressurizer safety valve short inlet piping
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 2.7E-4/d 95%: 8.0E-4/d 5%: 7.4E-6/d
Source: Oconee NPP PRA (tbl.b-1.) Ultimate source: generic data updated with plant specific operating experience
Comment: Prior:Median of General Atomic data base (GCR) for primary relief valves, range factor 10.
Operating experience: 10 demands, no falures.

VSBEB valve self operated primary safety valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close,given open
FAILURE RATE OR PROBABILITY mean : 2.0E-5/hr max: 2.0E-4/hr min: 8.0E-6/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion and IREP data
Comment: applies to BWR only

VSBEI valve self operated primary safety valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close,given open
FAILURE RATE OR PROBABILITY mean : 3.0E-2/d ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: aplies to BWR only

VSBOB valve self operated primary safety valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 2.0E-5/hr max: 2.0E-4/hr min: 8.0E-6/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion and IREP data
Comment: applies to BWR only

VSBOI valve self operated primary safety valves
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 1.0E-5/d ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: applies to BWR only

VRADG valve self operated relief
Component boundary: detail n/a Operating mode: closed Operating environment: normal
Generic failure mode: fail to remain in position* Original failure mode: spourious opening
FAILURE RATE OR PROBABILITY mean : 3.6E-6/hr ERROR FACTOR: 7
Source: German Risk Study (pg.F3-83) Ultimate source: generic data
Comment: Failure rate is combination of several generic data sources.

VRSDZ valve self operated relief/safety
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: premature opening or leakage
FAILURE RATE OR PROBABILITY mean : 1.6E-6/hr
Source: ZION NPP PSS (tbl.1.5.1-5) Ultimate source: generic data updated with plant operating experience
Comment: Priors:NUREG 1363 safety valves(PWR),premature opening (mean) and WASH 1400 relief valves, premature opening (distrib.).
Operating experience: 6.19E+5 hours of operation, 2 failures.

VSMEH valve self operated safety main steam
Component boundary: detail n/a Operating mode: closed Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close on demand
FAILURE RATE OR PROBABILITY mean : 2.6E-3/d 95%: 7.1E-3/d 5%: 8.8E-5/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 2.9E-3/d.Operating experience 10 demands, no failures.

VSMOH valve self operated safety main steam
Component boundary: detail n/a Operating mode: closed Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open on demand
FAILURE RATE OR PROBABILITY mean : 3.3E-4/d 95%: 1.1E-3/d 5%: 1.3E-5/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 3.3E-4/d. Operating experience 10 demands, no failures.

VSAEU valve self operated safety relief valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close
FAILURE RATE OR PROBABILITY mean : 7.0E-7/hr
Source: Sizewell B (PWR/RX312 pg.5) Ultimate source: assesed from nuclear experience and data
Comment: Assesment based on W data item and SRS data applicable to SRVs, (6.0E-3/d).If SRV are tested yearly stdby failrate of 7.0E-7/hr
gives the peak probability of 6.1E-3/d,what is pessimistic.

VVAEJ valve self operated safety relief valve BWR General Electric
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fails to open
FAILURE RATE OR PROBABILITY mean : 1.0E-5/d ERROR FACTOR: 3
Source: NUREG 4550, Vol.1,tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources
Comment: Value used is taken from IREP Procedures Guide.

VSPDV valve self operated safety valves PWR
Component boundary: valve body and internals, operating mechanism Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: premature open
FAILURE RATE OR PROBABILITY mean : 3.4E-6/hr 95%: 5.4E-6/hr 5%: 2.0E-6/hr
Source: NUREG 1363 (1982) (pg.468) Ultimate source: US plants LER reports evaluation
Comment:

VSPOV valve self operated safety valves PWR
Component boundary: valve body and internals, operating mechanism Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open
FAILURE RATE OR PROBABILITY mean : 3.9E-3/d 95%: 7.4E-3/d 5%: 1.8E-3/d
Source: NUREG 1363 (1982) (pg.465) Ultimate source: US plants LER reports evaluation
Comment: Overall data.Standby hourly rate is 1.7E-6/hr. Demand rate is taking into account 5 years test interval,and operational demands in observed period (demand=1/2 of all forced scrams,PWR)

VVAEB valve self operated vacuum breaker
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close
FAILURE RATE OR PROBABILITY mean : 6.0E-8/hr max: 4.0E-7/hr min: 2.0E-8/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion and IREP data
Comment: applies to BWR only

VVAEI valve self operated vacuum breaker
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to close
FAILURE RATE OR PROBABILITY mean : 1.0E-5/d ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: applies only to BWR

VVAOB valve self operated vacuum breaker
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 6.0E-8/hr max: 4.0E-7/hr min: 2.0E-8/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion and IREP data
Comment: aplies to BWR only

VVAOI valve self operated vacuum breaker
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: failure to open
FAILURE RATE OR PROBABILITY mean : 1.0E-5/d ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: applies only to BWR

VVACW valve self operated vacuum valve
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY median: 3.0E-5/d 95%: 1.0E-4/d 5%: 1.0E-5/d ERROR FACTOR: 3
Source: WASH 1400 (table III 4-1) Ultimate source: assesed from industrial and military experience ana data
Comment: Failure to operate include changing state fron closed to open or from open to closed position.

VCUEG valve self operated (motor operated) check stop check
Component boundary: including operator Operating mode: standby Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close
FAILURE RATE OR PROBABILITY mean : 7.4E-6/hr ERROR FACTOR: 4
Source: German Risk Study (pg.F3-78) Ultimate source: generic data and operating experience
Comment: In FTs this component is included for isolation of accumulators. Operating experience for electrical operator part of valve gives failure rate of 4.3E-6/hr.

VCUOG valve self operated (motor operated) check stop check
Component boundary: without operator (motor) Operating mode: standby Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open
FAILURE RATE OR PROBABILITY median: 1.5E-6/hr ERROR FACTOR: 10
Source: German Risk Study (tb.F3,7-1) Ultimate source: generic data sources
Comment: In FTs this component is included for isolation of accumulators. Principal reference NPRDS annual report 1976.

VCU8G valve self operated (motor operated) stop check
Component boundary: detail n/a Operating mode: standby Operating environment: normal
Generic failure mode: internal leak Original failure mode: internal leakage
FAILURE RATE OR PROBABILITY median: 1.0E-5/hr ERROR FACTOR: 10
Source: German Risk Study (tb.F3,7-1) Ultimate source: generic data
Comment: It is assumed that stop check valve is somewhat better in terms of probability of internal leak than regular check valve. Failure rate is combination of several generic sources.

VSADG valve self operated (pilot operated) safety
Component boundary: detail n/a Operating mode: closed Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: spourious opening
FAILURE RATE OR PROBABILITY median: 2.0E-6/hr ERROR FACTOR: 7
Source: German Risk Study (tb.F3,7-1) Ultimate source: generic data
Comment: Failure rate is combination of several generic data sources.

VSRDT valve self operated (pilot operated) safety valve (pressure relief system) pipe dimensions 125,150,300 mm
Component boundary: Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position* Original failure mode: spourious opening
FAILURE RATE OR PROBABILITY mean : 1.3E-6/d 95%: 7.5E-6/d REPAIR TIME: 9 hours
Source: Swedish Rel.data book, tbl.22 Ultimate source: plant operating experience (7 BWR plants)
Comment: Critical failures reported on 2 plants. Spurious opening include all detected leakages at power. Operatin
expereicne data for this failure mode n/a.

VSRET valve self operated (pilot operated) safety valve (pressure relief system) pipe dimensions 125,150,300 mm
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: failure to reclose
FAILURE RATE OR PROBABILITY mean : 2.4E-3/d 95%: 7.2E-3/d REPAIR TIME: 9 hours
Source: Swedish Rel.data book, tbl.22 Ultimate source: plant operating experience (BWR plants), ATV reports, LERs
Comment: Total pop.126.No.of demands 1281.No.of failures 2. Pilot valve see "vwket". a=0.0232; b=9.67
Critical failures reported on 2 plants.

VRRCG valve self operated (pilot or power operated) pressurizer relief
Component boundary: detail n/a Operating mode: closed Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to open or to close
FAILURE RATE OR PROBABILITY median: 4.0E-3/d ERROR FACTOR: 6
Source: German Risk Study (tb.F3,7-1) Ultimate source: operating experience
Comment: Generic data seems not to be applicable due to different types and failure modes.

VWMCT valve self operated, motor operated (redundant closure) stop check pipe dimension 500mm, 600mm (main steam system valve)
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to change position
FAILURE RATE OR PROBABILITY mean : 2.5E-2/d 95%: 7.7E-2/d REPAIR TIME: 4 hours
Source: Swedish Rel.data book, tbl.14 Ultimate source: plant operating experience (6 BWR plants),ATV reports, LERs
Comment: Total pop.24. No.of demands per operational time 632. No.of failures 16.Fail.mostly related to open/close oper.by motor.Press
clsing fction 10 times more reliable.a=0937;b=36.1.Crit f.at 5 pl

VDODH valve solenoid operated all systems, except HVAC
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer closed
FAILURE RATE OR PROBABILITY mean : 8.7E-7/hr 95%: 2.0E-6/hr 5%: 1.0E-7/hr
Source: Old PWR Ultimate source: generic data updated with plant operating expereince
Comment: Generic mean 1.3E-6/hr. Operating experience 8.1E+5 hours of operation, no failures.

VDOEH valve solenoid operated all systems, except HVAC
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close on demand
FAILURE RATE OR PROBABILITY mean : 1.7E-3/d 95%: 2.9E-3/d 5%: 5.5E-4/d
Source: Old PWR Ultimate source: generic data updated with plant operating expereince
Comment: Genreic mean 2.4E-3/d. Operating experience 2263 demands, 4 failures.

VDOOH valve solenoid operated all systems, except HVAC
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open on demand
FAILURE RATE OR PROBABILITY mean : 1.0E-3/d 95%: 1.7E-3/d 5%: 2.4E-4/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 2.4E-3/d. Operating expereince 2263 demands, 2 failures.

VDHDH valve solenoid operated used in HVAC
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to remain in position Original failure mode: transfer closed
FAILURE RATE OR PROBABILITY mean : 7.9E-7/hr 95%: 2.2E-6/hr 5%: 4.5E-8/hr
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 1.3E-6/hr. Operating experience 2.4E+5 hours of operation , no failures.

VDHEH valve solenoid operated used in HVAC
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to close Original failure mode: fail to close on demand
FAILURE RATE OR PROBABILITY mean : 8.0E-4/d 95%: 1.7E-3/d 5%: 7.6E-5/d
Source: Old PWR Ultimate source: generic data updated with plant operating experience
Comment: Generic mean 2.4E-3/d. Operating experience 538 demands, no failures.

VDHOH valve solenoid operated used in HVAC
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to open Original failure mode: fail to open on demand
FAILURE RATE OR PROBABILITY mean : 7.4E-3/d 95%: 1.2E-2/d 5%: 3.7E-3/d
Source: Old PWR Ultimate source: generic data updated uith plant operating expereince
Comment: Generic mean 2.4E-3/d. Operating experience 538 demands, 5 failures.

VDAAF valve solenoid operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: all modes Original failure mode: all modes
FAILURE RATE OR PROBABILITY mean : 2.7E-7/hr 95%: 3.5E-7/hr 5%: 2.1E-7/hr ERROR FACTOR: 1.3 REPAIR TIME: 5 hours
Source: HWR data Ultimate source: HWR operating expereince
Comment: Pop.2635.Cum.operating time 145.2E+6 hours.39 failures."All modes incl:1)passing,2)plugged,3)faulty operation,4)unspecified.Contrib of 4)is dominant, other about equal (6 times lower)

VDACB valve solenoid operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 2.0E-6/hr max: 1.0E-5/hr min: 8.0E-7/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert opinion and IREP data
Comment:

VDACG valve solenoid operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: fail to open or to close
FAILURE RATE OR PROBABILITY mean : 3.7E-5/hr ERROR FACTOR: 20
Source: German Risk Study (pg.P3-75) Ultimate source: generic data
Comment: There is no specific operating experience data for this component and failure rate is combination of several generic data sources (6).

VDACI valve solenoid operated general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to operate
FAILURE RATE OR PROBABILITY mean : 1.0E-3/d ERROR FACTOR: 3
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment:

VDACJ valve solenoid operated general

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: fail to change position Original failure mode: fails to operate

FAILURE RATE OR PROBABILITY mean : 1.0E-3/d ERROR FACTOR: 3

Source: NUREG 4550, Vol.1,tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources

Comment: Same value as for air operated valve. Two types of failures included in the failure rate: valve hardware fault (1.0E-3) and command circut faults (1.0E-4).

VDACW valve solenoid operated general

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: fail to change position Original failure mode: failure to operate

FAILURE RATE OR PROBABILITY median: 1.0E-3/d 95%: 3.0E-3/d 5%: 3.0E-4/d ERROR FACTOR: 3

Source: WASH 1400 (table III 4-1) Ultimate source: assesed from nuclear,industrial and military experience and data

Comment: Based on presence of proper input signal Failure of a valve to operate include changing state from closed to open or fron open to closed position.

VDADW valve solenoid operated general

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: fail to remain in position Original failure mode: failure to remain open(plug)

FAILURE RATE OR PROBABILITY median: 1.0E-4/d 95%: 3.0E-4/d 5%: 3.0E-5/d ERROR FACTOR: 3

Source: WASH 1400 (table III 4-1) Ultimate source: ultimate data source not known

Comment: Failure to remain open refers to reduction of flow to unusable level due to foreign material or gate failure.Not included in data is inadvertant or false signal driving valve closed.

VDATW valve solenoid operated general

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: rupture Original failure mode: rupture

FAILURE RATE OR PROBABILITY median: 1.0E-8/hr 95%: 1.0E-7/hr 5%: 1.0E-9/hr ERROR FACTOR: 10

Source: WASH 1400 (table III 4-1) Ultimate source: ultimate data source not known

Comment:

VDAYJ valve solenoid operated general

Component boundary: detail n/a Operating mode: all Operating environment: normal

Generic failure mode: leakage/external leak Original failure mode: fails from plugging

FAILURE RATE OR PROBABILITY mean : 4.0E-5/d ERROR FACTOR: 3

Source: NUREG 4550,Vol.1,tbl.VIII.1-2 Ultimate source: assesed from several nuclear data sources

Comment: The same value as for air operated valve. Value is based on NRC LER data summary (1.0E-7/hr) assuming one month (720 hrs) test interval.

VDNCT valve solenoid operated general (normally activated)
Component boundary: detail n/a Operating mode: normally activated Operating environment: normal
Generic failure mode: fail to change position Original failure mode: failure to function
FAILURE RATE OR PROBABILITY mean : 7.1E-7/hr 95%: 3.7E-6/hr REPAIR TIME: 3 hours
Source: Swedish Rel.data book, tbl.23 Ultimate source: plant operating experience (7 BWR plants), ATV reports, LERs
Comment: Total pop.513.Operating time 2260E+4 hours. No.of failures 16. Critical failures reported on 2 plants.
a=0.0487; b=68600

CWCGW wire control circut wire typical circut, several joints
Component boundary: wire section wth soldered and lug connection to comp.& term board Operating mode: all Operating environment: normal
Generic failure mode: short to ground Original failure mode: short to ground
FAILURE RATE OR PROBABILITY median: 3.0E-7/hr 95%: 3.0E-6/hr 5%: 3.0E-8/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-2) Ultimate source: assesed form nuclear, industrial exeprience and expert opinion
Comment: Data do not permit a unique separation of failure modes in all cases; hence failure modes listed for wires and terminal boards
are not necesary independent, and should not be combined.

CWCHW wire control circut wire typical circut, several joints
Component boundary: wire section with soldered and lug connection to comp.& term.boar Operating mode: all Operating environment: normal
Generic failure mode: short circut Original failure mode: short to power
FAILURE RATE OR PROBABILITY median: 1.0E-8/hr 95%: 1.0E-7/hr 5%: 1.0E-9/hr ERROR FACTOR: 10
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from industrial experience and expert opinion
Comment: Data do not permit a unique separation of failure modes in all cases; hence failure modes listed for wires and terminal boards
are not necesary indpendent, and should not be combined.

CWCIW wire control circut wire typical circut, several joints
Component boundary: wire section with soldered and lug connection to comp.&term.board Operating mode: all Operating environment: normal
Generic failure mode: open circut Original failure mode: open circut
FAILURE RATE OR PROBABILITY median: 3.0E-6/hr 95%: 1.0E-5/hr 5%: 1.0E-6/hr ERROR FACTOR: 3
Source: WASH 1400 (table III 4-2) Ultimate source: assesed from industrial,nuclear experience, expert opinion
Comment: Data do not permit a unique separation of failure modes in all cases; hence failure modes listed for wires and terminal boards
are not necessary independent, and should not be combined

CWAGB wire general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: short to ground Original failure mode: short to ground
FAILURE RATE OR PROBABILITY mean : 1.0E-6/hr max: 5.0E-6/hr min: 2.0E-8/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment:

CWAGI wire general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: short to ground Original failure mode: short to ground
FAILURE RATE OR PROBABILITY mean : 3.0E-7/hr ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: Given value is per circut Given value is consistent with IEEE 500 data for 1000 ft circut

CWAHB wire general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: short circut Original failure mode: short to power
FAILURE RATE OR PROBABILITY mean : 3.0E-8/hr max: 2.0E-7/hr min: 6.E-10/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment:

CWAHI wire general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: short circut Original failure mode: short to power
FAILURE RATE OR PROBABILITY mean : 3.0E-8/hr ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: Given value is per circut Given value is consistent with IEEE 500 data for 1000 ft circut

CWAIB wire general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: open circut Original failure mode: open circut
FAILURE RATE OR PROBABILITY mean : 1.0E-5/hr max: 5.0E-5/hr min: 2.0E-7/hr
Source: NUREG 2815 (table C.1.) Ultimate source: expert judgement and IREP data
Comment:

CWAII wire general
Component boundary: detail n/a Operating mode: all Operating environment: normal
Generic failure mode: open circut Original failure mode: open circut
FAILURE RATE OR PROBABILITY mean : 3.0E-6/hr ERROR FACTOR: 10
Source: IREP NUREG 2728 (tb.5.1-1) Ultimate source: expert opinion
Comment: Given value is per circut Given value is consistent with IEEE 500 data for 1000 ft circut

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