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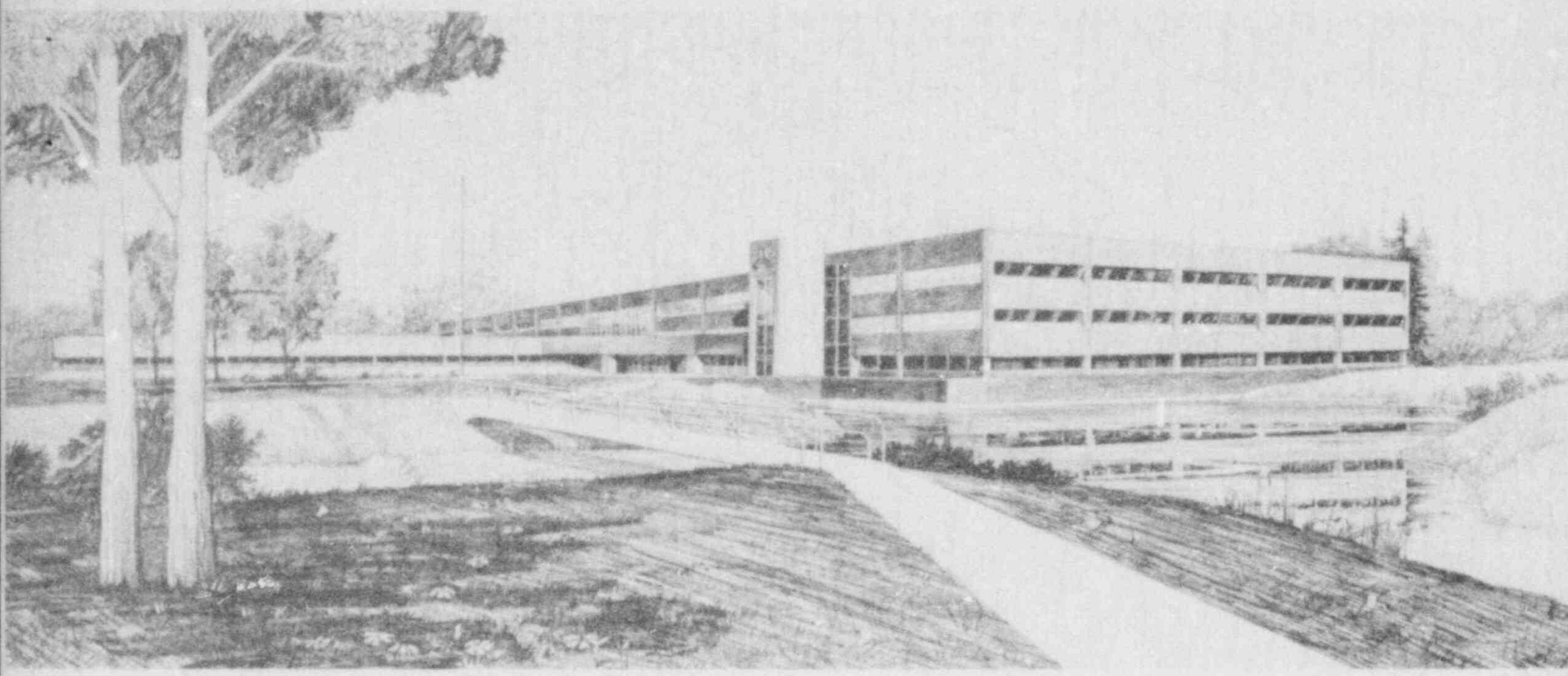

Idaho National Engineering Laboratory
Operated by the U.S. Department of Energy

# Data Summaries of Licensee Event Reports of Inverters at U.S. Commercial Nuclear Power Plants January 1, 1976 to December 31, 1982

Sharon R. Brown
Mike Trojovsky

August 1984



Prepared for the
U.S. Nuclear Regulatory Commission
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# DATA SUMMARIES OF LICENSEE EVENT REPORTS OF INVERTERS AT U.S. COMMERCIAL NUCLEAR POWER PLANTS JANUARY 1, 1976 TO DECEMBER 31, 1982

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Published August 1984

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# ABSTRACT

This report describes a computer-based data file developed from Licensee Event Reports (LERs) of inverters in U.S. commercial nuclear power plants for the period January 1, 1976 to December 31, 1982. In addition to the creation of the file, summaries of data contained in the file were made to obtain data for risk assessment and statistical purposes. Gross constant failure rates were estimated for inverters found in selected systems. Explanations, figures, and summary tables of the results are provided.

FIN No. A6393—Data Development and Evaluation

# SUMMARY

The Reliability and Statistics Branch of EG&G Idaho, Inc. reviewed Licensee Event Reports (LERs), both qualitatively and quantitatively, to extract reliability information, in support of the United States Nuclear Regulatory Commission's (USNRC's) effort to gather and analyze fault (failure and command fault) data concerning nuclear power plants. LERs submitted by the utilities to the USNRC from January 1, 1976 through December 31, 1982 pertaining to inverters, are the source of information used in this report. For the seven year period covered by this report, 21,424 LERs were manually screened and 145 were deemed as appropriate inverter events for this report. From the 145 applicable LERs, 161 one-line descriptions (involving 177 faults) were derived and entered into a data base. Of the 177 faults, 166 (94%) were classified as actual failures. The remaining 11 were identified as being command faults.

A computerized data base of component/system operational experiences categorized by standard reliability characteristics was developed to provide an efficient and accurate way of retrieving and sorting the various reliability data. In addition to developing a data base, summaries of data contained in the file were made to obtain data for risk and statistical purposes. Gross constant failure rates were estimated for inverters found in selected systems. Explanations, figures, and summary tables of the results are provided.

The greatest majority of the inverter events reported described catastrophic failures of inverters (no output or inoperable). The fault mode reduced capability (operational but at a reduced capacity) was considered; however, only a few inverters exhibited this mode.

In PWR plants the essential ac electrical distribution system experienced most of the inverter faults, while in BWR plants the low pressure coolant injection system experienced most of the inverter faults. The overall failure rate calculated for inverters found in the essential ac distribution and low pressure coolant injection systems that experienced the fault mode inoperable was 1E-5 failures per hour.

The component faults and failure rates summarized in this report should be interpreted as tentative gross indicators of true fault trends and failure rates. Because subjective judgments had to be made regarding pertinence of recorded events, and because some component faults may not be recorded in the LERs, the individual analyst should confirm the applicability of the component faults and failure rates for their specific uses.

## FOREWORD

This report is one in a series summarizing the statistics of Licensee Event Reports (LERs) as recorded by the United States Nuclear Regulatory Commission (USNRC). The goal of the report is twofold: (a) to summarize the data for risk and statistical analyses, and (b) to obtain gross constant failure rate estimates.

Owing to the subjective judgments that had to be made regarding population sizes and pertinence of recorded events, and because some component faults may not be recorded in the LERs, the component failure rates estimated in this report should be interpreted as being only tentative gross indicators of the true failure rates. Furthermore, because LER reporting requirements can differ from plant to plant, comparisons of plant-to-plant failure rates should be interpreted with care; a higher failure rate may simply be because of stricter reporting requirements. The analyst must validate the applicability of the LER-derived failure rates for specific uses. As more data are collected and more analyses are performed in the future, improved failure rate estimates will be produced.

Failure rates are only one of many kinds of information presented in this report. Tables and discussions classify faults according to fault modes, fault causes, and systems affected. Gross time trends are examined. Human errors are identified as are common cause and recurring faults. Each LER analyzed is presented in a useful, summarized form, and all evaluations are presented so that analysts can modify the authors' calculations or perform their own evaluations if so desired.

R. C. Robinson
USNRC Project Manager
February 1984

The previous reports in this series of data summaries of the Licensee Event Reports are:

1. W. H. Hubble and C. F. Miller, *Data Summaries of Licensee Event Reports of Control Rods and Drive Mechanisms at U.S. Commercial Nuclear Power Plants January 1, 1972 to April 30, 1978*, NUREG/CR-1331, February 1980.

2. J. P. Poloski and W. H. Sullivan, *Data Summaries of Licensee Event Reports of Diesel Generators at U.S. Commercial Nuclear Power Plants January 1, 1976 to December 31, 1978*, NUREG/CR-1362, March 1980.

3. D. W. Sams and M. Trojovsky, *Data Summaries of Licensee Event Reports of Primary Containment Penetrations at U.S. Commercial Nuclear Power Plants January 1, 1976 to December 31, 1978*, NUREG/CR-1730, September 1980.

4. M. Trojovsky, *Data Summaries of Licensee Event Reports of Pumps at U.S. Commercial Nuclear Power Plants January 1, 1972 to September 30, 1980*, NUREG/CR-1205, Revision 1, January 1982.

5. C. F. Miller et al., *Data Summaries of Licensee Event Reports of Valves at U.S. Commercial Nuclear Power Plants January 1, 1976 to December 31, 1980*, NUREG/CR-1363, Revision 1, October 1982.

6. M. Trojovsky and S. R. Brown, *Data Summaries of Licensee Event Reports of Selected Instrumentation and Control Components at U.S. Commercial Nuclear Power Plants January 1, 1976 to December 31, 1981*, NUREG/CR-1740, Revision 1, July 1984.

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# NOMENCLATURE

This section contains terms, acronyms, and abbreviations.

## Terms

1. **Component**—The largest entity of hardware for which data are most generally collected and expected to be available (e.g., pump with motor, valve with operator, amplifier, pressure transmitter). It is generally an off-the-shelf item procured by the system designer as a basic building block for their system. It would be distinguished from seals, bearings, nuts, bolts, and other piece parts from which the component is manufactured.

2. **System**—A collection of components arranged so as to provide a desired function (e.g., Containment Spray System, Residual Heat Removal System, High Pressure Coolant Injection System).

3. **Fault**—As used in the context of this report fault refers to failures and command faults. The terms failure or command fault will be used when referring to one or the other.

4. **Failure**—A subset of a fault that represents an irreversible state of a component such that it must be repaired in order for it to perform its design function. Failures are sometimes classified as primary or secondary failures. A primary failure is the so-called *random failure* found in the literature. It results from no external cause. A secondary failure results when the component is subject to conditions that exceed its design envelope (e.g., excessive voltage, pressure, shock, vibration, temperature). However, in classifying failures for this report, no distinction has been made between these two classifications.

5. **Command Fault**—An event in which the component did not function as required, not because of a failure in the component, but because of inputs or lack of inputs to the component as supplied by personnel, other components, or the environment external to the component. This is a reversible state of the component that can be corrected once the faulty input is corrected. No component repair is required.

6. **Common Cause Failure**—Two or more redundant components failing together or having the potential to fail within a relatively short period of time because of a single causal event. Multiple common cause failures are usually secondary failures.

7. **Fault Cause**—The identified cause and sequence of events that prevented the component from performing its intended function.

8. **Fault Mode**—The manner in which a component ceases to perform its intended function.

9. **Demand Failure or Fault Rate**—The probability (per demand) that a component will not operate properly when required to start, change state, or function.

10. **Operating Failure or Fault Rate**—The probability (per hour) of a failure or fault for those components required to operate or function for a period of time.

11. **Standby Failure or Fault Rate**—The probability (per hour) of a failure or fault for those components that are normally dormant or in a standby state until tested or required to operate or function for a period of time.

## Acronyms and Abbreviations

| | |
|---|---|
| ac | Alternating Current |
| ADJ | Adjusting |
| ADS | Automatic Depressurization System |
| AFW | Auxiliary Feedwater |
| ANNUNC, ANNUNCIATR | Annunciator |
| AUTO | Automatic |
| AUX | Auxiliary |
| B, BAB & WIL, B&W | Babcock & Wilcox |
| B/U | Backup |
| BATT, BTTRY | Battery |
| BC | Battery Charger |
| BRD | Board |
| BRKR | Breaker |
| BWR | Boiling Water Reactor |
| BWST | Borated Water Storage Tank |
| C, CE, COMB ENG | Combustion Engineering |
| C C COMD | Common Cause Command Fault |
| CABNT | Cabinet |
| CAP | Capacitor |
| CCW | Component Cooling Water |
| CHNL | Channel |
| CIRC | Circulating |
| CKT | Circuit |
| CNNCTN | Connection |
| CNTNMNT, CONT | Containment |
| CNTRL,CNTROL | Control |
| CNTRLLR | Controller |
| COM CAUSE | Common Cause |
| COMP, COMPON | Component |
| COOLG | Cooling |
| CR | Control Room |
| CRD | Control Rod Drive, Card |
| CSI | Containment Spray Injection |
| CVCS | Chemical Volume Control System |
| dc | Direct Current |
| DEENRGZD | Deenergized |
| DEENRGZG | Deenergizing |
| DETCTN | Detection |
| DFCTV | Defective |
| DFCTV PROC | Defective Procedures |
| DG, D/G | Diesel Generator |
| DHR(S) | Decay Heat Removal (System) |
| ECCS | Emergency Core Cooling System |
| ELEC DISTR | Essential ac Electrical Distribution |
| ELEC MALF | Electrical Malfunction |
| EMERG | Emergency |
| EOL | End of Life |

| | |
|---|---|
| EQUALZG | Equalizing |
| ESF | Engineered Safety Features |
| ESFAS | Engineered Safety Features Actuation System |
| FAB/CON/QC | Fabrication/Construction/Quality Control |
| FAILD | Failed |
| FAILR(S) | Failure(s) |
| FIRING CRD | Firing Circuit |
| FREQ | Frequency |
| FSAR | Final Safety Analysis Report |
| FUNCTN | Function |
| G, GE, GEN ELEC | General Electric |
| HPCI | High Pressure Coolant Injection |
| HPSI | High Pressure Safety Injection |
| HV | High Voltage |
| I&C | Instrumentation & Control |
| ICS | Integrated Control System |
| INADV | Inadvertent |
| INADQ | Inadequate |
| INITIATG | Initiating |
| INOP | Inoperable |
| INSTLD | Installed |
| INSTRMNTN | Instrumentation |
| INTRFC | Interface |
| LER | Licensee Event Report |
| LOSP | Loss of Off-Site Power |
| LPCI | Low Pressure Coolant Injection |
| LPCS | Low Pressure Core Spray |
| LPSI | Low Pressure Safety Injection |
| MAIN, MAINT | Maintenance |
| MALFUN | Malfunction |
| MAN | Manual |
| MCC | Motor Control Center |
| MECH MALF | Mechanical Malfunction |
| MFG | Manufacturing |
| MFR | Manufacturer |
| MG | Motor Generator |
| MOV | Motor Operated Valve |
| MS | Main Steam |
| NAT'L | Natural |
| NIH | National Institute of Health |
| NO | Number |
| NORMAL OP | Normal Plant Operation |
| NRC | Nuclear Regulatory Commission |
| NSIC | Nuclear Safety Information Center |
| NSSS | Nuclear Steam Supply System |
| OOS | Out Of Service |

| | |
|---|---|
| OP | Operating |
| OSCLTR | Oscillator |
| OV | Overvoltage |
| OVERHTG | Overheating |
| PCIS | Primary Containment Isolation System |
| PCS | Primary Coolant System |
| PER MAIN | Personnel Maintenance |
| PER OPER | Personnel Operation |
| PERS, PERSNL | Personnel |
| PER TEST | Personnel Testing |
| PPS | Plant Protection System |
| PRBLEM, PRBLMS | Problem(s) |
| PRESS | Pressure |
| PRTCTN | Protection |
| PRVNT | Prevent |
| PS | Power Supply |
| PWR | Pressurized Water Reactor, Power |
| PZR | Pressurizer |
| QA | Quality Assurance |
| QC | Quality Control |
| R C C COMD | Recurring Common Cause Command Fault |
| R C CAUSE | Recurring Common Cause |
| RCIC | Reactor Core Isolation Cooling |
| RCP | Reactor Coolant Pump |
| RCS | Reactor Coolant System |
| REC COMD | Recurring Command Fault |
| REC REVIEW | Record Review |
| REC'D | Received |
| REDUC CAP | Reduced Capability |
| REG | Regulator |
| RHR | Residual Heat Removal |
| RPLCD | Replaced |
| RPS | Reactor Protection System |
| RRP | Reactor Recirculation Pump |
| RSTR | Resistor |
| RTGB | Reactor Turbine General Board |
| RWCU | Reactor Water Cleanup |
| RWST | Refueling Water Storage Tank |
| RWT | Refueling Water Tank |
| RX | Reactor |
| S/U | Startup |
| SCR | Silicon Controlled Rectifier |
| SD, S/D | Shutdown |
| SEQ | Sequence |
| SERV WTR | Service Water |
| SFAS | Safety Features Actuation System |
| SG, S/G | Steam Generator |
| SHORTG | Shorting |
| SI | Safety Injection, Static Inverter |
| SIAS | Safety Injection Actuation System |

| | |
|---|---|
| STAT | Station |
| STM | Steam |
| SUP | Supply |
| SW | Switch, Service Water |
| SYS | System |
| | |
| TS | Technical Specification |
| TECH | Technician |
| TRBLSHTG | Troubleshooting |
| TRANSM, TX | Transmitter |
| TRNSFORMER | Transformer |
| TRNSISTOR | Transistor |
| TRP, TRPD | Trip, Tripped |
| TURB | Turbine |
| | |
| UPS | Uninterruptible Power Supply |
| USNRC | United States Nuclear Regulatory Commission |
| UV | Undervoltage |
| | |
| VENT, VENTILATN | Ventilation |
| VLTG, VOLT | Voltage |
| | |
| W, WESTING | Westinghouse |
| | |
| XFMR | Transformer |
| XIENT | Transient |
| XMITTER, XMTR | Transmitter |
| XSTR | Transistor |

# DATA SUMMARIES OF LICENSEE EVENT REPORTS OF INVERTERS AT U.S. COMMERCIAL NUCLEAR POWER PLANTS JANUARY 1, 1976 TO DECEMBER 31, 1982

## INTRODUCTION

Licensee Event Reports (LERs) submitted between January 1, 1976 and December 31, 1982 that pertain to inverters have been evaluated and are presented herein, in support of the United States Nuclear Regulatory Commission's (USNRC's) continuing effort to gather and analyze fault (failure and command fault) data for active and passive components in nuclear power plants.

The data reported in the LERs were qualitatively evaluated and pertinent information (e.g., fault mode, fault cause, event date) contained in each LER describing an inverter event was coded into a one-line description of the event. Each one-line description was then stored in a computer-based data file for future use. Data in this computerized file can be searched, sorted, collated, retrieved, updated, and displayed by almost any item of information contained in the original LER. For example, plant, Nuclear Steam Supply System (NSSS) vendor, event date, fault mode, and fault cause data can all be accessed and manipulated by the analyst. This feature makes the one-line LER data base useful for obtaining various statistics for use in this report and future analyses.

Various failure rates (herein called *LER rates*) were estimated for inverters for each operating U.S. commercial nuclear power plant having population data, with the exception of three plants that were considered atypical for this report. These estimates were averaged to obtain inverter LER rates for the four NSSS vendors considered. Finally, specific plant failure data were averaged to obtain an LER rate for pressurized water reactors (PWRs), boiling water reactors (BWRs), and the aggregate of both reactor types.

LER rates are useful for probabilistic analyses such as gross risk and reliability evaluations. However, when using the LER rates, the analyst must apply them with caution. LER rates reported herein are estimates based on the component failures reported in the LER system. These failures do not necessarily comprise all failures for any given component and, hence, may not represent the component's actual failure rate. There are various reasons why all failures may not be reported. For example, plant status (at power, cold shutdown, refueling) at the time of failure and the failure's impact on the system or subsystem are two factors that can influence whether or not a failure is reported. The estimation of exposure time during which failures can occur is another source of variation in the LER rates. This time depends on the number of selected components in the facility and the operating time of each component. Appendix A contains a further discussion on the variations in LER reporting.

The body of this report has two major parts. First, the methodology used in encoding the LERs is described. Included are the assumptions, definitions, and limitations used in carrying out the analysis. Next, a summary of the data according to various encoded characteristics is provided. In Appendix A, some of the causes for the variations in LER reporting are explained. Appendix B describes the LER coding scheme. Appendix C discusses the methods used to estimate the LER rates. Appendixes D through G contain sorts of the one-line descriptions by NSSS vendor, human factors, system, and type of event, respectively. Appendix H is a sort, by NSSS vendor, containing additional information not found in the previous one-line descriptions. For quick reference, Appendix I contains a listing of the LER numbers for the LERs included in this report Appendix J contains the results of the LER rate estimations.

# LER EVALUATION AND CODING METHODOLOGY

## Scope

In the context of this report, an inverter is any static device that has the capability of converting dc power into ac power for loads requiring a reliable and constant power supply independent of the plants' normal and emergency ac power distribution systems.

**Component Boundaries**. Any electrical or mechanical piece of equipment that is required for the proper operation of the inverter, excluding any electrical or mechanical piece of equipment situated upstream or downstream of the input or output leads, respectively, was considered part of the inverter.

For this report, the term *component* refers to inverters. However, it was also possible to identify the faulted subcomponent that led to the faulted condition of the inverter. The twenty-two subcomponents identified for use are listed below (see also SUB COMP in Appendix B):

1. Annunciator control card
2. Capacitor
3. Choke
4. Control card/control module
5. Cooling fan
6. Diode
7. Driver board
8. Firing circuit
9. Frequency board
10. Fuse
11. Inductor
12. Oscillator
13. Power supply (internal)
14. Protection card
15. Rectifier
16. Relay
17. Resistor
18. Switch
19. Transformer
20. Transistor
21. Undervoltage coil
22. Voltage regulator.

**LER Selection**. In order to ensure completeness of the LERs pertaining to inverters the entire USNRC LER file[a] was obtained for the period January 1, 1976 through December 31, 1982.[1-2] Additional information for several events was found in *Nuclear Power Experience*.[3]

The total number of LERs reviewed for this report was 21,424. However, not all of these LERs were used for this analysis with many having been excluded for one or more of the following reasons:

1. The LERs pertained to components outside the scope of this report.

2. The LERs were submitted by three plants considered atypical. These plants are Fort St. Vrain (gas-cooled), Humboldt Bay (BWR/1, 63 megawatts), and La Crosse (the only plant with Allis-Chalmers as the NSSS vendor). Also, Indian Point 1 differs from the 77 plants evaluated in this report, because it was shutdown and defueled prior to January of 1976. Consideration was given to Dresden 1, but any events after October 31, 1978 are not considered because of the extended shutdown which started on October 31, 1978, and which was still in effect on December 31, 1982. LERs submitted by Three Mile Island 1 and 2 prior to the March 28, 1979 accident are considered in this report. Events from either plant after that date are excluded, as Three Mile Island 2 is still shutdown, and Three Mile Island 1 is shutdown due to a restraining order.

3. The LERs were submitted prior to the date of initial criticality for the respective plant. Sequoyah 2 was the only exception to this case. Sequoyah 1 took the responsibility of submitting LERs that reported faults occurring to Sequoyah 2's inverters due to station or site related loads. Since Sequoyah 1 reported them after its date of initial criticality, they are included in the data base.

## LER Classification

The purpose of this report is to provide reliability data, quantitative and qualitative, on inverters

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a. Currently maintained by Oak Ridge National Laboratory.

in commercial nuclear power plants. A computerized data base of component/system operational experiences categorized by standard reliability characteristics was developed to provide an efficient and accurate way of retrieving and sorting the various reliability data.

The USNRC LER system contains a centralized source of component/system operational experiences of off-normal events in the nuclear industry. The USNRC LER file, however, is not a reliability data base. Therefore, direct transcription of these LERs for reliability purposes is not usually possible. At times, there is some correlation between what is coded in a LER and what is needed in the inverter reliability data base. In these cases, a direct transcription was made. However, the descriptive text of the LER provided the bulk of the information needed for the data base. This text also provided the mechanism to check for errors in any coded portions of the original LER—that portion providing information on system, component, component subcode, cause, etc.

Although most LERs contain only a single report involving one event (a failure or a command fault), some LERs contain multiple reports, each involving either single or multiple events. For the case where there existed multiple reports in the LER, an appropriate one-line data record was created in the data base for each report contained in the LER. For the case where the LER described multiple faults involving like components, information was encoded into the one-line data record to account for the number of faults.

A detailed explanation of the coding scheme is given in Appendix B. A discussion of the assumptions and definitions used to encode certain fields within the one-line data record is provided below. Four fields in each one-line data record contain items that are used for identification purposes: NSSS vendor, plant, LER number, and LER control number. These items need no explanation other than that provided in Appendix B.

**Fault/Failure**. As defined in the "Nomenclature" section, a fault refers to failures and command faults. A failure implies that a component must be repaired or replaced in order for it to perform as designed. A command fault is an event in which the component of interest does not fail, but is in the wrong state because of external inputs or lack of inputs. An inverter failing because an operator inadvertently opened the supply breaker is an example of a command fault.

**Fault Mode**. Initially, a cursory evaluation of the applicable LERs was conducted to ensure that the fault modes defined in this report would encompass the bulk of the LERs. Because of the lack of detailed information in most of the LER event descriptions, only two modes are defined. The modes are:

1. Reduced capability
2. Inoperable.

The reduced capability fault mode describes an event in which the component is operational but does not have full output capacity. Reduced capability implies some adjustment or corrective action was needed, but not replacement, for a component to reach full output capacity. An example of a reduced capability command fault is a technician setting the inverter voltage regulator incorrectly, while a reduced capability failure is voltage regulator setpoint drift (due to aging or other equipment related reasons).

The fault mode, inoperable, is used to describe events where there is no output from the component, or major component repair or replacement was needed. Command faults such as an open power supply breaker that prevents the inverter from supplying power to loads fall into the inoperable fault mode. Appendix B provides the details of the coding used to provide this information.

**Fault Cause**. The ten fault causes used are those stated in the respective LERs, and should be self-explanatory (see Appendix B). Most causes were identified by screening the cause description text of the LER. The cause stated in the text was entered in the one-line data record.

**Event Classification (Age or Frequency of Use)**. Each component fault was reviewed to determine if the fault was related to the frequency of use (starts, stops, openings, closings, etc.) of the component or, simply, the age of the component. As the standby time or running time increases, the cumulative chance of an age-related fault increases. The cumulative chance of a frequency-of-use-related fault increases as the number of demands or cycles on the component increases. The number of demands or cycles is not necessarily a linearly-increasing function of time.

Knowing a relationship between age-related and frequency-related faults can aid in establishing or evaluating a testing policy. If frequency-related faults predominate for a particular component, increased testing (which would place more demands on the component) may not be appropriate. Conversely, if age-related faults predominate, increased testing would be appropriate, because as the time interval between tests decreases, so does the chance of a component being unavailable. As an example of how such distinctions were made, a component that faulted because of electronic or electrical piece part deterioration was considered an age-related fault, while a component fault that resulted from a broken linkage arm or handswitch was considered a frequency-of-use-related fault.

All reports involving personnel error were classified as frequency, because it was felt that the probability of these events increased as the number of personnel interaction with the component increased. When a LER did not provide adequate cause information to enable one to determine the event classification, unknown was used to classify these events.

The original LERs do not contain a coded field indicating whether a fault is age- or frequency-related, nor is the reporting organization required to provide such an assessment in the text of the LER. Therefore, the code that appears in the one-line summaries is the result of a subjective review of the available information; other analysts may draw different conclusions.

**Type of Event.** Seven types of events are of special interest for risk/reliability consideration:

1. Recurring failure
2. Common cause failure
3. Recurring common cause failure
4. Command fault
5. Recurring command fault
6. Common cause command fault
7. Recurring common cause command fault.

The events not coded as one of these specified types are considered to be *random* failures. In the context of this report, random failures refer to occurrences that do not meet the definitions of the other types of events.

*Recurring* in this report means two or more LERs from a plant (unit) or plants at one site (e.g., Quad-Cities 1 and 2) reporting problems of a similar enough nature that some note should be taken. No attempt is made to compare events at Quad-Cities 1 with Zion 1 (i.e., to identify intersite faults). One other criterion for classifying an event as recurring is to have an LER state that "this is a recurring failure," or that "similar failures have been reported on this component."

A *common cause* failure classifies not only simultaneous failures of two or more components, but also includes single failures where the potential for two or more component failures exists. The latter are considered common cause candidates. If there was any doubt as to whether or not an event was common cause, the event was coded as common cause. An example of a common cause failure is water leaking from the roof causing short circuit failures of two or more inverters. If the same common cause was reported more than once at one plant, this was coded as *recurring common cause*.

A *command fault* is a fault where there is no actual physical failure of the component, but where the component is in the wrong state because of factors external to the component. External factors, such as human error or failure of a component that interfaces with the faulted component, account for most command faults. For example, if an inverter's dc supply breaker failed, leaving the inverter inoperable, it is not an inverter failure; the inverter would operate satisfactorily if power were available. However, if there was any doubt as to whether the fault was considered a failure or command fault, the fault was considered a failure. *Recurring command faults* describe events that include the criteria for both recurring and command faults. *Common cause command faults* occur when two or more components are affected by, or have the potential to be affected by, a single command fault. As before, these components do not experience an actual failure, but are in the wrong state due to input (or lack of input) from other components. An example of a common cause command fault is maintenance personnel incorrectly setting the output frequency of several inverters. When the reported problem was both a recurring and common cause command fault, the term *recurring common cause command fault* was used to identify the fault.

**System.** When performing a review of all the plants' Final Safety Analysis Reports (FSARs) it was found that the inverters were in systems that provide constant, uninterruptible power to essential ac loads. The names of these systems varied from plant to plant, but the function and loads of the inverters found in these systems were relatively similar. The following list gives examples of these types of systems.

1. 120 and/or 240 Volt-ac Vital Instrument Power Supply System

2. 120 and/or 240 Volt-ac Essential Power System

3. 120 and/or 240 Volt Uninterruptible Power Supply (UPS) System.

Events occurring to inverters in these systems were coded as *Essential ac Electrical Distribution System*. The LERs also reference inverters that are assigned to specific loads in one system only (i.e., ADS, LPCI, HPCI, RCIC, and containment). Events occurring to inverters of this type were assigned the applicable system code.

One terminology conflict occurred in assigning systems to the one-liners in this manner. Vermont Yankee designated as 480 Vac UPS inverters that were felt to be LPCI inverters. These inverters were coded as LPCI inverters to be consistent with the other BWR plants that reported LPCI inverters, and to allow segregation of these inverters from the other smaller inverters ($\sim$200 kVA smaller) found in the UPS systems of other plants.

**Event Date.** The event date in the one-line data record corresponds to the event date reported in the LER. The LER event date, however, is not necessarily the date on which the fault occurred. There are instances when a component is discovered faulted and has obviously been faulted for a considerable time. The LER event date actually corresponds to the date the fault was discovered. The event date was assumed to correspond to the date of the component fault. Such an assumption, however, does not significantly impact any of the results presented in this report.

**Manufacturer.** The LERs provide a coded field for the manufacturer of a failed component. However, the manufacturer code in the LER is sometimes missing and sometimes not appropriate for the component coded in the data base. On occasion the manufacturer given in the LER was not the inverters' manufacturer. References were made in the LER as to the inverters' subcomponent (e.g., relay, fuse, or capacitor) or to the failed component that was responsible for the inverters' command fault (e.g., an open circuit breaker). Due to these reporting variations no attempt was made to further evaluate the manufacturers reported. However, the codes are available in the data base should a more detailed study of the LERs be undertaken.

**Activity Resulting in Discovery.** Each one-line data record contains a code that indicates the activity taking place that led to the discovery of the event. In some instances, the activity *was* the cause of the event. Although the original LER contains a specific field for this information, the text of the LER is primarily relied upon to obtain this information.

Some examples of how the activity codes have been used are shown below.

| Event | Activity |
|---|---|
| An alarm sounds during power operation. | Normal plant operation |
| An operator spotting a failure on a "walk-down" observation tour. | Normal plant operation |
| A component powered by an inverter (such as a valve) fails during a test due to inverter failure. | Normal plant operation |
| An inverter failing during a monthly test. | Testing |

If a test is done at weekly (or greater) intervals it is considered testing; while at daily intervals it is considered normal plant operation.

**Flagging.** Each one-line data record was evaluated to determine whether or not the event might need to be *flagged* for possible future evaluation. Two specific types of events were flagged: (a) those inverter events that caused an inadvertent scram or accident (i.e., loss of coolant flow) and (b) those inverter events that failed to mitigate an accident or inadvertent scram. For inverter events not meeting either of these conditions that deserved additional attention, a third code was used.

There are more fields contained in the data record that have not been presented here because they are self-explanatory and need little or no insight as to the methodology used to encode them into the data record. For information pertaining to these fields see Appendix B.

## LER Rate Estimations

The scope of the LER rate estimation in this report is limited owing to the limited availability of component populations. In the sections below, the data for rate estimations and the estimations themselves are described.

**Data Collection.** The data necessary to estimate the LER rates are (a) the inverter population, (b) the exposure time, and (c) the number of inverter failures. These data were obtained from various sources. The following discussion presents the assumptions and sources used to arrive at the values for each of these data needs.

***Populations.*** A comprehensive source of data from which to obtain all inverter populations within each plant was not found. The sources used to obtain the population data for each plant were the individual plant FSARs, USNRC's "Gray Books," and documented correspondence between the USNRC and the plants.[4-8] The latter was used to resolve conflicts between inverter populations found in the FSARs and what was recorded in the LERs. Such conflicts occurred with eight plants: Fitzpatrick, Hatch 1 and 2, Oconee 1, 2, and 3, Millstone 2, and Vermont Yankee 1.

The four BWR plants (Fitzpatrick, Hatch 1 and 2, and Vermont Yankee 1) underwent major electrical modifications in order to provide an independent power supply to their LPCI valves which resulted in the addition of two LPCI inverters per plant or unit. If other BWR plants were required to make these electrical modifications and no faults occurred to these inverters warranting the submittal of a LER, there would be no conflicts to identify and consequently no LPCI inverter population data for these plants. It is believed that these electrical modifications were a result of the reviews performed on all BWR plants when they were required to modify their LPCI systems to prevent *run out* of the LPCI pumps. It has been assumed that these four BWR plants were the only BWR plants required to install LPCI inverters.

Millstone 2 added another inverter to the 125 Vdc vital instrument system before 1976. Oconee Nuclear Station started out with vital ac system inverters that had loads on them from all three units, and were shared between the three units, then switched to a vital ac system where the inverters were not shared between each unit. No other plants had shared inverters.

There were two inverters found at San Onofre 2 that had a LPCI suction header valve as the only load off each inverter. This type of power supply system was atypical of the rest of the PWR systems. Therefore, San Onofre 2's LPCI inverters were not included in the failure rate calculations.

***Time.*** Generally, the exposure time for each inverter within a plant that was included in the LER rate estimates was either (a) the calendar hours from January 1, 1976 to December 31, 1982, for those plants that achieved initial criticality prior to January 1, 1976 (61,368 hours) or (b) the calendar hours from the date of initial criticality to December 31, 1982 for those plants that achieved initial criticality after January 1, 1976. The dates for plant initial criticality were obtained from the USNRC's "Gray Books."[9] A secondary source of nuclear power plant information was *Commercial Nuclear Power Plants* published by NUS Corporation.[10]

This exposure time is based on the assumption that the inverters that were depicted in the plants' FSARs or their USNRC correspondence were operational and normally energized from the date of initial criticality. It is beyond the scope of this report to determine any down time an inverter may have experienced due to planned or unplanned maintenance.

The following is a discussion of the exceptions to the previous sets of criteria for establishing the exposure time for those inverters considered in the LER rate calculations.

The exposure time for the inverters found at Sequoyah 2 is the same exposure time placed on Sequoyah 1's inverters, even though Sequoyah 2 achieved initial criticality after Sequoyah 1. It was obvious from the LERs that Sequoyah 1 had taken the responsibility of reporting the faults that occurred to Sequoyah 2's inverters due to station or site related loads that came off of Sequoyah 2's inverters.

The exposure times for those LPCI inverters that were installed after initial plant criticality were taken from the date ending the refueling outage when the LPCI modifications were estimated to have been completed. The following is a list of these plants' refueling outages and the completion dates of the outages.

| Plant | Refueling | Date Ending the Refueling Outage |
|---|---|---|
| Fitzpatrick | 1977 | September 26, 1977 |
| Hatch 1 | 1978 | April 15, 1978 |
| Vermont Yankee 1 | 1976 | August 8, 1976 |

The modifications previously described for Hatch 2, Millstone 2, and Oconee occurred before initial criticality or before January 1, 1976 and hence are not exceptions.

Exposure times per inverter for the plants that added inverters after initial criticality are averaged over the plants' total inverter exposure time. For example, consider a plant having four inverters for three years (1976-1978) and six inverters for four years (1979-1982). Such a plant would have 36 inverter • years. This would be reported as though the plant had had six inverters for six years, or four inverters for nine years, etc. Integer values are needed for computing purposes, and six years would be chosen since this is less than the report time span of seven years.

***Failures.*** The number of failures used in the calculation of the LER rates was extracted from the coded one-line LERs stored in the computer-based data file. Not all of the inverters that were coded were included in the LER rate estimates. Only those inverters that experienced the fault mode inoperable and were part of the essential ac electrical distribution system or LPCI system were included in the LER rate estimates. Command faults were not combined (as in previous reports) with the failures to produce a second set of LER rates. Due to the scarcity of command faults found in the computer data base, the LER rate estimates that used command faults along with the failures would be similar to the LER rate estimates that used failures only.

In estimating LER rates for this report, each failure was assumed to be an individual random event, though in fact some events are suspected to be common cause. However, it is beyond the scope of this report to treat the common cause events differently when performing the LER rate estimates.

**LER Rate Estimations Performed.** Three sets of LER rates were estimated:

1. Operating failure rates, in failures per hour, that combined those inverters found in the following two sets.
2. Operating failure rates, in failures per hour, for those inverters found in the essential ac electrical distribution system.
3. Operating failure rates, in failures per hour, for those inverters found in the BWR system, LPCI.

During the collection of population data it was found that most of the inverters in the essential ac electrical distribution system have power ratings ranging from 5 to 50 kVA. All eight of the LPCI inverters have a 250 kVA rating. All of these inverters have basically the same principles of operation; however, the vast difference in the kVA ratings, and the loads off each inverter, between the two systems could lead to different failure rates between the inverters found in these two systems. In order to investigate this it is necessary to obtain the previously mentioned three sets of failure rates.

The computational formulas used to estimate the LER rates are discussed in Appendix C. Each set of the inverter failure rates were grouped as follows:

1. An LER rate for each licensed operating plant
2. An LER rate for each NSSS

3. An LER rate for PWRs and BWRs

4. An overall LER rate based on aggregating the failure data of each licensed operating plant.

In each of the above cases, if no population data were available for a particular LER rate calculation, then the applicable plant, NSSS, or reactor type (PWR or BWR) would be omitted from the calculation. For example, all but four plants were omitted from the LPCI inverter LER rate calculation since no LPCI inverters were known to exist for the omitted plants.

Chi-square confidence bounds were derived for each LER rate estimate. These confidence bounds are applicable only when all the components that are combined in an estimate have exactly the same LER rate. When components have different LER rates (e.g., because of individual component variations and different plant environments), the confidence interval describes only the average LER rate, not the individual component LER rates. The main use of these bounds is for comparisons. Narrow bounds apply to estimates that are based on more information (i.e., for a fixed LER rate, more failures and longer exposure times lead to narrow bounds).

# SUMMARY OF RESULTS

Table 1 presents an accounting of the number of LERs used in this report. Of the 177 faults in the data file, 166 (94%) were classified as component failures. The remaining 11 were identified as being command faults.

**Table 1. Accounting of inverter LERs**

| LERs | Numbers |
| --- | --- |
| Total screened | 21,424 |
| Total excluded after screening | 21,279 |
| Total coded | 145 |
| Total one-line data records created from the 145 LERs (8 LERs contained multiple reports resulting in 16 additional records) | 161 |
| Number of events contained in the 161 one-line data records (9 records contained multiple events resulting in 16 additional events) | 177 |

## Engineering Data

Presented in this engineering data summary are discussions, figures (bar graphs), and tables summarizing pertinent information contained in the data base. The figures and tables present the 177 faults by both failures and command faults. Many of the labels for the individual bars on the bar graphs had to be abbreviated; see the "Nomenclature" section for the full titles of these abbreviated labels. Percentages of the total number of faults associated with each variable can be found on each bar graph.

NOTE: The following discussion is based on raw counts and does not reflect differing numbers of inverters in different facilities. Thus, a relatively high incidence of events may not imply a relatively large failure rate. Failure rates are presented in the latter half of this summary.

**NSSS Vendor**. Figure 1 is a graph of the 177 faults by NSSS vendor. It is evident from

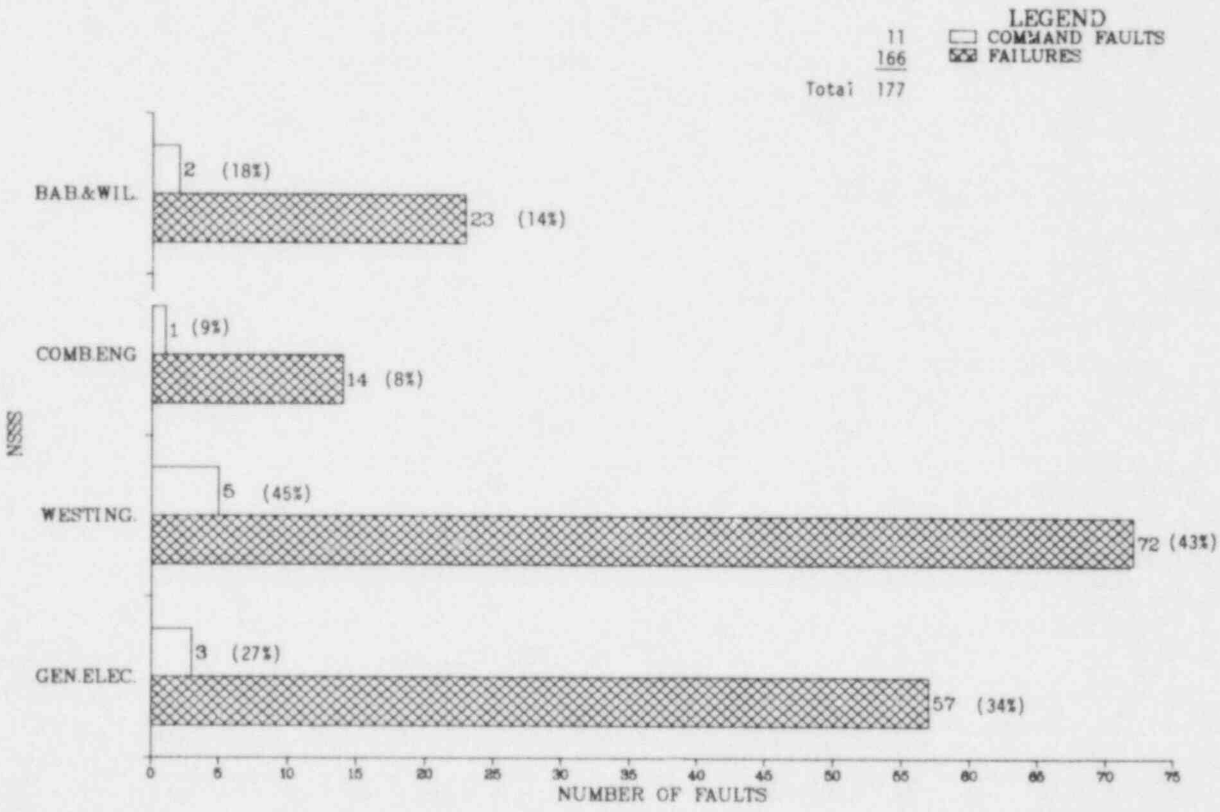


Figure 1. Summary of inverter faults by NSSS.

Figure 1 that Westinghouse reported the majority (43%) of the total faults. Refer to Appendix D for one-line descriptions sorted by NSSS vendor.

**Plant-Specific Data**. Figure 2 presents individual plant faults for all 77 plants in a highly visible form, grouped by NSSS vendor.

**Yearly Data Summaries**. This report covers a full seven years of inverter LERs. Time trends may not be discernable due to the scarcity of inverter faults reported during this time period but a yearly summary of inverter faults is presented in Table 2, for those who may be interested. Table 2 summarizes the inverter faults by year along with the plants cumulative calendar hours to provide a normalizing factor to account for new plants, or in the cases of Three Mile Island and Dresden 1, to account for the fact that data was not gathered after their extended shutdowns.

**Subcomponent**. Figure 3 presents the inverter faults by subcomponent. There were 58 (33%) faults coded unknown or not applicable in the subcomponent field. Fuses account for 17% (29) of the faults followed by capacitors with 13% (21) of the inverter faults.

**Fault Mode**. Figure 4 is a graph of the 177 faults by fault mode. It is evident from Figure 4 that inoperable failures accounted for the majority (162 or 92%) of the total faults.

**Fault Cause**. Figure 5 is a graph of the 177 faults by fault cause. It is evident from Figure 5 that electrical malfunction accounted for a major portion (97 or 55%) of the faults. There were 48 (27%) faults coded with unknown fault causes.

***Human Factors***. Figure 6 summarizes those failures and command faults caused by human factors. All faults related to personnel, design, fabrication, construction, quality control, and procedures were considered to fall into a general category of causes called human factors. Human factors account for 24 (14%) of the 177 faults. Of the 24 human factor faults, personnel errors during operation, maintenance, and testing account for 15 (63%) while design, fabrication, construction, quality control, and procedural errors account for the remaining 37%. Personnel maintenance is the largest single contributor to human factor faults at 42%, with design errors second with 25%.

Of the 24 human factor faults, 15 were identified as having involved acts of commission and 9 involved acts of omission. Refer to Appendix E for one-line descriptions sorted by human factors.

***Electrical Malfunction***. All the events caused by electrical malfunction resulted in failure. The fault cause electrical malfunction was a very broad term to classify the cause that led to the faulted inverter, especially when looking at an electrical piece of equipment such as an inverter. In order to get better insights as to what led to the electrical malfunction of an inverter, when it was not due to human factors, extreme environment, or mechanical malfunction, it is better to look at what subcomponent faulted that led to the electrical malfunction of the inverter. Most often this is the only insight obtainable that can lead to what caused the faulted condition of the inverter.

Figure 7 summarizes electrical malfunction failures by subcomponent. Electrical malfunction failures account for 97 (55%) of all the faults in this report. Of these 97 faults, capacitors accounted for the most with 20; and fuse failures are next with 18 failures.

**Fault Mode and Cause**. Table 3 summarizes the number of events in each fault mode by fault cause. Review of this table shows the major causes of faults for each fault mode. Electrical malfunction failures with the inoperable mode comprise the majority (96 or 56%) of the total inoperable mode. The next largest category consists of unknown failures with the inoperable mode with 26% (44) of the total inoperable mode.

**System**. Figures 8 and 9 present the inverter faults by system for both reactor types, PWR and BWR, respectively. Essential ac electrical distribution accounts for a large percentage of the faults. PWRs have 95% of their total faults attributing to this system while BWRs have 7%. The low pressure coolant injection (LPCI) system accounts for the majority of BWR system faults with 62%. Refer to Appendix F for one-line descriptions sorted by system.

**Type of Event**. Figure 10 presents a numerical summary of the faults by type of event, thus providing the analyst with an overall view of how the 177 faults are distributed as to type of event. No LERs involving the event categories command, recurring command, and recurring common cause command faults were found in this report.

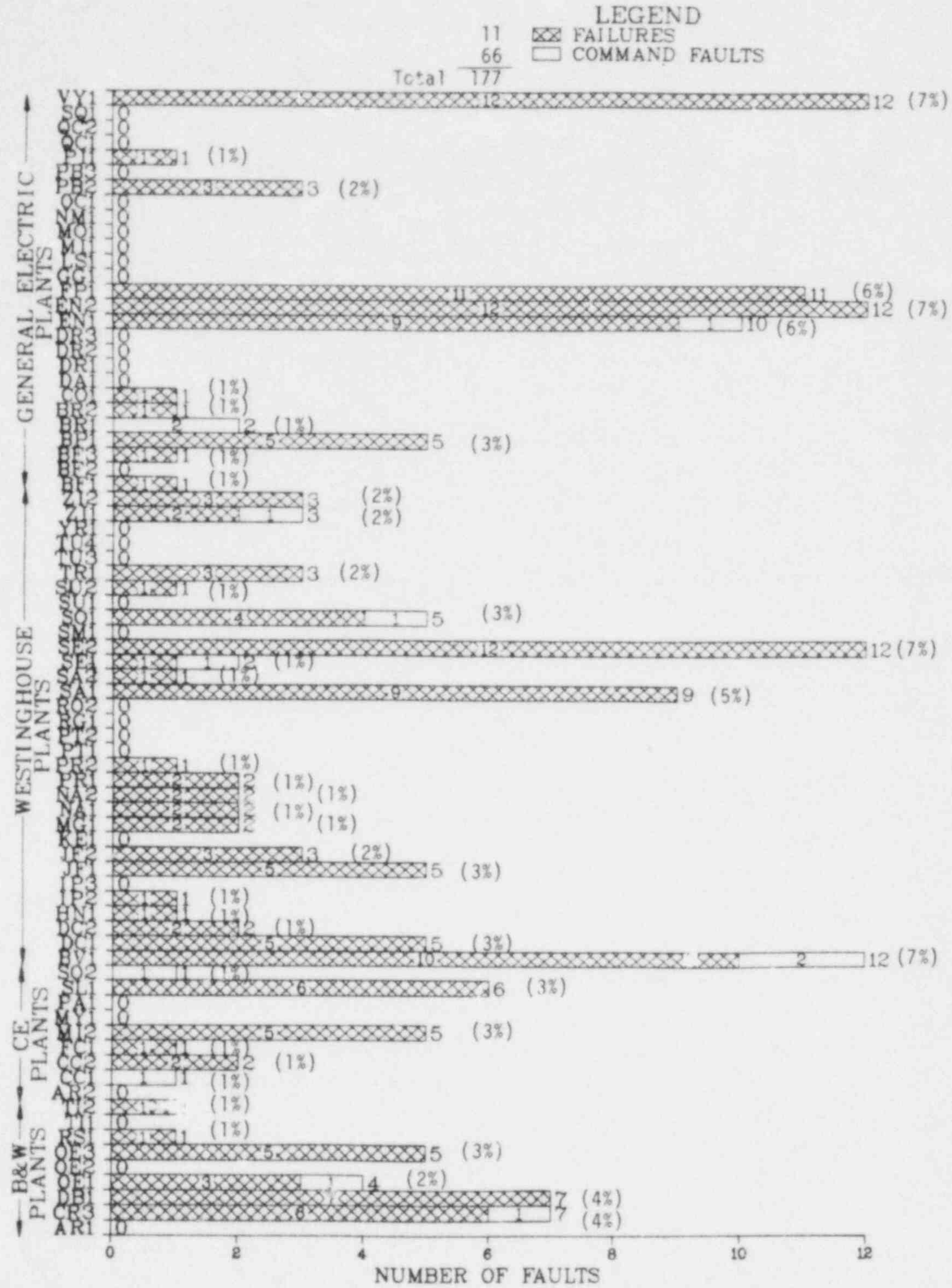


Figure 2 Summary of inverter faults by plant.

## Table 2. Summary of inverter faults by year

| Year | Failures Number | Failures Percent | Command Faults Number | Command Faults Percent | Total Number | Total Percent | Calendar Hours[a] |
|---|---|---|---|---|---|---|---|
| 1976 | 18 | 11 | 1 | 9 | 19 | 11 | 473,040 |
| 1977 | 11 | 7 | 2 | 18 | 13 | 7 | 523,416 |
| 1978 | 24 | 14 | 2 | 18 | 26 | 15 | 558,216 |
| 1979 | 19 | 11 | 1 | 9 | 20 | 11 | 556,056 |
| 1980 | 39 | 23 | 1 | 9 | 40 | 23 | 566,088 |
| 1981 | 30 | 18 | 2 | 18 | 32 | 18 | 588,816 |
| 1982 | 25 | 15 | 2 | 18 | 27 | 15 | 616,584 |
| Total | 166 | | 11 | | 177 | | 3,882,216 |

a. Hours are total calendar hours, for all operational plants considered in this report, during each year starting from January 1 of each year or the date of initial criticality.

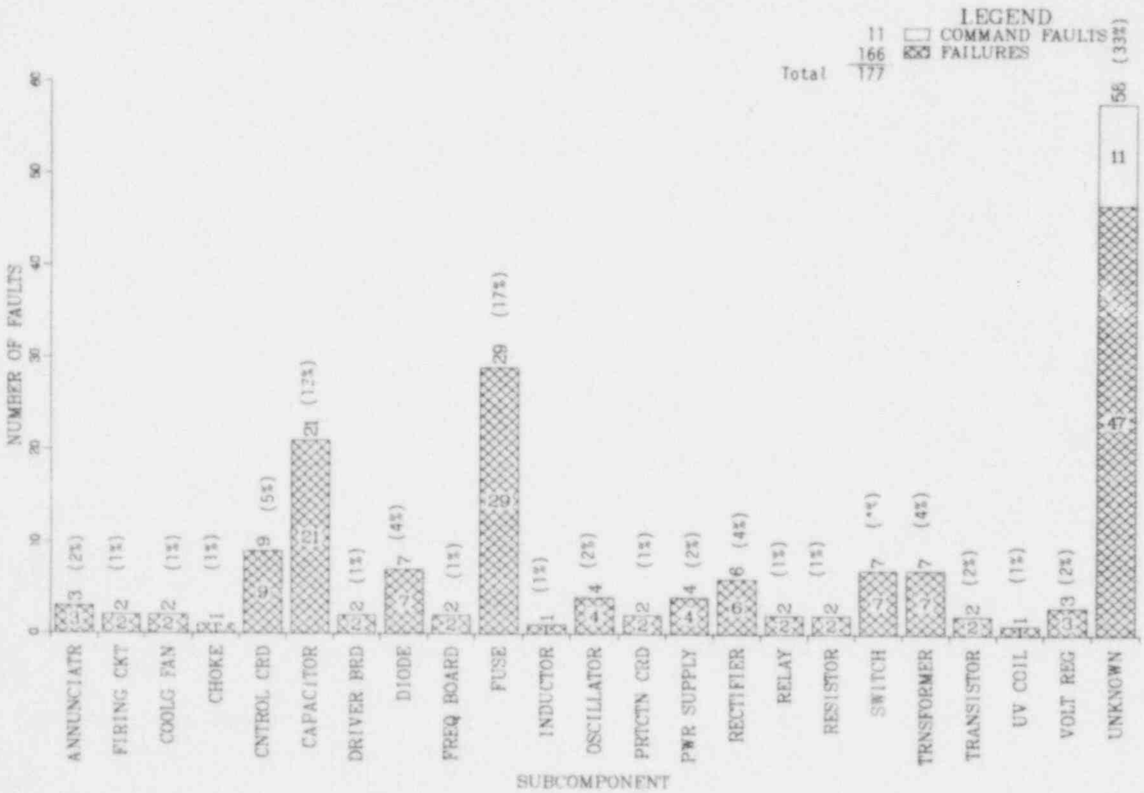


Figure 3. Summary of inverter faults by subcomponent.

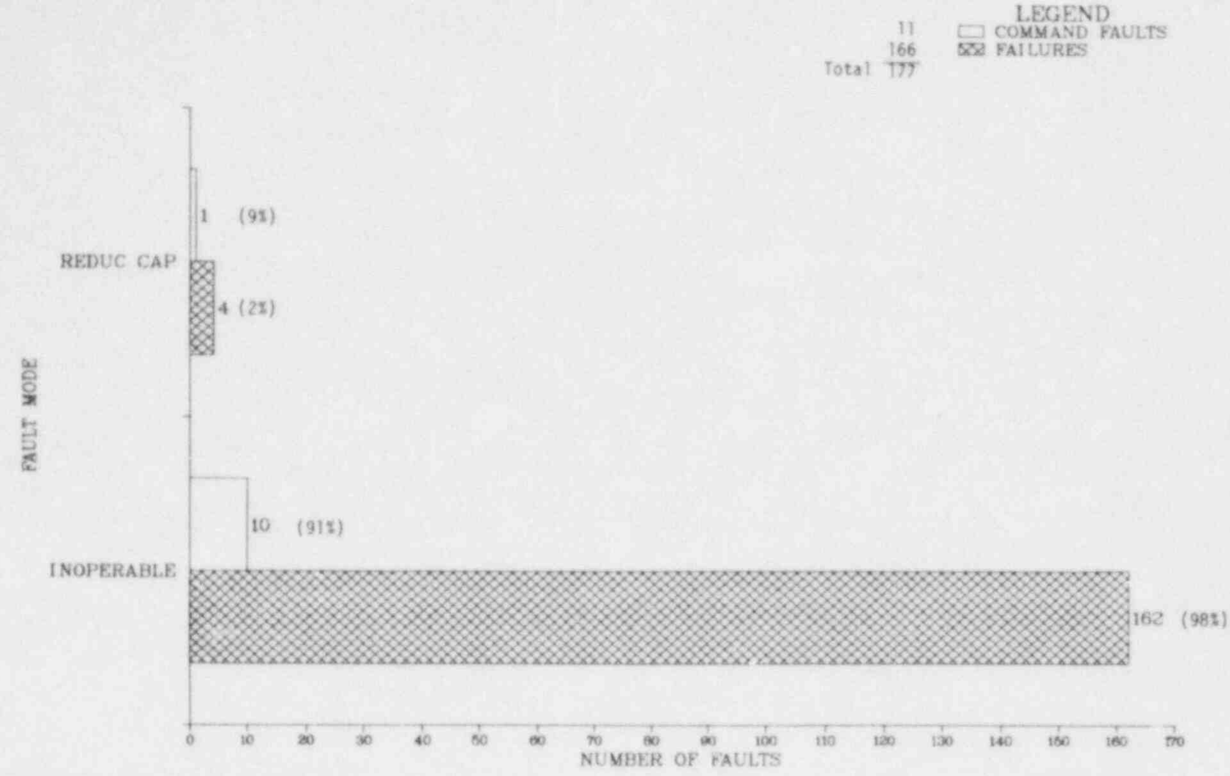


Figure 4. Summary of inverter faults by fault mode.

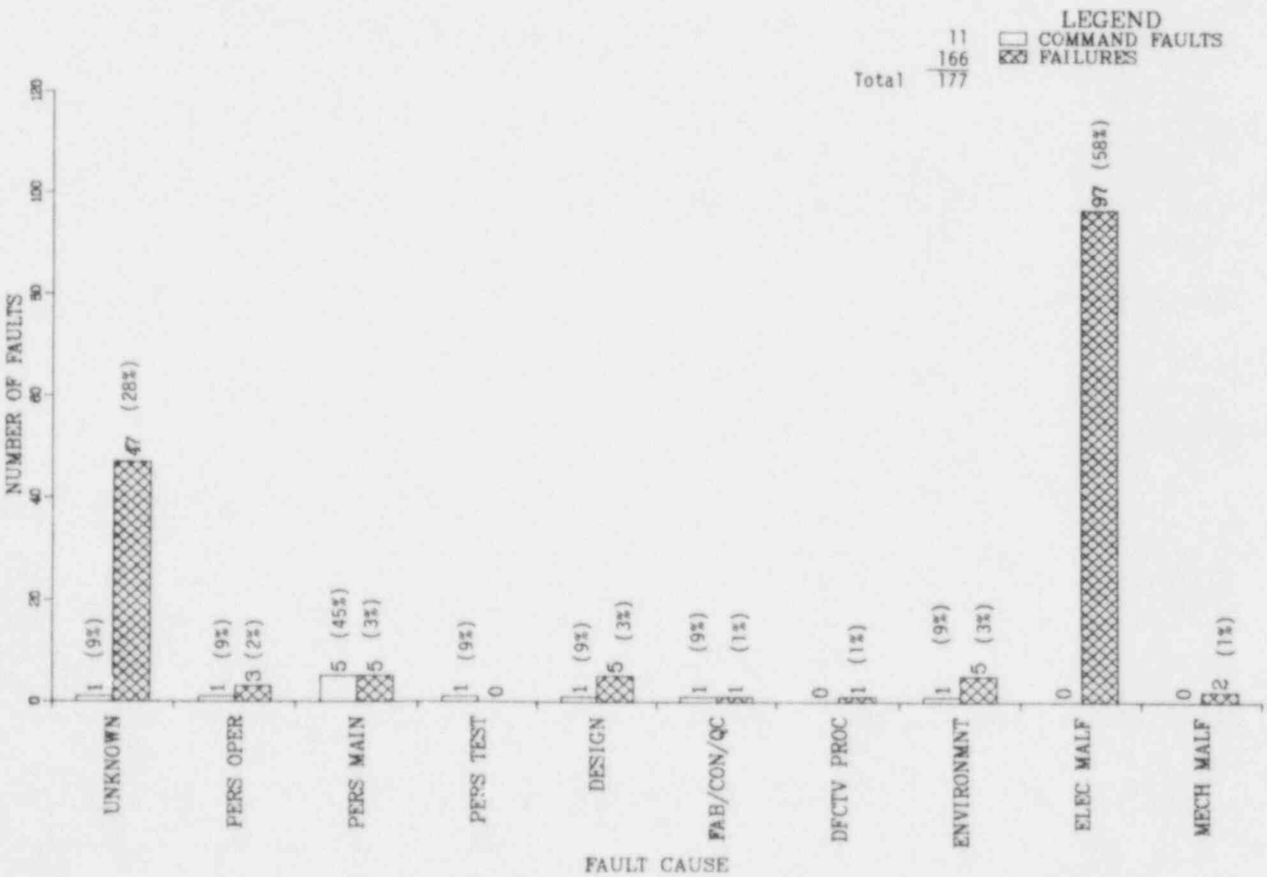


Figure 5. Summary of inverter faults by fault cause.

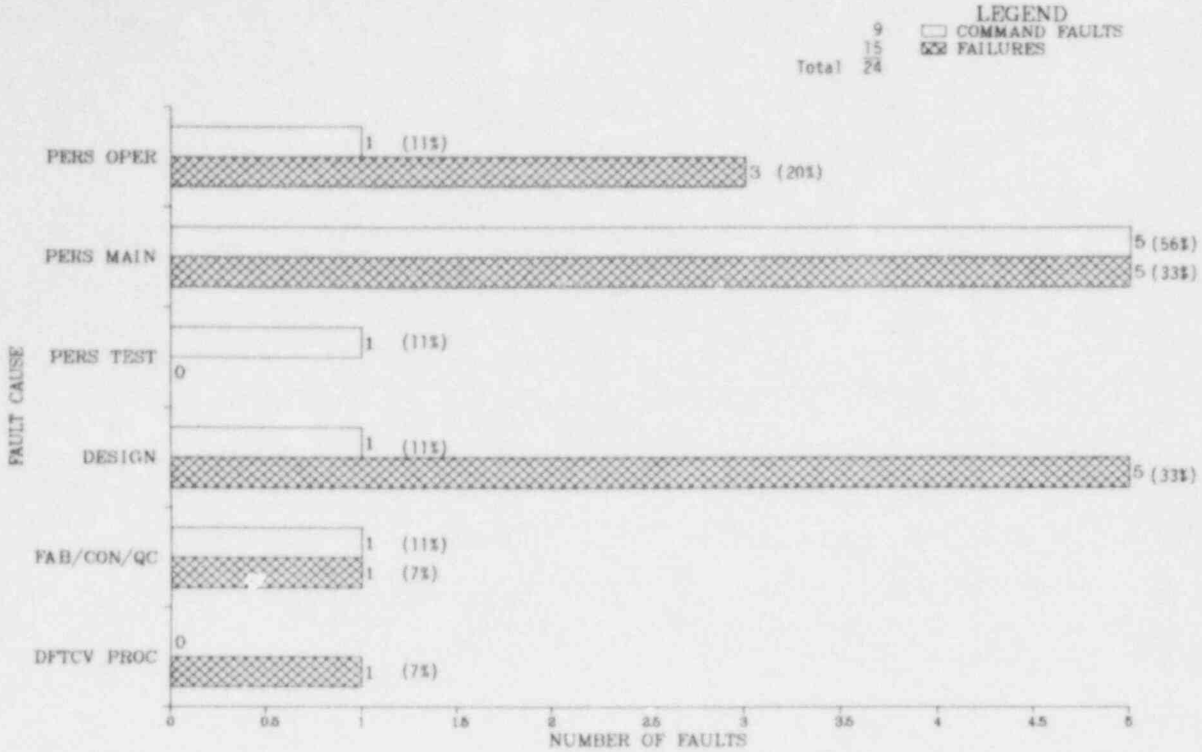


Figure 6. Summary of inverter faults caused by human factors.

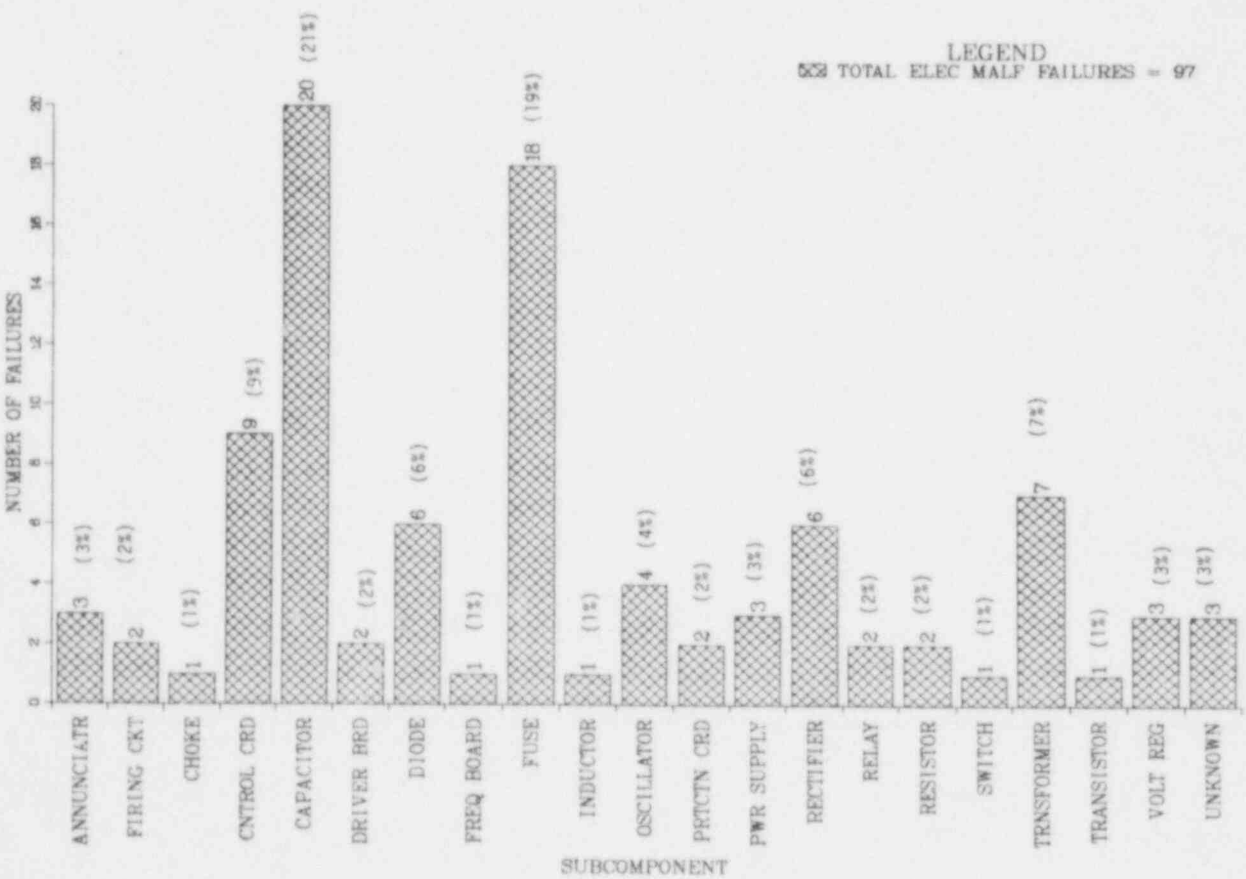


Figure 7. Summary of electrical malfunction failures by subcomponent.

## Table 3. Summary of inverter faults by fault cause and fault mode

| | Fault Mode | | | | | | | | Fault Cause Total | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Reduced Capability | | | | Inoperable | | | | | | | |
| | Failures | | Command Faults | | Failures | | Command Faults | | Failures | | Command Faults | |
| Fault Cause | Number | Percent | Number | Percent | Number | Percent | Number | Percent | Number | Percent | Number | Percent |
| Unknown | 3 | 75 | 0 | — | 44 | 27 | 1 | 10 | 47 | 28 | 1 | 9 |
| Personnel Operation | 0 | — | 0 | — | 3 | 2 | 1 | 10 | 3 | 2 | 1 | 9 |
| Personnel Maintenance | 0 | — | 0 | — | 5 | 3 | 5 | 50 | 5 | 3 | 5 | 45 |
| Personnel Testing | 0 | — | 0 | — | 0 | — | 1 | 10 | 0 | — | 1 | 9 |
| Design Error | 0 | — | 0 | — | 5 | 3 | 1 | 10 | 5 | 3 | 1 | 9 |
| Fabrication/Construction/ Quality Control | 0 | — | 1 | 100 | 1 | 1 | 0 | — | 1 | 1 | 1 | 9 |
| Defective Procedures | 0 | — | 0 | — | 1 | 1 | 0 | — | 1 | 1 | 0 | — |
| Extreme Environment | 0 | — | 0 | — | 5 | 3 | 1 | 10 | 5 | 3 | 1 | 9 |
| Electrical Malfunction | 1 | 25 | 0 | — | 96 | 59 | 0 | — | 97 | 58 | 0 | — |
| Mechanical Malfunction | 0 | — | 0 | — | 2 | 1 | 0 | — | 2 | 1 | 0 | — |
| FAULT MODE TOTAL | 4 | | 1 | | 162 | | 10 | | 166 | | 11 | |

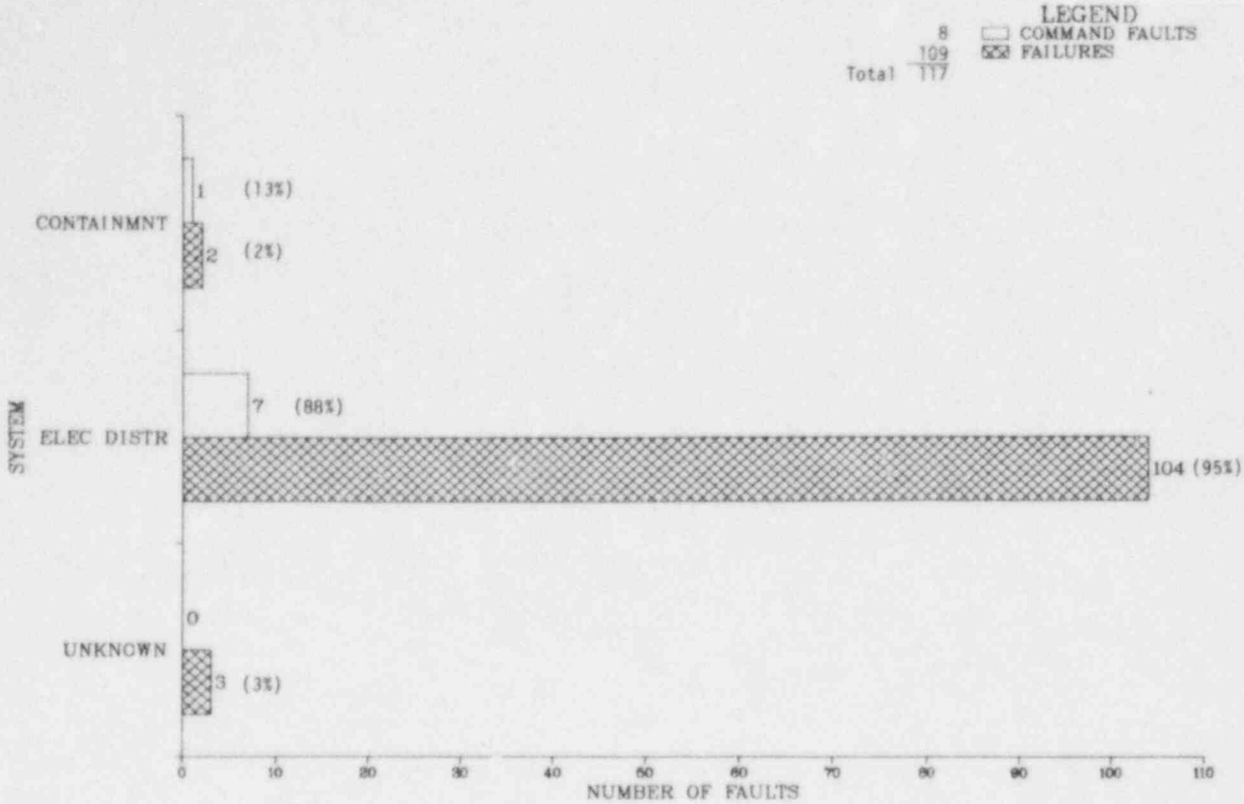


Figure 8. Summary of inverter faults by PWR systems.

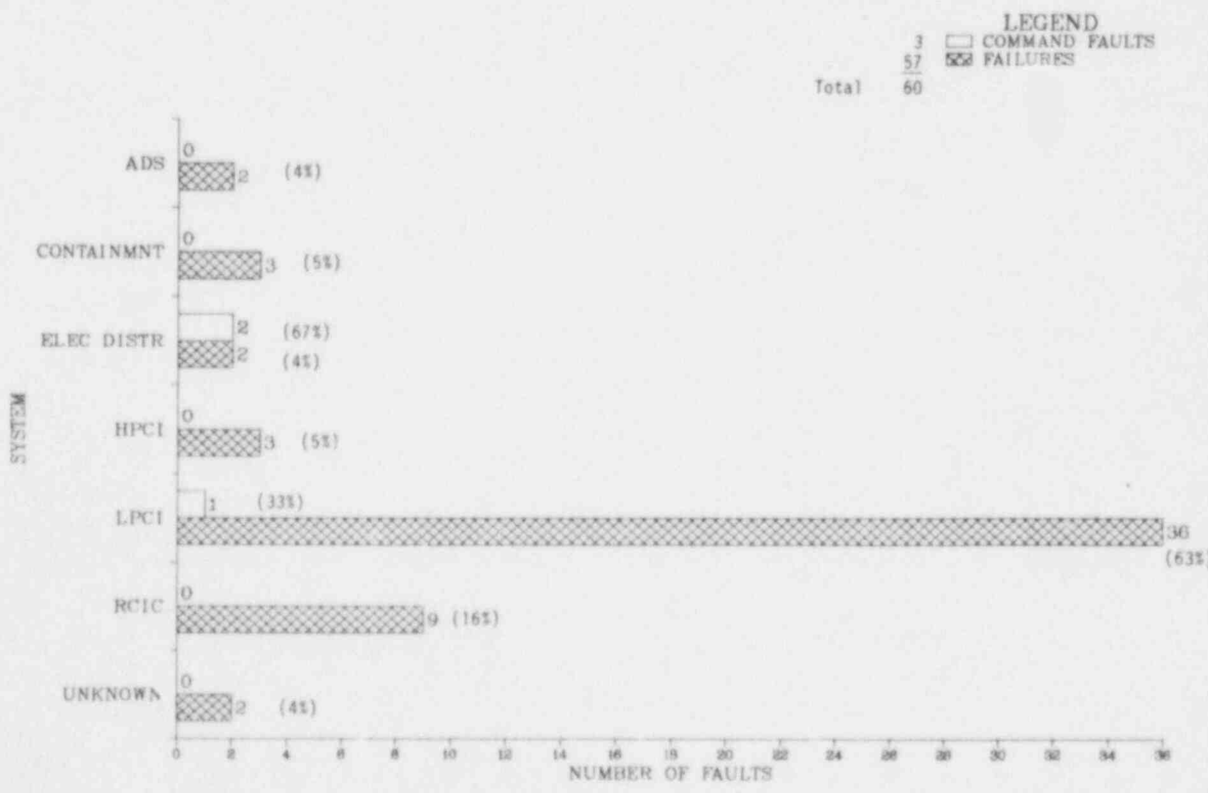


Figure 9. Summary of inverter faults by BWR systems.

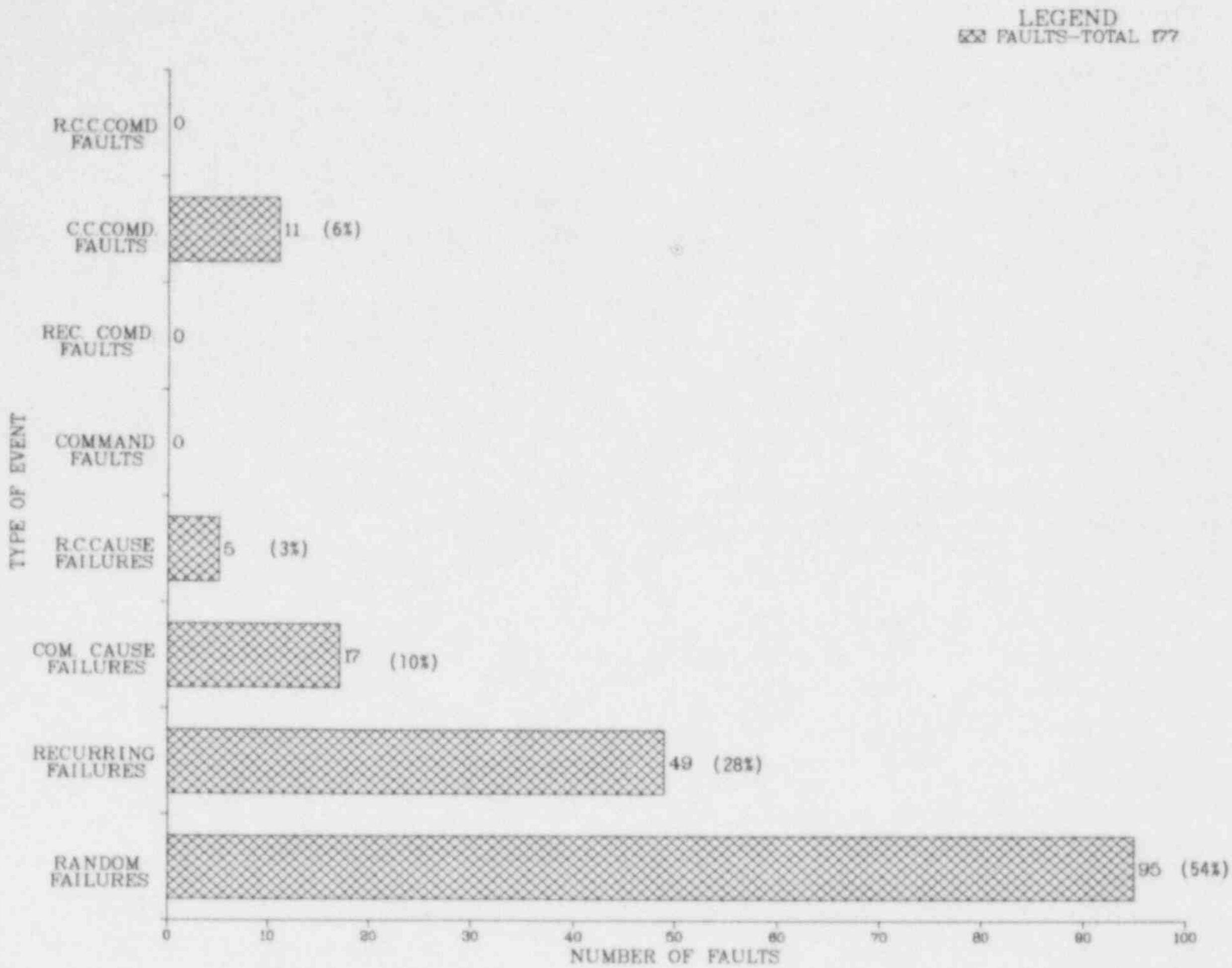


Figure 10. Summary of inverter faults by type of event.

A total of 33 (19%) events were regarded as common cause candidates. All the command faults were in this category. A total of 54 (31%) events were recurring. The following subsections discuss the various types of events in detail.

Appendix G provides a listing of one-line descriptions, sorted by type of event, for all types of events with the exception of random events. Using the information in this appendix, the analyst can identify the specific kinds of problems that are occurring and also which plants are experiencing these problems.

***Recurring Failure.*** Recurring failures accounted for 49 (28%) of the total number of inverter faults. Of these, 31 (63%) were reported by PWR plants and 18 (37%) were reported by BWR plants.

All 31 (100%) of the PWR recurring failures occurred in the essential ac electrical distribution system. The low pressure coolant injection system contained 12 (67%) of the 18 recurring failures reported by BWR plants.

All 49 of the recurring failures resulted in the inoperable failure mode, with 24 (49%) caused by electrical malfunction.

***Common Cause Failure.*** There were 17 (10%) inverter failures coded as common cause failures. Of these, PWR plants reported 14 (82%) while 3 (18%) were reported by BWR plants. All 14 (100%) of the PWR common cause failures occurred in the essential ac electrical distribution system. The BWR common cause failures were distributed as follows: 2 in the reactor core isolation cooling system and 1 in the low pressure coolant injection system.

Of the 17 common cause failures, 15 (88%) resulted in the inoperable failure mode during normal plant operation, and 12 (71%) were classified as frequency related events. Common cause failure causes were distributed as follows: 5 (29%) each for electrical malfunction and personnel maintenance, 3 (8%) for extreme environment, and 2 (12%) each for personnel operation and unknown.

***Recurring Common Cause Failure.*** There were 5 (3%) inverter failures coded as recurring common cause failures. All 5 (100%) were reported by PWR plants. Of the 5 PWR recurring common cause failures 4 occurred in the essential ac electrical distribution system.

All 5 of the recurring common cause failures resulted in the inoperable failure mode during normal plant operation. Of the 5 failures, 4 were coded as being caused by electrical malfunctions and 1 failure was caused by fabrication/construction/quality control.

**Common Cause Command Fault.** Eleven (6%) of the 177 inverter faults were coded as common cause command faults. Eight (73%) were reported by PWR plants and 3 (27%) were reported by BWR plants.

Of the 8 PWR common cause command faults, 7 (88%) occurred in the essential ac electrical distribution system and 1 (13%) occurred in the containment system. Two of the 3 BWR common cause command faults occurred in the essential ac electrical distribution system with the remaining fault occurring in the low pressure coolant injection system.

Ten (91%) of the common cause command faults were coded as being in the inoperable fault mode. As expected, the majority of the common cause command faults were classified as being frequency related.

**Event Classification.** Figure 11 presents the inverter faults by event classification. Age and frequency accounted for approximately the same percentage of faults with 37% and 34%, respectively. The LER cause description was the primary source used to determine whether an event was demand or time related. The quality of these descriptions prevented the classification of 29% of the 177 events. The classification method is subjective and care should be exercised when using this data.

**Activity Resulting in Discovery.** Figure 12 presents a graph of the number of faults by the activity in progress that lead to the discovery of the fault. The majority (158 or 89%) of the 177 faults were discovered during normal plant operations.

**Flagging.** Thirty-four (19%) of the 177 events were flagged. Twenty-three (13%) events were found to have caused an inadvertent scram or accident. Seven records, involving eleven inverters, were flagged for possible future reference (see Appendix H). These did not cause an inadvertent scram or accident, but it was felt that the events recorded in the LER (not necessarily the inverter events) may have had a very minor to major impact on the safe operation of the plant. Extreme care should be used in interpreting events that were flagged as being particularly safety-significant, because such interpretations among different people may vary widely.

There were no inverters, probably due to their functions and placements within a nuclear power plant, that failed to mitigate an accident.

## LER Rates

Table 4 summarizes the input data used for the LER rate estimations. As stated earlier, three sets of LER rates were estimated:

1. One estimate that included both the inverters in the essential ac distribution system and those found in the BWR LPCI system.

2. One estimate for those found in the essential ac distribution system.

3. One estimate for those found in the BWR LPCI system.

Not all the faults recorded in the data base qualified as an input to these estimates. In order for the faults to be qualified they were required to meet the following set of criteria.

1. The inverter faults were found in the essential ac distribution system or the LPCI system depending upon which LER estimate was performed

2. These faults were failures (i.e., not command faults)

3. The inverters were categorized in the inoperable fault mode.

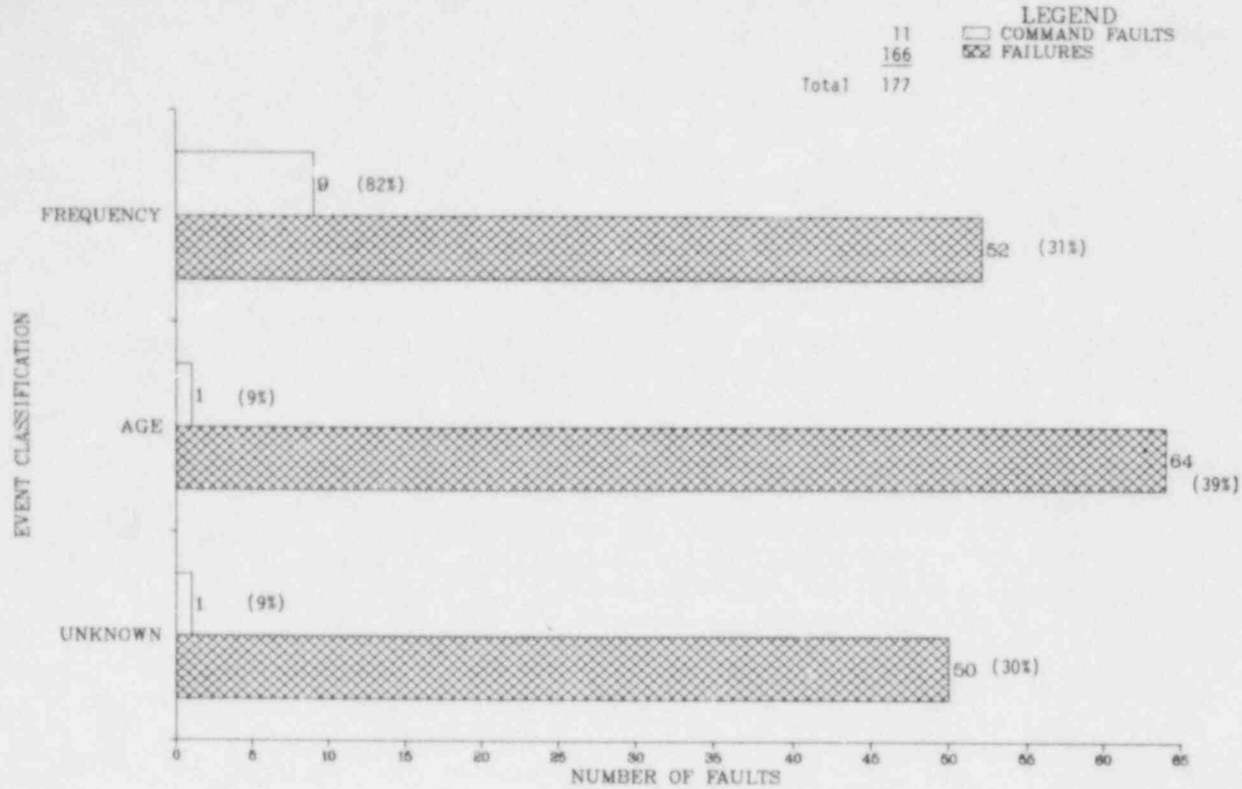


Figure 11. Summary of inverter faults by event classification.

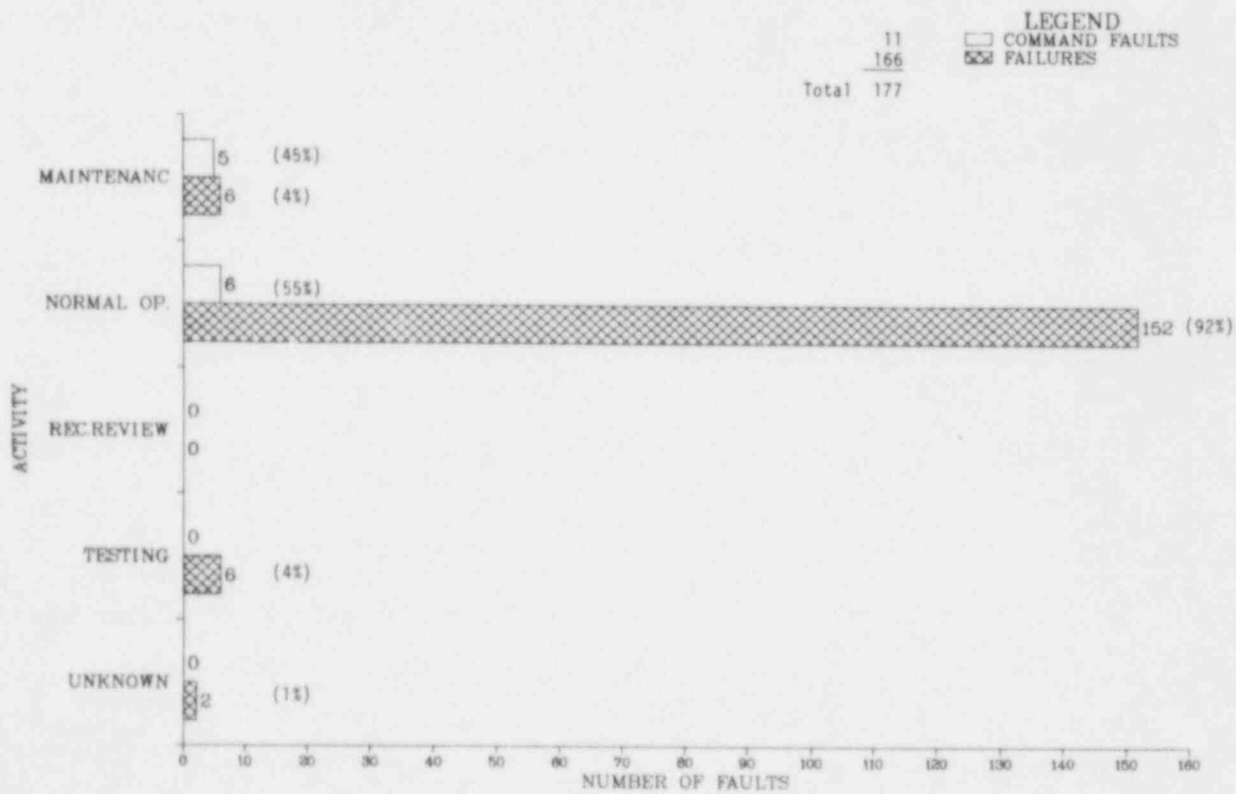


Figure 12. Summary of inverter faults by activity resulting in discovery.

Not all plants qualified to be considered in the LER rate estimates. As can be seen from Table 4 many BWR plants had no inverters in the LPCI system or essential ac distribution system.

NOTE: All the BWR plants that did not use inverters in their essential ac distribution system incorporated the use of motor, or motor-motor-generator sets to accomplish the same goal as the inverters do in other plants.

The above selection criteria resulted in 137 (of 162) inoperable failures being selected for LER rate analysis. Omitted are 25 inoperable failures from other systems (5 PWR, 20 BWR). The presentation in Table 4 allows the analyst to modify the data and corresponding LER rates if known differences exist.

Appendix J contains inverter LER rate estimations. The results of each estimate are in the form of up to five pages of computer output; as many as four pages for the plants of each of the four NSSS vendors, and one page containing Final Statistics. The Final Statistics section for each estimate contains the averaged NSSS vendor LER rates, averaged PWR LER rates, and an overall LER rate.

Along with the LER rates contained in this Final Statistics section, the upper 95% confidence limit and lower 5% confidence limit are calculated and expressed as a factor of the LER rate point estimate. To obtain the upper 95% limit, multiply the given LER rate point estimate by the upper multiple associated with this estimate. To obtain the corresponding lower 5% confidence limit, divide the LER rate estimate by the lower divisor associated with this point estimate. In other words:

multiply X.X times Y.YE-YY to obtain upper 95% confidence limit

and

divide Z.Z into Y.YE-YY for lower 5% confidence limit

where

X.X = upper 95% confidence multiplier

Y.YE-YY = LER rate point estimate and

Z.Z = lower 5% confidence divisor.

Figures 13a through 15 show the individual plant variation associated with the LER rate estimations by plotting the specific plant LER rates associated with the inoperable fault mode (see Appendix J for data).

These plots illustrate plant-to-plant variability in LER rate estimates within a vendor. An arrow for a lower confidence bound and the comment *lower bound = 0* indicate that the associated point estimate has no recorded faults and has been obtained from Equations C-6 through C-8. The arrows are employed to indicate a zero lower bound since it is impossible to actually show zero on the logarithmic scales used in the following figures. The LER rate plotted for a plant that reported no failures is the 50% point estimate for that plant (see Appendix C for calculation methodology).

The primary purpose for plotting the bounds is for comparisons. In examining these scatter plots, note that the point estimate of the operating failure rate increases with an increasing number of failures, and the width of the confidence interval decreases. Conversely, a small number of failures will lead to a smaller point estimate with a larger confidence interval (assuming the time is constant). This is because the width of the confidence bounds on a logarithmic scale is sensitive to changes in the number of failures.

The failure data are plotted by increasing failure rates. Scales vary between plots because the scale is automatically adjusted by the values associated with the plant having the highest upper 95% confidence limit and the lowest 5% confidence limit. Outliers are not necessarily indicators of exceptionally good or bad performers. That is, the plots should not be interpreted at face value without considering some of the underlying causes for LER variation (see Appendix A).

Table 5 summarizes the NSSS vendor's inverter rates.

Table 4. Summary of input data fo*r* inverter LER rate estimations

| Plant Name (Code) | System | Inverter Population | Hours Per Component | Total Failures |
|---|---|---|---|---|
| BABCOCK & WILCOX[a] | | | | |
| Arkansas Nuclear 1 (AR1) | Essential ac | 5 | 61368 | 0 |
| Crystal River 3 (CR3) | Essential ac | 5 | 52272 | 6 |
| Davis-Besse 1 (DB1) | Essential ac | 6 | 47232 | 7 |
| Oconee 1 (OE1) | Essential ac | 7 | 61368 | 3 |
| Oconee 2 (OE2) | Essential ac | 7 | 61368 | 0 |
| Oconee 3 (OE3) | Essential ac | 7 | 61368 | 5 |
| Rancho Seco 1 (RS1) | Essential ac | 4 | 61368 | 1 |
| Three Mile Island 1 (TI1) | Essential ac | 4 | 28392 | 0 |
| Three Mile Island 2 (TI2) | Essential ac | 5 | 8784 | 1 |
| NSSS Total | | | | 23 |
| COMBUSTION ENGINEERING[a] | | | | |
| Arkansas Nuclear 2 (AR2) | Essential ac | 5 | 35712 | 0 |
| Calvert Cliffs 1 (CC1) | Essential ac | 5 | 61368 | 0 |
| Calvert Cliffs 2 (CC2) | Essential ac | 5 | 53352 | 2 |
| Fort Calhoun 1 (FC1) | Essential ac | 6 | 61368 | 1 |
| Maine Yankee (MY1) | Essential ac | 5 | 61368 | 0 |
| Millstone 2 (MI2) | Essential ac | 6 | 61368 | 5 |
| Palisades (PA1) | Essential ac | 4 | 61368 | 0 |
| San Onofre 2 (S02) | Essential ac | 5 | 3816 | 0 |
| | LPCI[b] | — | — | — |
| St. Lucie 1 (SL1) | Essential ac | 5 | 58680 | 6 |
| NSSS Total | | | | 14 |
| WESTINGHOUSE[a] | | | | |
| Beaver Valley 1 (BV1) | Essential ac | 4 | 58248 | 8 |

Table 4. (continued)

| Plant Name (Code) | System | Inverter Population | Hours Per Component | Total Failures |
|---|---|---|---|---|
| WESTINGHOUSE[a] (continued) | | | | |
| Cook 1 (DC1) | Essential ac | 4 | 61368 | 5 |
| Cook 2 (DC2) | Essential ac | 4 | 42192 | 2 |
| Farley 1 (JF1) | Essential ac | 7 | 47304 | 5 |
| Farley 2 (JF2) | Essential ac | 7 | 14544 | 3 |
| Ginna (RG1) | Essential ac | 2 | 61368 | 0 |
| Haddam Neck (HN1) | Essential ac | 2 | 61368 | 1 |
| Indian Point 2 (IP2) | Essential ac | 2 | 61368 | 0 |
| Indian Point 3 (IP3) | Essential ac | 3 | 59064 | 0 |
| Kewaunee (KE1) | Essential ac | 7 | 61368 | 0 |
| McGuire 1 (MG1) | Essential ac | 6 | 12264 | 2 |
| North Anna 1 (NA1) | Essential ac | 5 | 41568 | 2 |
| North Anna 2 (NA2) | Essential ac | 5 | 22392 | 0 |
| Point Beach 1 (PT1) | Essential ac | 2 | 61368 | 0 |
| Point Beach 2 (PT2) | Essential ac | 2 | 61368 | 0 |
| Prairie Island 1 (PR1) | Essential ac | 6 | 61368 | 2 |
| Prairie Island 2 (PR2) | Essential ac | 6 | 61368 | 1 |
| Robinson 2 (R02) | Essential ac | 2 | 61368 | 0 |
| Salem 1 (SA1) | Essential ac | 4 | 53088 | 7 |
| Salem 2 (SA2) | Essential ac | 4 | 21024 | 1 |
| San Onofre 1 (SO1) | Essential ac | 3 | 61368 | 2 |
| Sequoyah 1 (SE1) | Essential ac | 4 | 21840 | 1 |
| Sequoyah 2 (SE2) | Essential ac | 4 | 21840 | 12 |
| Summer 1 (SM1) | Essential ac | 6 | 1704 | 0 |
| Surry 1 (SU1) | Essential ac | 3 | 61368 | 0 |

Table 4. (continued)

| Plant Name (Code) | System | Inverter Population | Hours Per Component | Total Failures |
|---|---|---|---|---|
| WESTINGHOUSE (continued) | | | | |
| Surry 2 (SU2) | Essential ac | 3 | 61368 | 1 |
| Trojan (TR1) | Essential ac | 5 | 61368 | 3 |
| Turkey Point 3 (TU3) | Essential ac | 2 | 61368 | 0 |
| Turkey Point 4 (TU4) | Essential ac | 2 | 61368 | 0 |
| Yankee-Rowe 1 (YR1) | Essential ac[c] | — | — | — |
| Zion 1 (ZI1) | Essential ac | 4 | 61368 | 2 |
| Zion 2 (ZI2) | Essential ac | 4 | 61368 | 3 |
| NSSS Total | | | | 63 |
| GENERAL ELECTRIC[a] | | | | |
| Big Rock Point 1 (BP1)[d] | Essential ac | — | — | — |
| | LPCI | — | — | — |
| Browns Ferry 1 (BF1) | Essential ac[c] | — | — | — |
| Browns Ferry 2 (BF2) | Essential ac[c] | — | — | — |
| Browns Ferry 3 (BF3) | Essential ac[c] | — | — | — |
| Brunswick 1 (BR1) | Essential ac | 2 | 54624 | 0 |
| Brunswick 2 (BR2) | Essential ac | 2 | 61368 | 0 |
| Cooper Station (CO1) | Essential ac | 2 | 61368 | 1 |
| Dresden 1 (DR1)[d] | Essential ac | — | — | — |
| | LPCI | — | — | — |
| Dresden 2 (DR2) | Essential ac[c] | — | — | — |
| Dresden 3 (DR3) | Essential ac[c] | — | — | — |
| Duane Arnold (DA1) | Essential ac[c] | — | — | — |
| Fitzpatrick (FP1) | Essential ac[c] | — | — | — |
| | LPCI | 2 | 46152 | 9 |
| Grand Gulf 1 (GG1) | Essential ac | 6 | 3672 | 0 |

Table 4. (continued)

| Plant Name (Code) | System | Inverter Population | Hours Per Component | Total Failures |
|---|---|---|---|---|
| GENERAL ELECTRIC[a] (continued) | | | | |
| Hatch 1 (EN1) | Essential ac | 1 | 61368 | 0 |
| | LPCI | 2 | 41328 | 8 |
| Hatch 2 (EN2) | Essential ac | 1 | 39408 | 0 |
| | LPCI | 2 | 39408 | 7 |
| La Salle 1 (LS1) | Essential ac | 1 | 4656 | 0 |
| Millstone 1 (MI1) | Essential ac[c] | — | — | — |
| Monticello (MO1) | Essential ac[c] | — | — | — |
| Nine Mile Point 1 (NM1) | Essential ac[c] | — | — | — |
| Oyster Creek 1 (OC1) | Essential ac[c] | — | — | — |
| Peach Bottom 2 (PB2) | Essential ac | 1 | 61368 | 0 |
| Peach Bottom 3 (PB3) | Essential ac | 1 | 61368 | 0 |
| Pilgrim 1 (PI1) | Essential ac[c] | — | — | — |
| Quad-Cities 1 (QC1) | Essential ac[c] | — | — | — |
| Quad-Cities 2 (QC2) | Essential ac[c] | — | — | — |
| Susquehanna 1 (SQ1) | Essential ac | 2 | 2712 | 0 |
| Vermont Yankee 1 (VY1) | Essential ac[c] | — | — | — |
| | LPCI | 2 | 56088 | 12 |
| NSSS Total | | | | 37 |
| GRAND TOTAL | | | | 137 |

a. Static inverters are not incorporated in LPCI systems, unless noted otherwise.

b. San Onofre 2's LPCI static inverters were considered atypical.

c. Motor- or motor-motor-generator sets instead of static inverters are incorporated in these systems.

d. No population data available.

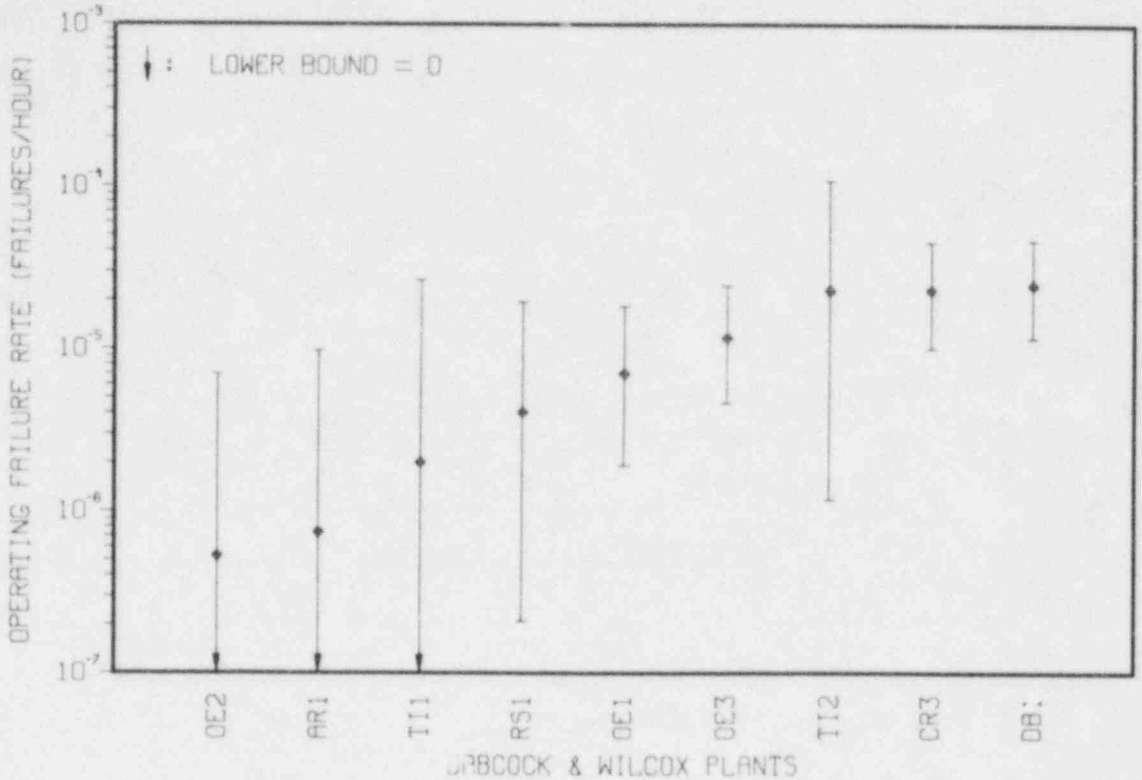


Figure 13a. Scatter plot of operating LER rates of essential ac electrical distribution static inverters, for Babcock & Wilcox plants, inoperable, command faults excluded.

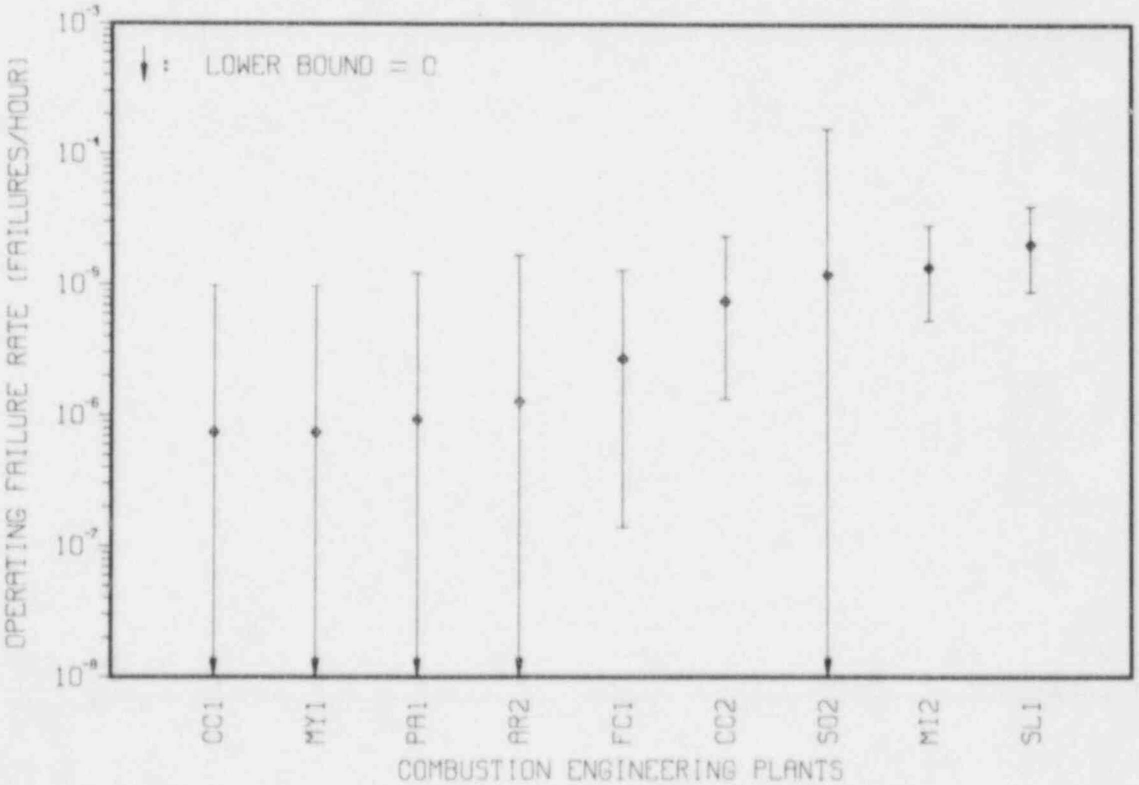


Figure 13b. Scatter plot of operating LER rates of essential ac electrical distribution static inverters, for Combustion Engineering plants, inoperable, command faults excluded.

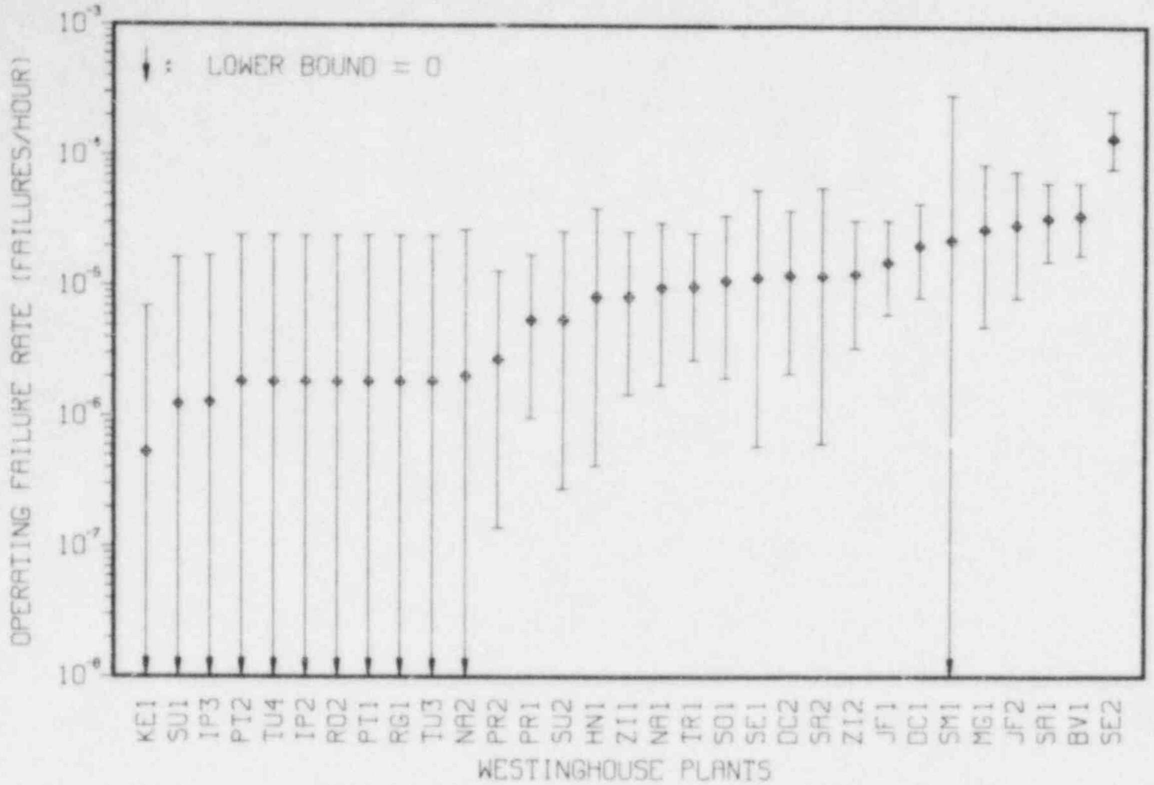


Figure 13c. Scatter plot of operating LER rates of essential ac electrical distribution static inverters, for Westinghouse plants, inoperable, command faults excluded.

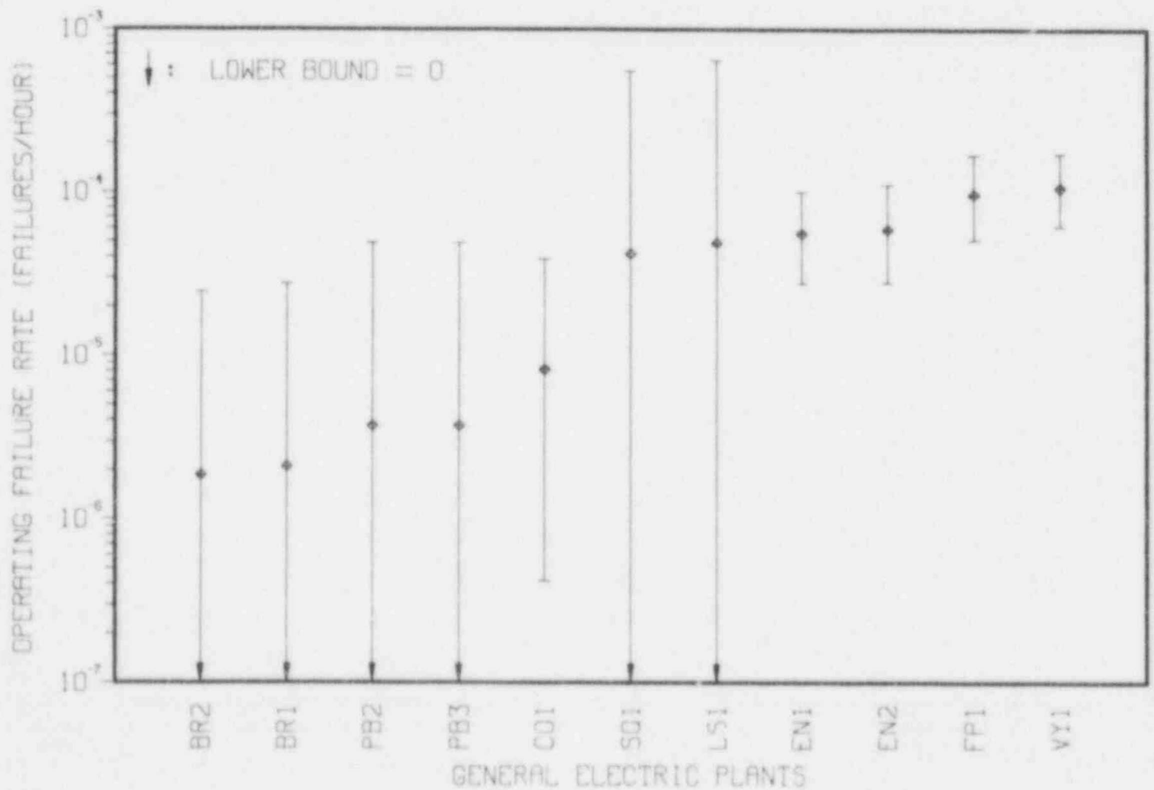


Figure 13d. Scatter plot of operating LER rates of essential ac electrical distribution and low pressure coolant injection static inverters, for General Electric plants, inoperable, command faults excluded.

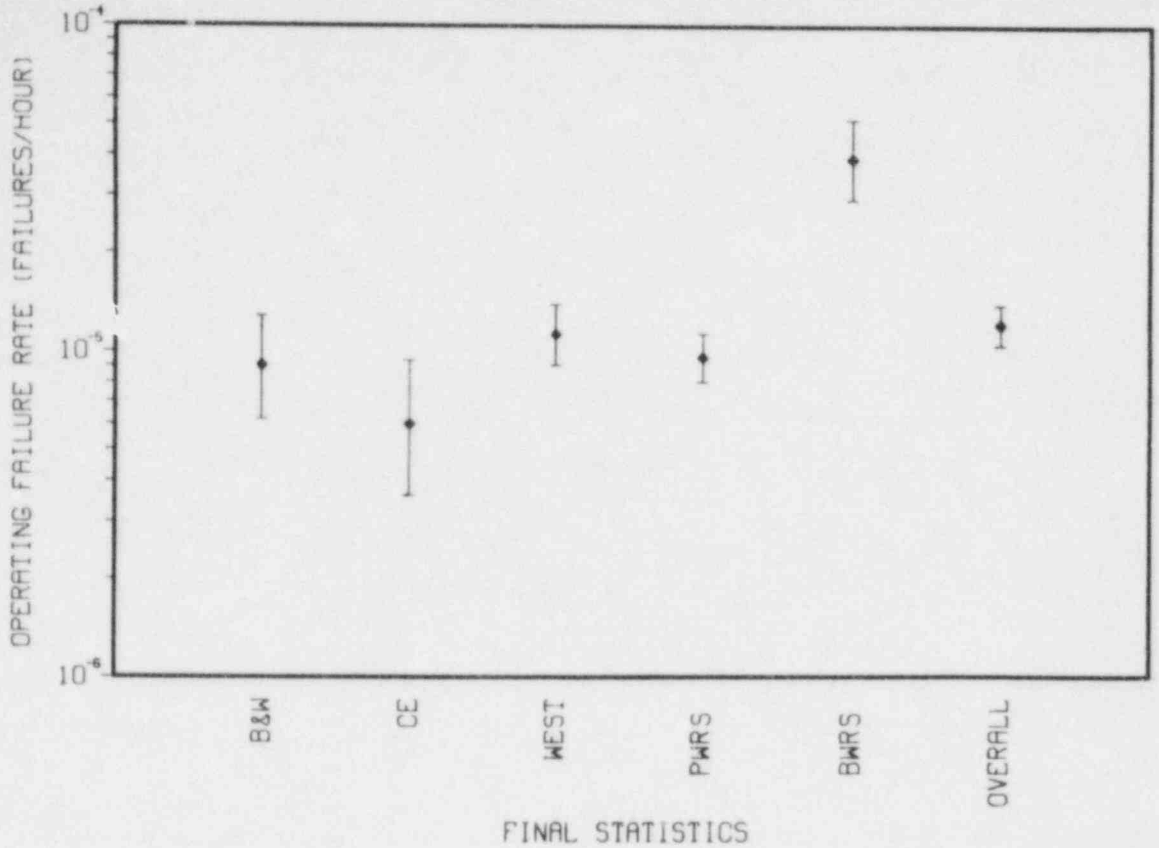


Figure 13e. Scatter plot summarizing operating LER rates of essential ac electrical distribution and low pressure coolant injection static inverters, inoperable, command faults excluded.

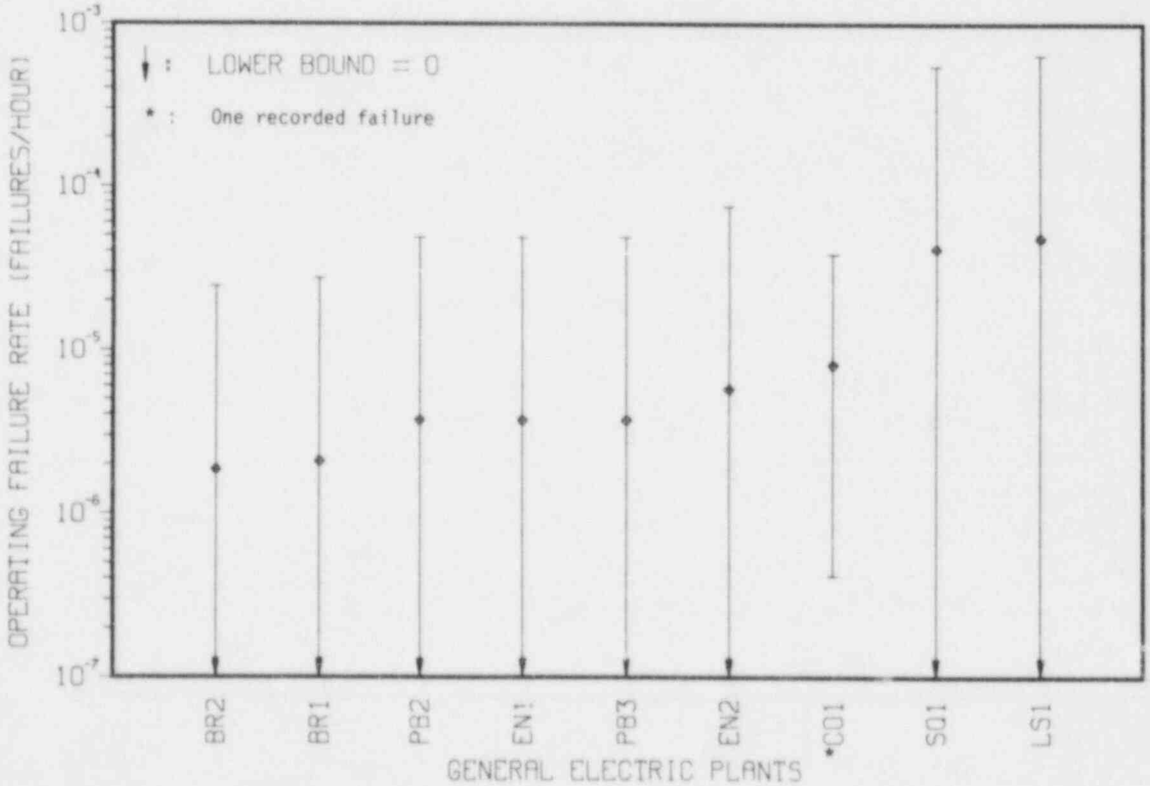


Figure 14. Scatter plot of operating LER rates of essential ac electrical distribution system static inverters, for General Electric plants, inoperable, command faults excluded.

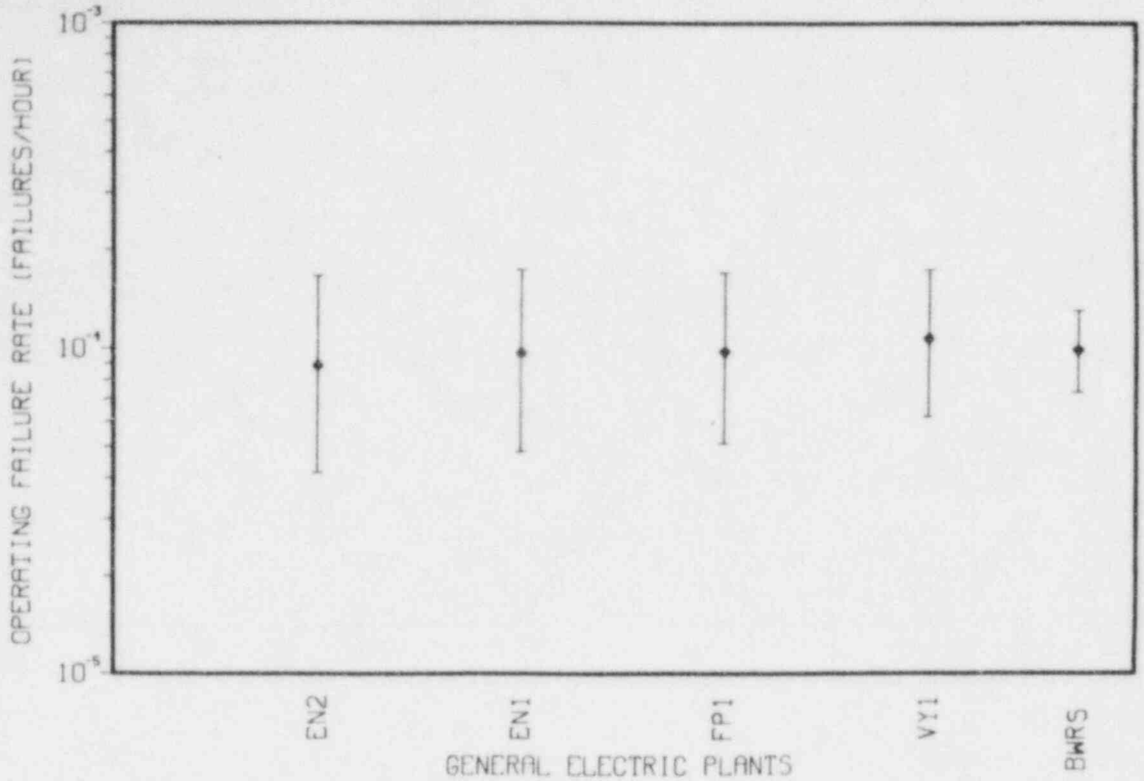


Figure 15. Scatter plot of operating LER rates of low pressure coolant injection system static inverters, for General Electric plants, inoperable, command faults excluded.

**Table 5. Summary of LER rates by NSSS**

| NSSS | System | Total Failures | Total Population Hours | Operating Failure Rate (Failures/Hour) |
|---|---|---|---|---|
| Babcock & Wilcox | Essential ac | 23 | 2,543,280 | 9.0E-06 |
| | LPCI[a] | — | — | — |
| | Combined | 23 | 2,543,280 | 9.0E-06 |
| Combustion Engineering | Essential ac | 14 | 2,353,368 | 5.9E-06 |
| | LPCI[a] | — | — | — |
| | Combined | 14 | 2,353,368 | 5.9E-06 |
| Westinghouse | Essential ac | 63 | 5,630,112 | 1.1E-05 |
| | LPCI[a] | — | — | — |
| | Combined | 63 | 5,630,112 | 1.1E-05 |
| PWRs | Essential ac | 100 | 10,526,760 | 9.5E-06 |
| | LPCI[a] | — | — | — |
| | Combined | 100 | 10,526,760 | 9.5E-06 |
| General Electric (BWRs) | Essential ac | 1 | 610,344 | 1.6E-06 |
| | LPCI | 36 | 365,952 | 9.8E-05 |
| | Combined | 37 | 976,296 | 3.8E-05 |
| Overall | Essential ac | 101 | 11,137,104 | 9.1E-06 |
| | LPCI | 36 | 365,952 | 9.8E-05 |
| | Combined | 137 | 11,503,056 | 1.2E-05 |

a. LPCI inverters were found not to be incorporated at the plants within these groupings, or in the case of San Onofre 2, were considered atypical.

# REFERENCES


1. NIH-LER data base 1976 - 1981.

2. Oak Ridge National Laboratory, *Licensee Event Report (LER) Compilation*, NUREG/CR-2000, Vol. 1 - 2, March 1982 - January 1984.

3. *Nuclear Power Experience*, Encino, California (a copyright publication of nuclear plant equipment problems, updated monthly).

4. U.S. Nuclear Regulatory Commission, *Operating Units Status Report—Licensed Operating Reactors*, NUREG/CR-0020, Vol. 1, No. 2, October 1977.

5. Power Authority of New York State, correspondence to USNRC, 1976 - 1977.

6. U.S. Nuclear Regulatory Commission, *Operating Units Status Report—Licensed Operating Reactors*, NUREG/CR-0020, Vol. 2, No. 5, May 1978.

7. Georgia Power, correspondence to USNRC, 1974 - 1978.

8. U.S. Nuclear Regulatory Commission, *Operating Units Status Report—Licensed Operating Reactors*, NUREG-0020-9, September 1976.

9. U.S. Nuclear Regulatory Commission, *Operating Units Status Report—Licensed Operating Reactors*, NUREG/CR-0020, Vol. 8, No. 1, January 1984.

10. NUS Corporation, *Commercial Nuclear Power Plants*, 16th ed., February 1984.

# APPENDIX A

# DISCUSSION OF THE CAUSES OF VARIATIONS IN LER REPORTING

# APPENDIX A

# DISCUSSION OF THE CAUSES OF VARIATIONS IN LER REPORTING

There are generally two criteria used by the utilities to determine reporting requirements for faults; these are: (a) technical specifications for each individual plant and (b) the LER reporting guide, Regulatory Guide 1.16.[A-1] The technical specifications for plants licensed prior to January 1, 1976, were independently written by individual plants without any planned uniformity among plants. All plants licensed after this date use standardized technical specifications that helped to create more uniform reporting. Three plants (Calvert Cliffs 1, Yankee-Rowe 1, and Brunswick 2) that received operating licenses prior to 1976 converted to standard technical specifications in 1977. In addition to technical specification standardization there have been changes in the rules that govern LER reporting since 1976. These updated rules and the standardized technical specifications are expected to result in more uniform LER reporting after January 1, 1976. But pre-1976 LER data, as well as LER data reported by plants that are not subject to standard technical specifications, will show considerable variation.

The above *mechanical* causes for LER reporting variations are explicable and expected. However, there are additional reporting variations. Differences in interpretation of the rules for submitting LER reports cause some variation. Also, variation is caused by the difficulty in determining the extent of safety and nonsafety systems and therefore, by the questions of what faults are or are not required to be reported. Finally, variation can be caused by the degree of importance assigned to the LER reports by management of the individual utilities. Such variation in both the quantity and quality of LERs submitted by similar plants may appear where one would expect a more uniform reporting.

The one thing that seems to have most hindered the development of uniform reporting is the lack of agreement about the purpose of a LER. Many persons feel that LERs are intended to highlight problem areas within the safety systems. Some feel that the LERs ought to be used to highlight generic problem areas. Many of these same people do not feel that these uses are compatible with the need to determine fault rate information. These differing viewpoints may be an additional reason for the variations in the quality and quantity of LERs received by the United States Nuclear Regulatory Commission. For further discussion of the causes of variations in LER reporting, see Reference A-2.

## References


A-1. U.S. Nuclear Regulatory Commission, *Reporting of Operating Information—Appendix A Technical Specification*, U.S. Nuclear Regulatory Commission Regulatory Guide 1.16, Rev. 4, August 1975.

A-2. Gerald L. Boner and Harvey W. Hanners, *Enhancement of Onsite Emergency Diesel Generator Reliability*, University of Dayton Research Institute, NUREG/CR-0660, 1979, pp. I-4,5, IV-5,6, V-10, and V-13.

# APPENDIX B

# ONE-LINE LER CODING SCHEME

# CONTENTS



# TABLES

# APPENDIX B

## ONE-LINE LER CODING SCHEME

In order to extract as much pertinent information as possible from the information provided in the original LER, and, at the same time, try to restrict the information to one line of computer output per LER, the following coding scheme was developed.

In general, the order of the discussion that follows is the order in which the various fields appear in the one-line descriptions of the inverter events. The headings used for the corresponding fields in the one-line descriptions are contained in parentheses following the topic headings used below.

### NSSS Vendor (NSSS)

The NSSS field indicates the vendor associated with the plant submitting the LER report. A 1-character field is used to store and display the vendor code. This field can be used as a sort key. The following list gives the code and corresponding NSSS vendor.

| Code | NSSS Vendor |
|---|---|
| B | Babcock & Wilcox |
| C | Combustion Engineering |
| W | Westinghouse |
| G | General Electric |

### Plant (PLANT)

A 3-character field was used to identify the commercial power plant responsible for submitting each LER. Table B-1 provides a list of the plants and codes and also supplies other plant information.[B-1] The PLANT field can be used as a sort key.

**Table B-1. General plant information**

| Plant Name (Docket Number) | Plant Code | Design Electrical Rating (MWe) | Date of Initial Criticality | Date of Commercial Operation | Location (State) | Architect/Engineer | Constructor |
|---|---|---|---|---|---|---|---|
| BABCOCK & WILCOX | | | | | | | |
| Arkansas Nuclear One 1 (50-313) | AR1 | 850 | 08/06/74 | 12/19/74 | AR | Bechtel | Bechtel |
| Crystal River 3 (50-302) | CR3 | 825 | 01/14/77 | 03/13/77 | FL | Gilbert Associates | J. A. Jones Construction |
| Davis-Besse 1 (50-346) | DB1 | 906 | 08/12/77 | 07/31/78 | OH | Bechtel | Bechtel |
| Oconee 1 (50-269) | OE1 | 887 | 04/19/73 | 07/15/73 | SC | Duke & Bechtel | Duke Power |
| Oconee 2 (50-270) | OE2 | 887 | 11/11/73 | 09/09/74 | SC | Duke & Bechtel | Duke Power |
| Oconee 3 (50-287) | OE3 | 887 | 09/05/74 | 12/16/74 | SC | Duke & Bechtel | Duke Power |
| Rancho Seco 1 (50-312) | RS1 | 918 | 09/16/74 | 04/17/75 | CA | Bechtel | Bechtel |
| Three Mile Island 1[a] (50-289) | TI1 | 819 | 06/05/74 | 09/02/74 | PA | Gilbert Associates | United Engineers & Constructors, Inc. |
| Three Mile Island 2[a] (50-320) | TI2 | 906 | 03/28/78 | 12/30/78 | PA | Burns & Roe | United Engineers & Constructors, Inc. |

## Table B-1. (continued)

| Plant Name (Docket Number) | Plant Code | Design Electrical Rating (MWe) | Date of Initial Criticality | Date of Commercial Operation | Location (State) | Architect/Engineer | Constructor |
|---|---|---|---|---|---|---|---|
| COMBUSTION ENGINEERING | | | | | | | |
| Arkansas Nuclear One 2 (50-368) | AR2 | 912 | 12/05/78 | 03/26/80 | AR | Bechtel | Bechtel |
| Calvert Cliffs 1 (50-317) | CC1 | 845 | 10/07/74 | 05/08/75 | MD | Bechtel | Bechtel |
| Calvert Cliffs 2 (50-318) | CC2 | 845 | 11/30/76 | 04/01/77 | MD | Bechtel | Bechtel |
| Fort Calhoun 1 (50-285) | FC1 | 478 | 08/06/73 | 06/20/74 | NB | Gibbs, Hill, Durham & Richardson, Inc. | Gibbs, Hill, Durham & Richardson, Inc. |
| Maine Yankee (50-309) | MY1 | 825 | 10/23/72 | 12/28/72 | ME | Stone & Webster | Stone & Webster |
| Millstone 2 (50-336) | MI2 | 870 | 10/17/75 | 12/26/75 | CT | Bechtel | Bechtel |
| Palisades (50-255) | PA1 | 805 | 05/24/71 | 12/31/71 | MI | Bechtel | Bechtel |
| San Onofre 2 (50-361) | SO2 | 1087 | 07/26/82 | 08/19/83 | CA | Bechtel | Bechtel |
| St. Lucie 1 (50-335) | SL1 | 830 | 04/22/76 | 12/21/76 | FL | Ebasco | Ebasco |
| WESTINGHOUSE | | | | | | | |
| Beaver Valley 1 (50-334) | BV1 | 835 | 05/10/76 | 10/01/76 | PA | Stone & Webster | Stone & Webster |
| Cook 1 (50-315) | DC1 | 1030 | 01/18/75 | 08/27/75 | MI | American Electric Power Service Corporation | American Electric Power Service Corporation |
| Cook 2 (50-316) | DC2 | 1100 | 03/10/78 | 07/01/78 | MI | American Electric Power Service Corporation | J. A. Jones Construction |
| Farley 1 (50-348) | JF1 | 829 | 08/09/77 | 12/01/77 | AL | Southern Services, Inc. | Bechtel |
| Farley 2 (50-364) | JF2 | 829 | 05/05/81 | 07/30/81 | AL | Southern Services, Inc. | Bechtel |
| Ginna (50-244) | RG1 | 470 | 11/08/69 | 07/01/70 | NY | Gilbert Associates | Bechtel |
| Haddam Neck (50-213) | HN1 | 582 | 07/24/67 | 01/01/68 | CT | Stone & Webster | Stone & Webster |

**Table B-1. (continued)**

| Plant Name (Docket Number) | Plant Code | Design Electrical Rating (MWe) | Date of Initial Criticality | Date of Commercial Operation | Location (State) | Architect/Engineer | Constructor |
|---|---|---|---|---|---|---|---|
| Indian Point 2 (50-247) | IP2 | 873 | 05/22/73 | 08/01/74 | NY | United Engineers & Constructors, Inc. | Westinghouse Development Corp. |
| Indian Point 3 (50-286) | IP3 | 965 | 04/06/76 | 08/30/76 | NY | United Engineers & Constructors, Inc. | Westinghouse Development Corp. |
| Kewaunee (50-305) | KE1 | 535 | 03/07/74 | 06/16/74 | WI | Pioneer Services & Engineering | Pioneer Services & Engineering |
| McGuire 1 (50-369) | MG1 | 1180 | 08/08/81 | 12/01/81 | NC | Duke Power | Duke Power |
| North Anna 1 (50-338) | NA1 | 907 | 04/05/78 | 06/06/78 | VA | Stone & Webster | Stone & Webster |
| North Anna 2 (50-339) | NA2 | 907 | 06/12/80 | 12/14/80 | VA | Stone & Webster | Stone & Webster |
| Point Beach 1 (50-266) | PT1 | 497 | 11/02/70 | 12/21/70 | WI | Bechtel | Bechtel |
| Point Beach 2 (50-301) | PT2 | 497 | 05/30/72 | 10/01/72 | WI | Bechtel | Bechtel |
| Prairie Island 1 (50-282) | PR1 | 530 | 12/01/73 | 12/16/73 | MN | Fluor Pioneer, Inc. | Northern States Power Company |
| Prairie Island 2 (50-306) | PR2 | 530 | 12/17/74 | 12/21/74 | MN | Fluor Pioneer, Inc. | Northern States Power Company |
| Robinson 2 (50-261) | RO2 | 700 | 09/20/70 | 03/07/71 | SC | Ebasco | Ebasco |
| Salem 1 (50-272) | SA1 | 1090 | 12/11/76 | 06/30/77 | NJ | Public Services & Gas Co. | United Engineers & Constructors, Inc. |
| Salem 2 (50-311) | SA2 | 1115 | 08/08/80 | 10/13/81 | NJ | Public Services & Gas Co. | United Engineers & Constructors, Inc. |
| San Onofre 1 (50-206) | SO1 | 436 | 06/14/67 | 01/01/68 | CA | Bechtel | Bechtel |
| Sequoyah 1 (50-327) | SE1 | 1148 | 07/05/80 | 07/01/81 | TN | Tennessee Valley Authority | Tennessee Valley Authority |
| Sequoyah 2 (50-328) | SE2 | 1148 | 11/05/81 | 06/01/82 | TN | Tennessee Valley Authority | Tennessee Valley Authority |
| Summer 1 (50-395) | SM1 | 900 | 10/22/82 | 01/01/84 | SC | Gilbert Associates | Daniel International |
| Surry 1 (50-280) | SU1 | 788 | 07/01/72 | 12/22/72 | VA | Stone & Webster | Stone & Webster |

## Table B-1. (continued)

| Plant Name (Docket Number) | Plant Code | Design Electrical Rating (MWe) | Date of Initial Criticality | Date of Commercial Operation | Location (State) | Architect/Engineer | Constructor |
|---|---|---|---|---|---|---|---|
| Surry 2 (50-281) | SU2 | 788 | 03/07/73 | 05/01/73 | VA | Stone & Webster | Stone & Webster |
| Trojan (50-344) | TR1 | 1130 | 12/15/75 | 05/20/76 | OR | Bechtel | Bechtel |
| Turkey Point 3 (50-250) | TU3 | 693 | 10/20/72 | 12/14/72 | FL | Bechtel | Bechtel |
| Turkey Point 4 (50-251) | TU4 | 693 | 06/11/73 | 09/07/73 | FL | Bechtel | Bechtel |
| Yankee-Rowe 1 (50-029) | YR1 | 175 | 08/19/60 | 07/01/61 | MA | Stone & Webster | Stone & Webster |
| Zion 1 (50-295) | ZI1 | 1040 | 06/19/73 | 12/31/73 | IL | Sargent & Lundy | Commonwealth Edison |
| Zion 2 (50-304) | ZI2 | 1040 | 12/24/73 | 09/17/74 | IL | Sargent & Lundy | Commonwealth Edison |
| GENERAL ELECTRIC | | | | | | | |
| Big Rock Point 1 (50-155) | BP1 | 72 | 09/27/62 | 03/29/63 | MI | Bechtel | Bechtel |
| Browns Ferry 1 (50-259) | BF1 | 1065 | 08/17/73 | 08/01/74 | AL | Tennessee Valley Authority | Tennessee Valley Authority |
| Browns Ferry 2 (50-260) | BF2 | 1065 | 07/20/74 | 03/01/75 | AL | Tennessee Valley Authority | Tennessee Valley Authority |
| Browns Ferry 3 (50-296) | BF3 | 1065 | 08/08/76 | 03/01/77 | AL | Tennessee Valley Authority | Tennessee Valley Authority |
| Brunswick 1 (50-325) | BR1 | 821 | 10/08/76 | 03/18/77 | NC | United Engineers & Constructors, Inc. | Brown & Root |
| Brunswick 2 (50-324) | BR2 | 821 | 03/20/75 | 11/03/75 | NC | United Engineers & Constructors, Inc. | Brown & Root |
| Cooper Station (50-298) | CO1 | 778 | 02/21/74 | 07/01/74 | NB | Burns & Roe | Burns & Roe |
| Dresden 1[b] (50-010) | DR1 | 200 | 10/15/59 | 07/04/60 | IL | Bechtel | Bechtel |
| Dresden 2 (50-237) | DR2 | 794 | 01/07/70 | 06/09/70 | IL | Sargent & Lundy | United Engineers & Constructors, Inc. |
| Dresden 3 (50-249) | DR3 | 794 | 01/31/71 | 11/16/71 | IL | Sargent & Lundy | United Engineers & Constructors, Inc. |

## Table B-1. (continued)

| Plant Name (Docket Number) | Plant Code | Design Electrical Rating (MWe) | Date of Initial Criticality | Date of Commercial Operation | Location (State) | Architect/Engineer | Constructor |
|---|---|---|---|---|---|---|---|
| Duane Arnold (50-331) | DA1 | 538 | 03/23/74 | 02/01/75 | IA | Bechtel | Bechtel |
| Fitzpatrick (50-333) | FP1 | 821 | 11/17/74 | 07/28/75 | NY | Stone & Webster | Stone & Webster |
| Grand Gulf 1 (50-416) | GG1 | 1250 | 08/01/82 | 1983 | MS | Bechtel | Bechtel |
| Hatch 1 (50-321) | EN1 | 777 | 09/12/74 | 12/31/75 | GA | Bechtel | Georgia Power Co. |
| Hatch 2 (50-366) | EN2 | 784 | 07/04/78 | 09/05/79 | GA | Bechtel | Georgia Power Co. |
| La Salle 1 (50-373) | LS1 | 1078 | 06/21/82 | NA | IL | Sargent & Lundy | Commonwealth Edison |
| Millstone 1 (50-245) | MI1 | 660 | 10/26/70 | 03/01/71 | CT | Ebasco | Ebasco |
| Monticello (50-263) | MO1 | 545 | 12/10/70 | 06/30/71 | MN | Bechtel | Bechtel |
| Nine Mile Point 1 (50-220) | NM1 | 620 | 09/05/69 | 12/01/69 | NY | Niagara Mohawk Power Corporation | Stone & Webster |
| Oyster Creek 1 (50-219) | OC1 | 650 | 05/03/69 | 12/01/69 | NJ | Burns & Roe | Burns & Roe |
| Peach Bottom 2 (50-277) | PB2 | 1065 | 09/16/73 | 07/05/74 | PA | Bechtel | Bechtel |
| Peach Bottom 3 (50-278) | PB3 | 1065 | 08/07/74 | 12/23/74 | PA | Bechtel | Bechtel |
| Pilgrim 1 (50-293) | PI1 | 655 | 06/16/72 | 12/01/72 | MA | Bechtel | Bechtel |
| Quad-Cities 1 (50-254) | QC1 | 789 | 10/18/71 | 02/18/73 | IL | Sargent & Lundy | United Engineers & Constructors, Inc. |
| Quad-Cities 2 (50-265) | QC2 | 789 | 04/26/72 | 03/10/73 | IL | Sargent & Lundy | United Engineers & Constructors, Inc. |
| Susquehanna 1 (50-387) | SQ1 | 1065 | 09/10/82 | 06/08/83 | PA | Bechtel | Bechtel |
| Vermont Yankee 1 (50-271) | VY1 | 514 | 03/24/72 | 11/30/72 | VT | Ebasco | Ebasco |

a. Plant shutdown since 03/28/79.

b. Plant shutdown since 10/31/78.

## Control/NSIC Number (CONTROL OR NSIC NUMBER)

To identify each one-line record within the data file, and to provide a cross-reference with the actual LER submitted to the USNRC, the unique six-digit control number assigned to the report by the USNRC was entered into the control number field. LERs received after December 31, 1981 were assigned a number by the Nuclear Safety Information Center (NSIC). There were some instances of several different reports being listed in the narrative summary of a single LER. To accommodate this situation, an alphabetic character was added to the six-digit number in order to separately identify each report. Thus, traceability back to the original LER number was maintained, yet each report remained unique. When a single LER reported more than one instance of the same event (e.g., "fuses in inverters 2 and 6 blew") in the summary description, an asterisk (*) was placed after the control number to flag the coded one-line description as containing multiple events. The corresponding number of events was then entered in the FAULT # field so that each event could be accounted for. The control number field can be used as a sort field, but it is primarily intended for data record identification within the data file.

## Event Date (EVENT DATE)

A six-digit field was used to record the date of the event: two digits each, for the month, day, and year. The EVENT DATE corresponds to the event date listed in the LER for each event. The month, day, or year can be used as sort keys.

## Component (COMP)

The static inverter was identified as the principal component and coded as SI.

## Subcomponent (SUB COMP)

This field lists the types of inverter subcomponents identified in the LERs. Some related types are combined under one code, as shown in the following list. This field can be used as a sort key.

| Code | Subcomponent |
|---|---|
| AC | Annunciator control card |
| CC | Firing circuit |
| CF | Cooling fan |
| CH | Choke |
| CL | Control card/control module |
| CP | Capacitor |
| DB | Driver board |
| DI | Diode |
| FB | Frequency board |
| FS | Fuse |
| IN | Inductor |
| OS | Oscillator |
| PC | Protection card |
| PS | Power supply (internal) |
| RC | Rectifier |
| RE | Relay |
| RS | Resistor |
| SW | Switch |
| TR | Transformer |
| TS | Transistor |
| UV | Undervoltage coil |
| VR | Voltage regulator |
| UU | Unknown/not applicable |

## System (SYSTEM)

A 1-character field is used to indicate the system that the inverter was a part of or the system that the inverter was supplying power to, whichever was applicable. This field can be used as a sort key. The following is a list of system codes and descriptions.

| Code | System |
|---|---|
| A | Automatic Depressurization System (ADS) |
| C | Containment (includes isolation control) |
| E | Essential ac electrical distribution |
| H | High pressure coolant injection (HPCI) |
| L | Low pressure coolant injection (LPCI) |
| Q | Reactor core isolation cooling (RCIC) (BWRs only) |
| P | Unknown |

## Fault Mode and Cause (MODE & CAUSE)

A 3-character field indicates the fault code. A 1-character subordinate field indicates the mode and a 2-character subordinate field indicates the cause. The following scheme was used to encode the various modes and causes identified in the LERs. Either field can be used as sort keys.

| Code | Fault Mode |
|---|---|
| A | Reduced capability |
| B | Inoperable |

| Code | Fault Cause |
|---|---|
| 00 | Unknown |
| 01 | Personnel operation |
| 02 | Personnel maintenance |
| 03 | Personnel testing |
| 04 | Design error |
| 05 | Fabrication/construction/quality control |
| 06 | Defective procedures |
| 07 | Extreme environment |
| 08 | Electrical malfunction |
| 09 | Mechanical malfunction |

## Activity Resulting in Discovery (ACTIVITY)

A 1-character code was used to indicate the activity taking place that caused or led to the discovery of the event. Any activity not specifically identified was considered to be *during normal plant operation*. This field can be used as a sort key. The coding scheme for this field is as follows.

| Code | Activity |
|---|---|
| M | Maintenance |
| N | Normal plant operation |
| R | Records review |
| T | Testing |
| U | Unknown |

## Type of Event (TYPE)

A 1-character field indicates the type of event identified in the LER. A blank in this field implies a random event. This field can be used as a sort key. The following scheme was used to identify the event types.

| Code | Type of Event |
|---|---|
| B | Recurring Common Cause Failure |
| C | Common Cause Failure |
| R | Recurring Failure |
| S | Command Fault |
| T | Recurring Command Fault |
| U | Common Cause Command Fault |
| V | Recurring Common Cause Command Fault |
| Blank | Random Failure |

## Event Classification (CLASS)

A 1-character field was used to classify the events as age-related or frequency-of-use-related. A **D** in this field was used for frequency-of-use-related events, and a **T** was used for age-related events. If no determination could be made, a **U** was inserted in this field. This field can be used as a sort key.

## Number of Faults (FAULT #)

The FAULT # field, mentioned in the Control/NSIC Number paragraph, was used to store a count of the number of events per one-line LER description. A blank in this field implies that the value of this field is one. Should there be more than one event per LER, the corresponding number of events is entered in this field.

## Fault Mode Description (MODE DESCRIPTION)

The LER narrative summary of the mode was condensed into a 50-character alphanumeric field. This field provides a short, concise description of the mode. It is not a sort field.

## Fault Cause Description (CAUSE DESCRIPTION)

A 41-character alphanumeric field was used for a narrative description of the cause. If no cause was reported, this field provided additional space for a description of the LER. It is not a sort field.

In order to provide as much information as possible in both the MODE and CAUSE DESCRIPTIONS, many words are abbreviated and many acronyms are used. Most of these acronyms can be found in the "Nomenclature" section at the beginning of this report.

Table B-2 provides the codes used in the one-line descriptions and is presented as a summary of the preceding discussion. One of these coding sheets will precede each sort of one-line descriptions in this report so that the reader need not continually refer to this appendix.

## Additional Information

Because of space limitations, additional information pertaining to manufacturer and various other items of interest is listed separately. Table B-3 provides the codes used in the additional information one-line descriptions. A discussion of the additional information fields follows.

**NSIC Volume/Number (NSIC VOLUME NUMBER).** This field was provided in order to identify the location of newer LERs located in the *Licensee Event Report (LER) Compilation* prepared from the data file of the Nuclear Safety Information Center (NSIC).[B-2]

**LER Number (LER NUMBER).** In addition to a plant docket number, each plant assigns a number to each LER that it submits. This number is assigned sequentially within each calendar year to every LER submitted by the plant. At the end of the calendar year the plant LER number will start again with 001 for the next year. A 3-character field was used to indicate the LER number associated with a particular plant. LER NUMBER can be used as a sort key, although it is primarily intended for data record identification within the data file.

**Report Type (REPORT TYPE).** The Report Type was taken directly from the LER. The letter **A** is used to indicate two-week reports, **B** is used to indicate 30-day reports, and **C** is used to indicate other types of reports. This information was not found in the NSIC data base's NUREG/CR-2000. Report Type is a sort field.

**Manufacturer (MANUFACTURER CODE).** A 4-character alphanumeric field is used to identify the manufacturer given in the LER. A blank was used in the manufacturer field, if no manufacturer was given in the LER. The codes used for the various manufacturers were taken from Exhibit J of the *Instructions for Preparation of Data Entry Sheets for Licensee Event Report (LER) File*.[B-3] The manufacturer field can be used as a sort key.

One should be cautious in using this manufacturer information because the manufacturer code in the LER is sometimes missing and sometimes not appropriate for the component coded in the data base.

**Repair Time (REPAIR TIME).** The REPAIR TIME field is a three-digit field used to store component repair time, when available, in hourly units.

**Flagging (FLAGGING).** Each one-line data record was evaluated to determine whether or not the event might need to be "flagged" for possible future evaluation. The letter **A** was used to identify those components which caused an inadvertent scram or accident (e.g., loss of coolant flow) upon failure, and **B** was used to identify those components which failed to mitigate an accident. In order to flag those events which we thought should have additional attention brought to them and were not included in the previous two codes, the letter **C** was used. FLAGGING is a sort field.

The fields contained in the Additional Information section are found in the one-line descriptions in Appendix H.

## References


B-1. U.S. Nuclear Regulatory Commission, *Operating Units Status Report—Licensed Operating Reactors*, NUREG/CR-0020, Vol. 8, No. 1, January 1984.

B-2. *Licensee Event Report (LER) Compilation*, NUREG/CR-2000, Vol. 1-2, March 1982-January 1984.

B-3. *Instructions for Preparation of Data Entry Sheets for Licensee Event Report (LER) File*, NUREG-0161, July 1977.

Table B-2. Codes used in one-line descriptions

## CODES USED IN LER ONE-LINE DESCRIPTIONS

### FAULT MODE

| CODE | DESCRIPTION |
| --- | --- |
| A | REDUCED CAPABILITY |
| B | INOPERABLE |

### SYSTEM

| CODE | DESCRIPTION |
| --- | --- |
| A | AUTOMATIC DEPRESSURIZATION SYSTEM (ADS) |
| C | CONTAINMENT (INCLUDES ISOLATION CONTROL) |
| E | ESSENTIAL AC ELECTRICAL DISTRIBUTION |
| H | HIGH PRESSURE COOLANT INJECTION (HPCI) |
| L | LOW PRESSURE COOLANT INJECTION (LPCI) |
| Q | REACTOR CORE ISOLATION COOLING (RCIC) |
| P | UNKNOWN |

### TYPE OF EVENT

| CODE | DESCRIPTION |
| --- | --- |
| B | RECURRING COMMON CAUSE FAILURE |
| C | COMMON CAUSE FAILURE |
| R | RECURRING FAILURE |
| S | COMMAND FAULT |
| T | RECURRING COMMAND FAULT |
| U | COMMON CAUSE COMMAND F[illegible] |
| V | RECURRING COMMON CAUSE COMMAND FAULT |
| BLANK | RANDOM FAILURE |

### FAULT CAUSE

| CODE | DESCRIPTION |
| --- | --- |
| 00 | UNKNOWN |
| 01 | PERSONNEL OPERATION |
| 02 | PERSONNEL MAINTENANCE |
| 03 | PERSONNEL TESTING |
| 04 | DESIGN ERROR |
| 05 | FABRICATION/CONSTRUCTION/QUALITY CONTROL |
| 06 | DEFECTIVE PROCEDURES |
| 07 | EXTREME ENVIRONMENT |
| 08 | ELECTRICAL MALFUNCTION |
| 09 | MECHANICAL MALFUNCTION |

### SUBCOMPONENT

| CODE | DESCRIPTION |
| --- | --- |
| AC | ANNUNCIATOR CONTROL CARD |
| CC | FIRING CIRCUIT |
| CF | COOLING FAN |
| CH | CHUKE |
| CL | CONTROL CARD/CONTROL MODULE |
| CP | CAPACITOR |
| DB | DRIVER BOARD |
| DI | DIODE |
| FB | FREQUENCY BOARD |
| FS | FUSE |
| IN | INDUCTOR |
| OS | OSCILLATOR |
| PC | PROTECTION CARD |
| PS | POWER SUPPLY (INTERNAL) |
| RC | RECTIFIER |
| RE | RELAY |
| RS | RESISTOR |
| SW | SWITCH |
| TR | TRANSFORMER |
| TS | TRANSISTOR |
| UV | UNDERVOLTAGE COIL |
| VR | VOLTAGE REGULATOR |
| UU | UNKNOWN/NOT APPLICABLE |

### ACTIVITY RESULTING IN DISCOVERY

| CODE | DESCRIPTION |
| --- | --- |
| M | MAINTENANCE |
| N | NORMAL PLANT OPERATION |
| R | RECORDS REVIEW |
| T | TESTING |
| U | UNKNOWN |

### NSSS VENDOR

| CODE | DESCRIPTION |
| --- | --- |
| B | BABCOCK & WILCOX |
| C | COMBUSTION ENGINEERING |
| W | WESTINGHOUSE |
| G | GENERAL ELECTRIC |

### COMPONENT

| CODE | DESCRIPTION |
| --- | --- |
| SI | STATIC INVERTER |

### EVENT CLASSIFICATION

| CODE | DESCRIPTION |
| --- | --- |
| D | FREQUENCY |
| T | AGE |
| U | UNKNOWN |

## Table B-3. Codes used in additional information one-line descriptions

ADDITIONAL CODES USED IN LER ONE-LINE DESCRIPTIONS

**MANUFACTURER CODE**

| CODE | DESCRIPTION |
| --- | --- |
| A499 | ASCO VALVES |
| C173 | C&D BATTERIES, DIVISION OF ELTRA CORP. |
| C782 | CYBEREX INC. |
| E355 | EXIDE INDUSTRIAL DIV. |
| G080 | GENERAL ELECTRIC CO. |
| G195 | GOULDS COMPANY (GOULDS) |
| G273 | GUARDIAN ELECTRIC |
| I202 | ITE IMPERIAL CORPORATION |
| L045 | LAMBDA ELECTRONICS |
| L295 | LUNDELL CONTROLS - TECHNOLOGY INC. |
| S240 | SOLA BASIC INDUSTRIES |
| S245 | SOLA ELECTRIC COMPANY |
| S250 | SOLID STATE CONTROLS, INC. |
| S379 | STATIC PRODUCTS |
| T248 | TOPAZ ELECTRONICS |
| W120 | WESTINGHOUSE ELECTRIC CORPORATION |
| W121 | WESTINGHOUSE ELECTRIC COMPANY (ELEV DIV) |
| BLANK | UNKNOWN |

**FLAGGING**

| CODE | DESCRIPTION |
| --- | --- |
| A | FAILED COMPONENT CAUSED AN ACCIDENT |
| B | COMPONENT FAILED TO MITIGATE AN ACCIDENT |
| C | SAFETY SIGNIFICANT |

**REPORT TYPE**

| CODE | DESCRIPTION |
| --- | --- |
| A | 2-WEEK REPORTS |
| B | 30-DAY REPORTS |
| C | OTHER |

# APPENDIX C

# LER RATE ESTIMATION METHODS

# APPENDIX C

## LER RATE ESTIMATION METHODS

To estimate the Licensee Event Report (LER) fault rates for components, the following well-known statistical methods were used for Type-I censored data with replacement.[C-1]

The general methods for estimating rates on an hourly basis and on a demand basis are

$$\hat{\lambda}(\text{hourly}) = \frac{N}{T} \qquad \text{(C-1)}$$

$$\hat{\lambda}(\text{demand}) = \frac{N}{D} \qquad \text{(C-2)}$$

where

$\hat{\lambda}$ = estimated fault rate

N = number of reported component faults

T = total time accrued by all components

D = total number of demands on all components.

The general computational formulas, Equations (C-1) and (C-2), may be applied to particular situations. The fault rate for a component in a particular plant is estimated by setting

$N = N_i$

$T = T_i$

$D = D_i$

where

$N_i$ = number of component faults in plant i

$T_i$ = total accrued hours of all like components in plant i

$D_i$ = total accrued number of demands on all like components in plant i.

In a similar manner, fault rates may be estimated for components manufactured by a particular vendor, for components in a particular plant type (PWR or BWR), or for components present in all plants.

Confidence limits for hourly fault rates were based on the assumption that the underlying component fault distributions are exponential; therefore, the resulting LER data are representable by a Poisson process. In demand evaluations, N is binomially distributed. However, since the probability of fault is small and the number of demands is large, the Poisson distribution may be used to approximate this variable. The generalized formulas for estimating 100 (1 - $\alpha$)% confidence limits on the fault rates are

$$\frac{\chi^2_{\alpha/2}(2N)}{2T} \le \lambda(\text{hourly}) \le \frac{\chi^2_{1-\alpha/2}(2N+2)}{2T} \qquad \text{(C-3)}$$

and

$$\frac{\chi^2_{\alpha/2}(2N)}{2D} \le \lambda(\text{demand}) \le \frac{\chi^2_{1-\alpha/2}(2N+2)}{2D} \qquad \text{(C-4)}$$

where

$\chi^2_a(b)$ = the chi-square variate at cumulative probability **a** with **b** degrees of freedom.

In these equations, $\alpha$ is the fraction left out of the intervals. For example, for 90% confidence limits $\alpha$ is 0.10, $\alpha/2$ is 0.05, and the upper limit uses the 95th percentile.

If D is small, then the Poisson approximation of the binomial distribution is not adequate, and 100 (1 - $\alpha$)% confidence limits for the demand fault rate are

$$\frac{NF_L}{D - N + 1 + NF_L} \le \lambda(\text{demand})$$

$$\le \frac{(N+1)F_U}{D - N + (N+1)F_U} \qquad \text{(C-5)}$$

where

$F_L = F_{\alpha/2}(2N, 2D - 2N + 2)$

$F_U = F_{1-\alpha/2}(2N + 2, 2D - 2N)$

$F_a(b,c)$ = F variate at cumulative probability **a** with **b** and **c** degrees of freedom.

As before, for 90% confidence limits the 0.05 and 0.95 quantities are used ($\alpha = 0.10$).

In this work, hourly rate confidence limits were always based on Equation (C-3). Demand rate confidence limits were based on Equation (C-4) if $D - N \geq 100$, and on Equation (C-5) otherwise.

The lower limits in Equations (C-3), (C-4), and (C-5) are not defined in cases where no faults are observed ($N = 0$). Zero is the appropriate lower limit in these cases. However, Equations (C-1) and (C-2) also give zero as the point estimate when $N = 0$. More realistic point estimates for such cases are

$$\hat{\lambda} = \frac{\chi^2_{0.50}(2N+1)}{2T} \qquad \text{(C-6)}$$

and

$$\hat{\lambda} = \frac{\chi^2_{0.50}(2N+1)}{2D} \qquad \text{(C-7)}$$

then

$$\hat{\lambda} = \frac{(2N+1)F_M}{2D - 2N + 1 + (2N+1)F_M} \qquad \text{(C-8)}$$

where

$F_M = F_{0.50}(2N + 1, 2D - 2N + 1)$

and the F and $\chi^2$ distribution percentile and degree of freedom notations are as defined above.

Equation (C-6) applies for hourly rates, while Equation (C-7) is used with the upper bound from Equation (C-4) and Equation (C-8) is used with Equation (C-5). Equations (C-6) and (C-7) are applicable to faults occurring according to a Poisson distribution regardless of the number of faults observed. A similar comment applies to Equation (C-8) and the binomial distribution. Typical estimates from Equation (C-6) are in the following table for comparison with Equation (C-1). Equation (C-6) has been used in other fault data studies, such as Reference C-2.

| N | $\hat{\lambda}$ |
|---|---|
| 30 | 30.15/T |
| 20 | 20.15/T |
| 10 | 10.15/T |
| 5 | 5.15/T |
| 2 | 2.18/T |
| 1 | 1.19/T |
| 0 | 0.23/T |

The estimates of Equations (C-6) through (C-8) can be obtained in two ways. The first is to consider shrinking the confidence intervals of Equations (C-3), (C-4), and (C-5) to the case where $\alpha = 1.00$ and both $\alpha/2$ and $1-\alpha/2$ are 0.5. Because of the differing degrees of freedom, the intervals do not shrink to a single point. The equations use an average for the differing degrees of freedom. Because the estimates use 50th percentiles, they are related to medians.

The second way of considering Equations (C-6) through (C-8) uses the medians directly. In a Bayesian context, $\lambda$ is regarded as a random variable. With Poisson sampling and a noninformative conjugate prior distribution, the posterior distribution for the occurrence rate has a gamma distribution with parameters[C-3]

$$(\alpha,\beta) = (N + 1/2, 1/T). \qquad \text{(C-9)}$$

Because the gamma distribution with parameters (N,2) is identical to the chi-square distribution with 2N degrees of freedom,[C-4] Equation (C-6) can be shown to be the median of the distribution described by Equation (C-9). Using a similar relation between beta and F distributions, Equation (C-8) can be derived as the median of the posterior fault rate distribution obtained in sampling from a binomial distribution with a noninformative conjugate prior distribution.

In summary, Equations (C-6), (C-7), and (C-8) describe median point estimates for the fault rate. They can be used when $N = 0$, and are more conservative in that case than the point estimates given in Equations (C-1) and (C-2). In this work, they are used with, respectively, the upper confidence limits in Equations (C-3), (C-4), and (C-5) whenever no faults are observed.

In estimating the above confidence limits, all components in the sample were assumed to have exactly the same true fault rate. No effort was made to account for possible variations arising from the mixture of populations having different true fault rates. For further discussion of the assumptions and limitations of these confidence limits, see References C-1 and C-5.

## References


C-1. L. J. Bain, *Statistical Analysis of Reliability and Life-Testing Models*, New York: Marcel Dekker, Inc., 1978, p. 157.

C-2. *NPRDS 1978 Annual Reports of Cumulative System and Component Reliability*, NUREG/CR-0942, Southwest Research Institute, September, 1979.

C-3. G. E. P. Box and G. C. Tiao, *Bayesian Inference in Statistical Analysis*, Addison-Wesley, Reading, MA, 1973.

C-4. N. R. Mann, R. E. Shafer, and N. D. Singpurwalla, *Methods for Statistical Analysis of Reliability and Life Data*, New York: John Wiley and Sons, Inc., 1974.

C-5. N. L. Johnson and S. Kotz, *Discrete Distributions*, New York: John Wiley and Sons, Inc., 1969, pp. 58-59 and 96.

# APPENDIX D

# INVERTER ONE-LINE DESCRIPTIONS SORTED BY NSSS VENDOR

# CODES USED IN LER ONE-LINE DESCRIPTIONS

## FAULT MODE

| CODE | DESCRIPTION |
|---|---|
| A | REDUCED CAPABILITY |
| B | INOPERABLE |

## SYSTEM

| CODE | DESCRIPTION |
|---|---|
| A | AUTOMATIC DEPRESSURIZATION SYSTEM (ADS) |
| C | CONTAINMENT (INCLUDES ISOLATION CONTROL) |
| E | ESSENTIAL AC ELECTRICAL DISTRIBUTION |
| H | HIGH PRESSURE COOLANT INJECTION (HPCI) |
| L | LOW PRESSURE COOLANT INJECTION (LPCI) |
| Q | REACTOR CORE ISOLATION COOLING (RCIC) |
| P | UNKNOWN |

## TYPE OF EVENT

| CODE | DESCRIPTION |
|---|---|
| B | RECURRING COMMON CAUSE FAILURE |
| C | COMMON CAUSE FAILURE |
| R | RECURRING FAILURE |
| S | COMMAND FAULT |
| T | RECURRING COMMAND FAULT |
| U | COMMON CAUSE COMMAND FAULT |
| V | RECURRING COMMON CAUSE COMMAND FAULT |
| BLANK | RANDOM FAILURE |

## FAULT CAUSE

| CODE | DESCRIPTION |
|---|---|
| 00 | UNKNOWN |
| 01 | PERSONNEL OPERATION |
| 02 | PERSONNEL MAINTENANCE |
| 03 | PERSONNEL TESTING |
| 04 | DESIGN ERROR |
| 05 | FABRICATION/CONSTRUCTION/QUALITY CONTROL |
| 06 | DEFECTIVE PROCEDURES |
| 07 | EXTREME ENVIRONMENT |
| 08 | ELECTRICAL MALFUNCTION |
| 09 | MECHANICAL MALFUNCTION |

## SUBCOMPONENT

| CODE | DESCRIPTION |
|---|---|
| AC | ANNUNCIATOR CONTROL CARD |
| CC | FIRING CIRCUIT |
| CF | COOLING FAN |
| CH | CHOKE |
| CL | CONTROL CARD/CONTROL MODULE |
| CP | CAPACITOR |
| DB | DRIVER BOARD |
| DI | DIODE |
| FB | FREQUENCY BOARD |
| FS | FUSE |
| IN | INDUCTOR |
| OS | OSCILLATOR |
| PC | PROTECTION CARD |
| PS | POWER SUPPLY (INTERNAL) |
| RC | RECTIFIER |
| RE | RELAY |
| RS | RESISTOR |
| SW | SWITCH |
| TR | TRANSFORMER |
| TS | TRANSISTOR |
| UV | UNDERVOLTAGE COIL |
| VR | VOLTAGE REGULATOR |
| UU | UNKNOWN/NOT APPLICABLE |

## ACTIVITY RESULTING IN DISCOVERY

| CODE | DESCRIPTION |
|---|---|
| M | MAINTENANCE |
| N | NORMAL PLANT OPERATION |
| R | RECORDS REVIEW |
| T | TESTING |
| U | UNKNOWN |

## NSSS VENDOR

| CODE | DESCRIPTION |
|---|---|
| B | BABCOCK & WILCOX |
| C | COMBUSTION ENGINEERING |
| W | WESTINGHOUSE |
| G | GENERAL ELECTRIC |

## COMPONENT

| CODE | DESCRIPTION |
|---|---|
| SI | STATIC INVERTER |

## EVENT CLASSIFICATION

| CODE | DESCRIPTION |
|---|---|
| D | FREQUENCY |
| T | AGE |
| U | UNKNOWN |

## INVERTER ONE-LINE DESCRIPTIONS SORTED BY NSSS VENDOR

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | SUBCOMP | SYSTEM | MODE & CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B | CR3 | 017321 | 030277 | SI | DI | E | B 8 | N | | T | | "B" INVERTER FAILED,CAUSED RX TRIP | OUTPUT DIODE FAILED |
| B | CR3 | 019021 | 090277 | SI | RC | E | B08 | N | | D | | "D" INVERTER FAILED | SILICON CONTROLLED RECTIFIER DEFECTIVE |
| B | CR3 | 019523 | 102677 | SI | UU | E | B00 | N | | U | | "A" INVERTER FAILED | NO CAUSE GIVEN |
| B | CR3 | 021210 | 042578 | SI | UU | E | A05 | N | U | D | | INVERTER 3A TRIPPING--WRONG FUSES INSTLD IN VITAL/ | BUS 3A DURING CONSTRUCTION/TESTING PHASE |
| B | CR3 | 022361 | 081978 | SI | UU | E | B08 | N | B | D | | INVERTER VBIT-1A FAILED-120VAC VITAL BUS 3A NO PWR | ELECTRONIC COMPONENT FAILRS W/ IN VBIT-1A |
| B | CR3 | 037006 | 041181 | SI | DI | E | B07 | N | R | T | | INVERTER "D" FAILED. INADQ VENT CAUSED OVERHTG // | SHORTED DIODE & BLEW FUSE |
| B | CR3 | 038100 | 071481 | SI | FS | E | B02 | M | C | D | | "A" INVERTER FAILED DEENRGZD 120 AC VITAL BUS #3A | INADV SHORTED STAT BATT DURING MAINTENANC |
| B | DB1 | 027478 | 110579 | SI | RS | E | B08 | N | | D | | BLOWN FUSE ON INVERTER YV2 OUTPUT | OPEN RESISTOR IN LOGIC PS OF INVERTER YV2 |
| B | DB1 | 032367A | 082280 | SI | FS | E | B08 | N | B | D | | FAILURE OF YV-2 INVERTER INPUT FUSE | EXACT CAUSE OF FUSE FAILURE UNDETERMINED |
| B | DB1 | 032367B | 082380 | SI | FS | E | B08 | N | B | D | | FAILURE OF YV-2 INVERTER INPUT FUSE | EXACT CAUSE OF FUSE FAILURE UNDETERMINED |
| B | DB1 | 033270 | 111280 | SI | FS | E | B02 | T | C | D | | GROUNDED YV2 INVERTER INPUT FUSE TOOK OUT Y2 BUS | GROUNDED OSCILLOSCOPE USED BY I&C PERSNL |
| B | DB1 | 039149 | 101881 | SI | DI | E | B08 | N | | T | | ESSENTIAL 120VAC INVERTER YV3 FAILED | RESISTOR/DIODE ON +15VDC LOGIC PS FAILED |
| B | DB1 | 173542 | 040982 | SI | FS | E | B02 | N | C | D | | OUTPUT FROM YV2 INVERTER TO Y2 BUS WAS LOST | FUSE BLEW DUE TO PERSONNEL MAINTENANCE |
| B | DB1 | 175395 | 060882 | SI | RC | E | B08 | N | C | T | | ESSENTIAL INVERTER YV2 FAILED | COMP FAILR W/ IN REGULATED RECTIFIER YRF2 |
| B | OE1 | 036123 | 011881 | SI | FS | E | B08 | N | | D | | 1DID VITAL INVERTER DC INPUT FUSE BLEW | POOR CNNCTN &/OR COMP PRBLMS IN LOGIC CRD |
| B | OE1 | 036241A | 012581 | SI | FS | E | B08 | N | | D | | 1DID VITAL INVERTER DC INPUT FUSE BLEW | BLOWN FUSES |
| B | OE1 | 036241B | 012581 | SI | UU | E | B00 | N | | U | | 1DIB INVERTER TRIPPED | EXACT CAUSE UNKNOWN |
| B | OE1 | 036241C | 012581 | SI | UU | E | B02 | M | U | D | | 1DID INVERTER TRIPPED | PERS OPENED AC OUTPUT BRKR MISTAKENLY |
| B | OE3 | 016137 | 091276 | SI | CP | E | B08 | N | | T | | THE 3 DIB VITAL BUS INVERTER FAILED | DIELECTRIC OF INPUT FILTER CAP BROKE DOWN |
| B | OE3 | 027697 | 111079 | SI | FS | E | B08 | N | | D | | ICS POWER LOST DUE TO INVERTER(KI) FAILED | BLOW FUSES |
| B | OE3 | 031182A | 050780 | SI | FS | E | B08 | N | R | D | | LOST AC VITAL INST BUS DUE TO INVERTER FAILURE | BLOWN FUSES |
| B | OE3 | 031182B | 050980 | SI | FS | E | B08 | N | R | D | | LOST AC VITAL INST BUS DUE TO INVERTER FAILURE | BLOWN FUSES/FAULTY TRANSISTOR |
| B | OE3 | 031182C | 051680 | SI | TS | E | B01 | N | | D | | INVERTER 3DIB TRIPPED WHEN POWER WAS TRANSFERRED / | /TO IT. BYPASS SWITCH POSSIBLY CLOSED. |
| B | RS1 | 026111 | 042279 | SI | UV | E | B04 | U | R | D | | S1A VITAL POWER INVERTER FAILED | DESIGN DEFICIENCY IN U.V. COIL |
| B | TI2 | 021952 | 032978 | SI | CL | E | B08 | N | | T | | VITAL BUS INVERTER FAILD TO FUNCTN PROPERLY | FAULTY INVERTER CNTRL MODULE AND FUSE |
| C | CC1 | 179674 | 110982 | SI | UU | E | B01 | M | U | D | | RX S/D DUE TO INVERTER DC FEEDER BREAKER TRIP | CONTRACTOR INADV TRPD OPEN INPUT BREAKER |
| C | CC2 | 017009 | 010677 | SI | FS | E | B09 | T | | D | | B PHASE COMPUTER INVERTER DC INPUT FUSE OPENED | CURRENT SURGE DUE TO SWITCHING OPERATION |
| C | CC2 | 183012 | 122882 | SI | FS | E | B00 | N | | U | | #22 INVERTER OUTPUT FUSE BLEW | SUSPECTED CAUSE--IMPROPER FUSE TYPE USED |
| C | FC1 | 020085 | 122577 | SI | VR | E | B08 | N | | T | | D CHANNEL INSTRUMENT INVERTER FAILED | CONSTANT VOLTAGE REGULATOR FAILED |
| C | MI2 | 02687' | 010579 | SI | CP | E | B08 | N | | T | | INVERTER NO. 4 FAILED | CAPACITORS AND OSCILLATOR BOARD FAILED |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C | MI2 | 172670* | 010682 | SI | FS | E | B02 | N | C | D | 2 | FUSES IN INVERTERS 2 AND 6 BLEW | SHORTED TEST LEAD FAILED CIRCUIT |
| C | MI2 | 175402* | 060682 | SI | FS | E | B07 | N | C | D | 2 | LOSS OF 120VAC (VIAC-1) BLOWS FUSES IN ESFAS CABNT | ROOF LEAK SHORTED 2 INVERTERS #5,6 |
| C | SL1 | 015004 | 052976 | SI | OS | E | B08 | N | | T | | 1C STATIC INVERTER FAILED(PS FOR AC INST,120 VOLT) | FAILED OSCILLATOR CIRCUIT BOARD |
| C | SL1 | 175205A | 062282 | SI | UU | E | B00 | N | R | U | | OUTPUT BRKR OF 1A STATIC INVERTER OPENED | NO APPARENT CAUSE COULD BE FOUND |
| C | SL1 | 175205B | 062382 | SI | OS | E | B08 | N | R | U | | 1A STATIC INVERTER OUTPUT BREAKER OPENED | OSCILLATOR CIPCUIT BOARD REPLACED |
| C | SL1 | 181486 | 122082 | SI | UU | E | B00 | N | R | U | | 1A INVERTER OUTPUT BRK OPENED;1/4 120VAC BUS LOST | NO APPARENT CAUSE OF FAILURE |
| C | SL1 | 181729 | 122582 | SI | FB | E | B00 | N | R | U | | 1A INVERTER OUTPUT BRK OPENED;1/4 120VAC BUS LOST | DEFECTIVE OUTPUT FREQUENCY MODULE |
| C | SL1 | 181038 | 123082 | SI | OS | E | B08 | N | | T | | 1A INVERTER OUTPUT BRK OPENED;1/4 120VAC BUS LOST | FREQUENCY OSCILLATOR HAD DRIFTED |
| W | BV1 | 014692 | 051076 | SI | CP | E | B08 | N | R | T | | INVERTER NO. 3 FAILED | OUTPUT FILTER CAPACITOR FAILED |
| W | BV1 | 015102 | 052776 | SI | CP | E | B08 | N | R | T | | INVERTER NO. 1 FAILED | OUTPUT FILTER CAPACITOR FAILED |
| W | BV1 | 015213 | 062376 | SI | UU | E | B00 | U | | U | | INVERTER NO. 3 APPARENTLY FAILED | NO CAUSE GIVEN |
| W | BV1 | 016280 | 102276 | SI | RC | E | B08 | N | R | T | | VITAL BUS INVERTER NO. 3 FAILED | SCRS AND OUTPUT FUSE FOUND BAD |
| W | BV1 | 016360 | 110676 | SI | UU | E | B03 | N | U | D | | INVERTER NO. 2 WAS MOMENTARILY OUT OF SERVICE | OUTPUT WAS SHORTED OUT BY PERSONNEL |
| W | BV1 | 017014 | 121576 | SI | DI | E | B08 | N | R | T | | NO. 1 VITAL BUS INVERTER FAILED | 1 DIODE AND TWO FUSES FOUND FAILED |
| W | BV1 | 023209 | 010278 | SI | UU | E | A00 | N | | U | | OUTPUT FREQUENCY OF NO. 4 INVERTER OSCILLATING | NO CAUSE GIVEN |
| W | BV1 | 025332 | 012079 | SI | UU | E | B00 | N | | U | | NO. 3 VITAL BUS INVERTER FAILED | FAULTY COMPONENTS |
| W | BV1 | 027140 | 091879 | SI | OS | E | A08 | N | | T | | NO. 4 VITAL BUS INVERTER FREQUENCY FOUND SPIKING | FAULTY OSCILLATOR CARD |
| W | BV1 | 028012 | 092079 | SI | UU | E | B00 | N | | U | | NO. 4 VITAL BUS INVERTER FAILED. RX TRIP OCCURRED/ | /AND SAFETY INJECTION OCCURRED. NO CAUSE |
| W | BV1 | 031239 | 050480 | SI | FS | E | B08 | N | R | D | | PWR LOST TO #4 VITAL BUS INVERTER DUE TO BLOWN // | MAIN PS FUSE. CAUSE UNKNOWN |
| W | BV1 | 173454 | 0[illegible]1482 | SI | UU | E | B02 | N | U | D | | NO. 3 INVERTER TRIPPED | PERSONNEL MAINTENANCE |
| W | DC1 | 017804 | 042177 | SI | FS | E | B08 | N | | D | | #4 INVERTER FAILED,CAUSED RX TRIP & SI | BLOWN FUSE |
| W | DC1 | 025643* | 032379 | SI | UU | E | B01 | N | C | D | 2 | TWO VITAL BUS INVERTERS FAILED SIMULTANEOUSLY | PARTS FAILED DUE TO DC SURGE. PERSONNEL |
| W | DC1 | 032503 | 083180 | SI | DI | E | B08 | N | R | T | | SHORTED DIODE IN CRID IV INVERTER | DIODE FAILED DUE TO NORMAL END OF LIFE |
| W | DC1 | 182697 | 082382 | SI | UU | E | B08 | N | | D | | AB EMERG DIESEL GENERATOR INVERTER FAILED. SOLID | STATE COMP, XFMR GATE, SHORTING BRD RPLCD |
| W | DC2 | 022280 | 061378 | SI | DI | E | B08 | N | C | T | | INVERTER FAILURE | DEFECTIVE DIODES AND SCR'S |
| W | DC2 | 037613 | 061281 | SI | CP | E | B08 | N | B | T | | FAILURE IN 120VAC VITAL BUS (CRID II) | C-2 CAPACITOR FAILED ALSO BLEW A FUSE |
| W | HN1 | 018775 | 071977 | SI | UU | E | B07 | N | C | T | | STATIC INVERTER FAILED | AMBIENT TEMP 40 DEG C. ABOVE DESIGN |
| W | IP2 | 022867 | 102278 | SI | UU | C | B00 | N | | U | | .5KVA STATIC INVERTER FAILD DEENRGZG CONT PRESS // | SAFEGUARDS LOGIC. DEFECTIVE INVERTER |
| W | JF1 | 02159[illegible] | 022178 | SI | UU | E | B00 | N | | U | | 120V VITAL BUS A DEENRGZD WHEN INVERTER A TRIPPED | EXACT CAUSE NOT IDENTIFIED |
| W | JF1 | 021592 | 022378 | SI | CP | E | B08 | N | R | D | | 120VAC VITAL BUS B DEENRGZD WHEN INVERTER 1B TRPD | FAULTY CAPACITOR WAS REPLACED |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W | JF1 | 021594 | 050978 | SI | UU | E | B00 | N | | U | | 120VAC VITAL BUS A DEENRGZD WHEN INVERTER A TRPD | EXACT CAUSE NOT IDENTIFIED |
| W | JF1 | 021591 | 053078 | SI | CP | E | B08 | N | R | D | | 120VAC BUS D DEENRGZD WHEN INVERTER 1D TRIPPED | CAPACITOR IN INVERTER FAILED |
| W | JF1 | 025439 | 011679 | SI | CH | E | B08 | N | | T | | 1B INVERTER TRIPPED (PS FOR 120V VITAL AC) | VARIOUS INTERNAL COMPONENTS FAILED |
| W | JF2 | 038879 | 092381 | SI | UU | E | B00 | M | | U | | INVERTER 2A TRPD--120VAC VITAL BUS 2A DEENERGIZED | TRANSIENT VOLTAGE SPIKE--CAUSE UNKNOWN |
| W | JF2 | 173252 | 031682 | SI | FS | E | B08 | N | | D | | INVERTER NO. 2B FAILED | FUSE BLEW IN VOLTAGE REGULATOR |
| W | JF2 | 17654.' | 072282 | SI | UU | E | B00 | N | | U | | INVERTER NO. 2G FAILED CAUSING LOSS OF POWER TO S/ | /UB COOLING MONITOR AND H2 MONITOR |
| W | MG1 | 174673 | 061382 | SI | RC | E | B08 | N | | D | | INVERTER EVIA INOP--LOST VITAL INST PWR CAUSD RX// | TRIPS. SCR SHORTING CKT BRD REPLACED |
| W | MG1 | 174671 | 062482 | SI | CP | E | B08 | N | | T | | STATIC INVERTER EVIA MALFUNC--RHR ISOL VLV CLOSED | 3 CAP IN OUTPUT CVT CAP BANK FAILED |
| W | NA1 | 031217 | 052380 | SI | FS | E | B08 | N | | D | | LOST VITAL BUS 1-III. CAUSE UNKNOWN--POSSIBLY // | VLTG SURGE TO DC/AC INVERTER BLEW 2 FUSES |
| W | NA1 | 032608 | 090880 | SI | UU | E | B00 | N | | U | | LOST PWR TO 120VAC VITAL BUS 1-IV | INVERTER SUPPLY BRKR FOUND OPEN |
| W | NA2 | 037674* | 060381 | SI | UU | E | A00 | N | C | U | 2 | VOLTAGE TRANSIENT THRU VITAL BUS INVERTERS 2-III// | & 2-IV. CAUSE UNKNOWN |
| W | PR1 | 015104 | 061576 | SI | TR | E | B08 | N | R | T | | NO. 13 INVERTER FAILED (PS TO INSTRUMENT BUS 113) | REGULATING TRANSFORMER ON OUTPUT FAILED |
| W | PR1 | 017425 | 031477 | SI | CP | E | B08 | N | R | T | | NO. 11 INVERTER FAILED | CAP ON OUTPUT SOLA TRANSFORMER FAILED |
| W | PR2 | 032962 | 1C0480 | SI | TR | E | B08 | N | | T | | #23 INVERTER FAILED DEENRGZG PANEL 213 | CONSTANT VOLTAGE TRANSFORMER FAILED |
| W | SA1 | 022426 | 082178 | SI | DI | E | B08 | N | | T | | VITAL INST BUS INVERTER 1A FUSES BLOWN | FAILD DIODE IN CNTRL CKT BRD |
| W | SA1 | 022420 | 082778 | SI | CL | E | B08 | N | R | T | | 1A INVERTER FAILD--FAILD ELECTRONIC COMP ON MASTER | //LOGIC CKT BRD CAUSD BLOWN FUSES |
| W | SA1 | 023232 | 112778 | SI | TR | E | B08 | N | R | T | | LOST 1B VITAL INSTRUMENT BUS | OUTPUT XFRMR IN SUPPLY INVERTER FAILED |
| W | SA1 | 023230 | 120878 | SI | UU | E | B00 | N | | U | | INVERTER DIDN'T SWITCH TO B/U BATTERY SUPPLY | NO CAUSE COULD BE DETERMINED |
| W | SA1 | 023513 | 012679 | SI | UU | E | B00 | N | | U | | 1B VITAL INSTRUMENT BUS INVERTER FAILED | NO CAUSE. INADVERTANT SI OCCURRED |
| W | SA1 | 027523 | 110579 | SI | CF | P | B09 | N | | T | | LOST METEORLOLGICAL INSTR/PWR SUP INVERTER FAILED | SEIZED MOTOR BEARINGS IN COOLING FAN |
| W | SA1 | 030231 | 012380 | SI | SW | P | B05 | N | B | D | | LOST METEOROLOGICAL INSTRUMENT | INVERTER HAD MAN NOT AUTO SW--MFG ERROR |
| W | SA1 | 039242 | 102981 | SI | UU | E | B00 | N | | U | | INADV SI DUE TO LOSS OF VITAL BUS 1A INVERTER | CAUSE UNKNOWN |
| W | SA1 | 039344 | 110681 | SI | UU | E | B00 | N | | U | | INADV SI DUE TO LOSS OF 1A VITAL INST BUS INVERTER | CAUSE UNKNOWN |
| W | SA2 | 181466 | 112982 | SI | PS | E | B08 | N | | D | | INVERTER PS FAILED CAUSD P-250 COMPUTER TO SHUTDWN | PS PROBLEM FROM FAILED OSCILLATOR CKT BRD |
| W | SE1 | 032879A | 092780 | SI | UU | E | B00 | N | | U | | VITAL INVERTER 2-IV OUTPUT BRKR TRIPPED | CAUSE NOT IDENTIFIED |
| W | SE1 | 032879B | 100180 | SI | SW | E | B08 | N | | T | | VITAL INVERTER 2-IV OUTPUT BRKR TRIPPED | BAD AUX SW ON THE K11 RELAY |
| W | SE1 | 032977 | 101480 | SI | CC | E | B08 | N | | T | | VITAL INVERTER 2-III OUTPUT BRKR TRIPPED | FIRING CKT CLOCK CARD RB5 FAILED |
| W | SE1 | 033295 | 111180 | SI | FS | E | B08 | N | | D | | VITAL INVERTER 1-I OUTPUT BRKR TRIPPED | INVERTER 1-I OUTPUT FUSES HAD BLOWN |
| W | SE1 | 033296* | 111880 | SI | UU | E | B00 | N | R | U | 9 | 9 VITAL INVERTER 2-III FAILURES BETWEEN 11-9-80&// | 11-23-80. NO CAUSES GIVEN |
| W | SE1 | 036667 | 013081 | SI | UU | E | B02 | M | U | D | | CONDUIT/CABLE SUPPLYING PWR TO VITAL INVERTER 1-I/ | /WAS CUT. CONSTRUCTION PERSONNEL ERROR |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W | SO1 | 015998 | 082376 | SI | PS | E | B00 | N | | U | | VITAL BUS #1 TRANSFERRED TO B/U POWER SOURCE | COMPONENT FAILURE IN #1 INVERTER.NO CAUSE |
| W | SO1 | 018440 | 061477 | SI | CP | E | B08 | N | | T | | DC INPUT FUSE OF UPS INVERTER OPENED | CAPACITORS IN BANKS C-4,C-6 HAD FAILED |
| W | SO1 | 020878A | 031578 | SI | CP | C | B08 | N | | T | | "A" INVERTER FAILED (ONE OF TWO FOR CSAS LOGIC) | CAPACITOR AND CHOKE IN OUTPUT SIDE FAILED |
| W | SO1 | 020878B | 031578 | SI | UU | C | B04 | N | U | D | | "B" INVERTER FOR CSAS TRIPPED ON TRANSFER | TRANSFER SWITCH WAS TOO FAST |
| W | SO1 | 021743 | 060778 | SI | CP | P | B08 | N | | D | | DC INPUT FUSE FOR MOV-850C INVERTER OPENED | GE CAPACITOR 28F5108 AND SCR-2 FAILED |
| W | SU2 | 179196 | 101082 | SI | IN | E | B08 | N | | T | | FAILED VITAL BUS-3 INVERTER/TURB RUNBACK,RX,TRP,SI | STATION BATT INVERTER INDUCTOR SHORTED |
| W | TR1 | 033305 | 111280 | SI | UU | E | B00 | T | | U | | 3 VITAL PREFERRED INSTR BUSES ON SAME EMERG TRAIN | #4 INVERTER APPARENTLY FAILED--NO CAUSE |
| W | TR1 | 039071 | 100481 | SI | RE | E | B08 | N | | T | | LOST PREFERRED INST BUS Y11--STATIC INVERTER OUTPT | //CURRENT SENSG RELAY FAILD. NAT'L EOL |
| W | TR1 | 172719 | 011682 | SI | UU | E | B00 | N | R | U | | INVERTER NO. 2 FAILED. CAUSED INADVERTANT SI | NO CAUSE GIVEN. |
| W | ZI1 | 025150 | 011279 | SI | UU | E | 300 | N | U | U | | INV 114 TRPD. FOUND 2.5KVA INV SECTION FAULTY. | LOOSE CONTACT IN DC BREAKER |
| W | ZI1 | 026916 | 081379 | SI | TR | E | B08 | N | | T | | INSTRUMENT INVERTER 114 TRIPPED | 5KVA TRANSFORMER REPLACED |
| W | ZI1 | 037631 | 052881 | SI | TR | E | B08 | N | R | D | | INST INVERTER 114 FAILED | XFRMR SHORTED BY HI INVERTER CIRC CURRENT |
| W | ZI2 | 020356 | 082077 | SI | TR | E | B08 | N | | D | | INVERTER NO. 213 FAILED (INSTRUMENT INVERTER) | SLAVE TRANSFORMER FAILE) BY OVERHEATING |
| W | ZI2 | 031066 | 041180 | SI | RC | E | B08 | N | | T | | INSTRUMENT INVERTER 214 FAILED | SCR FAILED IN SLAVE UNIT OF INVERTER |
| W | ZI2 | 037995 | 050781 | SI | TR | E | B08 | N | | D | | LOST POWER TO INVERTER 213 | XFRMR SHORTD BY HI INVERTER CIRC CURRENT |
| G | BF1 | 038008 | 070481 | SI | CL | P | B08 | T | R | T | | ALARM PANEL XA-55-8E INVERTER INOPERABLE | FAILED INVERTER CONTROL CARD |
| G | BF3 | 027049 | 091579 | SI | AC | P | B08 | N | | T | | ANNUNC PANEL XA-55-20B INOP INVERTER PRINTED CKT// | CARD FAILED DUE TO NATURAL AGING |
| G | BP1 | 022658 | 091078 | SI | FS | C | B04 | N | R | D | | BLOWN FUSE IN POWER SUPPLY INVERTER | XIENT SUP VLTG PROBLEM--NEEDS DUMMY LOAD |
| G | BP1 | 025806 | 031979 | SI | FS | C | B04 | N | | D | | CONTAINMENT VACUUM RELIEF LOOP POWER SUPPLY INVER/ | /TER FOUND INOPERABLE. BLOWN PS FUSE |
| G | BP1 | 026880 | 061679 | SI | FS | C | B04 | N | R | D | | CNTNMNT VACUUM RELIEF PS INVERTER FUSE BLEW | SUSCEPTIBLE TO INPUT SURGE |
| G | BP1 | 037801A | 061781 | SI | PS | A | B08 | M | R | T | | RX DEPRESSURIZATION LOOP B INVERTER FOUND INOP. | DEFECTIVE ELECTRONIC COMPONENTS |
| G | BP1 | 037801B | 062381 | SI | PS | A | B08 | M | R | T | | RX DEPRESSURIZATION LOOP B INVERTER FOUND INOP. | DEFECTIVE ELECTRONIC COMPONENTS |
| G | BR1 | 017085* | 011777 | SI | UU | E | B02 | M | U | D | 2 | CNTRL VLTG PS SET BELOW EQUALZG VLTG CAUSED TRIP | I&C TECH ERROR IN EQUALZG PLANT BATTERIES |
| G | BR2 | 030364 | 020480 | SI | UU | Q | B00 | N | | U | | STM LEAK DETCTN "A" LOGIC INVERTER'S HV TRPD LOW | NO CAUSE GIVEN |
| G | CO1 | 037646 | 050581 | SI | CP | E | B06 | T | | D | | STATIC INVERTER 1A'S SPIKE SUPPRESSOR CAP FAILED | AGED ELECTROLYTIC CAP/IMPROPR OP PROCEDUR |
| G | EN1 | 016840 | 112776 | SI | CP | Q | B08 | N | | T | | RCIC PS INVERTER E51-K603 FAILED | SHORTED CAPACITOR IN OUTPUT TRANSFORMER |
| G | EN1 | 033842 | 073180 | SI | UU | L | B07 | N | U | T | | B LPCI INVERTER TRPD THUS B LOOP OF RHR INOPERABLE | HI AMBIENT TEMPERATURE IN INVERTER ROOM |
| G | EN1 | 032376 | 082180 | SI | UU | L | B07 | N | R | T | | "B" LPCI INVERTER TRIPPED | HI AMBIENT TEMPERATURE IN INVERTER ROOM |
| G | EN1 | 037947A | 061081 | SI | SW | L | B00 | N | R | U | | B LPCI INVERTER R44-S003 TRPD ON HIGH TEMPERATURE | DEFECTIVE SWITCH IN INVERTER LEG |
| G | EN1 | 037947D | 061681 | SI | UU | L | B00 | N | R | U | 2 | B LIPCI INVERTER 2R44-S003 TRIPPED | UNKNOWN CAUSE |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G | EN1 | 037947B | 061881 | SI | SW | L | B00 | N | R | U | 2 | B LPCI INVERTER R44-S003 TRIPPED | DFCTV SWITCHES IN INVERTER LEGS |
| G | EN1 | 037947C | 062181 | SI | SW | L | B00 | N | R | U | | B LPCI INVERTER R44-S003 TRIPPED | DEFECTIVE SWITCH IN INVERTER LEG |
| G | EN1 | 177682 | 091182 | SI | CP | L | B08 | N | | D | | "A" LPCI INVERTER FAILED. OUTPUT FILTER CAPACITO/ | /R INSULATION SPAT,FAILED FUSES & CAP'S |
| G | EN2 | 022024 | 071778 | SI | FB | L | B08 | N | | T | | STATIC INVERTER(2R44-S002) OUTPUT BREAKER TRIPPED | FREQUENCY CARD(EXIDE PART #A13A9) FAILED |
| G | EN2 | 023200 | 120878 | SI | PC | L | B08 | N | | T | | STATIC INVERTER (2R44-S003) DC OUTPUT BRKR TRIPPED | AC/DC PROTECTION CARD(A13A12) FAILED |
| G | EN2 | 027611 | 111779 | SI | RE | L | B08 | N | | T | | "B" LPCI INVERTER TRIPPED | FAILED RELAY IN INVERTER FAILED |
| G | EN2 | 027848A | 121979 | SI | FS | Q | B08 | N | C | D | | "A" PS FOR RCIC STEAM LEAK DETECTION FAILED | FUSES BLEW DUE TO CURRENT SURGE |
| G | EN2 | 027848B | 122079 | SI | FS | Q | B08 | N | C | D | | "B" PS FOR RCIC STEAM LEAK DETECTION FAILED | FUSES BLEW DUE TO CURRENT SURGE |
| G | EN2 | 030041 | 011780 | SI | UU | H | B08 | N | | T | | HPCI AUTO FLO CNTRL PWR INVERTER'S HV TRPD LOW | INSTRUMENT DRIFT |
| G | EN2 | 030241 | 020280 | SI | CP | Q | B08 | T | | T | | RCIC REMOTE FLO CNTRL LOOP POWER INVERTER TRIPPED | DFCTV INPUT FILTER CAPACITORS |
| G | EN2 | 030980 | 042480 | SI | UU | Q | B00 | N | R | U | | REC'D RCIC LEAK DETECTION LOGIC PWR FAILURE ALARM | COMPONENT FAILURE OF INVERTER |
| G | EN2 | 036952 | 042181 | SI | CL | L | B08 | N | | U | | "A" LPCI INVERTER 2R44-S002 TRPD | LOGIC FAILURE CAUSED TRIP |
| G | EN2 | 038501 | 090481 | SI | VR | L | B08 | N | | T | | B LPCI INVERTER 2R44-S003 TRPD | GATE FIRING MODULE VOLTAGE REGULATOR FAIL |
| G | EN2 | 171785 | 112681 | SI | CC | L | B08 | M | | T | | B LPCI INVERTER (2R44-S003) GAVE HI PHASE CURRENTS | FAILED GATE FIRING MODULE |
| G | EN2 | 178916 | 100182 | SI | CF | L | B09 | N | | T | | INVERTER(2R44-S003) TRPD DUE TO LEG FAN FAILURE | #4 INVERTER LEG FAN BEARING FAILED |
| G | FP1 | 013966 | 010376 | SI | RS | Q | B08 | N | | D | | RCIC STATIC INVERTER(12-801A) FAILED | LEAD TO WIRE WOUND RESISTOR TOUCHED RSTR |
| G | FP1 | 015625 | 081576 | SI | UU | H | B00 | N | | U | | HPCI INVERTER 23-INV-79 TRIPPED AND WOULD NOT RES/ | /TART. NO CAUSE FOUND,INVERTER REPLACED |
| G | FP1 | 021432 | 051878 | SI | RC | L | B08 | N | | T | | LPCI INVERTER/CHARGER TRPD LOST B LPCI INDPNDNT // | PWR. FAILED SCR'S IN INVERTER/CHARGER |
| G | FP1 | 030177 | 012380 | SI | CP | L | B08 | N | | U | | LPCI INDPNDNT PS "A" INVERTER TRIPPED | INVERTER CNTRL CKT CAPACITORS FAILED |
| G | FP1 | 032373A | 081280 | SI | CL | L | B08 | N | | T | | "B" LPCI INVERTER TRIPPED | AC VOLTAGE/CURRENT CNTRL LOGIC CARD A12 |
| G | FP1 | 032373B | 082280 | SI | CL | L | B08 | N | | T | | "B" LPCI INVERTER TRIPPED | INVERTER LEG GATE FIRE CNTRL CKT FAILED |
| G | FP1 | 032373C | 090580 | SI | AC | L | B08 | N | | T | | "B" LPCI INVERTER TRIPPED | ANNUNCIATOR/CONTROL CARD 2 FAILED |
| G | FP1 | 032373D | 090680 | SI | AC | L | B08 | N | | T | | "B" LPCI INVERTER TRIPPED | ANNUNCIATOR/CONTROL CARD 2 FAILED |
| G | FP1 | 032718 | 091380 | SI | CL | L | B08 | N | | T | | "B" LPCI INVERTER TRIPPED | LOGIC CARD A2 FAILED |
| G | FP1 | 037379 | 051581 | SI | CP | L | B08 | N | R | D | | LPCI MOV INDEPENDENT POWER SUPPLY INVERTER A TRPD | SHORTED CAP IN GATE FIRING MODULE "A1" |
| G | FP1 | 181727 | 121582 | SI | CL | L | B08 | N | | D | | "A" LPCI INVERTER TRIPPED DUE TO ELECTRICAL FAILUR | GATE TIMING CONTROL CARD FAILED |
| G | PB2 | 017210 | 021977 | SI | UU | Q | B00 | N | | U | | RCIC STATIC INVERTER 2-13-90 TRIPPED WITHOUT AUTO/ | /MATIC RESET. NO CAUSE FOUND |
| G | PB2 | 021247 | 041978 | SI | TS | Q | B08 | N | | T | | INVERTER FAILD POWERS RCIC'S CNTRLLR & INSTRMNTN | DFCTV TRANSISTOR IN AUTO-RESET CIRCUIT |
| G | PB2 | 021248 | 042478 | SI | UU | H | B00 | N | | U | | HPCI STATIC INVERTER TRIPPED | NO FAULT COULD BE FOUND WITH THE INVERTER |
| G | PI1 | 038673 | 091281 | SI | CP | Q | B08 | N | | D | | FAILED INVERTER CAUSED GROUND FAULT ON 125VDC SYS | FAILED CAP IN DC/AC INVERTER |

INVERTER ONE-LINE DESCRIPTIONS SORTED BY NSSS VENDOR

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | SUBCOMP | SYSTEM | MODE CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G | VY1 | 015519 | 081376 | SI | SW | L | B04 | N | | D | | A 250 KVA UPS OUTPUT BREAKER TRIPPED | NOISE IN AN UNUSED STATIC SWITCH |
| G | VY1 | 015965 | 092076 | SI | FS | L | B08 | N | | D | | MOTOR CONTROL CENTER 89A LOST POWER DUE TO "A" UP/ | /S TRIPPED. BLOWN INVERTER LEG FUSE |
| G | VY1 | 016272 | 101976 | SI | CL | L | B08 | N | R | T | | UPS-1B TRIPPED WHEN OPENING VALVE RHR-27B | POSSIBLE LOGIC PROBLEM |
| G | VY1 | 016485 | 111876 | SI | VR | L | B08 | N | R | T | | UPS-1B TRIPPED WHILE TESTING RHR-27B VALVE | VOLTAGE REGULATOR AND SYSTEM LOGIC PRBLEM |
| G | VY1 | 016500* | 112976 | SI | DB | L | B08 | N | R | T | 2 | UPS-1A AND UPS-1B TRIPPED WHILE TESTING LPCI VALVE | 1A HAD FAILED DRIVER BOARD,1B HAD BAD REG |
| G | VY1 | 021542 | 053078 | SI | FS | L | B08 | N | | D | | 250KVA UNINTERRUPTIBLE PWR SUPPLY TRIPPED | BLOWN INVERTER LEG FUSE(2A18F2) |
| G | VY1 | 021768 | 061978 | SI | UU | L | B00 | N | | U | | LOSS OF VLTG TO MCC-89B | UNINTERRUPTIBLE POWER SUPPLY(UPS-1B) TRPD |
| G | VY1 | 021842 | 062978 | SI | PC | L | B08 | N | | T | | 250KVA UPS TRPD DUE TO INVERTER LEG FUSE(2A19F2)// | BLEW WHEN GATE INTRFC/PRTCTN LOGIC MALFUN |
| G | VY1 | 032080 | 071880 | SI | FS | L | B08 | N | C | D | | LOGIC PS BRD FAILED. 250KVA UNINTERRUPTIBLE PS // | TRPD DUE TO BLOWN LOGIC PS FUSE |
| G | VY1 | 173401 | 020682 | SI | CP | L | B08 | N | | T | | UPS-B AC GROUND AND BLOWN FUSE ALARM WAS RECEIVED | SUPPRESSION CAPACITOR FAILED BLOWING FUSE |
| G | VY1 | 172882 | 022382 | SI | CP | L | B08 | N | | T | | UPS "B" TRAIN TRIPPED | SHORTED CAPACITOR DUE TO AGE |

# APPENDIX E

## INVERTER ONE-LINE DESCRIPTIONS SORTED BY HUMAN FACTORS

# CONTENTS

# CODES USED IN LER ONE-LINE DESCRIPTIONS

## FAULT MODE

| CODE | DESCRIPTION |
|---|---|
| A | REDUCED CAPABILITY |
| B | INOPERABLE |

## SYSTEM

| CODE | DESCRIPTION |
|---|---|
| A | AUTOMATIC DEPRESSURIZATION SYSTEM (ADS) |
| C | CONTAINMENT (INCLUDES ISOLATION CONTROL) |
| E | ESSENTIAL AC ELECTRICAL DISTRIBUTION |
| H | HIGH PRESSURE COOLANT INJECTION (HPCI) |
| L | LOW PRESSURE COOLANT INJECTION (LPCI) |
| Q | REACTOR CORE ISOLATION COOLING (RCIC) |
| P | UNKNOWN |

## TYPE OF EVENT

| CODE | DESCRIPTION |
|---|---|
| B | RECURRING COMMON CAUSE FAILURE |
| C | COMMON CAUSE FAILURE |
| R | RECURRING FAILURE |
| S | COMMAND FAULT |
| T | RECURRING COMMAND FAULT |
| U | COMMON CAUSE COMMAND FAULT |
| V | RECURRING COMMON CAUSE COMMAND FAULT |
| BLANK | RANDOM FAILURE |

## FAULT CAUSE

| CODE | DESCRIPTION |
|---|---|
| 00 | UNKNOWN |
| 01 | PERSONNEL OPERATION |
| 02 | PERSONNEL MAINTENANCE |
| 03 | PERSONNEL TESTING |
| 04 | DESIGN ERROR |
| 05 | FABRICATION/CONSTRUCTION/QUALITY CONTROL |
| 06 | DEFECTIVE PROCEDURES |
| 07 | EXTREME ENVIRONMENT |
| 08 | ELECTRICAL MALFUNCTION |
| 09 | MECHANICAL MALFUNCTION |

## SUBCOMPONENT

| CODE | DESCRIPTION |
|---|---|
| AC | ANNUNCIATOR CONTROL CARD |
| CC | FIRING CIRCUIT |
| CF | COOLING FAN |
| CH | CHOKE |
| CL | CONTROL CARD/CONTROL MODULE |
| CP | CAPACITOR |
| DB | DRIVER BOARD |
| DI | DIODE |
| FB | FREQUENCY BOARD |
| FS | FUSE |
| IN | INDUCTOR |
| OS | OSCILLATOR |
| PC | PROTECTION CARD |
| PS | POWER SUPPLY (INTERNAL) |
| RC | RECTIFIER |
| RE | RELAY |
| RS | RESISTOR |
| SW | SWITCH |
| TR | TRANSFORMER |
| TS | TRANSISTOR |
| UV | UNDERVOLTAGE COIL |
| VR | VOLTAGE REGULATOR |
| UU | UNKNOWN/NOT APPLICABLE |

## ACTIVITY RESULTING IN DISCOVERY

| CODE | DESCRIPTION |
|---|---|
| M | MAINTENANCE |
| N | NORMAL PLANT OPERATION |
| R | RECORDS REVIEW |
| T | TESTING |
| U | UNKNOWN |

## NSSS VENDOR

| CODE | DESCRIPTION |
|---|---|
| B | BABCOCK & WILCOX |
| C | COMBUSTION ENGINEERING |
| W | WESTINGHOUSE |
| G | GENERAL ELECTRIC |

## COMPONENT

| CODE | DESCRIPTION |
|---|---|
| SI | STATIC INVERTER |

## EVENT CLASSIFICATION

| CODE | DESCRIPTION |
|---|---|
| D | FREQUENCY |
| T | AGE |
| U | UNKNOWN |

## PERSONNEL OPERATION

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | SUBCOMP | SYSTEM | MODE CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B | OE3 | 031182C | 051680 | SI | TS | E | 801 | N | | D | | INVERTER 3DIB TRIPPED WHEN POWER WAS TRANSFERRED / | /TO IT. BYPASS SWITCH POSSIBLY CLOSED. |
| C | CC1 | 179674 | 110982 | SI | UU | E | 801 | M | U | D | | RX S/D DUE TO INVERTER DC FEEDER BREAKER TRIP | CONTRACTOR INADV TRPD OPEN INPUT BREAKER |
| W | DC1 | 029643* | 032379 | SI | UU | E | 801 | N | C | D | 2 | TWO VITAL BUS INVERTERS FAILED SIMULTANEOUSLY | PARTS FAILED DUE TO DC SURGE. PERSONNEL |

## PERSONNEL MAINTENANCE

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | SUBCOMP | SYSTEM | MODE & CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B | CR3 | 038100 | 071481 | SI | FS | E | B02 | M | C | D | | "A" INVERTER FAILED DEENRGZD 120 AC VITAL BUS #3A | INADV SHORTED STAT BATT DURING MAINTENANC |
| B | DB1 | 033270 | 111280 | SI | FS | E | B02 | T | C | D | | GROUNDED YV2 INVERTER INPUT FUSE TOOK OUT Y2 BUS | GROUNDED OSCILLOSCOPE USED BY I&C PERSNL |
| B | DB1 | 173542 | 040982 | SI | FS | E | B02 | N | C | D | | OUTPUT FROM YV2 INVERTER TO Y2 BUS WAS LOST | FUSE BLEW DUE TO PERSONNEL MAINTENANCE |
| B | OE1 | 036241C | 012581 | SI | UU | E | B02 | M | U | D | | 1DID I[illegible]ERTER TRIPPED | PERS OPENED AC OUTPUT BRKR MISTAKENLY |
| C | MI2 | 172670* | 010682 | SI | FS | E | B02 | N | C | D | 2 | FUSES IN INVERTERS 2 AND 6 BLEW | SHORTED TEST LEAD FAILED CIRCUIT |
| W | BV1 | 173454 | 041482 | SI | UU | E | B02 | N | U | D | | NO. 3 INVERTER TRIPPED | PERSONNEL MAINTENANCE |
| W | SE1 | 036667 | 013081 | SI | UU | E | B02 | M | U | D | | CONDUIT/CABLE SUPPLYING PWR TO VITAL INVERTER 1-I/ | /WAS CUT. CONSTRUCTION PERSONNEL ERROR |
| G | BR1 | 017085* | 011777 | SI | UU | E | B02 | M | U | D | 2 | CNTRL VLTG PS SET BELOW EQUALZG VLTG CAUSED TRIP | I&C TECH ERROR IN EQUALZG PLANT BATTERIES |

PERSONNEL TESTING

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | COMP SUB | SYSTEM | MODE | CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W | BV1 | 016360 | 110676 | SI | UU | E | B03 | M | U | D | | | INVERTER NO. 2 WAS MOMENTARILY OUT OF SERVICE | OUTPUT WAS SHORTED OUT BY PERSONNEL |

## DESIGN ERROR

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | SUBCOMP | SYSTEM | MODE CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B | RS1 | 026111 | 042279 | SI | UV | E | B04 | U | R | D | | S1A VITAL POWER INVERTER FAILED | DESIGN DEFICIENCY IN U.V. COIL |
| W | SO1 | 0208788 | 031578 | SI | UU | C | B04 | M | U | D | | "B" INVERTER FOR CSAS TRIPPED ON TRANSFER | TRANSFER SWITCH WAS TOO FAST |
| G | BP1 | 022658 | 091078 | SI | FS | C | B04 | N | R | D | | BLOWN FUSE IN POWER SUPPLY INVERTER | XIENT SUP VLTG PROBLEM--NEEDS DUMMY LOAD |
| G | BP1 | 025806 | 031979 | SI | FS | C | B04 | N | | D | | CONTAINMENT VACUUM RELIEF LOOP POWER SUPPLY INVER/ | /TER FOUND INOPERABLE. BLOWN PS FUSE |
| G | BP1 | 026880 | 061679 | SI | FS | C | B04 | N | R | D | | CNTNMNT VACUUM RELIEF PS INVERTER FUSE BLEW | SUSCEPTIBLE TO INPUT SURGE |
| G | VY1 | 015519 | 081376 | SI | SW | L | B04 | N | | D | | A 250 KVA UPS OUTPUT BREAKER TRIPPED | NOISE IN AN UNUSED STATIC SWITCH |

## FABRICATION/CONSTRUCTION/QUALITY CONTROL

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | SUB COMP | SYSTEM | MODE & CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B | CR3 | 021210 | 042578 | SI | UU | E | A05 | N | U | D | | INVERTER 3A TRIPPING--WRONG FUSES INSTLD IN VITAL/ | BUS 3A DURING CONSTRUCTION/TESTING PHASE |
| W | SA1 | 030231 | 012380 | SI | SW | P | B05 | N | B | D | | LOST METEOROLOGICAL INSTRUMENT | INVERTER HAD MAN NCT AUTO SW--MFG ERROR |

## DEFECTIVE PROCEDURES

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | SUB COMP | SYSTEM | MODE | CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G | C01 | 037646 | 050581 | SI | CP | E | B0 | 6 | T | | D | | STATIC INVERTER 1A'S SPIKE SUPPRESSOR CAP FAILED | AGED ELECTROLYTIC CAP/IMPROPR OP PROCEDUR |

# APPENDIX F

## INVERTER ONE-LINE DESCRIPTIONS SORTED BY SYSTEM

# CONTENTS

# CODES USED IN LER ONE-LINE DESCRIPTIONS

## FAULT MODE

| CODE | DESCRIPTION |
|---|---|
| A | REDUCED CAPABILITY |
| B | INOPERABLE |

## SYSTEM

| CODE | DESCRIPTION |
|---|---|
| A | AUTOMATIC DEPRESSURIZATION SYSTEM (ADS) |
| C | CONTAINMENT (INCLUDES ISOLATION CONTROL) |
| E | ESSENTIAL AC ELECTRICAL DISTRIBUTION |
| H | HIGH PRESSURE COOLANT INJECTION (HPCI) |
| L | LOW PRESSURE COOLANT INJECTION (LPCI) |
| Q | REACTOR CORE ISOLATION COOLING (RCIC) |
| P | UNKNOWN |

## TYPE OF EVENT

| CODE | DESCRIPTION |
|---|---|
| B | RECURRING COMMON CAUSE FAILURE |
| C | COMMON CAUSE FAILURE |
| R | RECURRING FAILURE |
| S | COMMAND FAULT |
| T | RECURRING COMMAND FAULT |
| U | COMMON CAUSE COMMAND FAULT |
| V | RECURRING COMMON CAUSE COMMAND FAULT |
| BLANK | RANDOM FAILURE |

## FAULT CAUSE

| CODE | DESCRIPTION |
|---|---|
| 00 | UNKNOWN |
| 01 | PERSONNEL OPERATION |
| 02 | PERSONNEL MAINTENANCE |
| 03 | PERSONNEL TESTING |
| 04 | DESIGN ERROR |
| 05 | FABRICATION/CONSTRUCTION/QUALITY CONTROL |
| 06 | DEFECTIVE PROCEDURES |
| 07 | EXTREME ENVIRONMENT |
| 08 | ELECTRICAL MALFUNCTION |
| 09 | MECHANICAL MALFUNCTION |

## SUBCOMPONENT

| CODE | DESCRIPTION |
|---|---|
| AC | ANNUNCIATOR CONTROL CARD |
| CC | FIRING CIRCUIT |
| CF | COOLING FAN |
| CH | CHOKE |
| CL | CONTROL CARD/CONTROL MODULE |
| CP | CAPACITOR |
| DB | DRIVER BOARD |
| DI | DIODE |
| FB | FREQUENCY BOARD |
| FS | FUSE |
| IN | INDUCTOR |
| OS | OSCILLATOR |
| PC | PROTECTION CARD |
| PS | POWER SUPPLY (INTERNAL) |
| RC | RECTIFIER |
| RE | RELAY |
| RS | RESISTOR |
| SW | SWITCH |
| TR | TRANSFORMER |
| TS | TRANSISTOR |
| UV | UNDERVOLTAGE COIL |
| VR | VOLTAGE REGULATOR |
| UU | UNKNOWN/NOT APPLICABLE |

## ACTIVITY RESULTING IN DISCOVERY

| CODE | DESCRIPTION |
|---|---|
| M | MAINTENANCE |
| N | NORMAL PLANT OPERATION |
| R | RECORDS REVIEW |
| T | TESTING |
| U | UNKNOWN |

## NSSS VENDOR

| CODE | DESCRIPTION |
|---|---|
| B | BABCOCK & WILCOX |
| C | COMBUSTION ENGINEERING |
| W | WESTINGHOUSE |
| G | GENERAL ELECTRIC |

## COMPONENT

| CODE | DESCRIPTION |
|---|---|
| SI | STATIC INVERTER |

## EVENT CLASSIFICATION

| CODE | DESCRIPTION |
|---|---|
| D | FREQUENCY |
| T | AGE |
| U | UNKNOWN |

## PWR -- CONTAINMENT (INCLUDES ISOLATION CONTROL)

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | SUB COMP | SYSTEM | MODE | CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W | IP2 | 022867 | 102278 | SI | UU | C | B00 | | N | | U | | .5KVA STATIC INVERTER FAILD DEENRGZG CONT PRESS // | SAFEGUARDS LOGIC. DEFECTIVE INVERTER |
| W | SO1 | 020878A | 031578 | SI | CP | C | B08 | | N | | T | | "A" INVERTER FAILED (ONE OF TWO FOR CSAS LOGIC) | CAPACITOR AND CHOKE IN OUTPUT SIDE FAILED |
| W | SO1 | 020878B | 031578 | SI | UU | C | B04 | | N | U | D | | "B" INVERTER FOR CSAS TRIPPED ON TRANSFER | TRANSFER SWITCH WAS TOO FAST |

## PWR -- ESSENTIAL AC ELECTRICAL DISTRIBUTION

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | SUBCOMP | SYSTEM | MODE CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B | CR3 | 017321 | 030277 | SI | DI | E | B08 | N | | T | | "B" INVERTER FAILED,CAUSED RX TRIP | OUTPUT DIODE FAILED |
| B | CR3 | 019021 | 090277 | SI | RC | E | B08 | N | | D | | "D" INVERTER FAILED | SILICON CONTROLLED RECTIFIER DEFECTIVE |
| B | CR3 | 019523 | 102677 | SI | UU | E | B00 | N | | U | | "A" INVERTER FAILED | NO CAUSE GIVEN |
| B | CR3 | 021210 | 042578 | S' | UU | E | A05 | N | U | D | | INVERTER 3A TRIPPING--WRONG FUSES INSTLD IN VITAL/ | BUS 3A DURING CONSTRUCTION/TESTING PHASE |
| B | CR3 | 022361 | 081978 | SI | UU | E | B08 | N | B | D | | INVERTER VBIT-1A FAILED-120VAC VITAL BUS 3A NO PWR | ELECTRONIC COMPONENT FAILRS W/ IN VBIT-1A |
| B | CR3 | 037006 | 041181 | SI | DI | E | B07 | N | R | T | | INVERTER "D" FAILED. INADQ VENT CAUSED OVERHTG // | SHORTED DIODE & BLEW FUSE |
| B | CR3 | 038100 | 071481 | SI | FS | E | B02 | M | C | D | | "A" INVERTER FAILED DEENRGZD 120 AC VITAL BUS #3A | INADV SHORTED STAT BATT DURING MAINTENANC |
| B | DB1 | 027478 | 110579 | SI | RS | E | B08 | N | | D | | BLOWN FUSE ON INVERTER YV2 OUTPUT | OPEN RESISTOR IN LOGIC PS OF INVERTER YV2 |
| B | DB1 | 032367A | 082280 | SI | FS | E | B08 | N | B | D | | FAILURE OF YV-2 INVERTER INPUT FUSE | EXACT CAUSE OF FUSE FAILURE UNDETERMINED |
| B | DB1 | 032367B | 082380 | SI | FS | E | B08 | N | B | D | | FAILURE OF YV-2 INVERTER INPUT FUSE | EXACT CAUSE OF FUSE FAILURE UNDETERMINED |
| B | DB1 | 033270 | 111280 | SI | FS | E | B02 | T | C | D | | GROUNDED YV2 INVERTER INPUT FUSE TOOK OUT Y2 BUS | GROUNDED OSCILLOSCOPE USED BY I&C PERSNL |
| B | DB1 | 039149 | 101881 | SI | DI | E | B08 | N | | T | | ESSENTIAL 120VAC INVERTER YV3 FAILED | RESISTOR/DIODE ON +15VDC LOGIC PS FAILED |
| B | DB1 | 173542 | 040982 | SI | FS | E | B02 | N | C | D | | OUTPUT FROM YV2 INVERTER TO Y2 BUS WAS LOST | FUSE BLEW DUE TO PERSONNEL MAINTENANCE |
| B | DB1 | 175395 | 060882 | SI | RC | E | B08 | N | C | T | | ESSENTIAL INVERTER YV2 FAILED | COMP FAILR W/ IN REGULATED RECTIFIER YRF2 |
| B | DE1 | 036123 | 011881 | SI | FS | E | B08 | N | | D | | 1DID VITAL INVERTER DC INPUT FUSE BLEW | POOR CNNCTN &/OR COMP PRBLMS IN LOGIC CRD |
| B | DE1 | 036241A | 012581 | SI | FS | E | B08 | N | | D | | 1DID VITAL INVERTER DC INPUT FUSE BLEW | BLOWN FUSES |
| B | DE1 | 036241B | 012581 | SI | UU | E | B00 | N | | U | | 1DIB INVERTER TRIPPED | EXACT CAUSE UNKNOWN |
| B | DE1 | 036241C | 012581 | SI | UU | E | B02 | M | U | D | | 1DID INVERTER TRIPPED | PERS OPENED AC OUTPUT BRKR MISTAKENLY |
| B | DE3 | 016137 | 091276 | SI | CP | E | B08 | N | | T | | THE 3 DIB VITAL BUS INVERTER FAILED | DIELECTRIC OF INPUT FILTER CAP BROKE DOWN |
| B | DE3 | 027697 | 111079 | SI | FS | E | B08 | N | | D | | ICS POWER LOST DUE TO INVERTER(KI) FAILED | BLOW FUSES |
| B | DE3 | 031182A | 050780 | SI | FS | E | B08 | N | R | D | | LOST AC VITAL INST BUS DUE TO INVERTER FAILURE | BLOWN FUSES |
| B | DE3 | 031182B | 050980 | SI | FS | E | B08 | N | R | D | | LOST AC VITAL INST BUS DUE TO INVERTER FAILURE | BLOWN FUSES/FAULTY TRANSISTOR |
| B | DE3 | 031182C | 051680 | SI | TS | E | B01 | N | | D | | INVERTER 3DIB TRIPPED WHEN POWER WAS TRANSFERRED / | /TO IT. BYPASS SWITCH POSSIBLY CLOSED. |
| B | RS1 | 026111 | 042279 | SI | UV | E | B04 | U | R | D | | S1A VITAL POWER INVERTER FAILED | DESIGN DEFICIENCY IN U.V. COIL |
| B | TI2 | 021952 | 032978 | SI | CL | E | B08 | N | | T | | VITAL BUS INVERTER FAILD TO FUNCTN PROPERLY | FAULTY INVERTER CNTRL MODULE AND FUSE |
| C | CC1 | 179674 | 110982 | SI | UU | E | B01 | M | U | D | | RX S/D DUE TO INVERTER DC FEEDER BREAKER TRIP | CONTRACTOR INADV TRPD OPEN INPUT BREAKER |
| C | CC2 | 017009 | 010677 | SI | FS | E | B08 | T | | D | | B PHASE COMPUTER INVERTER DC INPUT FUSE OPENED | CURRENT SURGE DUE TO SWITCHING OPERATION |
| C | CC2 | 183012 | 122882 | SI | FS | E | B00 | N | | U | | #22 INVERTER OUTPUT FUSE BLEW | SUSPECTED CAUSE--IMPROPER FUSE TYPE USED |
| C | FC1 | 020085 | 122577 | SI | VR | E | B08 | N | | T | | D CHANNEL INSTRUMENT INVERTER FAILED | CONSTANT VOLTAGE REGULATOR FAILED |
| C | MI2 | 026871 | 010579 | SI | CP | E | B08 | N | | T | | INVERTER NO. 4 FAILED | CAPACITORS AND OSCILLATOR BOARD FAILED |

## PWR -- ESSENTIAL AC ELECTRICAL DISTRIBUTION

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | SUBCOMP | SYSTEM | MODE CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C | MI2 | 172670* | 010682 | SI | FS | E | B02 | N | C | D | 2 | FUSES IN INVERTERS 2 AND 6 BLEW | SHORTED TEST LEAD FAILED CIRCUIT |
| C | MI2 | 175402* | 060682 | SI | FS | E | B07 | N | C | D | 2 | LOSS OF 120VAC (VIAC-1) BLOWS FUSES IN ESFAS CABNT | ROOF LEAK SHORTED 2 INVERTERS #5,6 |
| C | SL1 | 015004 | 052976 | SI | OS | E | B08 | N | | T | | 1C STATIC INVERTER FAILED(PS FOR AC INST,120 VOLT) | FAILED OSCILLATOR CIRCUIT BOARD |
| C | SL1 | 175205A | 062282 | SI | UU | E | B00 | N | R | U | | OUTPUT BRKR OF 1A STATIC INVERTER OPENED | NO APPARENT CAUSE COULD BE FOUND |
| C | SL1 | 175205B | 062382 | SI | OS | E | B08 | N | R | U | | 1A STATIC INVERTER OUTPUT BREAKER OPENED | OSCILLATOR CIRCUIT BOARD REPLACED |
| C | SL1 | 181486 | 122082 | SI | UU | E | B00 | N | R | U | | 1A INVERTER OUTPUT BRK OPENED;1/4 120VAC BUS LOST | NO APPARENT CAUSE OF FAILURE |
| C | SL1 | 181729 | 122582 | SI | FB | E | B00 | N | R | U | | 1A INVERTER OUTPUT BRK OPENED;1/4 120VAC BUS LOST | DEFECTIVE OUTPUT FREQUENCY MODULE |
| C | SL1 | 181038 | 123082 | SI | OS | E | B08 | M | | T | | 1A INVERTER OUTPUT BRK OPENED;1/4 120VAC BUS LOST | FREQUENCY OSCILLATOR HAD DRIFTED |
| W | BV1 | 014692 | 051076 | SI | CP | E | B08 | N | R | T | | INVERTER NO. 3 FAILED | OUTPUT FILTER CAPACITOR FAILED |
| W | BV1 | 015102 | 052776 | SI | CP | E | B08 | M | R | T | | INVERTER NO. 1 FAILED | OUTPUT FILTER CAPACITOR FAILED |
| W | BV1 | 015213 | 062376 | SI | UU | E | B00 | U | | U | | INVERTER NO. 3 APPARENTLY FAILED | NO CAUSE GIVEN |
| W | BV1 | 016280 | 102276 | SI | RC | E | B08 | N | R | T | | VITAL BUS INVERTER NO. 3 FAILED | SCRS AND OUTPUT FUSE FOUND BAD |
| W | BV1 | 016360 | 110676 | SI | UU | E | B03 | N | U | D | | INVERTER NO. 2 WAS MOMENTARILY OUT OF SERVICE | OUTPUT WAS SHORTED OUT BY PERSONNEL |
| W | BV1 | 017014 | 121576 | SI | DI | E | B08 | N | R | T | | NO. 1 VITAL BUS INVERTER FAILED | 1 DIODE AND TWO FUSES FOUND FAILED |
| W | BV1 | 023209 | 010278 | SI | UU | E | A00 | N | | U | | OUTPUT FREQUENCY OF NO. 4 INVERTER OSCILLATING | NO CAUSE GIVEN |
| W | BV1 | 025332 | 012079 | SI | UU | E | B00 | N | | U | | NO. 3 VITAL BUS INVERTER FAILED | FAULTY COMPONENTS |
| W | BV1 | 027140 | 091879 | SI | OS | E | A08 | N | | T | | NO. 4 VITAL BUS INVERTER FREQUENCY FOUND SPIKING | FAULTY OSCILLATOR CARD |
| W | BV1 | 028012 | 092079 | SI | UU | E | B00 | N | | U | | NO. 4 VITAL BUS INVERTER FAILED. RX TRIP OCCURRED/ | /AND SAFETY INJECTION OCCURRED. NO CAUSE |
| W | BV1 | 031239 | 050480 | SI | FS | E | B08 | N | R | D | | PWR LOST TO #4 VITAL BUS INVERTER DUE TO BLOWN // | MAIN PS FUSE. CAUSE UNKNOWN |
| W | BV1 | 173454 | 041482 | SI | UU | E | B02 | N | U | D | | NO. 3 INVERTER TRIPPED | PERSONNEL MAINTENANCE |
| W | DC1 | 017804 | 042177 | SI | FS | E | B08 | N | | D | | #4 INVERTER FAILED,CAUSED RX TRIP & SI | BLOWN FUSE |
| W | DC1 | 025643* | 032379 | SI | UU | E | B01 | N | C | D | 2 | TWO VITAL BUS INVERTERS FAILED SIMULTANEOUSLY | PARTS FAILED DUE TO DC SURGE. PERSONNEL |
| W | DC1 | 032503 | 083180 | SI | DI | E | B08 | N | R | T | | SHORTED DIODE IN CRID IV INVERTER | DIODE FAILED DUE TO NORMAL END OF LIFE |
| W | DC1 | 182697 | 082382 | SI | UU | E | B08 | N | | D | | AB EMERG DIESEL GENERATOR INVERTER FAILED. SOLID | STATE COMP, XFMR GATE, SHORTING BRD RPLCD |
| W | DC2 | 022280 | 061378 | SI | DI | E | B08 | N | C | T | | INVERTER FAILURE | DEFECTIVE DIODES AND SCR'S |
| W | DC2 | 037613 | 061281 | SI | CP | E | B08 | N | B | T | | FAILURE IN 120VAC VITAL BUS (CRID II) | C-2 CAPACITOR FAILED ALSO BLEW A FUSE |
| W | HN1 | 018775 | 071977 | SI | UU | E | B07 | N | C | T | | STATIC INVERTER FAILED | AMBIENT TEMP 40 DEG C. ABOVE DESIGN |
| W | JF1 | 021593 | 022178 | SI | UU | E | B00 | N | | U | | 120V VITAL BUS A DEENRGZD WHEN INVERTER A TRIPPED | EXACT CAUSE NOT IDENTIFIED |
| W | JF1 | 021592 | 022378 | SI | CP | E | B08 | N | R | D | | 120VAC VITAL BUS B DEENRGZD WHEN INVERTER 1B TRPD | FAULTY CAPACITOR WAS REPLACED |
| W | JF1 | 021594 | 050978 | SI | UU | E | B00 | N | | U | | 120VAC VITAL BUS A DEENRGZD WHEN INVERTER A TRPD | EXACT CAUSE NOT IDENTIFIED |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W | JF1 | 021591 | 053078 | SI | CP | E | 808 | N | R | D | | 120VAC BUS D DEENRGZD WHEN INVERTER 1D TRIPPED | CAPACITOR IN INVERTER FAILED |
| W | JF1 | 025439 | 011679 | SI | CH | E | 808 | N | | T | | 1B INVERTER TRIPPED (PS FOR 120V VITAL AC) | VARIOUS INTERNAL COMPONENTS FAILED |
| W | JF2 | 038879 | 092381 | SI | UU | E | 800 | M | | U | | INVERTER 2A TRPD--120VAC VITAL BUS 2A DEENERGIZED | TRANSIENT VOLTAGE SPIKE--CAUSE UNKNOWN |
| W | JF2 | 173252 | 031682 | SI | FS | E | 808 | N | | D | | INVERTER NO. 2B FAILED | FUSE BLEW IN VOLTAGE REGULATOR |
| W | JF2 | 176542 | 072282 | SI | UU | E | 800 | N | | U | | INVERTER NO. 2G FAILED CAUSING LOSS OF POWER TO S/ | /UB COOLING MONITOR AND H2 MONITOR |
| W | MG1 | 174673 | 061382 | SI | RC | E | 808 | N | | D | | INVERTER EVIA INOP--LOST VITAL INST PWR CAUSD RX// | TRIPS. SCR SHORTING CKT BRD REPLACED |
| W | MG1 | 174671 | 062482 | SI | CP | E | 808 | N | | T | | STATIC INVERTER EVIA MALFUNC--RHR ISOL VLV CLOSED | 3 CAP IN OUTPUT CVT CAP BANK FAILED |
| W | NA1 | 031217 | 052380 | SI | FS | E | 808 | N | | D | | LOST VITAL BUS 1-III. CAUSE UNKNOWN--POSSIBLY // | VLTG SURGE TO DC/AC INVERTER BLEW 2 FUSES |
| W | NA1 | 032608 | 090880 | SI | UU | E | 800 | N | | U | | LOST PWR TO 120VAC VITAL BUS 1-IV | INVERTER SUPPLY BRKR FOUND OPEN |
| W | NA2 | 037674* | 060381 | SI | UU | E | A00 | N | C | U | 2 | VOLTAGE TRANSIENT THRU VITAL BUS INVERTERS 2-III// | & 2-IV. CAUSE UNKNOWN |
| W | PR1 | 015104 | 061576 | SI | TR | E | 808 | N | R | T | | NO. 13 INVERTER FAILED (PS TO INSTRUMENT BUS 113) | REGULATING TRANSFORMER ON OUTPUT FAILED |
| W | PR1 | 017425 | 031477 | SI | CP | E | 808 | N | R | T | | NO. 11 INVERTER FAILED | CAP ON OUTPUT SOLA TRANSFORMER FAILED |
| W | PR2 | 032962 | 100480 | SI | TR | E | 808 | N | | T | | #23 INVERTER FAILED DEENRGZG PANEL 213 | CONSTANT VOLTAGE TRANSFORMER FAILED |
| W | SA1 | 022426 | 082178 | SI | DI | E | 808 | N | | T | | VITAL INST BUS INVERTER 1A FUSES BLOWN | FAILD DIODE IN CNTRL CKT BRD |
| W | SA1 | 022420 | 082778 | SI | CL | E | 808 | N | R | T | | 1A INVERTER FAILD--FAILD ELECTRONIC COMP ON MASTER | //LOGIC CKT BRD CAUSD BLOWN FUSES |
| W | SA1 | 023232 | 112778 | SI | TR | E | 808 | N | R | T | | LOST 1B VITAL INSTRUMENT BUS | OUTPUT XFRMR IN SUPPLY INVERTER FAILED |
| W | SA1 | 023230 | 120878 | SI | UU | E | 800 | N | | U | | INVERTER DIDN'T SWITCH TO B/U BATTERY SUPPLY | NO CAUSE COULD BE DETERMINED |
| W | SA1 | 023513 | 012679 | SI | UU | E | 800 | N | | U | | 1B VITAL INSTRUMENT BUS INVERTER FAILED | NO CAUSE. INADVERTANT SI OCCURRED |
| W | SA1 | 039242 | 102981 | SI | UU | E | 800 | N | | U | | INADV SI DUE TO LOSS OF VITAL BUS 1A INVERTER | CAUSE UNKNOWN |
| W | SA1 | 039344 | 110681 | SI | UU | E | 800 | N | | U | | INADV SI DUE TO LOSS OF 1A VITAL INST BUS INVERTER | CAUSE UNKNOWN |
| W | SA2 | 161466 | 112982 | SI | PS | E | 808 | N | | D | | INVERTER PS FAILED CAUSD P-250 COMPUTER TO SHUTDOWN | PS PROBLEM FROM FAILED OSCILLATOR CKT BRD |
| W | SE1 | 032879A | 092780 | SI | UU | E | 800 | N | | U | | VITAL INVERTER 2-IV OUTPUT BRKR TRIPPED | CAUSE NOT IDENTIFIED |
| W | SE1 | 032879B | 100180 | SI | SW | E | 808 | N | | T | | VITAL INVERTER 2-IV OUTPUT BRKR TRIPPED | BAD AUX SW ON THE K11 RELAY |
| W | SE1 | 032977 | 101480 | SI | CC | E | 808 | N | | T | | VITAL INVERTER 2-III OUTPUT BRKR TRIPPED | FIRING CKT CLOCK CARD RB5 FAILED |
| W | SE1 | 033295 | 111180 | SI | FS | E | 808 | N | | D | | VITAL INVERTER 1-I OUTPUT BRKR TRIPPED | INVERTER 1-I OUTPUT FUSES HAD BLOWN |
| W | SE1 | 033296* | 111880 | SI | UU | E | 800 | N | R | U | 9 | 9 VITAL INVERTER 2-III FAILURES BETWEEN 11-9-80&// | 11-23-80. NO CAUSES GIVEN |
| W | SE1 | 036667 | 013081 | SI | UU | E | 802 | M | U | D | | CONDUIT/CABLE SUPPLYING PWR TO VITAL INVERTER 1-I/ | /WAS CUT. CONSTRUCTION PERSONNEL ERROR |
| W | SO1 | 015998 | 082376 | SI | PS | E | 800 | N | | U | | VITAL BUS #1 TRANSFERRED TO B/U POWER SOURCE | COMPONENT FAILURE IN #1 INVERTER.NO CAUSE |
| W | SO1 | 018440 | 061477 | SI | CP | E | 808 | N | | T | | DC INPUT FUSE OF UPS INVERTER OPENED | CAPACITORS IN BANKS C-4,C-6 HAD FAILED |
| W | SU2 | 179196 | 101082 | SI | IN | E | 808 | N | | T | | FAILED VITAL BUS-3 INVERTER/TURB RUNBACK,RX,TRP,SI | STATION BATT INVERTER INDUCTOR SHORTED |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W | TR1 | 033305 | 111280 | SI | UU | E | B00 | T | | U | | 3 VITAL PREFERRED INSTR BUSES ON SAME EMERG TRAIN | #4 INVERTER APPARENTLY FAILED--NO CAUSE |
| W | TR1 | 039071 | 100481 | SI | RE | E | B08 | N | | T | | LOST PREFERRED INST BUS Y11--STATIC INVERTER OUTPT | //CURRENT SENSG RELAY FAILD. NAT'L EOL |
| W | TR1 | 172719 | 011682 | SI | UU | E | B00 | N | R | U | | INVERTER NO. 2 FAILED. CAUSED INADVERTANT SI | NO CAUSE GIVEN. |
| W | ZI1 | 025150 | 011279 | SI | UU | E | B00 | N | U | U | | INV 114 TRPD. FOUND 2.5KVA INV SECTION FAULTY. | LOOSE CONTACT IN DC BREAKER |
| W | ZI1 | 026916 | 081379 | SI | TR | E | B08 | N | | T | | INSTRUMENT INVERTER 114 TRIPPED | 5KVA TRANSFORMER REPLACED |
| W | ZI1 | 037631 | 052881 | SI | TR | E | B08 | N | R | D | | INST INVERTER 114 FAILED | XFRMR SHORTED BY HI INVERTER CIRC CURRENT |
| W | ZI2 | 020356 | 082077 | SI | TR | E | B08 | N | | D | | INVERTER NO. 213 FAILED (INSTRUMENT INVERTER) | SLAVE TRANSFORMER FAILED BY OVERHEATING |
| W | ZI2 | 031066 | 041180 | SI | RC | E | B08 | N | | T | | INSTRUMENT INVERTER 214 FAILED | SCR FAILED IN SLAVE UNIT OF INVERTER |
| W | ZI2 | 037995 | 050781 | SI | TR | E | B08 | N | | D | | LOST POWER TO INVERTER 213 | XFRMR SHORTD BY HI INVERTER CIRC CURRENT |

## PWR -- UNKNOWN

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | SUBCOMP | SYSTEM | MODE | CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W | SA1 | 027523 | 110579 | SI | CF | P | 809 | N | | | T | | LOST METEORLOLGICAL INSTR/PWR SUP INVERTER FAILED | SEIZED MOTOR BEARINGS IN COOLING FAN |
| W | SA1 | 030231 | 012380 | SI | SW | P | 805 | N | | B | D | | LOST METEOROLOGICAL INSTRUMENT | INVERTER HAD MAN NCT AUTO SW--MFG ERROR |
| W | SO1 | 021743 | 060778 | SI | CP | P | 808 | N | | | D | | DC INPUT FUSE FOR MOV-850C INVERTER OPENED | GE CAPACITOR 28F5108 AND SCR-2 FAILED |

## BWR -- AUTOMATIC DEPRESSURIZATION

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | SUBCOMP | SYSTEM | MODE & CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G | BP1 | 037801A | 061781 | SI | PS | A | 808 | M | R | T | | RX DEPRESSURIZATION LOOP B INVERTER FOUND INOP. | DEFECTIVE ELECTRONIC COMPONENTS |
| G | BP1 | 037801B | 062381 | SI | PS | A | 808 | M | R | T | | RX DEPRESSURIZATION LOOP B INVERTER FOUND INOP. | DEFECTIVE ELECTRONIC COMPONENTS |

## BWR -- CONTAINMENT (INCLUDES ISOLATION CONTROL)

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | SUB COMP | SYSTEM | MODE / CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G | BP1 | 022658 | 091078 | SI | FS | C | 804 | N | R | D | | BLOWN FUSE IN POWER SUPPLY INVERTER | XIENT SUP VLTG PROBLEM--NEEDS DUMMY LOAD |
| G | BP1 | 025806 | 031979 | SI | FS | C | 804 | N | | D | | CONTAINHEMT VACUUM RELIEF LOOP POWER SUPPLY INVER/ | /TER FOUND INOPERABLE. BLOWN PS FUSE |
| G | BP1 | 026880 | 061679 | SI | FS | C | 804 | N | R | D | | CNTNMNT VACUUM RELIEF PS INVERTER FUSE BLEW | SUSCEPTIBLE TO INPUT SURGE |

## BWR -- ESSENTIAL AC ELECTRICAL DISTRIBUTION

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | SUBCOMP | SYSTEM | MODE | CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G | BR1 | 017085* | 011777 | SI | UU | E | B02 | | M | U | D | 2 | CNTRL VLTG PS SET BELOW EQUALZG VLTG CAUSED TRIP | I&C TECH ERROR IN EQUALZG PLANT BATTERIES |
| G | CO1 | 037646 | 050581 | SI | CP | E | B06 | | T | | D | | STATIC INVERTER IA'S SPIKE SUPPRESSOR CAP FAILED | AGED ELECTROLYTIC CAP/IMPROPR OP PROCEDUR |

## BWR -- HIGH PRESSURE COOLANT INJECTION

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | SUBCOMP | SYSTEM | MODE | CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G | EN2 | 030041 | 011780 | SI | UU | H | B08 | | N | | T | | HPCI AUTO FLO CNTRL PWR INVERTER'S HV TRPD LOW | INSTRUMENT DRIFT |
| G | FP1 | 015625 | 081576 | SI | UU | H | B00 | | N | | U | | HPCI INVERTER 23-INV-79 TRIPPED AND WOULD NOT RES/ | /TART. NO CAUSE FOUND,INVERTER REPLACED |
| G | PB2 | 021248 | 042478 | SI | UU | H | B00 | | N | | U | | HPCI STATIC INVERTER TRIPPED | NO FAULT COULD BE FOUND WITH THE INVERTER |

## BWR -- LOW PRESSURE COOLANT INJECTION

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | SUBCOMP | SYSTEM | MODE CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G | EN1 | 033842 | 073180 | SI | UU | L | B07 | M | U | T | | B LPCI INVERTER TRPD THUS B LOOP OF RHR INOPERABLE | HI AMBIENT TEMPERATURE IN INVERTER ROOM |
| G | EN1 | 032376 | 082180 | SI | UU | L | B07 | N | R | T | | "B" LPCI INVERTER TRIPPED | HI AMBIENT TEMPERATURE IN INVERTER ROOM |
| G | EN1 | 037947A | 061081 | SI | SW | L | B00 | N | R | U | | B LPCI INVERTER R44-S003 TRPD ON HIGH TEMPERATURE | DEFECTIVE SWITCH IN INVERTER LEG |
| G | EN1 | 037947D | 061681 | SI | UU | L | B00 | N | R | U | 2 | B LIPCI INVERTER 2R44-S003 TRIPPED | UNKNOWN CAUSE |
| G | EN1 | 037947B | 061881 | SI | SW | L | B00 | N | R | U | 2 | B LPCI INVERTER R44-S003 TRIPPED | DFCTV SWITCHES IN INVERTER LEGS |
| G | EN1 | 037947C | 062181 | SI | SW | L | B00 | N | R | U | | B LPCI INVERTER R44-S003 TRIPPED | DEFECTIVE SWITCH IN INVERTER LEG |
| G | EN1 | 177682 | 091182 | SI | CP | L | B08 | N | | D | | "A" LPCI INVERTER FAILED. OUTPUT FILTER CAPACITO/ | /R INSULATION SPAT,FAILED FUSES & CAP'S |
| G | EN2 | 022024 | 071778 | SI | FB | L | B08 | N | | T | | STATIC INVERTER(2R44-S002) OUTPUT BREAKER TRIPPED | FREQUENCY CARD(EXIDE PART #A13A9) FAILED |
| G | EN2 | 023200 | 120878 | SI | PC | L | B08 | N | | T | | STATIC INVERTER (2R44-S003) DC OUTPUT BRKR TRIPPED | AC/DC PROTECTION CARD(A13A12) FAILED |
| G | EN2 | 027611 | 111779 | SI | RE | L | B08 | N | | T | | "B" LPCI INVERTER TRIPPED | FAILED RELAY IN INVERTER FAILED |
| G | EN2 | 036952 | 042181 | SI | CL | L | B08 | N | | U | | "A" LPCI INVERTER 2R44-S002 TRPD | LOGIC FAILURE CAUSED TRIP |
| G | EN2 | 038501 | 090481 | SI | VR | L | B08 | N | | T | | B LPCI INVERTER 2R44-S003 TRPD | GATE FIRING MODULE VOLTAGE REGULATOR FAIL |
| G | EN2 | 171785 | 112681 | SI | CC | L | B08 | M | | T | | B LPCI INVERTER (2R44-S003) GAVE HI PHASE CURRENTS | FAILED GATE FIRING MODULE |
| G | EN2 | 178916 | 100182 | SI | CF | L | B09 | N | | T | | INVERTER(2R44-S003) TRPD DUE TO LEG FAN FAILURE | #4 INVERTER LEG FAN BEARING FAILED |
| G | FP1 | 021432 | 051878 | SI | RC | L | B08 | N | | T | | LPCI INVERTER/CHARGER TRPD LOST B LPCI INDPNDNT // | PWR. FAILED SCR'S IN INVERTER/CHARGER |
| G | FP1 | 030177 | 012380 | SI | CP | L | B08 | N | | U | | LPCI INDPNDNT PS "A" INVERTER TRIPPED | INVERTER CNTRL CKT CAPACITORS FAILED |
| G | FP1 | 032373A | 081280 | SI | CL | L | B08 | N | | T | | "B" LPCI INVERTER TRIPPED | AC VOLTAGE/CURRENT CNTRL LOGIC CARD A12 |
| G | FP1 | 032373B | 082280 | SI | CL | L | B08 | N | | T | | "B" LPCI INVERTER TRIPPED | INVERTER LEG GATE FIRE CNTRL CKT FAILED |
| G | FP1 | 032373C | 090580 | SI | AC | L | B08 | N | | T | | "B" LPCI INVERTER TRIPPED | ANNUNCIATOR/CONTROL CARD 2 FAILED |
| G | FP1 | 032373D | 090580 | SI | AC | L | B08 | N | | T | | "B" LPCI INVERTER TRIPPED | ANNUNCIATOR/CONTROL CARD 2 FAILED |
| G | FP1 | 032718 | 091380 | SI | CL | L | B08 | N | | T | | "B" LPCI INVERTER TRIPPED | LOGIC CARD A2 FAILED |
| G | FP1 | 037379 | 051581 | SI | CP | L | B08 | N | R | D | | LPCI MOV INDEPENDENT POWER SUPPLY INVERTER A TRPD | SHORTED CAP IN GATE FIRING MODULE "A1" |
| G | FP1 | 161727 | 121582 | SI | CL | L | B08 | N | | D | | "A" LPCI INVERTER TRIPPED DUE TO ELECTRICAL FAILUR | GATE TIMING CONTROL CARD FAILED |
| G | VY1 | 015519 | 081376 | SI | SW | L | B04 | N | | D | | A 250 KVA UPS OUTPUT BREAKER TRIPPED | NOISE IN AN UNUSED STATIC SWITCH |
| G | VY1 | 015965 | 092076 | SI | FS | L | B08 | M | | D | | MOTOR CONTROL CENTER 89A LOST POWER DUE TO "A" UP/ | /S TRIPPED. BLOWN INVERTER LEG FUSE |
| G | VY1 | 016272 | 101976 | SI | CL | L | B08 | N | R | T | | UPS-1B TRIPPED WHEN OPENING VALVE RHR-27B | POSSIBLE LOGIC PROBLEM |
| G | VY1 | 016485 | 111876 | SI | VR | L | B08 | N | R | T | | UPS-1B TRIPPED WHILE TESTING RHR-27B VALVE | VOLTAGE REGULATOR AND SYSTEM LOGIC PRBLEM |
| G | VY1 | 016500* | 112976 | SI | DB | L | B08 | N | R | T | 2 | UPS-1A AND UPS-1B TRIPPED WHILE TESTING LPCI VALVE | 1A HAD FAILED DRIVER BOARD,1B HAD BAD REG |
| G | VY1 | 021542 | 053078 | SI | FS | L | B08 | N | | D | | 250KVA UNINTERRUPTIBLE PWR SUPPLY TRIPPED | BLOWN INVERTER LEG FUSE(2A16F2) |
| G | VY1 | 021768 | 061978 | SI | UU | L | B00 | N | | U | | LOSS OF VLTG TO MCC-89B | UNINTERRUPTIBLE POWER SUPPLY(UPS-1B) TRPD |

## BWR -- LOW PRESSURE COOLANT INJECTION

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | SUBCOMP | SYSTEM | MODE | CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G | VY1 | 021842 | 062973 | SI | PC | L | B08 | | N | | T | | 250KVA UPS TRPD DUE TO INVERTER LEG FUSE(2A19F2)// | BLEW WHEN GATE INTRFC/PRTCTN LOGIC MALFUN |
| G | VY1 | 032080 | 071880 | SI | FS | L | B08 | | N | C | D | | LOGIC PS BRD FAILED. 250KVA UNINTERRUPTIBLE PS // | TRPD DUE TO BLOWN LOGIC PS FUSE |
| G | VY1 | 173401 | 020682 | SI | CP | L | B08 | | N | | T | | UPS-B AC GROUND AND BLOWN FUSE ALARM WAS RECEIVED | SUPPRESSION CAPACITOR FAILED BLOWING FUSE |
| G | VY1 | 172882 | 022382 | SI | CP | L | B08 | | N | | T | | UPS "B" TRAIN TRIPPED | SHORTED CAPACITOR DUE TO AGE |

## BWR -- REACTOR CORE ISOLATION COOLING

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | SUBCOMP | SYSTEM | MODE & CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G | BR2 | 030364 | 020480 | SI | UU | Q | 800 | N | | U | | STM LEAK DETCTN "A" LOGIC INVERTER'S HV TRPD LOW | NO CAUSE GIVEN |
| G | EN1 | 016840 | 112776 | SI | CP | Q | 808 | N | | T | | RCIC PS INVERTER E51-K603 FAILED | SHORTED CAPACITOR IN OUTPUT TRANSFORMER |
| G | EN2 | 027848A | 121979 | SI | FS | Q | 808 | N | C | D | | "A" PS FOR RCIC STEAM LEAK DETECTION FAILED | FUSES BLEW DUE TO CURRENT SURGE |
| G | EN2 | 027848B | 122079 | SI | FS | Q | 808 | N | C | D | | "B" PS FOR RCIC STEAM LEAK DETECTION FAILED | FUSES BLEW DUE TO CURRENT SURGE |
| G | EN2 | 030241 | 020280 | SI | CP | Q | 808 | T | | T | | RCIC REMOTE FLO CNTRL LOOP POWER INVERTER TRIPPED | DFCTV INPUT FILTER CAPACITORS |
| G | EN2 | 030980 | 042480 | SI | UU | Q | 800 | N | R | U | | REC'D RCIC LEAK DETECTION LOGIC PWR FAILURE ALARM | COMPONENT FAILURE OF INVERTER |
| G | FP1 | 013966 | 010376 | SI | RS | Q | 808 | N | | D | | RCIC STATIC INVERTER(12-801A) FAILED | LEAD TO WIRE WOUND RESISTOR TOUCHED RSTR |
| G | PB2 | 017210 | 021977 | SI | UU | Q | 800 | N | | U | | RCIC STATIC INVERTER 2-13-90 TRIPPED WITHOUT AUTO/ | /MATIC RESET. NO CAUSE FOUND |
| G | PB2 | 021247 | 041978 | SI | TS | Q | 808 | N | | T | | INVERTER FAILD POWERS RCIC'S CNTRLLR & INSTRMNTN | DFCTV TRANSISTOR IN AUTO-RESET CIRCUIT |
| G | PI1 | 038673 | 091281 | SI | CP | Q | 808 | N | | D | | FAILED INVERTER CAUSED GROUND FAULT ON 125VDC SYS | FAILED CAP IN DC/AC INVERTER |

## BWR -- UNKNOWN

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | SUB COMP | SYSTEM | MODE CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G | BF1 | 038008 | 070481 | SI | CL | P | 808 | T | R | T | | ALARM PANEL XA-55-8E INVERTER INOPERABLE | FAILED INVERTER CONTROL CARD |
| G | BF3 | 027049 | 091579 | SI | AC | P | 808 | H | | T | | ANNUNC PANEL XA-55-20B INOP INVERTER PRINTED CKT// | CARD FAILED DUE TO NATURAL AGING |

# APPENDIX G

## INVERTER ONE-LINE DESCRIPTIONS SORTED BY TYPE OF EVENT

## CONTENTS

# CODES USED IN LER ONE-LINE DESCRIPTIONS

## FAULT MODE

| CODE | DESCRIPTION |
|---|---|
| A | REDUCED CAPABILITY |
| B | INOPERABLE |

## SYSTEM

| CODE | DESCRIPTION |
|---|---|
| A | AUTOMATIC DEPRESSURIZATION SYSTEM (ADS) |
| C | CONTAINMENT (INCLUDES ISOLATION CONTROL) |
| E | ESSENTIAL AC ELECTRICAL DISTRIBUTION |
| H | HIGH PRESSURE COOLANT INJECTION (HPCI) |
| L | LOW PRESSURE COOLANT INJECTION (LPCI) |
| Q | REACTOR CORE ISOLATION COOLING (RCIC) |
| P | UNKNOWN |

## TYPE OF EVENT

| CODE | DESCRIPTION |
|---|---|
| B | RECURRING COMMON CAUSE FAILURE |
| C | COMMON CAUSE FAILURE |
| R | RECURRING FAILURE |
| S | COMMAND FAULT |
| T | RECURRING COMMAND FAULT |
| U | COMMON CAUSE COMMAND FAULT |
| V | RECURRING COMMON CAUSE COMMAND FAULT |
| BLANK | RANDOM FAILURE |

## FAULT CAUSE

| CODE | DESCRIPTION |
|---|---|
| 00 | UNKNOWN |
| 01 | PERSONNEL OPERATION |
| 02 | PERSONNEL MAINTENANCE |
| 03 | PERSONNEL TESTING |
| 04 | DESIGN ERROR |
| 05 | FABRICATION/CONSTRUCTION/QUALITY CONTROL |
| 06 | DEFECTIVE PROCEDURES |
| 07 | EXTREME ENVIRONMENT |
| 08 | ELECTRICAL MALFUNCTION |
| 09 | MECHANICAL MALFUNCTION |

## SUBCOMPONENT

| CODE | DESCRIPTION |
|---|---|
| AC | ANNUNCIATOR CONTROL CARD |
| CC | FIRING CIRCUIT |
| CF | COOLING FAN |
| CH | CHOKE |
| CL | CONTROL CARD/CONTROL MODULE |
| CP | CAPACITOR |
| DB | DRIVER BOARD |
| DI | DIODE |
| FB | FREQUENCY BOARD |
| FS | FUSE |
| IN | INDUCTOR |
| OS | OSCILLATOR |
| PC | PROTECTION CARD |
| PS | POWER SUPPLY (INTERNAL) |
| RC | RECTIFIER |
| RE | RELAY |
| RS | RESISTOR |
| SW | SWITCH |
| TR | TRANSFORMER |
| TS | TRANSISTOR |
| UV | UNDERVOLTAGE COIL |
| VR | VOLTAGE REGULATOR |
| UU | UNKNOWN/NOT APPLICABLE |

## ACTIVITY RESULTING IN DISCOVERY

| CODE | DESCRIPTION |
|---|---|
| M | MAINTENANCE |
| N | NORMAL PLANT OPERATION |
| R | RECORDS REVIEW |
| T | TESTING |
| U | UNKNOWN |

## NSSS VENDOR

| CODE | DESCRIPTION |
|---|---|
| B | BABCOCK & WILCOX |
| C | COMBUSTION ENGINEERING |
| W | WESTINGHOUSE |
| G | GENERAL ELECTRIC |

## COMPONENT

| CODE | DESCRIPTION |
|---|---|
| SI | STATIC INVERTER |

## EVENT CLASSIFICATION

| CODE | DESCRIPTION |
|---|---|
| Q | FREQUENCY |
| T | AGE |
| U | UNKNOWN |

## RECURRING COMMON CAUSE FAILURE

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | SUBCOMP | SYSTEM | MODE & CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B | CR3 | 022361 | 081978 | SI | UU | E | 808 | N | B | D | | INVERTER VBIT-1A FAILED-120VAC VITAL BUS 3A NO PWR | ELECTRONIC COMPONENT FAILRS W/ IN VBIT-1A |
| B | DB1 | 032367A | 082280 | SI | FS | E | 808 | N | B | D | | FAILURE OF YV-2 INVERTER INPUT FUSE | EXACT CAUSE OF FUSE FAILURE UNDETERMINED |
| B | DB1 | 032367B | 082380 | SI | FS | E | 808 | N | B | D | | FAILURE OF YV-2 INVERTER INPUT FUSE | EXACT CAUSE OF FUSE FAILURE UNDETERMINED |
| W | DC2 | 037613 | 061281 | SI | CP | E | 808 | N | B | T | | FAILURE IN 120VAC VITAL BUS (CRID II) | C-2 CAPACITOR FAILED ALSO BLEW A FUSE |
| W | SA1 | 030231 | 012380 | SI | SW | P | 805 | N | B | D | | LOST METEOROLOGICAL INSTRUMENT | INVERTER HAD MAN NOT AUTO SW--MFG ERROR |

## COMMON CAUSE FAILURE

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | COMP SUB | SYSTEM | MODE CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B | CR3 | 038100 | 071481 | SI | FS | E | B02 | M | C | D | | "A" INVERTER FAILED DEENRGZD 120 AC VITAL BUS #3A | INADV SHORTED STAT BATT DURING MAINTENANC |
| B | DB1 | 033270 | 111280 | SI | FS | E | B02 | T | C | D | | GROUNDED YV2 INVERTER INPUT FUSE TOOK OUT Y2 BUS | GROUNDED OSCILLOSCOPE USED BY I&C PERSNL |
| B | DB1 | 173542 | 040982 | SI | FS | E | B02 | N | C | D | | OUTPUT FROM YV2 INVERTER TO Y2 BUS WAS LOST | FUSE BLEW DUE TO PERSONNEL MAINTENANCE |
| B | DB1 | 175395 | 060882 | SI | RC | E | B08 | N | C | T | | ESSENTIAL INVERTER YV2 FAILED | COMP FAILR W/ IN REGULATED RECTIFIER YRF2 |
| C | MI2 | 172670* | C10682 | SI | FS | E | B02 | N | C | D | 2 | FUSES IN INVERTERS 2 AND 6 BLEW | SHORTED TEST LEAD FAILED CIRCUIT |
| C | MI2 | 175402* | 060682 | SI | FS | E | B07 | N | C | D | 2 | LOSS OF 120VAC (VIAC-1) BLOWS FUSES IN ESFAS CABNT | ROOF LEAK SHORTED 2 INVERTERS #5,6 |
| W | DC1 | 025643* | 032379 | SI | UU | E | B01 | N | C | D | 2 | TWO VITAL BUS INVERTERS FAILED SIMULTANEOUSLY | PARTS FAILED DUE TO DC SURGE. PERSONNEL |
| W | DC2 | 022280 | 061378 | SI | DI | E | B08 | N | C | T | | INVERTER FAILURE | DEFECTIVE DIODES AND SCR'S |
| W | HN1 | 018775 | 071977 | SI | UU | E | B07 | N | C | T | | STATIC INVERTER FAILED | AMBIENT TEMP 40 DEG C. ABOVE DESIGN |
| W | NA2 | 037674* | 060381 | SI | UU | E | A00 | N | C | U | 2 | VOLTAGE TRANSIENT THRU VITAL BUS INVERTERS 2-III// | & 2-IV. CAUSE UNKNOWN |
| G | EN2 | 027848A | 121979 | SI | FS | Q | B08 | N | C | D | | "A" PS FOR RCIC STEAM LEAK DETECTION FAILED | FUSES BLEW DUE TO CURRENT SURGE |
| G | EN2 | 027848B | 122079 | SI | FS | Q | B08 | N | C | D | | "B" PS FOR RCIC STEAM LEAK DETECTION FAILED | FUSES BLEW DUE TO CURRENT SURGE |
| G | VY1 | 032080 | 071880 | SI | FS | L | B08 | N | C | D | | LOGIC PS BRD FAILED. 250KVA UNINTERRUPTIBLE PS // | TRPD DUE TO BLOWN LOGIC PS FUSE |

## RECURRING FAILURE

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | SUBCOMP | SYSTEM | MODE CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B | CR3 | 037006 | 041181 | SI | DI | E | B07 | N | R | T | | INVERTER "D" FAILED. INADQ VENT CAUSED OVERHTG // | SHORTED DIODE & BLEW FUSE |
| B | DE3 | 031182A | 050780 | SI | FS | E | B08 | N | R | D | | LOST AC VITAL INST BUS DUE TO INVERTER FAILURE | BLOWN FUSES |
| B | DE3 | 031182B | 050980 | SI | FS | E | B08 | N | R | D | | LOST AC VITAL INST BUS DUE TO INVERTER FAILURE | BLOWN FUSES/FAULTY TRANSISTOR |
| B | RS1 | 026111 | 042279 | SI | UV | E | B04 | U | R | D | | S1A VITAL POWER INVERTER FAILED | DESIGN DEFICIENCY IN U.V. COIL |
| C | SL1 | 175205A | 062282 | SI | UU | E | B00 | N | R | U | | OUTPUT BRKR OF 1A STATIC INVERTER OPENED | NO APPARENT CAUSE COULD BE FOUND |
| C | SL1 | 175205B | 062382 | SI | OS | E | B08 | N | R | U | | 1A STATIC INVERTER OUTPUT BREAKER OPENED | OSCILLATOR CIRCUIT BOARD REPLACED |
| C | SL1 | 181486 | 122082 | SI | UU | E | B00 | N | R | U | | 1A INVERTER OUTPUT BRK OPENED;1/4 120VAC BUS LOST | NO APPARENT CAUSE OF FAILURE |
| C | SL1 | 181729 | 122582 | SI | FB | E | B00 | N | R | U | | 1A INVERTER OUTPUT BRK OPENED;1/4 120VAC BUS LOST | DEFECTIVE OUTPUT FREQUENCY MODULE |
| W | BV1 | 014692 | 051076 | SI | CP | E | B08 | N | R | T | | INVERTER NO. 3 FAILED | OUTPUT FILTER CAPACITOR FAILED |
| W | BV1 | 015102 | 052776 | SI | CP | E | B08 | N | R | T | | INVERTER NO. 1 FAILED | OUTPUT FILTER CAPACITOR FAILED |
| W | BV1 | 016280 | 102276 | SI | RC | E | B08 | N | R | T | | VITAL BUS INVERTER NO. 3 FAILED | SCRS AND OUTPUT FUSE FOUND BAD |
| W | BV1 | 017014 | 121576 | SI | DI | E | B08 | N | R | T | | NO. 1 VITAL BUS INVERTER FAILED | 1 DIODE AND TWO FUSES FOUND FAILED |
| W | BV1 | 031239 | 050480 | SI | FS | E | B08 | N | R | D | | PWR LOST TO #4 VITAL BUS INVERTER DUE TO BLOWN // | MAIN PS FUSE. CAUSE UNKNOWN |
| W | DC1 | 032503 | 083180 | SI | DI | E | B08 | N | R | T | | SHORTED DIODE IN CRID IV INVERTER | DIODE FAILED DUE TO NORMAL END OF LIFE |
| W | JF1 | 021592 | 022378 | SI | CP | E | B08 | N | R | D | | 120VAC VITAL BUS B DEENRGZD WHEN INVERTER 1B TRPD | FAULTY CAPACITOR WAS REPLACED |
| W | JF1 | 021591 | 053078 | SI | CP | E | B08 | N | R | D | | 120VAC BUS D DEENRGZD WHEN INVERTER 1D TRIPPED | CAPACITOR IN INVERTER FAILED |
| W | PR1 | 015104 | 061576 | SI | TR | E | B08 | N | R | T | | NO. 13 INVERTER FAILED (PS TO INSTRUMENT BUS 113) | REGULATING TRANSFORMER ON OUTPUT FAILED |
| W | PR1 | 017425 | 031477 | SI | CP | E | B08 | N | R | T | | NO. 11 INVERTER FAILED | CAP ON OUTPUT SCLA TRANSFORMER FAILED |
| W | SA1 | 022420 | 082778 | SI | CL | E | B08 | N | R | T | | 1A INVERTER FAILD--FAILD ELECTRONIC COMP ON MASTER | //LOGIC CKT BRD CAUSD BLOWN FUSES |
| W | SA1 | 023232 | 112778 | SI | TR | E | B08 | N | R | T | | LOST 1B VITAL INSTRUMENT BUS | OUTPUT XFRMR IN SUPPLY INVERTER FAILED |
| W | SE1 | 033296* | 111880 | SI | UU | E | B00 | N | P | U | 9 | 9 VITAL INVERTER 2-III FAILURES BETWEEN 11-9-80&// | 11-23-80. NO CAUSES GIVEN |
| W | IR1 | 172719 | 011682 | SI | UU | E | B00 | N | R | U | | INVERTER NO. 2 FAILED. CAUSED INADVERTANT SI | NO CAUSE GIVEN. |
| W | ZI1 | 037631 | 052881 | SI | TR | E | B08 | N | R | D | | INST INVERTER 114 FAILED | XFRMR SHORTED BY HI INVERTER CIRC CURRENT |
| G | BF1 | 038008 | 070481 | SI | CL | P | B08 | T | R | T | | ALARM PANEL XA-55-8E INVERTER INOPERABLE | FAILED INVERTER CONTROL CARD |
| G | BP1 | 022658 | 091078 | SI | FS | C | B04 | N | R | D | | BLOWN FUSE IN POWER SUPPLY INVERTER | XIENT SUP VLTG PROBLEM--NEEDS DUMMY LOAD |
| G | BP1 | 026880 | 061679 | SI | FS | C | B04 | N | R | D | | CNTNMNT VACUUM RELIEF PS INVERTER FUSE BLEW | SUSCEPTIBLE TO INPUT SURGE |
| G | BP1 | 037801A | 061781 | SI | PS | A | B08 | M | R | T | | RX DEPRESSURIZATION LOOP B INVERTER FOUND INOP. | DEFECTIVE ELECTRONIC COMPONENTS |
| G | BP1 | 037801B | 062381 | SI | PS | A | B08 | M | R | T | | RX DEPRESSURIZATION LOOP B INVERTER FOUND INOP. | DEFECTIVE ELECTRONIC COMPONENTS |
| G | EN1 | 032376 | 082180 | SI | UU | L | B07 | N | R | T | | "B" LPCI INVERTER TRIPPED | HI AMBIENT TEMPERATURE IN INVERTER ROOM |
| G | EN1 | 037947A | 061081 | SI | SW | L | B00 | N | R | U | | B LPCI INVERTER R44-S003 TRPD ON HIGH TEMPERATURE | DEFECTIVE SWITCH IN INVERTER LEG |

## RECURRING FAILURE

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | COMP SUBCOMP | SYSTEM | MODE & CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| G | EN1 | 037947D | 061681 | SI | UU | L | BCO | N | R | U | 2 | B LIPCI INVERTER 2R44-S003 TRIPPED | UNKNOWN CAUSE |
| G | EN1 | 037947B | 061881 | SI | SW | L | B00 | N | R | U | 2 | B LPCI INVERTER R44-S003 TRIPPED | DFCTV SWITCHES IN INVERTER LEGS |
| G | EN1 | 037947C | 062181 | SI | SW | L | B00 | N | R | U | | B LPCI INVERTER R44-S003 TRIPPED | DEFECTIVE SWITCH IN INVERTER LEG |
| G | EN2 | 030980 | 042480 | SI | UU | Q | B00 | N | R | U | | REC'D RCIC LEAK DETECTION LOGIC PWR FAILURE ALARM | COMPONENT FAILURE OF INVERTER |
| G | FP1 | 037379 | 051561 | SI | CP | L | B08 | N | R | D | | LPCI MOV INDEPENDENT POWER SUPPLY INVERTER A TRPD | SHORTED CAP IN GATE FIRING MODULE "A1" |
| G | VY1 | 016272 | 101976 | SI | CL | L | B08 | N | R | T | | UPS-1B TRIPPED WHEN OPENING VALVE RHR-27B | POSSIBLE LOGIC PROBLEM |
| G | VY1 | 016485 | 111876 | SI | VR | L | B08 | N | R | T | | UPS-1B TRIPPED WHILE TESTING RHR-27B VALVE | VOLTAGE REGULATOR AND SYSTEM LOGIC PRBLEM |
| G | VY1 | 016500* | 112976 | SI | DB | L | B08 | N | R | T | 2 | UPS-1A AND UPS-1B TRIPPED WHILE TESTING LPCI VALVE | 1A HAD FAILED DRIVER BOARD, 1B HAD BAD REG |

## COMMON CAUSE COMMAND FAULT

| NSSS | PLANT | CONTROL OR NSIC NUMBER | EVENT DATE | COMP | COMP SUBP | SYSTEM | MODE CAUSE | ACTIVITY | TYPE | CLASS | FAULT # | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B | CR3 | 021210 | 042578 | SI | UU | E | A05 | N | U | D | | INVERTER 3A TRIPPING--WRONG FUSES INSTLD IN VITAL/ | BUS 3A DURING CONSTRUCTION/TESTING PHASE |
| B | OE1 | 036241C | 012581 | SI | UU | E | B02 | M | U | D | | 1D1D INVERTER TRIPPED | PERS OPENED AC OUTPUT BRKR MISTAKENLY |
| C | CC1 | 179674 | 110982 | SI | UU | E | B01 | M | U | D | | RX S/D DUE TO INVERTER DC FEEDER BREAKER TRIP | CONTRACTOR INADV TRPD OPEN INPUT BREAKER |
| W | BV1 | 016360 | 110676 | SI | UU | E | B03 | N | U | D | | INVERTER NO. 2 WAS MOMENTARILY OUT OF SERVICE | OUTPUT WAS SHORTED OUT BY PERSONNEL |
| W | BV1 | 173454 | 041482 | SI | UU | E | B02 | N | U | D | | NO. 3 INVERTER TRIPPED | PERSONNEL MAINTENANCE |
| W | SE1 | 036667 | 013081 | SI | UU | E | B02 | M | U | D | | CONDUIT/CABLE SUPPLYING PWR TO VITAL INVERTER 1-I/ | /WAS CUT. CONSTRUCTION PERSONNEL ERROR |
| W | SO1 | 0208788 | 0315[illegible]8 | SI | UU | C | B04 | N | U | D | | "B" INVERTER FOR CSAS TRIPPED ON TRANSFER | TRANSFER SWITCH WAS TOO FAST |
| W | ZI1 | 025150 | 011279 | SI | UU | E | B00 | N | U | U | | INV 114 TRPD. FOUND 2.5KVA INV SECTION FAULTY. | LOOSE CONTACT IN DC BREAKER |
| G | BR1 | 017085* | 011777 | SI | UU | E | B02 | M | U | D | 2 | CNTRL VLTG PS SET BELOW EQUALZG VLTG CAUSED TRIP | I&C TECH ERROR IN EQUALZG PLANT BATTERIES |
| G | EN1 | 033842 | 073180 | SI | UU | L | B07 | N | U | T | | B LPCI INVERTER TRPD THUS B LOOP OF RHR INOPERABLE | HI AMBIENT TEMPFRATURE IN INVERTER ROOM |

# APPENDIX H

# ADDITIONAL INFORMATION CONTAINED IN INVERTER ONE-LINE DESCRIPTIONS

# CODES USED IN LER ONE-LINE DESCRIPTIONS

## FAULT MODE

| CODE | DESCRIPTION |
|---|---|
| A | REDUCED CAPABILITY |
| B | INOPERABLE |

## SYSTEM

| CODE | DESCRIPTION |
|---|---|
| A | AUTOMATIC DEPRESSURIZATION SYSTEM (ADS) |
| C | CONTAINMENT (INCLUDES ISOLATION CONTROL) |
| E | ESSENTIAL AC ELECTRICAL DISTRIBUTION |
| H | HIGH PRESSURE COOLANT INJECTION (HPCI) |
| L | LOW PRESSURE COOLANT INJECTION (LPCI) |
| O | REACTOR CORE ISOLATION COOLING (RCIC) |
| P | UNKNOWN |

## TYPE OF EVENT

| CODE | DESCRIPTION |
|---|---|
| B | RECURRING COMMON CAUSE FAILURE |
| C | COMMON CAUSE FAILURE |
| R | RECURRING FAILURE |
| S | COMMAND FAULT |
| T | RECURRING COMMAND FAULT |
| U | COMMON CAUSE COMMAND FAULT |
| V | RECURRING COMMON CAUSE COMMAND FAULT |
| BLANK | RANDOM FAILURE |

## FAULT CAUSE

| CODE | DESCRIPTION |
|---|---|
| 00 | UNKNOWN |
| 01 | PERSONNEL OPERATION |
| 02 | PERSONNEL MAINTENANCE |
| 03 | PERSONNEL TESTING |
| 04 | DESIGN ERROR |
| 05 | FABRICATION/CONSTRUCTION/QUALITY CONTROL |
| 06 | DEFECTIVE PROCEDURES |
| 07 | EXTREME ENVIRONMENT |
| 08 | ELECTRICAL MALFUNCTION |
| 09 | MECHANICAL MALFUNCTION |

## SUBCOMPONENT

| CODE | DESCRIPTION |
|---|---|
| AC | ANNUNCIATOR CONTROL CARD |
| CC | FIRING CIRCUIT |
| CF | COOLING FAN |
| CH | CHOKE |
| CL | CONTROL CARD/CONTROL MODULE |
| CP | CAPACITOR |
| DB | DRIVER BOARD |
| DI | DIODE |
| FB | FREQUENCY BOARD |
| FS | FUSE |
| IN | INDUCTOR |
| OS | OSCILLATOR |
| PC | PROTECTION CARD |
| PS | POWER SUPPLY (INTERNAL) |
| RC | RECTIFIER |
| RE | RELAY |
| RS | RESISTOR |
| SW | SWITCH |
| TR | TRANSFORMER |
| TS | TRANSISTOR |
| UV | UNDERVOLTAGE COIL |
| VR | VOLTAGE REGULATOR |
| UU | UNKNOWN/NOT APPLICABLE |

## ACTIVITY RESULTING IN DISCOVERY

| CODE | DESCRIPTION |
|---|---|
| M | MAINTENANCE |
| N | NORMAL PLANT OPERATION |
| R | RECORDS REVIEW |
| T | TESTING |
| U | UNKNOWN |

## NSSS VENDOR

| CODE | DESCRIPTION |
|---|---|
| B | BABCOCK & WILCOX |
| C | COMBUSTION ENGINEERING |
| W | WESTINGHOUSE |
| G | GENERAL ELECTRIC |

## COMPONENT

| CODE | DESCRIPTION |
|---|---|
| SI | STATIC INVERTER |

## EVENT CLASSIFICATION

| CODE | DESCRIPTION |
|---|---|
| D | FREQUENCY |
| T | AGE |
| U | UNKNOWN |

ADDITIONAL CODES USED IN LER ONE-LINE DESCRIPTIONS

MANUFACTURER CODE

| CODE | DESCRIPTION |
|---|---|
| A499 | ASCO VALVES |
| C173 | C&D BATTERIES, DIVISION OF ELTRA CORP. |
| C782 | CYBEREX INC. |
| E355 | EXIDE INDUSTRIAL DIV. |
| G080 | GENERAL ELECTRIC CO. |
| G195 | GOULDS COMPANY (GOULDS) |
| G273 | GUARDIAN ELECTRIC |
| I202 | ITE IMPERIAL CORPORATION |
| L045 | LAMBDA ELECTRONICS |
| L295 | LUNDELL CONTROLS - TECHNOLOGY INC. |
| S240 | SOLA BASIC INDUSTRIES |
| S245 | SOLA ELECTRIC COMPANY |
| S250 | SOLID STATE CONTROLS, INC. |
| S379 | STATIC PRODUCTS |
| T248 | TOPAZ ELECTRONICS |
| W120 | WESTINGHOUSE ELECTRIC CORPORATION |
| W121 | WESTINGHOUSE ELECTRIC COMPANY (ELEV DIV) |
| BLANK | UNKNOWN |

FLAGGING

| CODE | DESCRIPTION |
|---|---|
| A | FAILED COMPONENT CAUSED AN ACCIDENT |
| B | COMPONENT FAILED TO MITIGATE AN ACCIDENT |
| C | SAFETY SIGNIFICANT |

REPORT TYPE

| CODE | DESCRIPTION |
|---|---|
| A | 2-WEEK REPORTS |
| B | 30-DAY REPORTS |
| C | OTHER |

## ADDITIONAL INFORMATION CONTAINED IN INVERTER ONE-LINE DESCRIPTIONS

| NSSS | PLANT | CONTROL OR NSIC NUMBER | NSIC VOLUME | NSIC NUMBER | LER NUMBER | REPORT TYPE | COMP SUBCOMP | MANUFACTURER CODE | REPAIR TIME | FLAGGING | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B | CR3 | 017321 | | | 020 | A | DI | S250 | | A | "B" INVERTER FAILED,CAUSED RX TRIP | OUTPUT DIODE FAILED |
| B | CR3 | 019021 | | | 115 | B | RC | S250 | | | "D" INVERTER FAILED | SILICON CONTROLLED RECTIFIER DEFECTIVE |
| B | CR3 | 019523 | | | 137 | B | UU | S250 | | | "A" INVERTER FAILED | NO CAUSE GIVEN |
| B | CR3 | 021210 | | | 028 | B | UU | I202 | | | INVERTER 3A TRIPPING--WRONG FUSES INSTLD IN VITAL/ | BUS 3A DURING CONSTRUCTION/TESTING PHASE |
| B | CR3 | 022361 | | | 042 | B | UU | S250 | | | INVERTER VBIT-1A FAILED-120VAC VITAL BUS 3A NO PWR | ELECTRONIC COMPONENT FAILRS W/ IN VBIT-1A |
| B | CR3 | 037006 | | | 021 | B | DI | | | A | INVERTER "D" FAILED. INADQ VENT CAUSED OVERHTG // | SHORTED DIODE & BLEW FUSE |
| B | CR3 | 038100 | | | 046 | B | FS | C173 | | A | "A" INVERTER FAILED DEENRGZD 120 AC VITAL BUS #3A | INADV SHORTED STAT BATT DURING MAINTENANC |
| B | DB1 | 027478 | | | 107 | B | RS | C782 | 60 | | BLOWN FUSE ON INVERTER YV2 OUTPUT | OPEN RESISTOR IN LOGIC PS OF INVERTER YV2 |
| B | DB1 | 032367A | | | 064 | C | FS | | 6 | | FAILURE [illegible] YV-2 INVERTER INPUT FUSE | EXACT CAUSE OF FUSE FAILURE UNDETERMINED |
| B | DB1 | 032367B | | | 064 | C | FS | | 4 | | FAILURE OF YV-2 INVERTER INPUT FUSE | EXACT CAUSE OF FUSE FAILURE UNDETERMINED |
| B | DB1 | C33270 | | | 081 | B | FS | | 2 | A | GROUNDED YV2 INVERTER INPUT FUSE TOOK OUT Y2 BUS | GROUNDED OSCILLOSCOPE USED BY I&C PERSNL |
| B | DB1 | 039149 | | | 066 | B | DI | C782 | 35 | | ESSENTIAL 120VAC INVERTER YV3 FAILED | RESISTOR/DIODE ON +15VDC LOGIC PS FAILED |
| B | DB1 | 173542 | 1 | 7 | 020 | | FS | | | | OUTPUT FROM YV2 INVERTER TO Y2 BUS WAS LOST | FUSE BLEW DUE TO PERSONNEL MAINTENANCE |
| B | DB1 | 175395 | 1 | 9 | 029 | | RC | | | | ESSENTIAL INVERTER YV2 FAILED | COMP FAILR W/ IN REGULATED RECTIFIER YRF2 |
| B | DE1 | 036123 | | | 002 | B | FS | | | | 1D1D VITAL INVERTER DC INPUT FUSE BLEW | POOR CNNCTN &/OR COMP PRBLMS IN LOGIC CRD |
| B | DE1 | 036241A | | | 003 | B | FS | E355 | | | 1D1D VITAL INVERTER DC INPUT FUSE BLEW | BLOWN FUSES |
| B | DE1 | 036241B | | | 003 | B | UU | E355 | | | 1D1B INVERTER TRIPPED | EXACT CAUSE UNKNOWN |
| B | DE1 | 036241C | | | 003 | B | UU | E355 | | | 1D1D INVERTER TRIPPED | PERS OPENED AC OUTPUT BRKR MISTAKENLY |
| B | DE3 | 016137 | | | 016 | A | CP | | | | THE 3 D1B VITAL BUS INVERTER FAILED | DIELECTRIC OF INPUT FILTER CAP BROKE DOWN |
| B | DE3 | 027697 | | | 013 | A | FS | E355 | | C | ICS POWER LOST DUE TO INVERTER(KI) FAILED | BLOW FUSES |
| B | DE3 | 031182A | | | 008 | B | FS | E355 | | | LOST AC VITAL INST BUS DUE TO INVERTER FAILURE | BLOWN FUSES |
| B | DE3 | 031182B | | | 008 | B | FS | E355 | | | LOST AC VITAL INST BUS DUE TO INVERTER FAILURE | BLOWN FUSES/FAULTY TRANSISTOR |
| B | DE3 | 031182C | | | 008 | B | TS | E355 | | | INVERTER 3D1B TRIPPED WHEN POWER WAS TRANSFERRED / | /TO IT. BYPASS SWITCH POSSIBLY CLOSED. |
| B | RS1 | 026111 | | | 003 | B | UV | W120 | | | S1A VITAL POWER INVERTER FAILED | DESIGN DEFICIENCY IN U.V. COIL |
| B | TI2 | 021952 | | | 021 | B | CL | S250 | | | VITAL BUS INVERTER FAILD TO FUNCTN PROPERLY | FAULTY INVERTER CNTRL MODULE AND FUSE |
| C | CC1 | 179574 | 2 | 2 | 068 | | UU | | | A | RX S/D DUE TO INVERTER DC FEEDER BREAKER TRIP | CONTRACTOR INADV TRPD OPEN INPUT BREAKER |
| C | CC2 | 017009 | | | 009 | B | FS | E355 | | | B PHASE COMPUTER INVERTER DC INPUT FUSE OPENED | CURRENT SURGE DUE TO SWITCHING OPERATION |
| C | CC2 | 183012 | 2 | 7 | 055 | | FS | E355 | | | #22 INVERTER OUTPUT FUSE BLEW | SUSPECTED CAUSE--IMPROPER FUSE TYPE USED |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C | FC1 | 020085 | | | 042 | B | VR | S250 | | | D CHANNEL INSTRUMENT INVERTER FAILED | CONSTANT VOLTAGE REGULATOR FAILED |
| C | MI2 | 026871 | | | 001 | B | CP | S250 | | | INVERTER NO. 4 FAILED | CAPACITORS AND OSCILLATOR BOARD FAILED |
| C | MI2 | 172670* | 1 | 5 | 002 | | FS | | | C | FUSES IN INVERTERS 2 AND 6 BLEW | SHORTED TEST LEAD FAILED CIRCUIT |
| C | MI2 | 175402* | 1 | 9 | 024 | | FS | S250 | | C | LOSS OF 120VAC (VIAC-1) BLOWS FUSES IN ESFAS CABNT | ROOF LEAK SHORTED 2 INVERTERS #5,6 |
| C | SL1 | 015004 | | | 026 | B | CS | G195 | | | 1C STATIC INVERTER FAILED(PS FOR AC INST,120 VOLT) | FAILED OSCILLATOR CIRCUIT BOARD |
| C | SL1 | 175205A | 1 | 9 | 026 | | UU | | | | OUTPUT BRKR OF 1A STATIC INVERTER OPENED | NO APPARENT CAUSE COULD BE FOUND |
| C | SL1 | 175205B | 1 | 9 | 026 | | CS | | | | 1A STATIC INVERTER OUTPUT BREAKER OPENED | OSCILLATOR CIRCUIT BOARD REPLACED |
| C | SL1 | 181486 | 2 | 5 | 068 | | UU | G195 | | | 1A INVERTER OUTPUT BRK OPENED;1/4 120VAC BUS LOST | NO APPARENT CAUSE OF FAILURE |
| C | SL1 | 181729 | 2 | 5 | 067 | | FB | A499 | | | 1A INVERTER OUTPUT BRK OPENED;1/4 120VAC BUS LOST | DEFECTIVE OUTPUT FREQUENCY MODULE |
| C | SL1 | 181038 | 2 | 4 | 071 | | CS | | | | 1A INVERTER OUTPUT BRK OPENED;1/4 120VAC BUS LOST | FREQUENCY OSCILLATOR HAD DRIFTED |
| W | BV1 | 014692 | | | 029 | B | CP | S379 | | | INVERTER NO. 3 FAILED | OUTPUT FILTER CAPACITOR FAILED |
| W | BV1 | 015102 | | | 038 | B | CP | S379 | | | INVERTER NO. 1 FAILED | OUTPUT FILTER CAPACITOR FAILED |
| W | BV1 | 015213 | | | 044 | B | UU | S379 | | | INVERTER NO. 3 APPARENTLY FAILED | NO CAUSE GIVEN |
| W | BV1 | 016280 | | | 074 | C | RC | S379 | | | VITAL BUS INVERTER NO. 3 FAILED | SCRS AND OUTPUT FUSE FOUND BAD |
| W | BV1 | 016360 | | | 081 | C | UU | | | | INVERTER NO. 2 WAS MOMENTARILY OUT OF SERVICE | OUTPUT WAS SHORTED OUT BY PERSONNEL |
| W | BV1 | 017014 | | | 093 | B | DI | | | | NO. 1 VITAL BUS INVERTER FAILED | 1 DIODE AND TWO FUSES FOUND FAILED |
| W | BV1 | 023209 | | | 002 | B | UU | | | A | OUTPUT FREQUENCY OF NO. 4 INVERTER OSCILLATING | NO CAUSE GIVEN |
| W | BV1 | 025332 | | | 006 | B | UU | S379 | | A | NO. 3 VITAL BUS INVERTER FAILED | FAULTY COMPONENTS |
| W | BV1 | 027140 | | | 038 | B | OS | | | | NO. 4 VITAL BUS INVERTER FREQUENCY FOUND SPIKING | FAULTY OSCILLATOR CARD |
| W | BV1 | 028012 | | | 039 | C | UU | S379 | | A | NO. 4 VITAL BUS INVERTER FAILED. RX TRIP OCCURRED/ | /AND SAFETY INJECTION OCCURRED. NO CAUSE |
| W | BV1 | 031239 | | | 028 | B | FS | | | | PWR LOST TO #4 VITAL BUS INVERTER DUE TO BLOWN // | MAIN PS FUSE. CAUSE UNKNOWN |
| W | BV1 | 173454 | 1 | 7 | 015 | | UU | | | | NO. 3 INVERTER TRIPPED | PERSONNEL MAINTENANCE |
| W | DC1 | 017804 | | | 022 | B | FS | W120 | | A | #4 INVERTER FAILED,CAUSED RX TRIP & SI | BLOWN FUSE |
| W | DC1 | 025643* | | | 022 | C | UU | S250 | | C | TWO VITAL BUS INVERTERS FAILED SIMULTANEOUSLY | PARTS FAILED DUE TO DC SURGE. PERSONNEL |
| W | DC1 | 032503 | | | 020 | B | DI | S250 | | A | SHORTED DIODE IN CRID IV INVERTER | DIODE FAILED DUE TO NORMAL END OF LIFE |
| W | DC1 | 182697 | 2 | 7 | 076 | | UU | | 118 | | AB EMERG DIESEL GENERATOR INVERTER FAILED. SOLID | STATE COMP, XFMR GATE, SHORTING BRD RPLCD |
| W | DC2 | 022280 | | | 062 | B | DI | S250 | | | INVERTER FAILURE | DEFECTIVE DIODES AND SCR'S |
| W | DC2 | 037613 | | | 027 | B | CP | | | A | FAILURE IN 120VAC VITAL BUS (CRID II) | C-2 CAPACITOR FAILED ALSO BLEW A FUSE |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W | HN1 | 018775 | | | 013 | C | UU | W120 | | | STATIC INVERTER FAILED | AMBIENT TEMP 40 DEG C. ABOVE DESIGN |
| W | IP2 | 022867 | | | 031 | C | UU | S250 | | | .5KVA STATIC INVERTER FAILD DEENRGZG CONT PRESS // | SAFEGUARDS LOGIC. DEFECTIVE INVERTER |
| W | JF1 | 021593 | | | 030 | B | UU | W120 | | | 120V VITAL BUS A DEENRGZD WHEN INVERTER A TRIPPED | EXACT CAUSE NOT IDENTIFIED |
| W | JF1 | 021592 | | | 031 | B | CP | W120 | | | 120VAC VITAL BUS B DEENRGZD WHEN INVERTER 1B TRPD | FAULTY CAPACITOR WAS REPLACED |
| W | JF1 | 021594 | | | 029 | B | UU | W120 | | | 120VAC VITAL BUS A DEENRGZD WHEN INVERTER A TRPD | EXACT CAUSE NOT IDENTIFIED |
| W | JF1 | 021591 | | | 032 | B | CP | W120 | | | 120VAC BUS D DEENRGZD WHEN INVERTER 1D TRIPPED | CAPACITOR IN INVERTER FAILED |
| W | JF1 | 025439 | | | 002 | B | CH | W120 | | | 1B INVERTER TRIPPED (PS FOR 120V VITAL AC) | VARIOUS INTERNAL COMPONENTS FAILED |
| W | JF2 | 038879 | | | 040 | B | UU | W120 | 11 | | INVERTER 2A TRPD--120VAC VITAL BUS 2A DEENERGIZED | TRANSIENT VOLTAGE SPIKE--CAUSE UNKNOWN |
| W | JF2 | 173252 | 1 | 7 | 011 | | FS | | | | INVERTER NO. 2B ?AILED | FUSE BLEW IN VOLTAGE REGULATOR |
| W | JF2 | 176542 | 1 | 11 | 032 | | UU | | | | INVERTER NO. 26 FAILED CAUSING LOSS OF POWER TO S/ | /UB COOLING MONITOR AND H2 MONITOR |
| W | MG1 | 174673 | 1 | 9 | 052 | | RC | S250 | | A | INVERTER EVIA INOP--LOST VITAL INST PWR CAUSD RX// | TRIPS. SCR SHORTING CKT BRD REPLACED |
| W | MG1 | 174671 | 1 | 9 | 053 | | CP | S250 | | | STATIC INVERTER EVIA MALFUNC--RHR ISOL VLV CLOSED | 3 CAP IN OUTPUT CV? ?AP BANK FAILED |
| W | NA1 | 031217 | | | 047 | A | FS | S250 | | A | LOST VITAL BUS 1-III. CAUSE UNKNOWN--POSSIBLY // | VLTG SURGE TO DC /AC INVERTER BLEW 2 FUSES |
| W | NA1 | 032608 | | | 080 | B | UU | S250 | | | LOST PWR TO 120VAC VITAL BUS 1-IV | INVERTER SUPPLY BRKR FOUND OPEN |
| W | NA2 | 037674* | | | 055 | C | UU | W121 | | C | VOLTAGE TRANSIENT THRU VITAL BUS INVERTERS 2-I?I// | & 2-IV. CAUSE UNKNOWN |
| W | PR1 | 015104 | | | 030 | B | TR | S245 | | | NO. 13 INVERTER FAILED (PS TO INSTRUMENT BUS 113) | REGULATING TRANSFORMER ON OUTP?T FAILED |
| W | PR1 | 017425 | | | 008 | B | CP | S245 | | | NO. 11 INVERTER FAILED | CAP ON OUTPUT SOLA TRANSFORMER FAILED |
| W | PR2 | 032962 | | | 029 | B | TR | S245 | | | #23 INVERTER FAILED DEENRGZG PANEL 213 | CONSTANT VOLTAGE TRANSFORMER FAILED |
| W | SA1 | 022426 | | | 051 | B | DI | | | | VITAL INST BUS INVERTER 1A FUSES BLOWN | FAILD DIODE IN CN?RL CKT BRD |
| W | SA1 | 022420 | | | 057 | B | CL | | | | 1A INVERTER FAILD--FAILD ELECTRONIC COMP ON MASTER | //LOGIC CKT BRD CAUSD BLOWN FUSES |
| W | SA1 | 023232 | | | 073 | C | TR | | | A | LOST 1B VITAL INSTRUMENT BUS | OUTPUT XFRMR IN SUPPLY INVERTER FAILED |
| W | SA1 | 023230 | | | 076 | B | UU | L045 | | | INVERTER DIDN'T SWITCH TO B/U BATTERY SUPPLY | NO CAUSE COULD BE DETERMINED |
| W | SA1 | 023513 | | | 074 | A | UU | | | A | 1B VITAL INSTRUMENT BUS INVERTER FAILED | NO CAUSE. INADVERTANT SI OCCURRED |
| W | SA1 | 027523 | | | 072 | B | CF | | 74 | | LOST METEORLOLGICAL INSTR/PWR SUP INVERTER FAILED | SEIZED MOTOR BEARINGS IN COOLING FAN |
| W | SA1 | 030231 | | | 006 | B | SW | | 17 | | LOST METEOROLOGICAL INSTRUMENT | INVERTER HAD MAN NOT AUTO SW--MFG ERROR |
| W | SA1 | 039242 | | | 107 | B | UU | | | A | INADV SI DUE TO LOSS OF VITAL BUS 1A INVERTER | CAUSE UNKNOWN |
| W | SA1 | 039344 | | | 110 | B | UU | | | A | INADV SI DUE TO LOSS OF 1A VITAL INST BUS INVERTER | CAUSE UNKNOWN |
| W | SA2 | 181466 | 2 | 5 | 145 | | PS | S250 | | | INVERTER PS FAILED CAUSD P-250 COMPUTER TO SHUTDWN | PS PROBLEM FROM FAILED OSCILLATOR CKT BRD |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| W | SE1 | 032879A | | | 166 | B | UU | S379 | | | VITAL INVERTER 2-IV OUTPUT BRKR TRIPPED | CAUSE NOT IDENTIFIED |
| W | SE1 | 032879B | | | 166 | B | SW | S379 | | | VITAL INVERTER 2-IV OUTPUT BRKR TRIPPED | BAD AUX SW ON THE K11 RELAY |
| W | SE1 | 032977 | | | 169 | B | CC | S379 | 8 | | VITAL INVERTER 2-III OUTPUT BRKR TRIPPED | FIRING CKT CLOCK CARD R85 FAILED |
| W | SE1 | 033295 | | | 185 | B | FS | | 2 | | VITAL INVERTER 1-I OUTPUT BRKR TRIPPED | INVERTER 1-I OUTPUT FUSES HAD BLOWN |
| W | SE1 | 033296* | | | 187 | B | UU | S379 | | | 9 VITAL INVERTER 2-III FAILURES BETWEEN 11-9-80&// | 11-23-80. NO CAUSES GIVEN |
| W | SE1 | 036667 | | | 011 | A | UU | S250 | 5 | | CONDUIT/CABLE SUPPLYING PWR TO VITAL INVERTER 1-I/ | /WAS CUT. CONSTRUCTION PERSONNEL ERROR |
| W | SO1 | 015998 | | | | B | PS | W120 | | | VITAL BUS #1 TRANSFERRED TO B/U POWER SOURCE | COMPONENT FAILURE IN #1 INVERTEP.NO CAUSE |
| W | SO1 | 018440 | | | 008 | B | CP | G080 | 8 | | DC INPUT FUSE OF UPS INVERTER OPENED | CA"'CITORS IN BANKS C-4,C-6 HAD FAILED |
| W | SO1 | 020878A | | | 003 | A | CP | | | | "A" INVERTER FAILED (ONE OF TWO FOR CSAS LOGIC) | CAPACITOR AND CHOKE IN OUTPUT SIDE FAILED |
| W | SO1 | 020878B | | | 003 | A | UU | | 1 | | "B" INVERTER FOR CSAS TRIPPED ON TRANSFER | TRANSFER SWITCH WAS TOO FAST |
| W | SO1 | 021743 | | | 007 | B | CP | G080 | | | DC INPUT FUSE FOR MOV-850C INVERTER OPENED | GE CAPACITOR 28F5108 AND SCR-2 FAILED |
| W | SU2 | 179196 | 2 | 1 | 063 | | IN | | | A | FAILED VITAL BUS-3 INVERTER/TURB RUNBACK,RX,TRP,SI | STATION BATT INVERTER INDUCTOR SHORTED |
| W | TR1 | 033305 | | | 025 | B | UU | | 16 | C | 3 VITAL PREFERRED INSTR BUSES ON SAME EMERG TRAIN | #4 INVERTER APPARENTLY FAILED--NO CAUSE |
| W | TR1 | 039071 | | | 025 | B | RE | G273 | | | LOST PREFERRED INST BUS Y11--STATIC INVERTER OUTPT | //CURRENT SENSG RELAY FAILD. MAT'L EOL |
| W | TR1 | 172719 | 1 | 5 | 005 | | UU | | | A | INVERTER NO. 2 FAILED. CAUSED INADVERTANT SI | NO CAUSE GIVEN. |
| W | ZI1 | 025150 | | | 004 | [illegible] | UU | W120 | | | INV 114 TRPD. FOUND 2.5KVA INV SECTION FAULTY. | LOOSE CONTACT IN DC BREAKER |
| W | ZI1 | 026916 | | | 057 | B | TR | W120 | 4 | | INSTRUMENT INVERTER 114 TRIPPED | 5KVA TRANSFORMER REPLACED |
| W | ZI1 | 037631 | | | 022 | C | TR | S245 | | A | INST INVERTER 114 FAILED | XFRMR SHORTED BY HI INVERTER CIRC CURRENT |
| W | ZI2 | 020356 | | | 053 | B | TR | S240 | | | INVERTER NO. 213 FAILED (INSTRUMENT INVERTER) | SLAVE TRANSFORMER FAILED BY OVERHEATING |
| W | ZI2 | 031066 | | | 016 | B | RC | W120 | | | INSTRUMENT INVERTER 214 FAILED | SCR FAILED IN SLAVE UNIT OF INVERTER |
| W | ZI2 | 037995 | | | 015 | C | TR | S245 | | A | LOST POWER TO INVERTER 213 | XFRMR SHORTD BY HI INVERTER CIRC CURRENT |
| G | BF1 | 038008 | | | 039 | B | CL | L295 | | | ALARM PANEL XA-55-8E INVERTER INOPERABLE | FAILED INVERTER CONTROL CARD |
| G | BF3 | 027049 | | | 015 | B | AC | L295 | | | ANNUNC PANEL XA-55-20B INOP INVERTER PRINTED CKT// | CARD FAILED DUE TO NATURAL AGI:G |
| G | BP1 | 022658 | | | 040 | B | FS | T248 | | | BLOWN FUSE IN POWER SUPPLY INVERTER | XIENT SUP VLTG PROBLEM--NEEDS DUMMY LOAD |
| G | BP1 | 025806 | | | 015 | B | FS | T248 | | | CONTAINMENT VACUUM RELIEF LOOP POWER SUPPLY INVER/ | /TER FOUND INOPERABLE. BLOWN PS FUSE |
| G | BP1 | 026880 | | | 021 | B | FS | T248 | | | CNTNMNT VACUUM RELIEF PS INVERTER FUSE BLEW | SUSCEPTIBLE TO INPLT SURGE |
| G | BP1 | 037801A | | | 013 | B | PS | | 3 | | RX DEPRESSURIZATION LOOP B INVERTER FOUND INOP. | DEFECTIVE ELECTRONIC COMPONENTS |
| G | BP1 | 037801B | | | 013 | B | PS | | 3 | | RX DEPRESSURIZATION LOOP B INVERTER FOUND INOP. | DEFECTIVE ELECTRONIC COMPONENTS |

## ADDITIONAL INFORMATION CONTAINED IN INVERTER ONE-LINE DESCRIPTIONS

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G | BR1 | 017085* | | | 010 | B | UU | T246 | | A | CNTRL VLTG PS SET BELOW EQUALZG VLTG CAUSED TRIP | I&C TECH ERROR IN EQUALZG PLANT BATTERIES |
| G | BR2 | 030364 | | | 007 | B | UU | T248 | | | STM LEAK DETCTN "A" LOGIC INVERTER'S HV TRPD LOW | NO CAUSE GIVEN |
| G | CO1 | 037646 | | | 010 | B | CP | E355 | | | STATIC INVERTER 1A'S SPIKE SUPPRESSOR CAP FAILED | AGED ELECTROLYTIC CAP/IMPROPR OP PROCEDUR |
| G | EN1 | 016840 | | | 093 | A | CP | T248 | | | RCIC PS INVERTER E51-K603 FAILED | SHORTED CAPACITOR IN OUTPUT TRANSFORMER |
| G | EN1 | 033842 | | | 092 | B | UU | E355 | | C | B LPCI INVERTER TRPD THUS B LOOP OF RHR INOPERABLE | HI AMBIENT TEMPERATURE IN INVERTER ROOM |
| G | EN1 | 032376 | | | 102 | B | UU | E355 | | | "B" LPCI INVERTER TRIPPED | HI AMBIENT TEMPERATURE IN INVERTER ROOM |
| G | EN1 | 037947A | | | 052 | B | SW | E355 | | | B LPCI INVERTER R44-S003 TRPD ON HIGH TEMPERATURE | DEFECTIVE SWITCH IN INVERTER LEG |
| G | EN1 | 037947D | | | 052 | B | UU | E355 | | | B LIPCI INVERTER 2R44-S003 TRIPPED | UNKNOWN CAUSE |
| G | EN1 | 037947B | | | 052 | B | SW | E355 | | | B LPCI INVERTER R44-S003 TRIPPED | DFCTV SWITCHES IN INVERTER LEGS |
| G | EN1 | 037947C | | | 052 | B | SW | E355 | | | B LPCI INVERTER R44-S003 TRIPPED | DEFECTIVE SWITCH IN INVERTER LEG |
| G | EN1 | 177682 | 1 | 12 | 082 | | CP | | 72 | | "A" LPCI INVERTER FAILED. OUTPUT FILTER CAPACITO/ | /R INSULATION SPAT,FAILED FUSES & CAP'S |
| G | EN2 | 022024 | | | 004 | B | FB | E355 | | | STATIC INVERTER(2R44-S002) OUTPUT BREAKER TRIPPED | FREQUENCY CARD(EXIDE PART #A13A9) FAILED |
| G | EN2 | 023200 | | | 077 | B | PC | E355 | | | STATIC INVERTER (2R44-S003) DC OUTPUT BRKR TRIPPED | AC/DC PROTECTION CARD(A13A12) FAILED |
| G | EN2 | 027611 | | | 122 | B | RE | | | | "B" LPCI INVERTER TRIPPED | FAILED RELAY IN INVERTER FAILED |
| G | EN2 | 027848A | | | 135 | B | FS | T248 | | | "A" PS FOR RCIC STEAM LEAK DETECTION FAILED | FUSES BLEW DUE TO CURRENT SURGE |
| G | EN2 | 027848B | | | 135 | B | FS | T248 | | | "B" PS FOR RCIC STEAM LEAK DETECTION FAILED | FUSES BLEW DUE TO CURRENT SURGE |
| G | EN2 | 030041 | | | 003 | B | UU | T248 | | | HPCI AUTO FLO CNTRL PWR INVERTER'S HV TRPD LOW | INSTRUMENT DRIFT |
| G | EN2 | 030241 | | | 011 | B | CP | T248 | | | RCIC REMOTE FLO CNTRL LOOP POWER INVERTER TRIPPED | DFCTV INPUT FILTER CAPACITORS |
| G | EN2 | 030980 | | | 071 | B | UU | T248 | | | REC'D RCIC LEAK DETECTION LOGIC PWR FAILURE ALARM | COMPONENT FAILURE OF INVERTER |
| G | EN2 | 036952 | | | 038 | B | CL | E355 | | | "A" LPCI INVERTER 2R44-S002 TRPD | LOGIC FAILURE CAUSED TRIP |
| G | EN2 | 038501 | | | 085 | B | VR | E355 | 8 | | B LPCI INVERTER 2R44-S003 TRPD | GATE FIRING MODULE VOLTAGE REGULATOR FAIL |
| G | EN2 | 171785 | 1 | 3 | 117 | | CC | | | | B LPCI INVERTER (2R44-S003) GAVE HI PHASE CURRENTS | FAILED GATE FIRING MODULE |
| G | EN2 | 178916 | 2 | 1 | 114 | | CF | | | | INVERTER(2R44-S003) TRPD DUE TO LEG FAN FAILURE | #4 INVERTER LEG FAN BEARING FAILED |
| G | FP1 | 013966 | | | 001 | A | RS | | | | RC.: STATIC INVERTER(12-801A) FAILED | LEAD TO WIRE WOUND RESISTER TOUCHED *STR |
| G | FP1 | 015625 | | | 053 | B | UU | T248 | | | HPCI INVERTER 23-INV-79 TRIPPED AND WOULD NOT RES/ | /TART. NO CAUSE FOUND,INVERTER REPLACED |
| G | FP1 | 021432 | | | 040 | B | PC | E355 | | | LPCI INVERTER/CHARGER TRPD LOST B LPCI INDPNDNT // | PWR. FAILED SCR'S IN INVERTLR/CHARGER |
| G | FP1 | 030177 | | | 015 | B | CP | G080 | | | LPCI INDPNDNT PS "A" INVERTER TRIPPED | INVERTER CNTRL CKT CAPACITORS FAILED |
| G | FP1 | 032373A | | | 072 | B | CL | E355 | | | "B" LPCI INVERTER TRIPPED | AC VOLTAGE/CURRENT CNTRL LOGIC CARD A12 |

## ADDITIONAL INFORMATION CONTAINED IN INVERTER ONE-LINE DESCRIPTIONS

| NSSS | PLANT | CONTROL OR NSIC NUMBER | NSIC VOLUME | NSIC NUMBER | LER NUMBER | REPORT TYPE | COMP SUBCOMP | MANUFACTURER CODE | REPAIR TIME | FLAGGING | MODE DESCRIPTION | CAUSE DESCRIPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G | FP1 | 032373B | | | 072 | B | CL | E355 | | | "B" LPCI INVERTER TRIPPED | INVERTER LEG GATE FIRE CNTRL CKT FAILED |
| G | FP1 | 032373C | | | 072 | B | AC | E355 | | | "B" LPCI INVERTER TRIPPED | ANNUNCIATOR/CONTROL CARD 2 FAILED |
| G | FP1 | 032373D | | | 072 | B | AC | E355 | | | "B" LPCI INVERTER TRIPPED | ANNUNCIATOR/CONTROL CARD 2 FAILED |
| G | FP1 | 032718 | | | 075 | B | CL | E355 | 96 | | "B" LPCI INVERTER TRIPPED | LOGIC CARD A2 FAILED |
| G | FP1 | 037379 | | | 041 | B | CP | E355 | 24 | | LPCI MOV INDEPENDENT POWER SUPPLY INVERTER A TRPD | SHORTED CAP IN GATE FIRING MODULE "A1" |
| G | FP1 | 181727 | 2 | 5 | 056 | | CL | E355 | | | "A" LPCI INVERTER TRIPPED DUE TO ELECTRICAL FAILUR | GATE TIMING CONTROL CARD FAILED |
| G | PB2 | 017210 | | | C13 | B | UU | T248 | | | RCIC STATIC INVERTER 2-13-90 TRIPPED WITHOUT AUTO/ | /MATIC RESET. NO CAUSE FOUND |
| G | PB2 | 021247 | | | 026 | B | TS | T248 | 17 | | INVERTER FAILD POWERS RCIC'S CNTRLLR & INSTRMNTN | DFCTV TRANSISTOR IN AUTO-RESET CIRCUIT |
| G | PB2 | 021248 | | | 022 | B | UU | T248 | 7 | | HPCI STATIC INVERTER TRIPPED | NO FAULT COULD BE FOUND WITH THE INVERTER |
| G | PI1 | 038673 | | | 050 | A | CP | T248 | | | FAILED INVERTER CAUSED GROUND FAULT ON 125VDC SYS | FAILED CAP IN DC/AC INVERTER |
| G | VY1 | 015519 | | | 025 | B | SW | E355 | | | A 250 KVA UPS OUTPUT BREAKER TRIPPED | NOISE IN AN UNUSED STATIC SWITCH |
| G | VY1 | 015965 | | | 034 | B | FS | E355 | | | MOTOR CONTROL CENTER 89A LOST POWER DUE TO "A" UP/ | /S TRIPPED. BLOWN INVERTER LEG FUSE |
| G | VY1 | 016272 | | | 040 | B | CL | E355 | | | UPS-1B TRIPPED WHEN OPENING VALVE RHR-27B | POSSIBLE LOGIC PROBLEM |
| G | VY1 | 016485 | | | 043 | B | VR | E355 | | | UPS-1B TRIPPED WHILE TESTING RHR-27B VALVE | VOLTAGE REGULATOR AND SYSTEM LOGIC PRBLEM |
| G | VY1 | 016500* | | | 046 | A | DB | E355 | | | UPS-1A AND UPS-1B TRIPPED WHILE TESTING LPCI VALVE | 1A HAD FAILED DRIVER BOARD, 1B HAD BAD REG |
| G | VY1 | 021542 | | | 012 | B | FS | E355 | | | 250KVA UNINTERRUPTIBLE PWR SUPPLY TRIPPED | BLOWN INVERTER LEG FUSE(2A18F2) |
| G | VY1 | 021768 | | | 013 | B | UU | E355 | | | LOSS OF VLTG TO MCC-89B | UNINTERRUPTIBLE POWER SUPPLY(UPS-1B) TRPD |
| G | VY1 | 021842 | | | 019 | B | PC | E355 | | | 250KVA UPS TRPD DUE TO INVERTER LEG FUSE(2A19F2)// | BLEW WHEN GATE INTRFC/PRICIN LOGIC MALFUN |
| G | VY1 | 032080 | | | 024 | B | FS | E355 | 5 | | LOGIC PS BRD FAILED. 250KVA UNINTERRUPTIBLE PS // | TRPD DUE TO BLOWN LOGIC PS FUSE |
| G | VY1 | 173401 | 1 | 7 | 002 | | CP | | | | UPS-B AC GROUND AND BLOWN FUSE ALARM WAS RECEIVED | SUPPRESSION CAPACITOR FAILED BLOWING FUSE |
| G | VY1 | 172682 | 1 | 6 | 005 | | CP | | | | UPS "B" TRAIN TRIPPED | SHORTED CAPACITOR DUE TO AGE |

# APPENDIX I

## LISTING OF LER NUMBERS

| NSSS | PLANT | LER NUMBER | EVENT DATE | CONTROL OR NSIC NUMBER |
|---|---|---|---|---|
| B | CR3 | 77-020 | 030277 | 017321 |
| B | CR3 | 77-115 | 090277 | 019021 |
| B | CR3 | 77-137 | 102677 | 019523 |
| B | CR3 | 78-028 | 042578 | 021210 |
| B | CR3 | 78-042 | 081978 | 022361 |
| B | CR3 | 81-021 | 041181 | 037006 |
| B | CR3 | 81-046 | 071481 | 038100 |
| B | DB1 | 79-107 | 110579 | 027478 |
| B | DB1 | 80-064 | 082280 | 032367A |
| B | DB1 | 80-064 | 082380 | 032367B |
| B | DB1 | 80-081 | 111280 | 033270 |
| B | DB1 | 81-066 | 101881 | 039149 |
| B | DB1 | 82-020 | 040982 | 173542 |
| B | DB1 | 82-029 | 060882 | 175395 |
| B | OE1 | 81-002 | 011881 | 036123 |
| B | OE1 | 81-003 | 012581 | 036241A |
| B | OE1 | 81-003 | 012581 | 036241B |
| B | CF1 | 81-003 | 012581 | 036241C |
| B | OE3 | 76-016 | 091276 | 016137 |
| B | OE3 | 79-013 | 111079 | 027697 |
| B | OE3 | 80-008 | 050780 | 031182A |
| B | OE3 | 80-008 | 050980 | 031182B |
| B | OE3 | 80-008 | 051680 | 031182C |
| B | RS1 | 79-003 | 042279 | 026111 |
| B | TI2 | 78-021 | 032978 | 021952 |
| C | CC1 | 82-068 | 110982 | 179674 |
| C | CC2 | 77-009 | 010677 | 017009 |
| C | CC2 | 82-055 | 122882 | 183012 |
| C | FC1 | 77-042 | 122577 | 020085 |
| C | MI2 | 79-001 | 010579 | 026871 |
| C | MI2 | 82-002 | 010682 | 172670* |
| C | MI2 | 82-024 | 060682 | 175402* |
| C | SL1 | 76-026 | 052976 | 015004 |
| C | SL1 | 82-026 | 062282 | 175205A |
| C | SL1 | 82-026 | 062382 | 175205B |
| C | SL1 | 82-068 | 122082 | 181486 |
| C | SL1 | 82-067 | 122582 | 181729 |
| C | SL1 | 82-071 | 123082 | 181038 |
| W | BV1 | 76-029 | 051076 | 0146[illegible]2 |
| W | BV1 | 76-038 | 052776 | 0151[illegible]2 |
| W | BV1 | 76-044 | 062376 | 015213 |
| W | BV1 | 76-074 | 102276 | 016280 |
| W | BV1 | 76-081 | 110676 | 016360 |
| W | BV1 | 76-093 | 121576 | 017014 |
| W | BV1 | 78-002 | 010278 | 023209 |
| W | BV1 | 79-006 | 012079 | 025332 |
| W | BV1 | 79-038 | 091879 | 027140 |
| W | BV1 | 79-039 | 092079 | 028012 |
| W | BV1 | 80-028 | 050480 | 031239 |
| W | BV1 | 82-015 | 041482 | 173454 |
| W | DC1 | 77-022 | 042177 | 017804 |
| W | DC1 | 79-022 | 032379 | 025643* |
| W | DC1 | 80-020 | 033180 | 032503 |
| W | DC1 | 82-076 | 082382 | 182697 |
| W | DC2 | 78-062 | 061378 | 022280 |
| W | DC2 | 81-027 | 061281 | 037613 |
| W | HN1 | 77-013 | 071977 | 018775 |
| W | IP2 | 78-031 | 102278 | 022867 |
| W | JF1 | 78-030 | 022178 | 021593 |
| W | JF1 | 78-031 | 022378 | 021592 |
| W | JF1 | 78-029 | 050978 | 021594 |
| W | JF1 | 78-032 | 053078 | 021591 |
| W | JF1 | 79-002 | 011679 | 025439 |
| W | JF2 | 81-040 | 092381 | 038879 |
| W | JF2 | 82-011 | 031682 | 173252 |
| W | JF2 | 82-032 | 072282 | 176542 |
| W | MG1 | 82-052 | 061382 | 174673 |
| W | MG1 | 82-053 | 062482 | 174671 |
| W | NA1 | 80-047 | 052380 | 031217 |
| W | NA1 | 80-080 | 090880 | 032608 |
| W | NA2 | 81-055 | 060381 | 037674* |
| W | PR1 | 76-030 | 061576 | 015104 |
| W | PR1 | 77-008 | 031477 | 017425 |
| W | PR2 | 80-029 | 100480 | 032962 |
| W | SA1 | 78-051 | 082178 | 022426 |
| W | SA1 | 78-057 | 082778 | 022420 |
| W | SA1 | 78-073 | 112778 | 023232 |
| W | SA1 | 78-076 | 120878 | 023230 |
| W | SA1 | 79-074 | 012679 | 023513 |
| W | SA1 | 79-072 | 110579 | 027523 |
| W | SA1 | 80-006 | 012380 | 030231 |
| W | SA1 | 81-107 | 102981 | 039242 |
| W | SA1 | 81-110 | 110681 | 039344 |
| W | SA2 | 82-145 | 112982 | 181466 |
| W | SE1 | 80-166 | 092780 | 032879A |
| W | SE1 | 80-166 | 100180 | 032879B |
| W | SE1 | 80-169 | 101480 | 032977 |
| W | SE1 | 80-185 | 111180 | 033295 |
| W | SE1 | 80-187 | 111880 | 033296* |
| W | SE1 | 81-011 | 013081 | 036667 |
| W | SO1 | 76- | 082376 | 015998 |
| W | SO1 | 77-008 | 061477 | 018440 |
| W | SO1 | 78-003 | 031578 | 020878A |
| W | SO1 | 78-003 | 031578 | 020878B |
| W | SO1 | 78-007 | 060778 | 021743 |
| W | SU2 | 82-063 | 101082 | 179196 |
| W | TR1 | 80-025 | 111280 | 033305 |
| W | TR1 | 81-025 | 100481 | 039071 |
| W | TR1 | 82-005 | 011682 | 172719 |
| W | ZI1 | 79-004 | 011279 | 025150 |

| NSSS | PLANT | LER NUMBER | EVENT DATE | CONTROL OR NSIC NUMBER |
|---|---|---|---|---|
| W | ZI1 | 79-057 | 081379 | 026916 |
| W | ZI1 | 81-022 | 052881 | 037631 |
| W | ZI2 | 77-053 | 082077 | 020356 |
| W | ZI2 | 80-016 | 041180 | 031066 |
| W | ZI2 | 81-015 | 050781 | 037995 |
| G | BF1 | 81-039 | 070481 | 038008 |
| G | BF3 | 79-015 | 091579 | 027049 |
| G | BP1 | 78-040 | 091078 | 022658 |
| G | BP1 | 79-015 | 031979 | 025806 |
| G | BP1 | 79-021 | 061679 | 026880 |
| G | BP1 | 81-013 | 061781 | 037801A |
| G | BP1 | 81-013 | 062381 | 037801B |
| G | BK1 | 77-010 | 011777 | 017085* |
| G | BR2 | 80-007 | 020480 | 030364 |
| G | CO1 | 81-010 | 050581 | 037646 |
| G | EN1 | 76-093 | 112776 | 016840 |
| G | EN1 | 80-092 | 073180 | 033842 |
| G | EN1 | 80-102 | 082180 | 032376 |
| G | EN1 | 81-052 | 061081 | 037947A |
| G | EN1 | 81-052 | 061681 | 037947D |
| G | EN1 | 81-052 | 061881 | 037947B |
| G | EN1 | 81-052 | 062181 | 037947C |
| G | EN1 | 82-082 | 091182 | 177682 |
| G | EN2 | 78-004 | 071778 | 022024 |
| G | EN2 | 78-077 | 120878 | 023200 |
| G | EN2 | 79-122 | 111779 | 027611 |
| G | EN2 | 79-135 | 121979 | 027848A |
| G | EN2 | 79-135 | 122079 | 027848B |
| G | EN2 | 80-003 | 011780 | 030041 |
| G | EN2 | 80-011 | 020280 | 030241 |
| G | EN2 | 80-071 | 042480 | 030980 |

| NSSS | PLANT | LER NUMBER | EVENT DATE | CONTROL OR NSIC NUMBER |
|---|---|---|---|---|
| G | EN2 | 81-038 | 042181 | 036952 |
| G | EN2 | 81-085 | 090481 | 038501 |
| G | EN2 | 81-117 | 112681 | 171785 |
| G | EN2 | 82-114 | 100182 | 178916 |
| G | FP1 | 76-001 | 010376 | 013966 |
| G | FP1 | 76-053 | 081576 | 015625 |
| G | FP1 | 78-040 | 051878 | 021432 |
| G | FP1 | 80-015 | 012380 | 030177 |
| G | FP1 | 80-072 | 081280 | 032373A |
| G | FP1 | 80-072 | 082280 | 032373B |
| G | FP1 | 80-072 | 090580 | 032373C |
| G | FP1 | 80-072 | 090680 | 032373D |
| G | FP1 | 80-075 | 091380 | 032718 |
| G | FP1 | 81-041 | 051581 | 037379 |
| G | FP1 | 82-056 | 121582 | 181727 |
| G | PB2 | 77-013 | 021977 | 017210 |
| G | PB2 | 78-026 | 041978 | 021247 |
| G | PB2 | 78-022 | 042478 | 021248 |
| G | PI1 | 81-050 | 091281 | 038673 |
| G | VY1 | 76-025 | 081376 | 015519 |
| G | VY1 | 76-034 | 092076 | 015965 |
| G | VY1 | 76-040 | 101976 | 016272 |
| G | VY1 | 76-043 | 111876 | 016485 |
| G | VY1 | 76-046 | 112976 | 016500* |
| G | VY1 | 78-012 | 053078 | 021542 |
| G | VY1 | 78-013 | 061978 | 021768 |
| G | VY1 | 78-019 | 062978 | 021842 |
| G | VY1 | 80-024 | 071880 | 032080 |
| G | VY1 | 82-002 | 020682 | 173401 |
| G | VY1 | 82-005 | 022382 | 172882 |

# APPENDIX J

# RESULTS OF THE INVERTER LER RATE ESTIMATIONS

# CONTENTS

BABCOCK&WILCOX

ESSENTIAL AND LPCI STATIC INVERTERS-INOP-COMMAND FAULTS EXCLUDED

| | COMPONENT | | POPULATION | | OPERATING FAILURE RATE |
|---|---|---|---|---|---|
| PLANT | POPULATION | HOURS | FAILURES | HOURS | (FAILURES/HOUR) |
| AR1 | 5 | 61368 | 0 | 306840 | 7.4E-07 |
| CR3 | 5 | 52272 | 6 | 261360 | 2.3E-05 |
| DB1 | 6 | 47232 | 7 | 283392 | 2.5E-05 |
| OE1 | 7 | 61368 | 3 | 429576 | 7.0E-06 |
| OE2 | 7 | 61368 | 0 | 429576 | 5.3E-07 |
| OE3 | 7 | 61368 | 5 | 429576 | 1.2E-05 |
| RS1 | 4 | 61368 | 1 | 245472 | 4.1E-06 |
| TI1 | 4 | 28392 | 0 | 113569 | 2.0E-06 |
| TI2 | 5 | 8784 | 1 | 43920 | 2.3E-05 |
| | | TOTALS | 23 | 2543280 | AVG. 9.0E-06 |

COMBUSTION ENGINEERING

ESSENTIAL AND LPCI STATIC INVERTERS-INOP-COMMAND FAULTS EXCLUDED

| PLANT | COMPONENT POPULATION | COMPONENT HOURS | POPULATION FAILURES | POPULATION HOURS | | OPERATING FAILURE RATE (FAILURES/HOUR) |
| --- | --- | --- | --- | --- | --- | --- |
| AR2 | 5 | 35712 | 0 | 178560 | | 1.3E-06 |
| CC1 | 5 | 61368 | 0 | 306840 | | 7.4E-07 |
| CC2 | 5 | 53352 | 2 | 266760 | | 7.5E-06 |
| FC1 | 6 | 61368 | 1 | 368208 | | 2.7E-06 |
| MI2 | 6 | 61368 | 5 | 368208 | | 1.4E-05 |
| MY1 | 5 | 61368 | 0 | 306840 | | 7.4E-07 |
| PA1 | 4 | 61368 | 0 | 245472 | | 9.3E-07 |
| SL1 | 5 | 58680 | 6 | 293400 | | 2.0E-05 |
| SO2 | 5 | 3816 | 0 | 19080 | | 1.2E-05 |
| | | TOTALS | 14 | 2353368 | AVG. | 5.9E-06 |

J-002

WESTINGHOUSE

ESSENTIAL AND LPCI STATIC INVERTERS-INOP-COMMAND FAULTS EXCLUDED

| PLANT | COMPONENT POPULATION | COMPONENT HOURS | POPULATION FAILURES | POPULATION HOURS | OPERATING FAILURE RATE (FAILURES/HOUR) |
|---|---|---|---|---|---|
| BV1 | 4 | 58248 | 8 | 232992 | 3.4E-05 |
| DC1 | 4 | 61368 | 5 | 245472 | 2.0E-05 |
| DC2 | 4 | 42192 | 2 | 168768 | 1.2E-05 |
| HN1 | 2 | 61368 | 1 | 122735 | 8.1E-06 |
| IP2 | 2 | 61368 | 0 | 122736 | 1.[illegible]E-06 |
| IP3 | 3 | 59064 | 0 | 177192 | 1.3E-06 |
| JF1 | 7 | 47304 | 5 | 331128 | 1.5E-05 |
| JF2 | 7 | 14544 | 3 | 101808 | 2.9E-05 |
| KE1 | 7 | 61368 | 0 | 429576 | 5.3E-07 |
| MG1 | 6 | 12264 | 2 | 73584 | 2.7E-05 |
| NA1 | 5 | 41568 | 2 | 207840 | 9.6E-06 |
| NA2 | 5 | 22392 | 0 | 111960 | 2.0E-06 |
| PR1 | 6 | 61368 | 2 | 368208 | 5.4E-06 |
| PR2 | 6 | 61368 | 1 | 368208 | 2.7E-06 |
| PT1 | 2 | 61368 | 0 | 122736 | 1.9E-06 |
| PT2 | 2 | 61368 | 0 | 122736 | 1.9E-06 |
| RG1 | 2 | 61368 | 0 | 122736 | 1.9E-06 |
| RO2 | 2 | 61368 | 0 | 122736 | 1.9E-06 |
| SA1 | 4 | 53088 | 7 | 212352 | 3.3E-05 |
| SA2 | 4 | 21024 | 1 | 84096 | 1.2E-05 |
| SE1 | 4 | 21840 | 1 | 87360 | 1.1E-05 |
| SE2 | 4 | 21840 | 12 | 87360 | 1.4E-04 |
| SM1 | 6 | 1704 | 0 | 10224 | 2.2E-05 |
| SO1 | 3 | 61368 | 2 | 184104 | 1.1E-05 |
| SU1 | 3 | 61368 | 0 | 184104 | 1.2E-06 |
| SU2 | 3 | 61368 | 1 | 184104 | 5.4E-06 |
| TR1 | 5 | 61368 | 3 | 306840 | 9.8E-06 |
| TU3 | 2 | 61368 | 0 | 122736 | 1.9E-06 |
| TU4 | 2 | 61368 | 0 | 122736 | 1.9E-06 |
| ZI1 | 4 | 61368 | 2 | 245472 | 8.1E-06 |
| ZI2 | 4 | 61368 | 3 | 245472 | 1.2E-05 |
| | | TOTALS | 63 | 5630112 | AVG. 1.1E-05 |

J-003

GENERAL ELECTRIC

ESSENTIAL AND LPCI STATIC INVERTERS-INOP-COMMAND FAULTS EXCLUDED

| | COMPONENT | | POPULATION | | | |
|---|---|---|---|---|---|---|
| PLANT | POPULATION | HOURS | FAILURES | HOURS | | OPERATING FAILURE RATE (FAILURES/HOUR) |
| BR1 | 2 | 54624 | 0 | 109248 | | 2.1E-06 |
| BR2 | 2 | 61368 | 0 | 122736 | | 1.9E-06 |
| CO1 | 2 | 61368 | 1 | 122736 | | 8.1E-06 |
| EN1 | 3 | 48008 | 8 | 144024 | | 5.6E-05 |
| EN2 | 3 | 39408 | 7 | 118224 | | 5.9E-05 |
| FP1 | 2 | 46152 | 9 | 92304 | | 9.8E-05 |
| GG1 | 6 | 3672 | 0 | 22032 | | 1.0E-05 |
| LS1 | 1 | 4656 | 0 | 4656 | | 4.9E-05 |
| PB2 | 1 | 61368 | 0 | 61368 | | 3.7E-06 |
| PB3 | 1 | 61368 | 0 | 61368 | | 3.7E-06 |
| SQ1 | 2 | 2712 | 0 | 5424 | | 4.2E-05 |
| VY1 | 2 | 56088 | 12 | 112176 | | 1.1E-04 |
| | | TOTALS | 37 | 976296 | AVG. | 3.8E-05 |

FINAL STATISTICS

ESSENTIAL AND LPCI STATIC INVERTERS-INOP-COMMAND FAULTS EXCLUDED

| | OPERATING FAILURE RATE (FAILURES/HOUR) |
|---|---|
| | 1.4 |
| BAB.&WIL. | 9.0E-06 |
| | 1.5 |
| | 1.6 |
| COMB.ENG. | 5.9E-06 |
| | 1.7 |
| | 1.2 |
| WESTINGH. | 1.1E-05 |
| | 1.2 |
| | 1.2 |
| PWR'S | 9.5E-06 |
| | 1.2 |
| | 1.3 |
| GE (BWR'S) | 3.8E-05 |
| | 1.3 |
| | 1.2 |
| OVERALL | 1.2E-05 |
| | 1.2 |

X.X - UPPER 95% CONFIDENCE MULTIPLIER

Y.YE-YY - LER RATE ESTIMATE

Z.Z - LOWER 5% CONFIDENCE DIVISOR

J-005

ESSENTIAL STATIC INVERTERS-INOPERABLE-COMMAND FAULTS EXCLUDED

| | COMPONENT | | POPULATION | | |
|---|---|---|---|---|---|
| PLANT | POPULATION | HOURS | FAILURES | HOURS | OPERATING FAILURE RATE (FAILURES/HOUR) |
| AR1 | 5 | 61368 | 0 | 306840 | 7.4E-07 |
| CR3 | 5 | 52272 | 6 | 261360 | 2.3E-05 |
| DB1 | 6 | 47232 | 7 | 283392 | 2.5E-05 |
| DE1 | 7 | 61368 | 3 | 429576 | 7.0E-06 |
| DE2 | 7 | 61368 | 0 | 4[illegible]9576 | 5.3E-07 |
| DE3 | 7 | 61368 | 5 | 42[illegible]576 | 1.2E-05 |
| RS1 | 4 | 61368 | 1 | 245472 | 4.1E-06 |
| TI1 | 4 | 28392 | 0 | 113568 | 2.0E-06 |
| TI2 | 5 | 8784 | 1 | 43920 | 2.3E-05 |
| | | TOTALS | 23 | 2543280 | AVG. 9.0E-06 |

COMBUSTION ENGINEERING

ESSENTIAL STATIC INVERTERS-INOPERABLE-COMMAND FAULTS EXCLUDED

| | COMPONENT | | POPULATION | | | OPERATING FAILURE RATE (FAILURES/HOUR) |
|---|---|---|---|---|---|---|
| PLANT | POPULATION | HOURS | FAILURES | HOURS | | |
| AR2 | 5 | 35712 | 0 | 178560 | | 1.3E-06 |
| CC1 | 5 | 61368 | 0 | 306840 | | 7.4E-07 |
| CC2 | 5 | 53352 | 2 | 266760 | | 7.5E-06 |
| FC1 | 6 | 61368 | 1 | 368208 | | 2.7E-06 |
| MI2 | 6 | 61368 | 5 | 368208 | | 1.4E-05 |
| MY1 | 5 | 61368 | 0 | 306840 | | 7.4E-07 |
| PA1 | 4 | 61368 | 0 | 245472 | | 9.3E-07 |
| SL1 | 5 | 58680 | 6 | 293400 | | 2.0E-05 |
| SO2 | 5 | 3816 | 0 | 19080 | | 1.2E-05 |
| | | TOTALS | 14 | 2353368 | AVG. | 5.9E-06 |

WESTINGHOUSE

ESSENTIAL STATIC INVERTERS-INOPERABLE-COMMAND FAULTS EXCLUDED

| PLANT | COMPONENT POPULATION | COMPONENT HOURS | POPULATION FAILURES | POPULATION HOURS | OPERATING FAILURE RATE (FAILURES/HOUR) |
|---|---|---|---|---|---|
| BV1 | 4 | 58248 | 8 | 232992 | 3.4E-05 |
| DC1 | 4 | 61368 | 5 | 245472 | 2.0E-05 |
| DC2 | 4 | 42192 | 2 | 168768 | 1.2E-05 |
| HN1 | 2 | 61368 | 1 | 122736 | 8.1E-06 |
| IP2 | 2 | 61368 | 0 | 122736 | 1.9E-06 |
| IP3 | 3 | 59064 | 0 | 177192 | 1.3E-06 |
| JF1 | 7 | 47304 | 5 | 331128 | 1.5E-05 |
| JF2 | 7 | 14544 | 3 | 101808 | 2.9E-05 |
| KE1 | 7 | 61368 | 0 | 429576 | 5.3E-07 |
| MG1 | 6 | 12264 | 2 | 73584 | 2.7E-05 |
| NA1 | 5 | 41568 | 2 | 207840 | 9.6E-06 |
| NA2 | 5 | 22392 | 0 | 111960 | 2.0E-06 |
| PR1 | 6 | 61368 | 2 | 368208 | 5.4E-06 |
| PR2 | 6 | 61368 | 1 | 368208 | 2.7E-06 |
| PT1 | 2 | 61368 | 0 | 122736 | 1.9E-06 |
| PT2 | 2 | 61368 | 0 | 122736 | 1.9E-06 |
| RG1 | 2 | 61368 | 0 | 122736 | 1.9E-06 |
| RO2 | 2 | 61368 | 0 | 122736 | 1.9E-06 |
| SA1 | 4 | 53088 | 7 | 212352 | 3.3E-05 |
| SA2 | 4 | 21024 | 1 | 84096 | 1.2E-05 |
| SE1 | 4 | 21840 | 1 | 87360 | 1.1E-05 |
| SE2 | 4 | 21840 | 12 | 87360 | 1.4E-04 |
| SM1 | 6 | 1704 | 0 | 10224 | 2.2E-05 |
| SO1 | 3 | 61368 | 2 | 184104 | 1.1E-05 |
| SU1 | 3 | 61368 | 0 | 184104 | 1.2E-06 |
| SU2 | 3 | 61368 | 1 | 184104 | 5.4E-06 |
| TR1 | 5 | 61368 | 3 | 306840 | 9.8E-06 |
| TU3 | 2 | 61368 | 0 | 122736 | 1.9E-06 |
| TU4 | 2 | 61368 | 0 | 122736 | 1.9E-06 |
| ZI1 | 4 | 61368 | 2 | 245472 | 8.1E-06 |
| ZI2 | 4 | 61368 | 3 | 245472 | 1.2E-05 |
| | | TOTALS | 63 | 5630112 | AVG. 1.1E-05 |

GENERAL ELECTRIC

ESSENTIAL STATIC INVERTERS-INOPERABLE-COMMAND FAULTS EXCLUDED

| | COMPONENT | | POPULATION | | OPERATING FAILURE RATE |
|---|---|---|---|---|---|
| PLANT | POPULATION | HOURS | FAILURES | HOURS | (FAILURES/HOUR) |
| BR1 | 2 | 54624 | 0 | 109248 | 2.1E-06 |
| BR2 | 2 | 61368 | 0 | 122736 | 1.9E-06 |
| CO1 | 2 | 61368 | 1 | 122736 | 8.1E-06 |
| EN1 | 1 | 61368 | 0 | 61368 | 3.7E-06 |
| EN2 | 1 | 39408 | 0 | 39408 | 5.8E-06 |
| GG1 | 6 | 3672 | 0 | 22032 | 1.0E-05 |
| LS1 | 1 | 4656 | 0 | 4656 | 4.9E-05 |
| PB2 | 1 | 61368 | 0 | 61368 | 3.7E-06 |
| PB3 | 1 | 61368 | 0 | 61368 | 3.7E-06 |
| SQ1 | 2 | 2712 | 0 | 5424 | 4.2E-05 |
| | | TOTALS | 1 | 610344 | AVG. 1.6E-06 |

FINAL STATISTICS

ESSENTIAL STATIC INVERTERS-INOPERABLE-COMMAND FAULTS EXCLUDED

| | OPERATING FAILURE RATE (FAILURES/HOUR) |
|---|---|
| | 1.4 |
| BAB.&WIL. | 9.0E-06 |
| | 1.5 |
| | 1.6 |
| COMB.ENG. | 5.9E-06 |
| | 1.7 |
| | 1.2 |
| WESTINGH. | 1.1E-05 |
| | 1.2 |
| | 1.2 |
| PWR'S | 9.5E-06 |
| | 1.2 |
| | 4.7 |
| GE (BWR'S) | 1.6E-06 |
| | 19.5 |
| | 1.2 |
| OVERALL | 9.1E-06 |
| | 1.2 |

X.X - UPPER 95% CONFIDENCE MULTIPLIER
Y.YE-YY - LER RATE ESTIMATE
Z.Z - LOWER 5% CONFIDENCE DIVISOR

GENERAL ELECTRIC

LPCI STATIC INVERTERS-INOPERABLE-COMMAND FAULTS EXCLUDED

| PLANT | COMPONENT POPULATION | COMPONENT HOURS | POPULATION FAILURES | POPULATION HOURS | OPERATING FAILURE RATE (FAILURES/HOUR) |
|---|---|---|---|---|---|
| EN1 | [illegible] | 41328 | 8 | 82656 | 9.7E-05 |
| EN2 | 2 | 39408 | 7 | 78816 | 8.9E-05 |
| FP1 | 2 | 46152 | 9 | 92304 | 9.8E-05 |
| VY1 | 2 | 56088 | 12 | 112176 | 1.1E-04 |
| | | TOTALS | 36 | 365952 | AVG. 9.8E-05 |

FINAL STATISTICS

LPCI STATIC INVERTERS-INOPERABLE-COMMAND FAULTS EXCLUDED

| | OPERATING FAILURE RATE (FAILURES/HOUR) |
|---|---|
| | 1.3 |
| GE (BWR'S) | 9.8E-05 |
| | 1.3 |
| | 1.3 |
| OVERALL | 9.5E-05 |
| | 1.3 |

X.X - UPPER 95% CONFIDENCE MULTIPLIER
Y.YE-YY - LER RATE ESTIMATE
Z.Z - LOWER 5% CONFIDENCE DIVISOR

NRC FORM 335 (2-84) NRCM 1102, 3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

# BIBLIOGRAPHIC DATA SHEET

SEE INSTRUCTIONS ON THE REVERSE

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12. SUPPLEMENTARY NOTES

13. ABSTRACT (200 words or less)

This report describes a computer-based data file developed from Licensee Event Reports (LERs) of inverters in U.S. commercial nuclear power plants for the period January 1, 1976 to December 31, 1982. In addition to the creation of the file, summaries of data contained in the file were made to obtain data for risk assessment and statistical purposes. Gross constant failure rates were estimated for inverters found in selected systems. Explanations, figures, and summary tables of the results are provided.

14. DOCUMENT ANALYSIS – a. KEYWORDS/DESCRIPTORS

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Inverters
Failure rates

b. IDENTIFIERS/OPEN-ENDED TERMS

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