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Generic component reliability data for research reactor PSA

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FOREWORD

Probabilistic safety assessments (PSAs) are increasingly used for safety evaluation of research reactors. PSA methodology and approaches for research reactors are in general similar to those used for power reactors. However, there are some significant differences. The main differences are related to the set of data to be used for quantifying the models.

As component reliability data for research reactors was not available in 1988, the IAEA initiated a co-ordinated research programme on data acquisition for research reactors. The aim of the programme was to develop rules and procedures for data collection (published as IAEA-TECDOC-636) and to conduct a data collection exercise on thirteen reactor facilities in ten participating countries.

The programme lasted for four years. The data collection exercise resulted in a database containing reliability parameters for more than one thousand research reactor components. All the data is based on the operating experience of participating reactors. The database was compiled during the final research co-ordination meeting held in Chalk River, Canada, in 1993.

The report was written by contributors from Austria, Canada and Switzerland and the production was co-ordinated by B. Tomic of the Safety Assessment Section of the Division of Nuclear Safety. It includes data supplied by all the participants in the co-ordinated research programme.

EDITORIAL NOTE

CONTENTS

1. INTRODUCTION

Information on reliability data for research reactor components was not readily available in the literature in 1988. Similar information for power reactors is widely available for most power reactor types, either on a commercial basis or from open literature sources [1-3]. Component reliability data sources for power reactors should provide the best alternative source of relevant data, in the absence of either site-specific or generic research reactor data. The use of component reliability data for power reactors, as an alternative to site-specific or generic research reactor data, does however have two basic disadvantages. Firstly, design and operational differences in many power reactor components make comparisons difficult. The result is increased uncertainty in the application of a generic reliability data source for power reactors to a specific research reactor application due to differences in component type, size and application. Secondly, there are numerous research reactor components that have no counterpart in power reactors.

To overcome the problem of data availability, the IAEA initiated a Co-ordinated Research Programme (CRP) on Data Acquisition for Probabilistic Safety Analysis (PSA) Studies for Research Reactors, aimed at providing the necessary generic component reliability database. The database, used by most CRP participants, was generated using the DES Data Entry System [4]. The CRP participant from ANSTO developed this system for use in conjunction with the data collection process. DES was made available to other participants for data collection and is available from the IAEA for use as a reliability database. The report provides the user with the generic component reliability database in a summarized spreadsheet format.

While this report focuses primarily on the needs of research reactor PSA, the generic component database also provides a useful reference source of reliability data for other research reactor applications. For example, typical applications would be the comparison of generic data sources for other research reactor types for the purposes of producing annual reactor operating review reports, or for updating reactor safety analysis reports. This type of comparison may assist in providing useful information about both systems and component operation, in light of international experience with similar research reactor types and equipment. For example, fuel failure rate data or regulating system failure rate comparisons could provide valuable input into research reactor upgrades/deterministic safety analysis programmes in order to supplement the decision making process for potential design and/or operational changes.

Ideally, failure data used for safety and reliability analyses should be based on site-specific data. However, the production of accurate site-specific data requires the expenditure of considerable resources to develop and maintain an extensive database. The collection of database source information from the field — i.e. from reactor maintenance and/or operations reports — requires a systematic approach and an ongoing commitment, if the information is to be processed efficiently and if it is to be kept up to date. In addition to the need for operational and maintenance staff to provide raw data input, a software system and analytical personnel to process the raw data are also required. The data processing primarily produces component-reliability-parameter statistics and trend analysis data. The reliability parameter data is often formatted so that information can interface directly with PSA studies. For example, component failure rate data may be linked to a PSA-specific basic event labelling format. The use of generic data by itself will not provide an adequate data source to aid in trend analysis of site-specific system equipment. Generic data can still, however, indicate whether there may be site-specific features or site-specific equipment problems that may be considerably different from that which might be predicted from international generic sources of other research reactors. The component reliability data in this report is applicable across a broad range of research reactor types and sizes.

1.1. BACKGROUND

During 1986-1988 the IAEA undertook a Co-ordinated Research Programme (CRP) on PSA for research reactors which helped to promote and foster an international exchange of information between national institutes and universities on the subject [5, 6]. During this period, extensive systematic PSA studies on research reactors were also being both contemplated for the first time and initiated. The need for development of a research reactor component reliability database was identified from the research reactor PSA CRP work. This resulted in the setting up of the research reactor data acquisition CRP. The application of PSA and the subsequent relevant database development on research reactors followed similar developments for power reactors [1].

The current document was prepared using the framework of the data acquisition CRP. It is based on the first meeting of the CRP held in Vienna in October 1989. A second meeting was held in Beijing, China, in October 1990 and the final meeting was held in Chalk River, Canada in July 1993. The report was completed in Vienna in December 1993. All members of the CRP contributed component reliability data to the final database.

The CRP project officer was B. Tomic from the IAEA's Safety Assessment Section of the Division of Nuclear Safety. Following the Beijing meeting, IAEA-TECDOC-636 was produced [7]. This document provided the definition of terms to be used in the component data collection, derived specifically to cover research reactors. It also contains all the definitions necessary to classify research reactor equipment, and to identify and group individual component boundary and component failure type definitions. Relevant reliability parameters are also defined and the method of calculation is shown in Ref. [7]. The various definitions are not repeated in the current report since Ref. [7] is intended to be a supporting document for the user of the database. An updated version of the component group listing, the breakdown of component groups into component types, and the associated coding is provided in Tables I and II. The failure mode code definitions of Ref. [7] are listed in Table III.

1.2. PURPOSE

The purpose of this document is to supplement the information in Ref. [7] and to provide reference generic component-reliability information for a variety of research reactor types. As noted in Section 2 and Table IV, component data accumulated over many years is in the database. It is expected that the report should provide representative data which will remain valid for a number of years. The database provides component failure rates on a time and/or demand related basis according to the operational modes of the components.

No update of the database is presently planned. As a result of the implementation of data collection systems in the research reactors represented in these studies, updating of data from individual facilities could be made available by the contributing research reactor facilities themselves.

As noted in Section 1.1, the report does not include a detailed discussion of information regarding component classification and reliability parameter definitions, which is provided in Ref. [7]. The report does provide some insights and discussions regarding the practicalities of the data collection process and some guidelines for database usage.

2. REACTOR FACILITIES AND DATA COLLECTION METHOD

A total of 12 research reactors from 9 participating countries are represented within the CRP. Failure data on components have been submitted from each of these facilities. The data collection period varied according to the facility, ranging from 2 to 28 years. Reactor-power ratings varied from 100 kW(th) to 135 MW(th). The number of components monitored varied from fewer than 20 to about 10 000 per facility. Essentially all participants used component definitions from Ref. [7]. The raw data sources were reactor log books, maintenance records and other documented operational experience. A compilation of the various general features of the reactor facility types and data is summarized in Table IV.

At the start of this programme no formal system for recording component reliability data was in place in most facilities. After 1986 the initiation of PSA studies at most of these facilities provided an impetus for the development of a component reliability database. The database systems in the contributing facilities are subsequently being maintained on a continuing basis for the purpose of long-term trend and equipment monitoring.

As noted in Section 1, the DES data entry system [4], was used by a number of participants to input and record raw data. The component database for this report has been compiled from the DES output information provided by the participants. It is represented in an easy-to-use spreadsheet format in Table VII. A description of the procedure for extracting reliability data from Table VII is provided in Section 4.

A wide variety of component types are referenced in the database coding system. Data is available on most component types. Coding for component types without data is maintained, for reference purposes, to allow for future additions to the database. In general, the data emphasizes major component types and failure rates which are dominated by top-event failure frequencies from PSA studies. Most of these components are of the active type (i.e. they rotate or move), although passive components (i.e. such as the reactor vessel and transformers) are also included.

The systems represented by the majority of the components are listed for each facility in Table IV. In general these are the most important safety systems, safety-related systems and key process systems that are most commonly analyzed in PSAs. The typical function and descriptions of these systems are provided in Ref. [8].

3. INSIGHTS FROM THE DATA COLLECTION PROCESS

The collection of component reliability data is invariably a tedious task unless a system is in place to perform this on a continuous long-term basis. This was rarely the case until relatively recently for research reactor facilities. By contrast, many power reactors have had formalized collection systems for component reliability data for many years. The lack of staff resources at research reactor facilities is one of the main reasons for the absence of a formal system. Another frequent difficulty is the lack of a computerized system for documenting maintenance and operating records. This means that the collection of field data from a variety of hard copy recording systems is time consuming. The quality of failure information also varies; it is primarily determined by the skill of maintenance and operations staff and how useful this type of information is regarded by reactor staff.

The features noted above are also not uncommon for non-nuclear process plants. Many of the contributing facilities utilized students for data collection and analysis.

After the data collection and analysis process, very useful feedback was received on operations and performance of equipment maintenance which led to improvements on equipment test and maintenance procedures and in the failure record keeping process. Identification of potential incipient failures and the trend of decreasing component reliability were other benefits obtained from the process. Generally, only when maintenance and operations staff can see direct usefulness of a reliability data system will improvements be made in the quality of inputting field data.

4. USE OF THE DATABASE

4.1. LOCATION OF COMPONENT RELIABILITY DATA

This section describes the process for use of the reliability database. To locate a specific component in the database, Table I should first be consulted. This list provides an alphabetic ordering by description/name of the different component groups. These component groups are defined as components of a given general component category (Table II column 1) e.g. sensors, which have different functions (e.g. flow sensors, level sensors). Having identified the two letter component group coding from Table I column 1, Table II is then consulted to locate the description of the closest match for a desired component. Table II, column 6 provides a component type listing which gives the highest level of description for a component. For example, different types of pressure sensors may be identified. The component type coding is a three letter code, given in Table II, column 5. Table II provides a complete listing of the component category, group and type descriptions, and codes in alphabetical order of the component type code. Table II is utilized by first locating the desired two letter component group code, provided in alphabetic ordering in column 3, and then reviewing the associated list of component types in column 6 until the closest match of a desired description is found.

Having identified the most relevant component type by its three letter identification code, Table V can then be used to provide an overview of the number of facilities which have recorded data on that component type. Table V also provides the relevant component type populations for each contributing facility. Table VI summarizes information on component types including manufacturer's information for each contributing facility. The table is presented per facility. A three-character code similar to that used in Table V is associated with each component type. To locate the specific reliability data available for the identified component type, Table VII is used.

Table VII, column 1 lists the three-letter component type codes alphabetically. Having located the component type code, the available data on that component for each facility can then be found. The legend for Table VII provides the necessary explanations for each of the columns. The two basic parameters: failure rate and failure per demand, with associated 90% confidence bounds, are provided. The raw data on component population, operating or calendar time, number of failures or demands are provided for the user as a check on the extent of the raw data.

4.2. ACCURACY OF RELIABILITY DATA

In addition to statistical uncertainty, discussed in Section 4.4, there are a number of causes which contribute to the inaccuracy of reliability data. Those causes influence both generic and facility-specific data. The following sections discuss the various causes.

The causes of differences in reliability data can be grouped in two areas, namely:

- differences in data collection or data processing;
- the actual component reliability is different.

In each of these areas a number of individual factors influencing reliability parameters has been identified. A short discussion of the most important factors is given below. Also, a discussion on data selection is included.

4.2.1. Data collection and processing

The inaccuracy in reliability data caused by data collection or data processing can be significant. Factors related to the following are discussed here:

- data sources;
- the ways the data is collected;
- data processing;
- definitions.

Data sources

The raw data is collected from historical records — i.e. log books, maintenance work records and test records. While the log books are generally considered to be the most accurate, a number of failures, especially on non-safety equipment, may not have been recorded. However, collecting data from the log books is extremely time consuming. Maintenance work orders are considered to be the most complete records, but the reliability of the information depends on the person completing the report. In many cases these are maintenance staff themselves, therefore the accuracy of the records (usually not computerized in research reactor facilities) varies. The direct consequence of incomplete records is usually an overestimation of component reliability. Therefore the reliability data may be biased.

Events without work request

Sometimes, relatively minor failures (such as mis-positioned valves) are reported during a test without a work request having been prepared. One example is a valve that opens only on second trial during a test (or after a small, local repair). Only a comment on a test sheet is written. There is no formal work order or any other documented evidence. Since some of the failures are not accounted for, reliability could be overestimated.

Failure of supporting equipment

Equipment failures may often be directly related to the failure of auxiliary equipment, support or control systems. Such failures, although effectively disabling the component, are not failures of the component. Some databases do not separate such failures. Since supporting equipment failures could actually dominate overall failure rate, this can cause substantial inaccuracy in the reported failure rate.

Coding errors

Coding errors are a classic problem encountered in every data collection exercise. Coding errors are present in both computerized and manual data collection, and are generally related to differing interpretations of criteria.

Failure rate denominators

The number of failures collected from the log books or maintenance/testing sheets are only one input used for the failure rate calculation. The number of demands, the failure exposure time or the component's running time, are also essential. In the standard failure rate calculation, the denominator is a quantitative measure of the stress that the component was subject to, related to a specific type of failure which may occur (failure mode).

The way the failure rate denominators are determined may produce a sizeable inaccuracy in a component's calculated failure rate. For equipment usually in standby mode, the data sources available today provide separate data on failures to start and failures to run (and sometimes on other failure modes such as leakage/rupture). The denominator for failures to run is a component's actual running time, which is usually estimated (e.g. 1 hour per test) and sometimes recorded.

4.2.2. Component reliability

Component reliability is a function of its design, use and maintenance. Components designed for specific research reactor application (especially safety related) are usually highly reliable and should be maintained as such during their lifetime. The reliability data, however, often show variations which are related to operating conditions and practices, component application and maintenance, and testing practices. A brief discussion of the influence of each of these is given below.

Operating conditions and practices

A facility's operating conditions and practices may greatly influence component reliability. Some of the influence factors are:

- operating mode;
- operating time and demands;
- operating environment.

The operating mode has been recognized as influencing equipment reliability, especially on active components (such as pumps). Some data sources provide separate data for running, alternating and standby categories. In the IAEA survey [9], variations of more than two orders of magnitude have been documented for the failure to run of motor-operated pumps when comparing between alternating pumps, running pumps and pumps where no mode has been specified. This finding supports the view that failure data for similar equipment having differing operating modes should be kept separate.

A component's failure to start may be caused by a demand related stress (e.g. vibration), or stress in standby (e.g. corrosion) or a combination of both. Most data sources disregard these differences and provide data on failure to start either as demand related or time related. When time related data are provided, the failure rate denomination is usually calendar time, or sometimes plant operating time. Since similar components at a different location may have a substantially different test interval, the actual number of demands in a period may vary, which in turn may greatly influence the failure rate. Some data collection systems also systematically collect information on the number of demands; in others the number of demands is estimated on the basis of testing demands owing to the costs of collecting the information.

Operating conditions may also influence component reliability. Examples of this would be ambient temperature, humidity, chemical control, radiation fields and vibration.

Design and application

Design and application of a component will have an important influence on reliability. The application of the component will determine the operating mode and environment. Variations due to these causes has been discussed in previous sections.

Maintenance and testing practices

Significant plant-to-plant variations for otherwise identical components can be identified. These variations are most probably caused by facility-specific maintenance and testing differences. The influence of the testing interval and practice has been extensively investigated. The testing interval has an influence on the failure rate, but it is strongly related to component type. The testing interval has greater influence on components where standby stresses dominate failure probability (usually motor operated valves) and lower on components with higher demand stresses (such as diesel generators and similar).

4.2.3. Data selection

As discussed, a number of factors may influence reliability data. Although it is difficult to quantify these, an order-of-magnitude estimate could be made.

The overall effect of the factors noted below can therefore substantially influence the results.

Since there is the possibility of a considerable variation in reliability data between different facilities, facility-specific data is the best possible source. However, when this data is sparse, other data sources must be used. In this case, their compatibility and applicability should be carefully assessed.

ESTIMATE OF RELIABILITY DATA ACCURACY WITH VARIOUS CAUSES OF VARIABILITY

Variability factor	Estimated accuracy
Collection related (comprehensiveness)	2 to 5
Failure severity/failure mode	< 2
Demand/operation attributes	< 2
Failures in shut down taken into account	2
Non-representative samples	2 to 10
Collection of denominators	2 to 5
Site effects (testing, maintenance)	2 to 10

When adopting reliability data from a data source, the definitions and their compatibility are first assessed. The background of a data source, including the ultimate data source, comprehensiveness of the data collection and data processing methods should be considered next. Finally, for reliability data originating at a research reactor, design (including age of design), operation, testing and maintenance practice should be examined for compatibility.

Although even the most careful data selection would not fully exclude the possibility of adopting incompatible data, the fact that the factors contributing to data accuracy have been recognized should ensure that the choice of data is reasonable.

4.3. RELIABILITY DATA ON COMMON CAUSE FAILURE

Quantification of common cause failure (CCF) data, in particular for system designs with redundant components, is an important aspect of PSA studies. CCF is also one of the most difficult areas in principle and in practice to obtain data. Collecting and reporting CCF data is a special aspect of reliability data collection. It is beyond the scope of this report to provide quantified data regarding component CCFs, as defined in Ref. [7], Section 5.2.5. Therefore CCF specific data are not included here. To provide this type of data requires a detailed review of individual failure events. The failure data provided by participants may include some common cause events. Experience with generic CCF data has shown that it is very unlikely that the common cause contribution is a significant percentage of the recorded failure events. It can therefore reasonably be assumed that data uncertainties due to common cause failures are negligible compared with statistical uncertainties, Section 4.4, and the other contributing sources of inaccuracy, Section 4.2, in the data.

4.4. UNCERTAINTY BOUNDS

Following accepted practice in most databases, statistical uncertainty is calculated as discussed in Ref. [7], Appendix D. The 90% confidence range with 5% and 95% limits around the mean value is defined. As noted in Ref. [7], failure rates and failures per demand utilize different expressions for the uncertainty calculations, although the differences between the calculations are not large. The spreadsheet software EXCEL, version 4.0A, used for the production of the Table VII database, provided the necessary chi-square and F function variables needed for the uncertainty calculation.

The uncertainty bound values for the failure rates are provided in the last columns of Table VII. Note that the uncertainty bounds associated with a demand failure are in dimensionless units. For cases with zero failure the numerator is set to 0.693 (taken from the 50% chi-squared value for one failure) for the entry in the "failure rate" column of Table VII and a zero value is entered into the "5%" sub-column of the "90% confidence bounds" column. In all other cases the entry in "failure rate" column is the mean failure rate.

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TABLE I. ALPHABETICAL LIST OF COMPONENT GROUPS AND ASSOCIATED CODES

The following list provides component groups in alphabetical order with the associated component group coding. The group coding consists of two capital letters: the first describes the main component type category, the second describes the component group.

Component Group Code	Component Group Description
QA	Air cooler
YA	Air filter
UN	Annunciator
BT	Battery
BC	Battery charger
GB	Beam ports, beam tubes
QB	Blower fan
CB	Bus
CC	Cable
KA	Circuit breaker
KD	Circuit breaker DC
KI	Circuit breaker indoor
KC	Circuit breaker molded type
KR	Circuit breaker, high reliability
JE	Clutch
QC	Compressor
NK	Computational module
NC	Computer
OC	Control rod
OR	Control rod drive
UC	Controller
EC	Converter
HC	Cooling tower
JC	Core structure
QD	Damper
DE	Diesel engine
DG	Diesel generator emergency AC
EX	Electrical equipment for experiments
QF	Fan cooler, containment
KS	Feeder (branch, junction)
YF	Filter
XT	Flux shaping element
XH	Fuel element HEU
XL	Fuel element LEU
XM	Fuel element MEU
XP	Fuel element process tubes
XC	Fuel element handling tool
XA	Fuel, general
KT	Fuse
DT	Gas turbine driven generator emergency AC
FY	Gasket
HX	Heat exchanger
EH	Heater electric
QV	HVAC unit annulus ventilation
UI	Indicating instrument
NO	Input/output device
IA	Instrumentation
IC	Instrumentation channel analog
ID	Instrumentation channel digital
NI	Interface
EI	Inverter
JI	Irradiation facilities
JL	Lube oil cooler
TE	Main facility transformer
UM	Manual control device
MA	Motor
MG	Motor generator
MS	Motor servo
FX	Orifice
EB	Panelboard

Component Group Code	Component Group Description
JP	Penetration containment
FE	Piping expansion joint
FN	Piping nozzle
FS	Piping straight section
FT	Piping tees
FW	Piping welds
GP	Pool, open swimming pool
EP	Power supply
ND	Printer
NP	Programable logic controller
PD	Pump diesel driven
PM	Pump motor driven
PT	Pump turbine driven
PW	Pump without driver
AR	Radiation monitors
UR	Reactor scram system
ER	Rectifier
XR	Reflector element, graphite
XB	Reflector, Beryllium
RW	Relay
RA	Relay auxiliary
RY	Relay coil
RX	Relay contacts
RC	Relay control
RP	Relay power
RR	Relay protective
RT	Relay time delay
FR	Rupture diaphragm
AC	Sensor core flux
AF	Sensor flow
AA	Sensor general
AL	Sensor level
AP	Sensor pressure
AS	Sensor speed
AT	Sensor temperature
AQ	Sensor water chemistry
WA	Shielding general
WF	Shielding irradiated fuel
WX	Shielding of experiments
NS	Signal conditioning system
NM	Signal modifier
UE	Solid state device
GS	Storage containers
YS	Strainer
SC	Switch contacts
SD	Switch digital channel
SF	Switch flow
SL	Switch level
SI	Switch limit
SM	Switch manual
SP	Switch pressure
ST	Switch temperature
SQ	Switch torque
SA	Switch, general
JT	Tank
GT	Tank, closed vessel
TA	Transformer
TT	Transformer auto
TI	Transformer instrumentation
TV	Transformer regulating

Component Group Code	Component Group Description
TX	Transformer for main facility supply
TU	Transformer substation
LC	Transmitter core flux
LF	Transmitter flow
LA	Transmitter general
LL	Transmitter level
LP	Transmitter pressure
LT	Transmitter temperature
VA	Valve air operated
VE	Valve explosive operated
VH	Valve hydraulic operated
VX	Valve manual
VM	Valve motor operated
VP	Valve piston operated
VC	Valve self operated
VD	Valve solenoid operated
VW	Valve without operator
CW	Wire

TABLE II. COMPONENT TYPE DESCRIPTIONS AND ASSOCIATED CODES

This table gives a description of each component category, group and type, in alphabetical order, of the three letter coding system. To find a specific component type, Table I may first have to be consulted as it provides the component group listing in alphabetical order. The coding system is based, to a large extent, on that formulated in Ref. [1].

Code	Component Category Description	Code	Component Group Description	Code	Component Type Description
A	Sensors	AA	Sensor general	AAA	Sensor general
		AC	Sensor core flux	ACA	Sensor core flux
				ACI	Ionisation chamber
				ACF	Fission counter
				ACS	Self powered detector
		AF	Sensor flow	AFA	Sensor flow
				AHA	Sensor humidity
		AL	Sensor level	ALA	Sensor level
				ALR	Sensor pool water level
		AQ	Sensor water chemistry	AQC	Sensor conductivity
				AQP	Sensor pH-value
		AP	Sensor pressure	APA	Sensor pressure
				APD	Sensor pressure difference
		AR	Radiation monitors	ARA	Aerosol monitor
				ARG	gamma monitor
				ARN	neutron monitor
				ARO	off-gas monitor
				ARU	radiation monitoring alarm unit
		AS	Sensor speed	ASA	sensor speed
		AT	Sensor temperature	ATA	sensor temperature
B	Batteries and chargers	BC	Battery charger	BCA	battery charger
				BCS	battery charger solid state
		BT	Battery	BTA	battery
				BTL	battery lead acid accumulator
				BTN	battery nickel cadmium accumulator
C	Conductors	CB	Bus	CB2	bus 120Vac , 220Vac sing. phase
				CB3	bus 220Vac, 380Vac three phase
				CB6	bus 6kV
				CBA	bus general power distr
				CBD	bus DC
		CC	Cable	CCP	cable power connection
				CCS	cable signal (supervisory)
		CW	Wire	CWA	wire
				CWC	wire control circuit typical circuit, several joints
D	Diesel generators, gas turbine driven generators	DE	Diesel engine	DEA	diesel engine
		DG	Diesel generator emergency AC	DGA	diesel generator emergency AC
		DT	Gas turbine driven generator emergency AC		
E	Other electrical equipment, electrical part of experimental installations	EB	Panelboard	EBA	terminal board
		EC	Converter	ECM	static converter for reactor main coolant pumps
		EH	Heater electric	EHA	air heater
				EHP	pressurizer heater
				EHO	oil heater
				EHT	heat tracing pipe heater
				EHW	water heater
		EI	Inverter	EIA	inverter
				EII	inverter instrument
				EIX	inverter static three phase
				EIZ	inverter static single phase
		EP	Power supply	EPA	power supply (instrumentation and control equipment)
				EPH	high voltage p.s. instrumentation
				EPU	uninterruptible p.s. < 1kVA
		ER	Rectifier	ERS	rectifier static

Code	Component Category Description	Code	Component Group Description	Code	Component Type Description
		EX	Electric equipment for experiments	EXA	Electric equipment for experiments, general
F	Piping	FE	Piping expansion joint	FEA	piping expansion joint
		FN	Piping nozzle	FNA	piping nozzle
				FNS	piping nozzle spray
		FR	Rupture diaphragm	FRA	Rupture diaphragm, general
		FS	Piping straight section	FS3	piping medium, 1" < diameter < = 3"
				FSA	piping straight section
				FSM	piping large, > 3" diameter
				FSS	piping small, < = 1" diameter
		FT	Piping tees	FTA	piping tees
		FW	Piping welds	FWA	piping welds, general
		FX	Orifice	FXA	orifice
		FY	Gasket	FYA	gasket
G	Pool, grid plate, beam ports, D2O-tank, storage containers	GB	Beam ports, beam tubes	GBC	thermal column
				GBR	beam port, radial
				GBT	beam port, tangential
		GP	Pool, open swimming pool	GPL	pool liner
				GPS	storage rack for fuel
		GS	Storage containers	GSF	storage and transp cont irrad fuel
				GSH	storage, fresh fuel
		GT	Tank, closed vessel	GTA	tank, reactor vessel
				GTD	tank, heavy water container
				GTE	expansion tank
H	Heat exchanger	HC	Cooling tower	HCA	cooling tower general
		HX	Heat exchanger	HXA	heat exchanger
				HXB	heat exch. straight tube horizontal shell and tube
				HXF	heat exch. fuel storage
				HXH	heat exch. U tube horizontal shell and tube
				HXM	heat exch. straight tube vertical shell and tube
				HXP	heat exch. plate type
				HXR	heat exch. pond heat removal
				HXT	heat exch. cleaning system
				HXV	heat exch. U tube vertical shell and tube
I	Instrumentation (channels, reactor protection system)	IA	Instrumentation	IAA	instrumentation
				IAR	control rod position indication
		IC	Instrumentation channel analog	ICA	instr. ch. analog general
				ICC	instr. ch. analog core flux
				ICF	instr. ch. analog flow
				ICL	instr. ch. analog level
				ICP	instr. ch. analog pressure
				ICS	instr. ch. analog seismic
				ICT	instr. ch. analog temperature
		ID	Instrumentation channel digital	IDA	instr. ch. digital, general
				IDC	instr. ch. digital core flux
				IDF	instr. ch. digital flow
				IDL	instr. ch. digital level
				IDP	instr. ch.digital pressure
				IDT	instr. ch. digital temp

Code	Component Category Description	Code	Component Group Description	Code	Component Type Description
J	Other mechanical equipment, lifting gear, structures, experimental setup	JC	Core structure	JCA	core structure, general
				JCG	grid plate
				JCT	fuel guide tubes
		JE	Clutch	JEE	clutch electrical
				JEM	clutch mechanical
		JI	Irradiation facilities	JIA	irradiation container
				JIH	hydraulic transfer system
				JIP	pneumatic transfer system
				JIR	irradiation rig, static
				JIS	rotary specimen rig
		JL	Lube oil cooler	JLC	lube oil cooler
		JP	Penetration	JPE	penetration electrical
				JPP	penetration piping
		JT	Tank	JTF	tank resin flushing
				JTR	tank storage RWST (refueling water storage tank)
K	Circuit breakers	KA	Circuit breaker	KAA	circuit breaker, general
				KAC	circuit breaker AC
		KC	Circuit breaker molded type	KCA	Circuit breaker molded type
		KD	Circuit breaker DC	KDC	circuit breaker DC
		KI	Circuit breaker indoor	KIA	circuit breaker indoor AC application
				KID	circuit breaker indoor DC application
				KIS	circuit breaker isolation, ground fault circuit interrupter
		KR	Circuit breaker, high reliability –	KRP	circuit breaker reactor protection system
		KS	Feeder (branch, junction)	KSF	feeder (junction box)
		KT	Fuse	KTA	fuse all voltage levels
L	Transmitters	LA	Transmitter general	LAA	transmitter general
		LC	Transmitter core flux	LCA	transmitter core flux
		LF	Transmitter flow	LFF	transmitter flow
		LL	Transmitter level	LLL	transmitter level
		LP	Transmitter pressure	LPP	transmitter pressure
		LT	Transmitter temperature	LTT	transmitter temperature
				LXR	transmitter pressure difference
M	Motors	MA	Motor	MAA	motor
				MAC	motor AC
				MAD	motor DC
				MAI	motor AC induction
		MG	Motor generator	MGX	motor generator
		MS	Motor servo	MSS	motor servo
N	Signal conditioning system, computers	NC	Computer	NCA	signal comparator bistable
				NCB	personal computer, PC
				NCD	data acquisition system
				NCH	high quality computer
				NCW	workstation computer
		ND	Printer	NDA	printer, general
		NI	Interface	NIN	computer network, general
		NK	Computational module	NKA	computational module
		NM	Signal modifier	NMA	signal modifier
				NMO	signal modifier voltage-pneumatic transducer
				NMP	signal modifier current-pneumatic transducer
				NMS	signal modifier square root extractor
				NMT	signal modifier current-current transducer
				NMV	signal modifier current voltage transducer

Code	Component Category Description	Code	Component Group Description	Code	Component Type Description
		NO	Input/output device	NOA	Input/output device
		NP	Programable logic controller	NPA	Programable logic controller
		NS	Signal conditioning system	NSA	signal conditioning system for core flux, level, pressure, temperature general
				NSC	sign cond sys core flux
				NSF	sign cond sys flow
				NST	sign cond sys temperature
O	Control rods and drive mechanisms	OC	Control rod	OCC	control rod cruciform, boron carbide control rods
				OCR	control rod single control rod assembly
				OCS	control rod clustered silver, indium, cadmium control rod
		OR	Control rod drive	ORA	control rod drive
P	Pumps	PD	Pump diesel driven	PDA	pump diesel driven
		PM	Pump motor driven	PMA	pump motor driven
		PT	Pump turbine driven	PTA	pump turbine driven
		PW	Pump without driver	PWB	pump horiz. 22-820 l/s
				PWC	pump centrifugal
				PWE	pumpl vert 70-1900 l/s
				PWS	pump
Q	HVAC and air handling equipment	QA	Air cooler	QAA	air cooler
		QB	Blower fan	QBF	blower fan
		QC	Compressor	QCI	compressor instrument air
		QD	Damper	QDA	damper
				QDM	damper manual(HVAC)
		QF	Fan cooler containment	QFH	fan cooler reactor building cooling unit
				QFV	fan containment ventilation fan
		QV	HVAC unit annulus ventilation	QVA	hvac unit auxiliary building
				QVB	hvac unit battery room ventilation
				QVE	hvac unit electric equipment area ventilation
				QVR	hvac unit control room ventilation
				QVS	hvac unit reactor hall
R	Relays	RA	Relay auxiliary	RAA	relay auxiliary
				RAS	solid state relay
		RC	Relay control	RCA	relay control AC
				RCD	relay control DC
				RCL	relay control
		RP	Relay power	RPH	relay power 300-460 A
				RPL	relay power 40-60 A
		RR	Relay protective	RRA	relay protective
				RRF	relay, frequency protection
				RRO	relay, overload protection
				RRV	relay, voltage protection
		RT	Relay time delay	RTA	relay time delay
				RTB	relay time delay bimetallic
				RTP	relay time delay pneumatic
				RTS	relay time delay solid state
		RW	Relay	RWA	relay, general
		RX	Relay contacts	RXA	relay contacts
		RY	Relay coil	RYA	relay coil
S	Switches	SA	Switch, general	SAA	switch, general
				SAM	micro switch
		SC	Switch contacts	SCC	switch contacts
		SD	Switch digital channel	SDA	switch digital channel pressure / vacuum, pressure, level
		SF	Switch flow	SFA	switch flow
		SI	Switch limit	SIA	switch limit
				SIE	switch limit electronic

Code	Component Category Description	Code	Component Group Description	Code	Component Type Description
		SL	Switch level	SLA	switch level
		SM	Switch manual	SMA	switch manual
		SP	Switch pressure	SPA	switch pressure
		SQ	Switch torque	SQA	switch torque
		ST	Switch temperature	STA	switch temperature
T	Transformers	TA	Transformer	TA2	transformer 220/120 V
				TA6	transformer 6kV/380V
				TAA	transformer, general
		TI	Transformer instrumentation	TIC	transformer (instrument transformer, current transformer)
				TIP	transformer instrument potential
		TT	Transformer auto	TTA	autotransformer, general
		TU	Transformer substation	TUA	transformer 500 to 1000 kVA
		TV	Transformer regulating	TVA	regulating transformer
		TX	Transformer for main facility supply		
U	Other I&C equipment, instrumentation for experiments	UC	Controller	UCA	controller
				UCE	controller electronic
				UCF	flow controller
				UCP	controller pneumatic
		UE	Solid state device	UEH	solid state devices high power application
				UEL	solid state devices low power application
				UEY	isolating diode assembly
		UI	Indicating instrument	UIA	analog display
				UID	digital instrument
				UIE	indicating instrument electronic
				UIL	indication lamp
				UIM	CRT screen, monitor
				UIR	recorder
				UIX	other indicating instrument
		UM	Manual control device	UMC	manual control device pushbutton
		UN	Annunciator	UNA	annunciator, general
				UNS	annunciator module solid state, LED-, LCD-display
		UR	Reactor scram system	URS	reactor scram system
V	Valves	VA	Valve air operated	VA1	valve air operated
				VAR	valve air operated all systems except raw water return line
		VC	Valve self operated	VCA	valve self operated check
		VD	Valve solenoid operated	VDA	valve solenoid operated
		VE	Valve explosive operated	VEA	valve explosive operated
		VH	Valve hydraulic operated	VHA	valve hydraulic operated
		VM	Valve motor operated	VMA	valve motor operated
		VP	Valve piston operated	VPA	valve piston operated
				VRA	valve relief
				VSA	valve safety
		VW	Valve without operator	VWA	valve angle valve
				VWB	valve ball valve
				VWG	valve gate
				VWJ	valve plug valve
				VWL	valve globe valve
				VWN	valve needle valve
				VWP	valve diaphragm
				VWT	valve butterfly valve
				VWU	valve nozzle valve
		VX	Valve manual	VXA	valve manual
W	Shielding and related mechanics	WA	Shielding general	WAA	shielding general
		WF	Shielding irradiated fuel	WFA	shielding irradiated fuel

Code	Component Category Description	Code	Component Group Description	Code	Component Type Description
		WX	Shielding of experiments	WXA	shielding of experiments
X	Fuel elements, reflector	XA	Fuel, general	XAA	fuel elm., general
				XAM	MTR fuel element, general
				XAT	TRIGA fuel element, general
		XB	Reflector, Beryllium	XBM	MTR stand refl.element Be metal
				XBN	MTR stand. refl element Be oxid
		XC	Fuel elm handling tool	XCA	fuel element handling tool, gen.
				XCM	fuel element handling tool, manual
				XCR	fuel element handling tool, remote
		XH	Fuel element HEU	XHA	fuel element HEU general
				XHM	fuel element HEU MTR standard
				XHN	fuel element HEU MTR regulating
				XHO	fuel element HEU general
				XHP	fuel element HEU general
				XHT	fuel element TRIGA, stand. FLIP
		XM	Fuel element MEU	XMM	
				XMN	
				XMO	
				XMP	
				XMR	fuel element rod type MEU
		XL	Fuel element LEU	XLA	fuel element LEU, general
				XLM	
				XLN	
				XLO	
				XLP	
				XLT	fuel element TRIGA, stand. LEU
				XLU	fuel element TRIGA, instr. LEU
		XP	Fuel element process tubes	XPA	fuel element process tube, gen.
		XR	Reflector element, graphite	XRM	Refl. element graphite, MTR
				XRT	Refl element graphite, TRIGA
		XT	Flux shaping element	XTM	Flux shaping element, MTR
Y	Strainers, filters, demineralizer	YA	Air filter	YAA	air filter
		YF	Filter	YFD	demineralizer
				YFM	filter liquid, mechanical restriction
				YFX	Ion exchanger filter
		YS	Strainer	YSF	strainer / filter
		YT	Intake screen	YTS	intake screen service water system

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TABLE III. FAILURE MODE CODE DEFINITIONS

Failure mode code	Failure mode
B	Degraded
C	Failure to change position
D	Failure to remain in position
E	Failure to close
O	Failure to open
F	Failure to function
G	Short to ground
H	Short circuit
I	Open circuit
Q	Plugged
K	Spurious function
R	Failure to run
S	Failure to start
X	Other critical faults
Y	Leakage
J	Rupture
M	Control rod failure

Note: Detailed definitions of each failure mode (with associated examples) are provided in IAEA-TECDOC-636 [7].

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TABLE IV. FEATURES OF THE CONTRIBUTING RESEARCH REACTOR FACILITIES AND DATA COLLECTION PROCESS

	Australia	Austria	Canada	China (PRC-M)	China (PRC-H)	Czech Rep
Facility Max Power 1st critical	HIFAR Lucas Heights 10 MW 1958	TRIGA Mark-II Vienna 250 kW 1962	NRU Chalk River 135 MW 1957	MTR China Atomic Inst Beijing 3 5 MW 1965	HWRR China Atomic Inst Beijing 15 MW 1980	LVR 15 Rez/Praha 15 MW 1990
Approx Operating Hours/Year	6500	2000	6500	3200	2600	3000
Main Utilization	Isotope Production, Neutron Activation Analysis (NAA) Silicon Doping Basic&Appl Physics Postdoc Studies	University Training, Education Basic & Applied Research	Isotope Production Materials Testing Basic & Applied Physics	Research Training Isotope Production	Basic & Applied Research Isotope Production	Isotope Production Reactor Eng Exp Materials Testing Silicon Doping
Period of Data Collection	1/85 - 6/93	11/81 - 3/93	1970 - 1993	1/65 - 6/93	7/58 - 6/93	1/91 - 3/93
Total Number of Components Investigated	~200	~200	~100	~200	~500	18
Data Sources	Maintenance Records	Log Books, Maintenance Records, Operating Exp	Log Books, Maintenance Records, Operating Exp	Log Books, Maintenance Records	Log Books, Maintenance Records	Log Books, Operating Exp
Main Systems of the Components Investigated	ECCS, Confinement Heat Removal System, Confinement Isolation System	RCS&RSS, I&C, Reactor, Sec Cooling, Ventilation System, Fuel, Electrical Power Systems	RCS&RSS, I&C, Reactor, Sec Cooling, Service Systems, Electrical Power Systems	RCS&RSS, I&C, Reactor, Sec Cooling, Fuel, ECCS, Ventilation	RCS&RSS, I&C, Reactor, Sec Cooling, Fuel, ECCS, Ventilation	RCS&RSS, I&C, Reactor, Sec Cooling, Power Supply, Electrical Power Systems

[1] Systems classified as in Ref [8]

	Indonesia			Slovenia	Switzerland	Vietnam
	(IN-S)	(IN-B)	(IN-Y)	(SLO)	(CH)	(VN)
Facility Max Power 1st critical	MPR-30 Serpong 30 MW 1987	TRIGA Mark-II Bandung 1 MW 1965	TRIGA Mark-II Yogjakarta 100 kW 1979	TRIGA Mark-II Ljubljana 250 kW 1966	MTR Würenlingen 10 MW 1957	IVV-9 Dalat 500 kW 1983
Approx Operating Hours/year	1300	1500	1000	3000	6000	1500
Main Utilization	Isotope Production Reactor Engineer Materials Testing	Education & Training Basic & Applied Physics	Education & Training Basic & Applied Physics	Basic & Applied Research Isotope Production Training & Education	Basic & Applied Research Isotope Production	Basic & Applied Research Isotope Production Training & Education NAA, Silicon Doping
Period of Data Collection	7/87 - 4/93	1/71 - 4/93	1/85 - 4/93	1/85 - 3/93	11/91 - 6/93	2/84 - 10/92
Total Number of Components Investigated	~10 000	620	940	~200	~400	~80
Data Sources	Log Books Maintenance Records	Log Books Maintenance Records	Log Books Maintenance Records	Log Books Maintenance Records Operating Exp	Log Books Maintenance Records	Log Books Maintenance Records
Main Systems of the Components Investigated	RCS&RSS, I&C, Reactor and Reac Cooling Systems, Fuel, Ventilation, Electrical Power Supply	RCS&RSS, I&C, Reactor and Reac Cooling Systems, Fuel, Ventilation, Electrical Power Supply	RCS&RSS, I&C, Reactor and Reac Cooling Systems, Fuel, Ventilation, Electrical Power Supply	RCS&RSS, I&C, Reactor and Reac Cooling Systems, Ventilation, Radiation Monitoring, Electrical Power Supply	RCS&RSS, I&C, Reactor and Reac Cooling Systems, Ventilation, Radiation Monitoring, Electrical Power Supply	RCS&RSS, I&C, Reactor and Reac Cooling Systems, Ventilation, Electrical Power Supply, Systems

[1] Systems classified as in Ref [8]

TABLE V. OVERVIEW OF COMPONENT TYPES AND POPULATIONS DOCUMENTED FOR EACH FACILITY

		AUS	A	CND	PRC-M	PRC-H	CZ	IN-B	IN-Y	IN-S	SLO	CH	VN	TOTAL
Comp. Type Code	Component Type Description	HIFAR	TRIGA-Wien	NRU	MTR	HWRR	LVR 15	TRIGA-Band.	TRIGA-Yogya	MPR30-Siwa	TRIGA-Ljubljana	SAPHIR	IVV9-Dalat	all facilities
AAA	sensor general													0
ACA	sensor core flux							4	4	9			9	26
ACI	ionisation chamber		3	8	8		12				4	7		42
ACF	fission counter		1								1	2		4
ACS	self powered detector											1		1
AFA	sensor flow		2					3	4	29	13	5	2	58
AHA	sensor humidity													0
ALA	sensor level		4					1	1	3		1		10
ALR	sensor pool water level		4							4		3	1	12
AQC	sensor conductivity		4					1	1	5		3		14
AQP	sensor pH-value							1	1	2		0		4
APA	sensor pressure		2					2	1	142		0		147
APD	sensor pressure difference									52		0		52
ARA	aerosol monitor		1							10		1		12
ARG	gamma monitor	17	12	4				7	6	17		12		75
ARN	neutron monitor		1					1	1			0		3
ARO	off-gas monitor		2							3		2		7
ARU	rad. monitoring alarm unit		1								1	1		3
ASA	sensor speed									35				35
ATA	sensor temperature		9					6	7	124	4	15	9	174
														0
BCA	battery charger							1	1	9				11
BCS	battery charger solid state													0
BTA	battery						3	4	4	3				14
BTL	battery lead acid accumulator			2	1									3
BTN	battery nickel cadmium accumulator													0
														0
CB2	bus 120Vac, 220Vac sing. phase			1				1		2		2		6
CB3	bus 220Vac, 380Vac three phase			1				1	1	3		2	3	11
CB6	bus 6kV							1	1	1				3
CBA	bus general power distr.			1										1
CBD	bus DC			1						9		0	2	12
CCP	cable power connection												10	10
CCS	cable signal (supervisory)													0
CWA	wire													0
CWC	wire control circuit typical circuit, several joints													0
														0
DEA	diesel engine													0
DGA	diesel generator emergency AC		1	11			1	1	1	3			2	20
														0

		AUS	A	CND	PRC-M	PRC-H	CZ	IN-B	IN-Y	IN-S	SLO	CH	VN	TOTAL
Comp. Type Code	Component Type Description	HIFAR	TRIGA-Wien	NRU	MTR	HWRR	LVR 15	TRIGA-Band	TRIGA-Yogya	MPR30-Siwa	TRIGA-Ljubljana	SAPHIR	IVV9-Dalat	all facilities
														0
EBA	terminal board							4	1	4340			8	4353
ECM	static converter for reactor main coolant pumps													0
														0
EHA	air heater									11				11
EHP	pressurizer heater													0
EHO	oil heater									12				12
EHT	heat tracing pipe heater													0
EHW	water heater									3		1		4
EIA	inverter				2	2								4
EII	inverter instrument													0
EIX	inverter static three phase			3										3
EIZ	inverter static single phase		1	6						2		1		10
EPA	power supply (instrumentation and control equipment)						12							12
EPH	high voltage p.s. instr.		4										9	13
EPU	uninterruptible p.s. < 1kVA													0
ERS	rectifier static			2	6	2				9				19
EXA	el equip. for exp. general													0
														0
FEA	piping expansion joint			26				1						27
FNA	piping nozzle													0
FNS	piping nozzle spray							1	1					2
														0
FS3	3"							138	123	2378				2639
FSA	piping straight section								5					5
FSM	piping large, > 3" diameter							28		1230			9	1267
FSS	piping small, < = 1" diameter									1144				1144
FTA	piping tees							18	22	433				473
FWA	piping welds, general			407					198					605
FXA	orifice							1	2	19				22
FYA	gasket			148					136	393				677
														0
GBC	thermal column		1	1				1	1					4
GBR	beam port, radial		3	13				3	3	4		5		31
GBT	beam port, tangential		1	1				1	1	2		2		8
GBL	pool liner		1					1	1	1		1		5
GBS	storage rack for fuel		3					2	2			10		17
GSF	storage and transp. cont. irrad. fuel		1					1	1			2		5
GSH	storage, fresh fuel		6									2		8

		AUS	A	CND	PRC-M	PRC-H	CZ	IN-B	IN-Y	IN-S	SLO	CH	VN	TOTAL
Comp. Type Code	Component Type Description	HIFAR	TRIGA-Wien	NRU	MTR	HWRR	LVR 15	TRIGA-Band.	TRIGA-Yogya	MPR30-Siwa	TRIGA-Ljubljana	SAPHIR	IVV9-Dalat	all facilities
GTA	tank, reactor vessel			3									1	4
GTE	expansion tank									3		1		4
														0
HCA	cooling tower general								2					2
HXA	heat exchanger	6									12		1	19
HXF	heat exch. fuel storage									3				3
HXH	heat exch. U tube horizontal shell and tube											2		2
HXM	heat exch. straight tube vertical shell and tube	3		8	2	2		2	2	2				21
HXP	heat exch. plate type		1											1
HXR	heat exch. pond heat removal									3				3
HXT	heat exch. cleaning system													0
HXV	heat exch. U tube vertical shell and tube							1	1			1		3
														0
IAA	instrumentation	7				60		1	1	1			15	85
IAR	control rod position indication		3										5	8
ICA	instr. ch. analog general				4	7						5		16
ICC	instr. ch. analog core flux		3		2	3	12	2	4	9	6	7	9	57
ICF	instr. ch. analog flow		2		6	1		3	4	29		4		49
ICL	instr. ch. analog level	4				1		1	1	13	9	1		30
ICP	instr. ch. analog pressure					2		2	1	47				52
ICS	instr. ch. analog seismic									11				11
ICT	instr. ch. analog temperature	3	3		6	51		6	6	40		15		130
IDA	instr. ch. digital, gen						12							12
IDC	instr. ch. digital core flux		4								3			7
IDF	instr. ch. digital flow											1		1
IDL	instr. ch. digital level													0
IDP	instr. ch.digital pressure													0
IDT	instr. ch. digital temp.		8											8
														0
JCA	core structure, general		1									1		2
JCG	grid plate		2											2
JCT	fuel guide tubes													0
JEE	clutch electrical													0
JEM	clutch mechanical													0
JHA	Heater	5												5
JIA	irradiation container							12	6	40				58
JIH	hydraulic transfer system													0
JIP	pneumatic transfer system		3	1				1	1	5		1		12

			AUS	A	CND	PRC-M	PRC-H	CZ	IN-B	IN-Y	IN-S	SLO	CH	VN	TOTAL
Comp Type Code	Component Type Description		HIFAR	TRIGA-Wien	NRU	MTR	HWRR	LVR 15	TRIGA-Band	TRIGA-Yogya	MPR30-Siwa	TRIGA-Ljubljana	SAPHIR	IVV9 Dalat	all facilities
JIR	irradiation rig, static	.		6					1	1	2		9		19
JIS	rotary specimen rig	.													0
JLC	lube oil cooler	.													0
JPE	penetration electrical	.							2	2					4
JPP	penetration piping	.							5	2	15		6		28
JTF	tank resin flushing	.							1	1	3				5
JTR	tank storage RWST (refueling water storage tank)	.							2		1		1		4
		.													0
		.													0
KAA	circuit breaker, general	.													0
KAC	circuit breaker ac	.							1	1					2
		.													0
KDC	circuit breaker DC	.													0
		.													0
KIA	circuit breaker indoor AC application	.		10							408			13	431
KID	circuit breaker indoor DC application	.									92				92
KIS	circuit breaker isolation, ground fault circuit interrupter	.		1											1
KRP	circuit breaker reactor protection	.		15									2		17
KSF	feeder (junction box)	.							2	2	1				5
KTA	fuse all voltage levels	.		20					3	3	178			3	207
		.													0
LAA	transmitter general	.									11			1	12
LCA	transmitter core flux	.		4										9	13
LFF	transmitter flow	.		2							13		5	2	22
LLL	transmitter level	.									12			1	13
LPP	transmitter pressure	.		4							12				16
LTT	transmitter temperature	.		9							25		15		49
LXR	transmitter pressure difference	.													0
		.													0
MAA	motor	.													0
MAC	motor ac	.				4			1	1					6
MAD	motor dc	.			4										4
MAI	motor AC induction	.	18		17				13	13					61
MGX	motor generator				2										2
MSS	motor servo	.		3					4	3	8				18
		.													0
NCA	signal comparator bistable	.				2	1								3
NCB	personal computer, PC	.						1	3	2					6
NCD	data acquisition system	.		2											2

		AUS	A	CND	PRC-M	PRC-H	CZ	IN-B	IN-Y	IN-S	SLO	CH	VN	TOTAL
Comp Type Code	Component Type Description	HIFAR	TRIGA-Wien	NRU	MTR	HWRR	LVR 15	TRIGA-Band	TRIGA-Yogya	MPR30-Siwa	TRIGA-Ljubljana	SAPHIR	IVV9-Dalat	all facilities
NCH	high quality computer		1							2		1		4
NCW	workstation computer													0
NDA	printer, general		2											2
NIN	computer network, general									1				1
NKA	computational module									3				3
NMA	signal modifier				8	8								16
NMO	signal modifier voltage-pneumatic transducer													0
NMP	signal modifier current-pneumatic transducer													0
NMS	signal modifier square root extractor													0
NMT	signal modifier current-current transducer													0
NMV	signal modifier current-voltage transducer													0
														0
														0
NSA	signal conditioning system for core flux, level, pressure, temperature general									2				2
NSC	sign. cond. sys. core flux		4					2		9			1	16
NSF	sign. cond. sys.flow		2											2
NST	sign. cond. sys.temperature		9											9
														0
OCC	control rod cruciform, boron carbide control rods													0
OCR	assembly		3	18	11		12	4			5		7	60
OCS	control rod clustered silver, indium, cadmium control rod				1									1
														0
ORA	control rod drive		3	18	10	20		4	3	8	15	5	7	93
														0
PDA	pump diesel driven													0
PMA	pump motor driven	2	1	16	8	ı	4			21	7		5	64
PTA	pump turbine driven													0
PWB	pump horiz. 22-820 l/s		1	10	1							2		14
PWC	pump centrifugal	8		8	11			4		6				37
PWE	pumpl vert. 70-1900 l/s		2		2	2						2		8
PWS	pump			2										
														0
QAA	air cooler							2	2	3				7

		AUS	A	CND	PRC-M	PRC-H	CZ	IN-B	IN-Y	IN-S	SLO	CH	VN	TOTAL
Comp. Type Code	Component Type Description	HIFAR	TRIGA-Wien	NRU	MTR	HWRR	LVR 15	TRIGA Band	TRIGA-Yogya	MPR30-Siwa	TRIGA-Ljubljana	SAPHIR	IVV9-Dalat	all facilities
QBF	blower fan	9						2	2	33			8	54
QCI	compressor instrument air	3	2	7				1	1	2				16
QDA	damper			5				4		86				95
QDM	damper manual (HVAC)							3	3					6
QFH	unit									15				15
QFV	*fan containment ventilation fan*		1	5							11			17
QVA	hvac unit auxiliary building													0
QVB	hvac unit battery room ventilation													0
QVE	hvac unit electric equipment area ventilation											1		1
QVR	hvac unit control room ventilation		1									1		2
QVS	hvac unit reactor hall	3	2									2		7
														0
RAA	relay auxiliary													0
RAS	solid state relay									39				39
RCA	relay control AC							1	1					2
RCD	relay control DC							12	12					24
RCL	relay control													0
RPH	relay power 300-460 A							8	8					16
RPL	relay power 40-60 A							10	10					20
RRA	relay protective							4						4
RRF	relay, frequency protection									67				67
RRO	*relay, overload protection*													0
RRV	relay, voltage protection											2		2
RTA	relay time delay								4	152			6	162
RTB	relay time delay bimetallic							1		31				32
RTP	relay time delay pneumatic								1					1
RTS	relay time delay solid state													0
RWA	relay, general						17	2		939				958
RXA	relay contacts							1						1
RYA	relay coil							6						6
														0
SAA	switch, general													0
SAM	micro switch		9							35				44
SCC	switch contacts							26						26
SDA	switch digital channel pressure / vacuum, pressure, level													0
SFA	switch flow												4	4
SIA	switch limit	58						8						66
SIE	switch limit electronic		9											9
SLA	switch level	15	3					1		9			2	30

		AUS	A	CND	PRC-M	PRC-H	CZ	IN-B	IN-Y	IN-S	SLO	CH	VN	TOTAL
Comp Type Code	Component Type Description	HIFAR	TRIGA-Wien	NRU	MTR	HWRR	LVR 15	TRIGA-Band	TRIGA-Yogya	MPR30-Siwa	TRIGA-Ljubljana	SAPHIR	IVV9-Dalat	all facilities
SMA	switch manual		10					25	14	126			8	183
SPA	switch pressure	3							2	8				13
SQA	switch torque								3					3
STA	switch temperature												2	2
TAA	transformer			3				1	1	31				36
TA2	transformer 220/120 V		1					1	1					3
TA6	transformer 6kV/380V		3		2			1	1	3			1	11
														0
TIC	transformer (instrument transformer, current transformer)							8	8	431				447
TIP	transformer instrument potential													0
														0
														0
														0
TVA	regulating transformer								1					1
														0
														0
UCA	controller						10						6	16
UCE	controller electronic							1						1
UCF	flow controller													0
UCP	controller pneumatic							1	1	1				3
UEH	solid state devices high power application													0
UEL	solid state devices low power application													0
UEY	isolating diode assembly													0
UIA	analog display		20					11	16	147		5		199
UID	digital instrument		10									6	2	18
UIE	indicating instrument electronic													0
UIL	indication lamp		30					26	30	247		200		533
UIM	CRT screen, monitor		3						2	2				7
UIR	recorder		2					1	4	2		12	5	26
UIX	other ind. instr.				6								2	8
UMC	manual control device pushbutton							1		1		2	13	17
UNA	annunciator				6			1	1				1	9
UNS	annunciator module solid state, LED-, LCD-display													0
URS	reactor scram system				4	2		4	3	3		1		17
														0
VA1	valve air operated			2										2

			AUS	A	CND	PRC-M	PRC-H	CZ	IN-B	IN-Y	IN-S	SLO	CH	VN	TOTAL
Comp Type Code	Component Type Description		HIFAR	TRIGA-Wien	NRU	MTR	HWRR	LVR 15	TRIGA-Band	TRIGA-Yogya	MPR30-Siwa	TRIGA-Ljubljana	SAPHIR	IVV9-Dalat	all facilities
VAR	valve air operated all systems except raw water return line	.													0
VCA	valve self operated check	.			8	11	3							5	27
VDA	valve solenoid operated	.	17												17
VEA	valve explosive operated	.													0
VHA	valve hydraulic operated	.													0
VMA	valve motor operated	.	3	1	22	7	3	2			136		2	6	182
VPA	valve piston operated	.													0
VRA	valve relief	.													0
VSA	valve safety	.													0
VWA	valve angle valve	.													0
VWB	valve ball valve	.	2								13				15
VWG	valve gate	.				20									20
VWJ	valve plug valve	.													0
VWL	valve globe valve	.													0
VWN	valve needle valve	.													0
VWP	valve diaphragm	.													0
VWT	valve butterfly valve	.	5								30				35
VWU	valve nozzle valve	.													0
VXA	valve manual	.	2	30		10	74	18	31	31			12	21	229
		.													0
WAA	shielding general	.		1						1					2
WFA	shielding irrad. fuel	.		1											1
		.													0
		.													0
XAA	fuel elm., general	.													0
XAM	MTR fuel elm., general	.											120		120
XAT	TRIGA fuel elm., general	.													0
XBM	MTR stand. refl.elm. Be metal	.													0
XBN	MTR stand. refl.elm. Be oxid	.													0
		.													0
XCA	fuel elm. handling tool, gen.	.													0
XCM	fuel elm. handling tool, manual	.		1					2						3
XCR	fuel elm. handling tool, remote	.													0
XHA	fuel elm. HEU general	.													0
XHM		.													0
XHN		.													0
XHO		.													0
XHP		.													0
XHT	Fuel elm. TRIGA, stand. FLIP	.		9											9
XMM		.													0

		AUS	A	CND	PRC-M	PRC-H	CZ	IN-B	IN-Y	IN-S	SLO	CH	VN	TOTAL
Comp Type Code	Component Type Description	HIFAR	TRIGA-Wien	NRU	MTR	HWRR	LVR 15	TRIGA-Band	TRIGA-Yogya	MPR30-Siwa	TRIGA-Ljubljana	SAPHIR	IVV9-Dalat	all facilities
XMN														0
XMO														0
XMP														0
XMR	fuel elm. rod type MEU				30								89	119
XLA	fuel elm. LEU, general													0
XLM										58				58
XLN														0
XLO										15				15
XLP														0
XLT	Fuel elm. TRIGA, stand LEU		85					95	143					323
XLU	Fuel elm. TRIGA, instr. LEU		4					1	4					9
XPA	fuel elm process tube, gen.													0
XPM	fission products monitoring system					1								
XRM	Refl. elm. graphite, MTR													0
XRT	Refl. elm graphite, TRIGA		16										1	17
XTM	Tail. elm. MTR standard													0
														0
YAA	air filter		50											50
YFD	demineralizer							2		4				6
YFM	filter liquid, mechanical restriction		4					2	1	12				19
YFX	Ion exchanger filter		1					2	1	10			1	15
YSF	strainer / filter		1					2		23			2	28
YTS	intake screen service water system							1		4				5
														0
	Total	193	512	795	191	245	116	630	907	14203	91	534	329	18743

TABLE VI. SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY

This table provides specific information on component type, in alphabetical order, and component type code for each facility. The information is not intended to provide complete descriptions of components, but does provide some information on the component manufacturer, component design specifics and any test or operational features that the contributors consider relevant. It is recognized that this information does not provide complete descriptions but it nevertheless provides information at a more specific level than the component type descriptions of Table II.

ACI	Trip and control ion chambers TQU (6 × 10^{-14}A/n) 300 Vdc input
ARG	Gamma monitor (1) actuates Emergency Filter System (AEP 5180 type)
ARG	Gamma monitor (3) actuates EFS system (Eberline type)
BTL	120 × 2.15 V cells, Gould 2 banks of 60 cells each, discharge tested twice per year 3 hr mission (degraded failure is failure to complete mission test), failure to run is failure to operate on demand
CBA	Bus 600 Vac
CBD	Bus 115 DC
CB2	Bus 120 Vac
DGA	Emergency diesel generator (10) (125 to 200 kVA) 6 cyl Cummins & GM, tested once per 4 weeks
DGA	Emergency diesel generator (1) (250 kVa) 6 cyl Cummins, tested once per week
EIZ	Inverter (old) CTS sine wave, AC, static switch bypass, 7.5 kW, input 125 Vdc output 115 Vac
EIZ	Inverter (new) SAB NIFE, 120PW7-5-107, input 120 Vdc, 84 amp, 7.5 kW 120 Vac output 60 cps single phase
ERS	Stativolt silicon diode, 150 kW, 600 V, 3 phase, output 120 Vdc, convection cooled
FEA	Steel expansion bellows, 304 st steel (>15 cm diam), main coolant system
FSL	Piping st steel, 142 m length, > 15 cm diam, (<700 kPa service), main coolant system, 270 welds
FSM	Carbon steel secondary system piping, 120 cm diam, 0.95 cm thick, 536 m total length, <700 kPa service
FSM	Carbon steel 46 cm diam process system piping ≈60 m total length
FSS	St steel instrumentation piping, <1 cm diam, total length approx 200 m (<700kPa service)
FS3	Carbon steel piping 5 cm process water lines, <700kPa service
FYA	Main coolant system stainless steel piping flange joints (gasket and flange assemblies) 25" diam
GCB	graphite thermal column outside calandria (2.4 m × 3.2 m × 3.7 m long)
GBR	Calandria beam hole tube (13), re-entrant tube, leaks requiring replacement
GBT	Calandria elliptical through tube (1) (leaks requiring replacement)
GTD	Calandria (3), Alcan 57SASTM 5052 (leak level sufficient for replacement)
HXM	Heat exchanger 304 stainless steel ≈25 MW, single pass countercurrent shell and tube Andale company, vertical
J19	Pneumatic transfer system piping installation (in core and out of core)
MAD	Motor generator set, Westinghouse, shunt wound, 75 kW, 125DC supply 1200 rpm, output 600 Vac 60 cps, 1 operational, 1 stand-by
OCS	Shut off rod, mechanical failure to drop, 18 rods

OCS	Shutoff rod magnet failure to release on de-energization, 18 rods
ORA	Control rod (18) weight (211 kg) 12 cm diam, max speed 15 cm/sec motor Diehl induction 200 watt, 115 Vac
PMA	Hydraulic pumps fuelling machine 6 kW Sperry Controller GE motor 11 kW, 700 rpm variable speed VSG pump
PMA	Main pump AC motors (8), 187 kW, 2300 V, 2 speed AC, 1800 rpm, 60 cps, 3 phase
PMA	Main pump DC motors (4), 15 kW, Westinghouse, DC shunt, 690 rpm, 115 Vdc
PMA	Purification system pump motors (2), AC induction, Westinghouse, vertical, 19 kW, 3600 rpm, 550 V
PWC	Main circulating pumps, centrifugal, 230 kg/s, Ingersoll Rand, (57 m head)
PWS	Purification system pumps (2), Allis Chalmers, 21 kg/s, head 64 m, centrifugal
QCI	Worthington (3), reciprocating, 17 m^3/m, discharge pressure 700 kPa, 75 kW English Electric motor, 600 V, 3 phase 60 cps
QCI	Joy Manufacturing (1), 3 stage centrifugal 57 m^3/m, 700 kPa discharge pressure, 336 kW Reliance electric motor, 2300 V, 3 phase 60, cycles
QCI	Nash Nytor (3), 11 m^3/m, rotary vane water seal, 520 kPag, GE, 110 kW motor 600 V, 3 phase, 60 cps
QDA	Fan dampers (6), butterfly double acting electric solenoid for dampers (monthly test) 5.7 m^3/s flow
QDA	Emergency filter system dampers (4), 90 cm diam, pneumatic, flow 6m^3/s
QFV	Ventilation fans, Canadian Sirocco Company, 12000 cfm, 5.7 m^3/s, 56 kW
QFV	El & C controls fan motors 56 kW, 600 V, 395 rpm fan 1800 rpm motor, 3 phase, double vbelt
TUA	Transformer substation English Electric 500 kVa, 2400/600 V 3p 60 cps delta primary star secondary
TUA	Transformer substation English Electric 1000 kVa, 2400/600 V 3p 60 cps delta primary star secondary
VA1	emergency check valve, pneumatic operation, 30 cm diam
VCA	Pump discharge check valve, horizontal swing 25 cm tilting dist, dominion
VMA	Main isolating electric operated gate valve 30 cm diam
VMA	Main isolating electric operated gate valve 15 cm diam

Name of Facility: BANDUNG, INDONESIA

ACA	Reuter Stokes Reuter Stokes
EPA	ORTEC
IAA	General Atomic
ICC	General Atomic
ICF	General Atomic
ICL	General Atomic
ORA	General Atomic
PMA	General Atomic
PWC	General Atomic
UIR	General Atomic
VMA	General Atomic

Name of Facility: BEIJING MTR, CHINA

ICF	Flow rate measuring system with indicator
ICT	Temperature measuring system with thermo couple sensor and recorder
PMA	Feed water make-up pump, horizontal motor drive, low flow rate
PWC	Pump motor drive centrifugal, horizontal low head
VMA	Motor operated valve, 200 cm diam
VXA	Manually operated valve, 20 to 40 cm diam
XMR	*16 rod fuel element assembly*

ACA Sensor core flux: Type: KNK-15, KNK-3. Number of sensors: 9
Operational mode: in operation. Time period: 22/2/84 - 31/10/92.
Operational time: 13348 hr.

ATA Sensor temperature. Type: TCP-5076, TCM-5071. Number of sensors: 9.
Operational mode: in operation. Time period: 22/2/84 - 31/10/92.

EPA Power supplies: 5V, 24V and 48V power supplies

IAA Control and averaging block, type BM-14R. Automatic regulating block type: BUM-21-R - AR regulating logic block - Shim rod control logic block - shim rod drive control relay block - safety control logic block - safety drive control relay block.

ICC Channel power measurement of source range, type BIK01.
Channel power measurement, intermediate range, type BIK02
Channel power measurement, power range, type BIK03.

KTA Fuse 6kV, type: PK4-10-160/160/-20IZ. Number of fuses: 3
Operational mode: in operation. Time period: 22/2/84-31/10/92

ORA AR control rod drive. Type ADP-362. AC-motor, end position contactor, position potentiometer, speed generator, steel cable/drum drive with counter weight.

Shim and safety rod drive, type D-500 MF. DC-motor, magnet, position potentiometer, end position contactor, fiction gear, steel cable and drum drive.

PMA
- Primary pump, type 4KG-12K-14-2, flow: 90 m^3/hr
- Secondary pump type KM-90/25, flow: 90 m^3/h
- Purification system pump, of spent fuel storage, type: XM2/25-K-2V

QBF
- Cooling tower fan, type 1 VG-25
- V-1 fan, type CP 7-40-5
- V-2, type CT-70-8
- P-3, type CT-70-8

VIR
- Recorder, primary coolant flowmeter type KCU 2-004
- Recorder, secondary coolant flowmeter, type KCU 2-004
- Recorder, temperature type KCM2-028, KCM2-021

VMA
- V-1 motor operated valves, type IAO 1009
- V-2 motor operated valves, type IAO 1009
- P-3 motor operated valves, type IAO 1009

VXA
- Manual valve in reactor cooling primary circuit
- Manual valve in reactor cooling secondary circuit
- Manual valve in the reactor purification system, manual valve in purification system of spent fuel storage

Name of Facility: KARTINI, INDONESIA

ACA	Reuter Stokes
EPA	ORTEC
IAA	General Atomic
ICC	General Atomic
ICF	General Atomic
ICL	General Atomic
ICT	Leader
ORA	General Atomic
PMA	General Atomic
PWC	General Atomic
UIR	Honeywell

Name of Facility: REZ (LVR-15), CZECH REPUBLIC

ACA Fission chambers wide-band RJ-1300 for startup channels and fission chambers RWKJ-81c for other (log, lin. and power protection) channels
Manufacturer: IBJ Swierk, Poland

EPA Power supply ZRM-6B3
Manufacturer: IBJ Swierk, Poland

ICC Startup (TIP-GB2), lin. TPP-6B12, log. TPL-6B12 and power protection channels (linear scale) Manufacturer: IBJ Swierk

ORA Control electronic unit UR-70 Manufacturer Skoda, Czech Republic

PMA Main and emergency pumps 150-NHD-250-55-7C-20-09 (META34 YC-AC motor; META 34 - DC motor) Manufacturer SIGMA, Czech Rep.

VMA Gate valve type C23-204-040-200 (DN 200), C23-204-040-300 (DN 300). Manufacturer Skoda, Czech Rep.

Name of Facility: TRIGA LJUBLJANA, SLOVENIA (SLO)

ICC Compensated ion chamber (LOG channel) sensitivity: 2×10^{-14} amp/nv
Manufacturer H&B (Hartman & Brown)

ICC Uncompensated ion chamber (LIN channel) sensitivity 7.7×10^{-15} amp/nv
Manufacturer: H&B (Hartman & Brown)

ICC Compensated ion chamber (startup) 5×10^{-5} watt to 50 watt
Manufacturer: H&B (Hartman & Brown)

ORA Rod drive mechanism
Rod drive mechanism has a selection switch for setting operating mode stationary (continuous) or pulse. The power level in stationary mode is manually by a twelve position switch on the control panel

PWC Primary coolant pump, flow: 70 m^3/h, head: 20 m.
Centrifugal AC motor driven pump, motion line diameter of 5 cm, discharge line diameter of 4 cm

PMA Water tower pump, flow: 23 m^3/min, discharge line diameter: 10 cm

Name of Facility: SAFIR, SWITZERLAND

ACA	Ionization chamber 20th century RC6EB
ARA	Aerosol monitor LBxxxx Berthold
EPA	Gutdoor 220V 50Hz 10U VA 30 min
IAA	EIR op amp - channel
ICC	Merlin, Gerin, transistorized equipment, lin DC-channels
ICF	Fischer & Porter - magneto-dynamic flow meter channel, 5l/s
PWC	motor driven pump, vertical 20l/s, 4 kW
YFZ	mixed bed ion exchanger 120l Lewatit (M500 + S 100)

Name of Facility: TRIGA VIENNA, AUSTRIA

ACA	Compensated ionization chamber: RC6EB, 20th century
ARA	Hartmann & Braun, GM counter with filter (1975)
EPA	Hartmann & Braun HR Series, (1968)
IAA	Hartmann & Braun HR Series, 5 nuclear channels (1968)
ICC	Hartmann & Braun HR - linear channel (1968)
ICF	(1) Flow channel for primary cooling circuit: up to 30 m^3/h (2) Flow channel for purification flow: up to 3 m^3/h
ICL	Hartmann & Braun HR-Series (1968)
ICT	Hartmann & Braun HR-Series (1968)
KTA	Fuses in each circuit of RSS, IC system
ORA	BODINE Motor, General Atomic, rod drives for shim., reg. and transient rod
PMA	(1) Primary pump: 11 kW, flow up to 30 m^3/h (2) Purification pump: 2 kW, flow up to 3 m^3/h
UIR	AEG (1968), 2 recorders, type CL 20, CL 21
VMA	Motor operated valve to close secondary water supply, pipe diameter 80 mm
VXA	Manual valves in primary and secondary coolant, pipe diameter 80 mm

TABLE VII. COMPONENT RELIABILITY DATABASE

Table VII provides the raw component reliability data and associated calculated reliability parameters. Specific definitions of the information in each column is provided.

Code	3 letter component type code from Table II reference listing
Component type description	A description of the component type
Reactor code	The alphanumeric code of Table IV, row 1, which identifies the reactor facility for the component type
Components	The total number of component types for which data are available for a given facility
Calendar time	The cumulative component (x) calendar time for the specific component type (component calendar hours)
Operating time	The cumulative component (x) operating time for the specific component type (component operating hours)
Demands	The cumulative component (x) demands to operate for the specific component type (component demands)
Failure mode	The failure mode code for the component type from Table III
Failures	The number of failures of a given failure mode, corresponding to either the cumulative calendar time, cumulative operating time or the cumulative number of demands
Failure rate	The number of failures per million hours, the number of failures per cumulative million operating hours or per cumulative million calendar hours. For certain components: piping and piping welds. The failure rate units are quoted in failures per h and failures per m.h and failures per weld.h
Demand failure rate[1]	The failure per cumulative number of demands
Failure rate 90% confidence bounds	The 5% and 95% confidence bounds for either the failure rate or the demand failure rate, based on Ref. [7]. For zero failures only the 95% bound is quoted

[1] For zero failures the corresponding chi-square 50% statistical prediction $\chi^2(0.50,2)/2T$ is used where T is the total time or total number of demands.

			Reactor	Components	Cummulative calendar time	Cummulative operating time	Demands	Failure modes		Failures	Failure rate	Failure probability	90% Confidence bounds	
code	component type description		code	#	Mill.h	Mill. h	#	crit	deg	#	1e-6/h	1/demand	5%	95%
AAA	sensor general	.												
ACA	sensor core flux	.	A	3	0.297			F		2	6.7	-	1.2	15.9
ACA		.	VN	9		0.120			B	1	8.3	-	2.7	24.9
ACA		.	IN-Y	4	0.282			F		1	3.5	-	0.2	10.6
		.	IN-S	9	0.603			F		6	10.0	-	4.3	17.4
ACA		.	IN-B	4	0.483			F		10	20.7	-	11.2	32.5
ACI	ionisation chamber	.	CZ	12		0.076		C		4	52.9	-	36.4	102.6
ACI			CND	8	2.220			F		1	0.5	-	0.0	1.3
ACF	fission counter	.									-	-	-	-
ACS	self powered detector	.	CH	3	0.042			X		2	48.0	-	8.5	113.8
AFA	sensor flow	.	VN	2		0.057		F		3	53.0	-	36.4	111.2
AFA		.	IN-Y	4	0.282			F		5	17.7	-	7.0	32.5
		.	IN-S	70	4.687			F		8	1.7	-	0.8	2.8
AHA	sensor humidity	.									-	-	-	-
ALA	sensor level	.	CH	12	0.167				B	1	6.0	-	0.3	18.0
ALA		.	CH	12	0.167				K	7	42.0	-	19.7	71.0
ALA		.	CH	12	0.167			X		1	6.0	-	0.3	18.0
		.	IN-S	38	2.544			F		10	3.9	-	2.1	6.2
ALA		.	IN-B	1	0.121			F		1	8.3	-	0.4	24.8
ALR	sensor pool water level	.	VN	1		0.025		F		0	28.2	-	0.0	121.7
AQC	sensor conductivity	.	IN-S	5	0.335			F		2	6.0	-	1.1	14.2
AQP	sensor pH-value	.	IN-S	2	0.134			F		2	14.9	-	2.7	35.4
APA	sensor pressure	.	IN-S	142	9.508			F		16	1.7	-	1.1	2.4
APD	sensor pressure difference	.									-	-	-	-
ARA	aerosol monitor	.	CH	1	0.014			F		1	72.0	-	3.7	215.6
ARA		.	CH	1	0.014				R	20	1439.3	-	953.8	2006.3
ARA		.	A	1	0.099			F		2	20.2	-	3.6	47.8
ARA		.	SLO	1	0.044			F		2	46.0	-	8.2	109.1
ARA		.	SLO	1	0.044				K	1	23.0	-	1.2	68.9
ARG	gamma monitor	.	CH	12	0.167			X		5	30.0	-	11.8	54.9
ARG		.	CH	12	0.167				K	61	365.8	-	292.3	446.1
ARG		.	CH	12	0.167				B	3	18.0	-	4.9	37.8
ARG		.	CH	12	0.167			F		1	6.0	-	0.3	18.0
ARG		.	A	12	1.190			F		2	1.7	-	0.3	4.0
ARG		.	AUS	17	1.258			F		10	7.9	-	4.3	12.5
ARG		.	AUS	17	1.258				B	13	10.3	-	6.1	15.5
ARG			CND	1	0.035			F		4	114.2	-	39.0	221.3
ARG			CND	3	0.026					0	26.7	-	0.0	115.2
ARG		.	AUS	17	1.258				K	13	10.3	-	6.1	15.5
ARN	neutron monitor	.									-	-	-	-
ARO	off-gas monitor	.									-	-	-	-
ARU	radiation monitoring alarm unit	.									-	-	-	-

		Reactor	Components	Cummulative calendar time	Cummulative operating time	Demands	Failure modes		Failures	Failure rate	Failure probability	90% Confidence bounds	
code	component type description	code	#	Mill.h	Mill. h	#	crit	deg	#	1e-6/h	1/demand	5%	95%
ASA	sensor speed									-	-	-	-
ATA	sensor temperature	SLO	1		0.020			K	1	50.0	-	34.8	149.8
ATA		VN	9		0.120		F		0	5.8	-	0.0	24.9
ATA		IN-B	6	0.725			F		1	1.4	-	0.1	4.1
ATA		IN-S	124	8.303			F		13	1.6	-	0.9	2.3
										-	-	-	-
BCA	battery charger									-	-	-	-
BCS	battery charger solid state									-	-	-	-
BTA	battery	CZ	4	0.025						27.5	-	0.0	118.9
BTA		IN-S	164	10.981			F		111	10.1	-	8.6	11.7
BTL	battery lead acid accumulator	PRC-M	1	0.073			F		4	54.7	-	18.7	106.1
BTL	battery lead acid accumulator	CND	1	0.088		12	B/R		0	7.9	0.056	0.0	34.2
BTL	battery lead acid accumulator	CND	1	0.219			F		1	4.6	-	0.2	13.7
										-	-	-	-
CB2	bus 120Vac , 220Vac sing. phase	CH	1	0.014			I		1	72.0	-	3.7	215.6
CB2		CND	1	0.300					0	2.3	-	0.0	10.0
CB3	bus 220Vac, 380Vac three phase	VN	3		0.225		F		0	3.1	-	0.0	13.3
CB6	bus 6kV									-	-	-	-
CBA	bus general power distr.	CND	1	0.300					0	2.3	-	0.0	10.0
CBD	bus DC	VN	2		0.027		F		0	25.8	-	0.0	111.4
CCP	*cable power connection*	VN	10		0.751		F		0	0.9	-	0.0	4.0
CCS	cable signal (supervisory)									-	-	-	-
CWA	wire									-	-	-	-
CWC	wire control circuit typical circuit, several joints									-	-	-	-
										-	-	-	-
DEA	diesel engine									-	-	-	-
DGA	diesel generator emergency AC	CZ	1		0.006					110.0	-	0.0	475.5
DGA		VN	2			1606	S		10	-	0.003	0.0	0.0
DGA		VN	2		0.024		R		17	702.2	-	641.5	1003.8
DGA		IN-S	3	0.201			F		7	34.8	-	16.4	59.0
DGA	125 to 200 kVA	CND	10			4250	S		149	-	0.004	-	0.0
DGA	125 to 200 kVA	CND	10		0.004		R		27	6818.2	-	4000.0	9110.3
DGA	250 kVA	CND	1			1123	S		8	-	0.007	-	0.0
DGA	250 kVA	CND	1		0.00068		R		5	7309.9	-	5000.0	13382.3
										-	-	-	-
EBA	switchgear panel'	CZ	12		0.076		I		2	26.5	-	15.4	62.7
EBA		IN-Y	4				F		5	-	-	-	-
EBA		IN-B	4	0.483			F		1	2.1	-	0.1	6.2
EBA		IN-S	4340	290.606			F		7	0.0	-	0.0	0.0

			Reactor	Components	Cummulative calendar time	Cummulative operating time	Demands	Failure modes		Failures	Failure rate	Failure probability	90% Confidence bounds	
code	component type description		code	#	Mill.h	Mill. h	#	crit	deg	#	1e-6/h	1/demand	5%	95%
ECM	static converter for reactor main coolant pumps	.									-	-	-	-
EHA	air heater	.	IN-S	11	0.737			F		4	5.4	-	1.9	10.5
EHP	pressurizer heater	.									-	-	-	-
EHO	oil heater	.									-	-	-	-
EHT	heat tracing pipe heater	.									-	-	-	-
EHW	water heater	.									-	-	-	-
EIA	inverter	.									-	-	-	-
EII	inverter instrument	.									-	-	-	-
EIX	inverter static three phase	.									-	-	-	-
EIZ	inverter static single phase (old)	.	CND	3	0.122			F		24	196.7	-	135.6	267.1
EIZ	inverter static single phase (new)		CND	3	0.060			F		1	16.7	-	0.9	49.9
EPA	power supply (instrumentation and	.	CH	1	0.006			F		1	181.8	-	9.3	544.7
EPA		.	CH	1	0.014				B	1	72.0	-	3.7	215.6
EPA		.	CZ	12		0.076			B	4	52.9	-	36.4	102.6
EPA		.	A	4	0.397			F		2	5.0	-	0.9	12.0
EPA		.	VN	8		0.107		F		4	37.5	-	24.1	72.6
EPA		.	VN	8			7511	F		37	-	0.001	-	0.0
EPA		.	VN	8		0.107			B	1	9.4	-	3.3	28.1
EPH	high voltage p.s. instr.	.	VN	9			9657	F		2	-	0.00002	-	0.0
EPH		.	VN	9		0.120			B	2	16.6	-	8.0	39.5
EPU	uninterruptible p.s. <1kVA	.									-	-	-	-
ERS	rectifier static	.	CND	2		0.175		F		2	11.4	-	4.6	27.1
EXA	el.equip. for exp. general	.									-	-	-	-
		.									-	-	-	-
FEA	piping expansion joint	.	IN-Y	2		0.141		Y		2	14.2	-	6.6	33.7
FEA			CND	26	7.500			Y/J		0	0.09	-	0.0	0.4
FNA	piping nozzle	.									-	-	-	-
FNS	piping nozzle spray	.									-	-	-	-
FRA	bursting disk	.	AUS	2	0.148			Y		2	13.5	-	2.4	32.0
FS3	piping medium, 1" < diameter	.	IN-Y	10	0.705			Y		1	1.4	-	0.1	4.2
FS3		.	IN-S	237	15.870			Y		8	0.5	-	0.3	0.8
FS3	carbon steel		CND		0.270						2.6	-	0.0	11.1
FSA	piping straight section	.									-	-	-	-
FSL	st. steel piping large, 137m, 270 welds		CND		0.270			Y/J			2.6	-	0.0	11.1
FSM	piping large, > 3" diameter	.	VN	9		0.131		Y		2	15.3	-	7.3	36.3
FSM		.	IN-B	3	0.363			Y		1	2.8	-	0.1	8.3
FSM	carbon steel, 120 cm diameter, 536 m		CND		0.290						2.4	-	0.0	10.3
FSM	carbon steel, 46 cm diameter		CND		0.290						2.4	-	0.0	10.3

			Reactor	Components	Cummulative calendar time	Cummulative operating time	Demands	Failure modes		Failures	Failure rate	Failure probability	90% Confidence bounds	
code	component type description		code	#	Mill.h	Mill. h	#	crit	deg	#	1e-6/h	1/demand	5%	95%
FSS	piping small, < = 2.5 cm diameter, 169 welds	.	CND		0.290			J			2.4	-	0.0	10.3
FTA	piping tees	.	IN-Y	22	1.551			Y		1	0.6	-	0.0	1.9
FWA	piping welds, general	.									-	-	-	-
FXA	orifice	.									-	-	-	-
FYA	gasket	.	IN-Y	136	9.586			Y		10	1.0	-	0.6	1.6
FYA		.	IN-S	393	26.315			Y		47	1.8	-	1.4	2.2
FYA			CND	148	22.169			J		1	0.05	-	0.0	0.1
		.									-	-	-	-
GBC	thermal column	.	CND	1	0.184			F		0	3.8	-	0.0	16.3
GBR	beam port, radial	.	CH	1	0.014			Y		6	431.8	-	188.0	756.6
GBR			CND	13	2.390			Y		0	0.29	-	0.0	1.3
GBT	beam port, tangential	.	CND	1	0.184			Y		1	5.4	-	0.3	16.3
GBL	pool liner	.									-	-	-	-
GBS	storage rack for fuel	.	IN-B	2	0.242			F		1	4.1	-	0.2	12.4
GSF	storage and transp. cont. irrad.	.									-	-	-	-
GSH	storage, fresh fuel	.									-	-	-	-
GTA	tank, reactor vessel	.	CH	2	0.028			F		1	36.0	-	1.8	107.8
GTA		.	IN-B	1	0.121			???		2	16.5	-	2.9	39.2
GTA		.	CND	3	0.684			Y		1	1.5	-	0.1	4.4
GTA			CND	3	0.684			J		0	1.0	-	0.0	4.4
GTE	expansion tank	.									-	-	-	-
		.									-	-	-	-
HCA	cooling tower general	.	IN-Y	2	0.141			O		4	28.4	-	9.7	55.0
HXA	heat exchanger	.	IN-B	4	0.483			J		1	2.1	-	0.1	6.2
HXA		.	IN-B	4	0.483			J		1	2.1	-	0.1	6.2
HXA		.	IN-S	7	0.469			F		5	10.7	-	4.2	19.5
HXA		.	AUS	6	0.444				B	1	2.3	-	0.1	6.7
HXA			HXM	8		0.272		Y		0	2.6	-	0.0	11.0
HXB	heat exch. straight tube horizontal shell and tube	.	PRC-M	2	0.145			F		21	144.5	-	96.9	200.0
HXB		.	PRC-H	2	0.149			F		23	154.2	-	105.4	210.6
HXF	heat exch. fuel storage	.									-	-	-	-
HXH	heat exch. U tube horizontal shell and tube	.									-	-	-	-
HXM		.	IN-S	2	0.134			Y		1	7.5	-	0.4	22.4
HXM			CND	8	2.200			Y		0	0.3	-	0.0	1.4
HXM	heat exch. straight tube vertical shell and tube	.	IN-B	2	0.242			Y		2	8.3	-	1.5	19.6
HXP	heat exch. plate type	.									-	-	-	-
HXR	heat exch. pond heat removal	.									-	-	-	-

			Reactor	Components	Cummulative calendar time	Cummulative operating time	Demands	Failure modes		Failures	Failure rate	Failure probability	90% Confidence bounds	
code	component type description		code	#	Mill.h	Mill. h	#	crit	deg	#	1e-6/h	1/demand	5%	95%
HXV	heat exch. U tube vertical shell and tube	.									-	-	-	-
		.									-	-	-	-
IAA	instrumentation	.	A	4	0.397			F		3	7.6	-	2.1	15.9
IAA		.	VN	15		0.200		F		15	74.9	-	55.2	109.3
IAA		.	VN	15		0.200			B	28	139.8	-	112.8	186.0
IAA		.	IN-S	1	0.067			F		7	104.5	-	49.1	176.9
IAA		.	PRC-H	60	3.725			F		48	12.9	-	10.0	16.1
IAA		.	AUS	4	0.296			F		1	3.4	-	0.2	10.1
IAA		.	AUS	4	0.296				B	5	16.9	-	6.7	30.9
IAA		.	AUS	4	0.296				K	2	6.8	-	1.2	16.0
IA2	instrumentation/2	.	AUS	3	0.222				B	13	58.6	-	34.6	87.6
IA2		.	AUS	3	0.222			F		7	31.5	-	14.8	53.3
IA2		.	AUS	3	0.222				K	3	13.5	-	3.7	28.4
IAR	control rod position indication	.	SLO	1		0.020		M		2	100.0	-	77.9	237.2
IAR		.	VN	5		0.067			B	4	59.9	-	42.3	116.2
ICA	instr. ch. analog general	.									-	-	-	-
ICC	instr. ch. analog core flux	.	CH	7	0.097				B	25	257.0	-	178.7	347.0
ICC		.	CH	7	0.097			F		12	123.4	-	71.2	187.2
ICC		.	CH	7	0.097				K	12	123.4	-	71.2	187.2
ICC		.	CH	7	0.097			I		2	20.6	-	3.7	48.8
ICC		.	CH	7	0.097			X		1	10.3	-	0.5	30.8
ICC		.	CZ	12		0.076		F		1	13.2	-	5.9	39.6
ICC		.	CZ	12		0.076			B	8	105.8	-	82.4	173.9
ICC		.	SLO	3		0.060			B	3	50.0	-	34.8	104.9
ICC		.	VN	9		0.120			B	8	66.6	-	48.3	109.4
ICC		.	VN	9		0.120		F		5	41.6	-	27.3	76.2
ICC		.	IN-B	2	0.242			F		5	20.7	-	8.2	37.9
ICC		.	PRC-M	2	0.146			F		13	88.9	-	52.6	133.0
ICC		.	PRC-H	6	0.372			F		4	10.7	-	3.7	20.8
		.									-	-	-	-
ICF	instr. ch. analog flow	.	CH	2	0.028				B	1	36.0	-	1.8	107.8
ICF		.	A	2	0.198			F		1	5.0	-	0.3	15.1
ICF		.	PRC-M	6	0.389			F		36	92.4	-	68.6	119.1
ICF		.	PRC-H	1	0.072			F		2	27.7	-	4.9	65.8
ICL	instr. ch. analog level	.	IN-S	13	0.870			F		1	1.1	-	0.1	3.4
ICL		.	PRC-H	1	0.062			F		3	48.3	-	13.2	101.4
ICL	'	.	AUS	4	0.296				B	4	13.5	-	4.6	26.2
ICP	instr. ch. analog pressure	.	IN-S	47	3.147			F		13	4.1	-	2.4	6.2
ICP		.	PRC-H	2	0.124			F		7	56.4	-	26.5	95.4
ICS	instr. ch. analog seismic	.									-	-	-	-
ICT	instr. ch. analog temperature	.	A	3	0.297			F		3	10.1	-	2.7	21.2

			Reactor	Components	Cummulative calendar time	Cummulative operating time	Demands	Failure modes		Failures	Failure rate	Failure probability	90% Confidence bounds	
code	component type description		code	#	Mill.h	Mill. h	#	crit	deg	#	1e-6/h	1/demand	5%	95%
ICT		.	PRC-M	1	0.040			F		13	321.1	-	189.9	480.3
ICT		.	PRC-H	5	0.310			F		12	38.7	-	22.3	58.7
ICT		.	AUS	3	2.220			F		7	3.2	-	1.5	5.3
IDA	instr. ch. digital, general	.									-	-	-	-
IDC	instr. ch. digital core flux	.									-	-	-	-
IDF	instr. ch. digital flow	.									-	-	-	-
IDL	instr. ch. digital level	.									-	-	-	-
IDP	instr. ch.digital pressure	.									-	-	-	-
IDT	instr. ch. digital temp.	.									-	-	-	-
IRC	reactor reg sys.	.	PRC-M	2	0.127			F		23	181.0	-	123.7	247.3
		.									-	-	-	-
JCA	core structure, general	.									-	-	-	-
JCG	grid plate	.									-	-	-	-
JCT	fuel guide tubes	.									-	-	-	-
JEE	clutch electrical	.									-	-	-	-
JEM	clutch mechanical	.									-	-	-	-
JHA	heater	.	AUS	2	0.148				B	2	13.5	-	2.4	32.0
JH2	heater 2	.	AUS	3	0.222			F		15	67.6	-	41.6	98.6
JH2		.	AUS	3	0.222				B	1	4.5	-	0.2	13.5
JIA	irradiation container	.	CH	15	0.208			X		2	9.6	-	1.7	22.8
JIH	hydraulic transfer system	.									-	-	-	-
JIP	pneumatic transfer system	.	CH	1	0.014			X		1	72.0	-	3.7	215.6
JIP		.	A	3	0.297			Y		1	3.4	-	0.2	10.1
JIP		.	IN-Y	1	0.070			F		1	14.2	-	0.7	42.5
JIP			CND	1	0.300			F		0	2.3	-	0.0	10.0
JIR	irradiation rig, static	.	A	6	0.595			Y		1	1.7	-	0.1	5.0
JIS	rotary specimen rig	.									-	-	-	-
JLC	lube oil cooler	.									-	-	-	-
JPE	penetration electrical	.									-	-	-	-
JPP	penetration piping	.									-	-	-	-
JTF	tank resin flushing	.									-	-	-	-
JTR	tank storage RWST (refueling water storage tank)	.									-	-	-	-
		.									-	-	-	-
KAA	circuit breaker, general	.	A	10	0.992			F		2	2.0	-	0.4	4.8
KAA		.	VN	13							-	-	-	-
KAC	circuit breaker ac	.									-	-	-	-
		.									-	-	-	-
KDC	circuit breaker DC	.									-	-	-	-
		.									-	-	-	-
KIA	circuit breaker indoor AC application	.									-	-	-	-

			Reactor	Components	Cummulative calendar time	Cummulative operating time	Demands	Failure modes		Failures	Failure rate	Failure probability	90% Confidence bounds	
code	component type description		code	#	Mill.h	Mill. h	#	crit	deg	#	1e-6/h	1/demand	5%	95%
KID	circuit breaker indoor DC application	.									-	-	-	-
KIS	circuit breaker isolation, ground fault circuit interrupter	.									-	-	-	-
KRP	circuit breaker reactor protection	.	A	15	1.487			F		40	26.9	-	20.3	34.2
KSF	feeder (junction box)	.	IN-S	1	0.067			F		5	74.7	-	29.4	136.7
KTA	fuse all voltage levels	.	A	20	1.983			F		10	5.0	-	2.7	7.9
KTA		.	IN-B	3	0.363			F		2	5.5	-	1.0	13.1
KTA		.	IN-S	178	11.919			F		26	2.2	-	1.5	2.9
		.									-	-	-	-
LAA	transmitter general	.									-	-	-	-
LCA	transmitter core flux	.	VN	9		0.120		F		1	8.3	-	2.7	24.9
LCA		.	VN	9			9657		B	2	-	0.00002	0.0	0.0
LFF	transmitter flow	.	SLO	1		0.020					34.7	-	0.0	149.8
LFF		.	VN	2		0.029		F		8	275.3	-	237.6	452.5
LLL	transmitter level	.	SLO	1	0.044			F		1	23.0	-	1.2	68.9
LLL		.	VN	1		0.025			B	1	40.6	-	26.5	121.7
LLL		.	VN	1		0.025		F		3	121.9	-	96.6	255.8
LPP	transmitter pressure	.									-	-	-	-
LTT	transmitter temperature	.									-	-	-	-
LXR	transmitter pressure difference	.									-	-	-	-
		.									-	-	-	-
MAA	motor	.	IN-B	14	1.692			S		2	1.2	-	0.2	2.8
MAA		.	IN-S	89	5.959			F		11	1.8	-	1.0	2.8
MAC	motor ac	.									-	-	-	-
MAD	motor dc	.	CND	2		0.130		R		3	23.1	-	13.1	48.4
MAI	motor AC induction	.	AUS	18	1.332				B	6	4.5	-	2.0	7.9
MAI		.	AUS	18	1.332			R		3	2.3	-	0.6	4.7
MAI		.	AUS	18	1.332			S		1	0.8	-	0.0	2.2
MGX	motor generator	.	CND	2		0.130		R		1	7.7	-	2.2	23.0
MSS	motor servo	.	IN-S	8	0.536			F		4	7.5	-	2.6	14.5
		.									-	-	-	-
NCA	signal comparator bistable	.	CZ	17		0.107		F		4	37.3	-	24.1	72.4
NCA		.	PRC-H	1	0.062			F		4	64.4	-	22.0	124.9
NCB	personal computer, PC	.	A	2	0.198				B	2	10.1	-	1.8	23.9
NCD	data acquisition system	.									-	-	-	-
NCH	high quality computer	.	CH	2	0.028			F		2	72.0	-	12.8	170.7
NCH		.	CZ	1		0.006		F		1	158.7	-	129.9	475.5
NCW	workstation computer	.									-	-	-	-
NDA	printer, general	.									-	-	-	-
NIN	computer network, general	.									-	-	-	-
NKA	computational module	.	IN-Y	2	0.141			F		1	7.1	-	0.4	21.2

			Reactor	Components	Cummulative calendar time	Cummulative operating time	Demands	Failure modes		Failures	Failure rate	Failure probability	90% Confidence bounds	
code	component type description		code	#	Mill.h	Mill. h	#	crit	deg	#	1e-6/h	1/demand	5%	95%
NMA	signal modifier	.	SLO	1		0.020					34.7	-	0.0	149.8
NMO	signal modifier voltage-pneumatic transducer	.									-	-	-	-
NMP	signal modifier current-pneumatic transducer	.									-	-	-	-
NMS	signal modifier square root extractor	.									-	-	-	-
NMT	signal modifier current-current transducer	.									-	-	-	-
NMV	signal modifier current-voltage transducer	.	IN-B	2	0.242			F		1	4.1	-	0.2	12.4
		.									-	-	-	-
NSA	signal conditioning system for core flux, level, pressure, temperature general	.									-	-	-	-
NSC	sign. cond. sys. core flux	.	VN	1		0.013			B	17	1273.6	-	650.0	1820.6
NSC		.	IN-Y	4	0.282			F		1	3.5	-	0.2	10.6
NSC		.	IN-B	2	0.242			F		3	12.4	-	3.4	26.0
NSF	sign. cond. sys.flow	.	IN-Y	2	0.141			F		1	7.1	-	0.4	21.2
NST	sign. cond. sys.temperature	.									-	-	-	-
		.									-	-	-	-
OCC	control rod cruciform, boron carbide control rods	.	IN-S	8	0.536			M		1	1.9	-	0.1	5.6
OCR	control rod single control rod assembly	.	A	3	0.297			M		2	6.7	-	1.2	15.9
OCR		.	PRC-M	11	0.737			M		14	19.0	-	11.5	28.1
OCS	control rod clustered silver, indium, cadmium control rod	.	CZ	12		0.076		C		10	132.3	-	106.5	207.7
OCS		.	PRC-M	1		0.067		F		1	14.9	-	6.6	44.7
OCR	electromagnet failure		CND	18	4.250			F		0	0.16	-	0.0	0.7
OCR	mech. failure		CND	18			15940	F		1	-	0.000003	0.0	0.0
ORA	CRDM	.	CZ	12		0.076		C		37	489.4	-	438.7	628.8
ORA		.	A	3	0.297			C		2	6.7	-	1.2	15.9
ORA		.	CZ	12		0.076		D		2	26.5	-	15.4	62.7
ORA		.	SLO	1		0.020		D		1	50.0	-	34.8	149.8
ORA	control rod drive	.	VN	7		0.093		C		13	139.1	-	112.8	208.1
ORA		.	IN-Y	3	0.211			F		2	9.5	-	1.7	22.4
ORA		.	IN-B	4	0.483			F		4	8.3	-	2.8	16.0
ORA		.	PRC-M	11		0.338		S		2	5.9	-	1.1	14.0
ORA		.	PRC-M	11		0.338		F		8	23.7	-	13.1	38.9
ORA		.	PRC-H	12		0.754		F		11	14.6	-	6.6	22.5
ORA		.	CND	18	0.310			F		7	22.6	-	10.6	38.2

			Reactor	Components	Cummulative calendar time	Cummulative operating time	Demands	Failure modes		Failures	Failure rate	Failure probability	90% Confidence bounds	
code	component type description		code	#	Mill.h	Mill. h	#	crit	deg	#	1e-6/h	1/demand	5%	95%
PDA	pump diesel driven	.									-	-	-	-
PMA	*pump motor driven*	.	CZ	9		0.057		R		5	88.2	-	67.4	161.4
PMA		.	CZ	9		0.057		H		1	17.6	-	8.7	52.8
PMA		.	CZ	9		0.057		I		1	17.6	-	8.7	52.8
PMA		.	A	1	0.099			F		1	10.1	-	0.5	30.2
PMA		.	SLO	1		0.020		R		1	50.0	-	34.8	149.8
PMA		.	VN	5		0.073		R		14	192.7	-	160.9	284.5
PMA		.	VN	5			1712	S		9	-	0.001	0.0	0.0
PMA		.	IN-Y	4	0.282			R		2	7.1	-	1.3	16.8
PMA		.	IN-B	21	1.406			F		20	14.2	-	9.4	19.8
PMA		.	PRC-M	2	0.028			R		2	70.5	-	12.5	167.2
PMA		.	PRC-M	2	0.028			S		0	24.4	-	0.0	105.6
PMA		.	AUS	2	0.148				B	5	33.8	-	13.3	61.8
PMA	main pump AC motors		CND	8		0.850		R		27	31.8	-	19.3	42.4
PMA			CND	8			3700	S		8	-	0.0003	0.0	0.0
PMA	main pump DC motors		CND	4			807	S		1	-	0.0003	0.0	0.0
PMA	purification pump motors		CND	2		0.140		R		5	35.7	-	22.5	65.4
PMA			CND	2			60	S		1	-	0.008	0.0	0.1
PTA	pump turbine driven	.									-	-	-	-
PWB	pump horiz. 22-820 l/s	.	CH	2	0.028			R		1	36.0	-	1.8	107.8
PWB		.	A	1	0.099			R		1	10.1	-	0.5	30.2
PWB		.	PRC-M	1	0.001			R		1	2000.0	-	102.6	5991.5
PWC	pump centrifugal	.	CH	1	0.014			F		1	72.0	-	3.7	215.6
PWC		.	CH	1	0.014			R		1	72.0	-	3.7	215.6
PWC		.	SLO	1		0.008		F		1	125.0	-	100.2	374.5
PWC		.	IN-Y	2	0.141			S		1	7.1	-	0.4	21.2
PWC		.	IN-Y	2	0.141			R		4	28.4	-	9.7	55.0
PWC		.	IN-B	4	0.483			R		1	2.1	-	0.1	6.2
PWC		.	IN-B	4	0.483			S		1	2.1	-	0.1	6.2
PWC		.	IN-B	4	0.483			Y		1	2.1	-	0.1	6.2
PWC		.	PRC-M	4		0.291		R		39	134.2	-	108.3	171.4
PWC		.	PRC-M	4		0.291		S		8	27.5	-	16.2	45.2
PWC		.	AUS	2	0.148				B	1	6.8	-	0.3	20.2
PWC		.	AUS	2	0.148			F		1	6.8	-	0.3	20.2
PWC		.	AUS	2	0.148			Y		1	6.8	-	0.3	20.2
PWC	main pumps		CND	8		0.850		R		8	9.4	-	3.3	15.5
PW2	centrifugal pump/2	.	AUS	6	0.444				B	3	6.8	-	1.8	14.2
PW2		.	AUS	6	0.444			Y		2	4.5	-	0.8	10.7
PWE	pumpl vert. 70-1900 l/s	.	CH	2	0.028			R		2	72.0	-	12.8	170.7
PWE		.	CH	2	0.028			S		1	36.0	-	1.8	107.8
PWE		.	PRC-M	2		0.008		S		1	130.2	-	104.7	390.1
PWE		.	PRC-H	3		0.224		R		30	134.1	-	108.3	176.7

			Reactor	Components	Cummulative calendar time	Cummulative operating time	Demands	Failure modes		Failures	Failure rate	Failure probability	90% Confidence bounds	
code	component type description		code	#	Mill.h	Mill. h	#	crit	deg	#	1e-6/h	1/demand	5%	95%
PWE		.	PRC-H	3		0.224		S		6	26.8	-	15.4	47.0
PWS	purification pumps		CND	2		0.140		R		6	42.9	-	28.1	75.1
PWS	purification pumps		CND	2			60	S		1	-	0.008	0.0	0.1
		.									-	-	-	-
QAA	air cooler	.									-	-	-	-
QBF	blower fan	.	VN	8		0.173		R		16	92.3	-	70.9	133.2
QBF		.	VN	8			6309	S		8	-	-	-	0.0
QBF		.	IN-Y	2	0.141			R		4	28.4	-	9.7	55.0
QBF		.	IN-B	2	0.242			S		1	4.1	-	0.2	12.4
QBF		.	IN-S	33	2.210			F		59	26.7	-	21.3	32.7
QBF		.	AUS	9	0.666			F		2	3.0	-	0.5	7.1
QCI	compressor instrument air	.	IN-S	2	0.134			F		9	67.2	-	35.1	107.8
QCI		.	AUS	3	0.222			F		2	9.0	-	1.6	21.4
QCI		.	AUS	3	0.222			Y		3	13.5	-	3.7	28.4
QCI	(Worthington)		CND	3		0.015		R		2	133.3	-	107.4	316.3
QCI	(Joy)		CND	1		0.035		R		16	457.1	-	408.4	659.9
QCI	✓		CND	3		0.005		R		1	201.4	-	169.2	603.2
QDA	damper	.	IN-Y	3	0.211			F		1	4.7	-	0.2	14.2
QDA		.	IN-B	7	0.846			F		1	1.2	-	0.1	3.5
QDA			CND	6			210	E/O		3	-	0.002	0.0	0.0
QDA			CND	4			359			1	-	0.0007	0.0	0.0
QDM	damper manual(HVAC)	.									-	-	-	-
QFH	fan cooler reactor building cooling unit	.	CH	2	0.028			X		1	36.0	-	1.8	107.8
QFH		.	CH	2	0.028				B	1	36.0	-	1.8	107.8
QFH		.	CH	2	0.028				K	10	359.8	-	195.2	565.1
QFH		.	SLO	1		0.020		R		5	250.0	-	214.4	457.7
QFV	fan containment ventilation fan	.	CND	5		0.688		R		1	1.5	-	0.0	4.4
QFV	fan containment I&C controls		CND	5		0.081		R		18	222.2	-	188.5	314.8
QFV											-	-	-	-
QVA	hvac unit auxiliary building	.									-	-	-	-
QVB	hvac unit battery room ventilation	.									-	-	-	-
QVE	hvac unit electric equipment area ventilation	.									-	-	-	-
QVR	hvac unit control room ventilation	.	A	1	0.099			F		1	10.1	-	0.5	30.2
QVS	hvac unit reactor hall	.									-	-	-	-
		.									-	-	-	-
RAA	relay auxiliary	.									-	-	-	-
RAS	solid state relay	.									-	-	-	-
RCA	relay control AC	.									-	-	-	-
RCD	relay control DC	.									-	-	-	-
RCL	relay control	.									-	-	-	-

			Reactor	Components	Cummulative calendar time	Cummulative operating time	Demands	Failure modes		Failures	Failure rate	Failure probability	90% Confidence bounds	
code	component type description		code	#	Mill.h	Mill. h	#	crit	deg	#	1e-6/h	1/demand	5%	95%
RPH	relay power 300-460 A	.									-	-	-	-
RPL	relay power 40-60 A	.									-	-	-	-
RRA	relay protective	.									-	-	-	-
RRF	relay, frequency protection	.									-	-	-	-
RRO	relay, overload protection	.									-	-	-	-
RRV	relay, voltage protection	.									-	-	-	-
RTA	relay time delay	.	VN	6			6438	C		1	-	0.000	0.0	0.0
RTB	relay time delay bimetallic	.									-	-	-	-
RTP	relay time delay pneumatic	.									-	-	-	-
RTS	relay time delay solid state	.									-	-	-	-
RWA	relay, general	.	IN-B	2	0.242			F		2	8.3	-	1.5	19.6
RWA		.	IN-S	939	62.875			F		9	0.1	-	0.1	0.2
RXA	relay contacts	.	IN-B	1	0.121			F		1	8.3	-	0.4	24.8
RYA	relay coil	.									-	-	-	-
		.									-	-	-	-
SAA	switch, general	.									-	-	-	-
SAM	micro switch	.									-	-	-	-
SCC	switch contacts	.	IN-Y	9	0.634			F		4	6.3	-	2.2	12.2
SCC		.	IN-B	26	3.142			F		7	2.2	-	1.0	3.8
SCC		.	IN-S	35	2.344			F		25	10.7	-	7.4	14.4
SDA	switch digital channel pressure / vacuum, pressure, level	.	CH	2	0.028				K	1	36.0	-	1.8	107.8
SFA	switch flow	.	VN	4			1624		F	1	-	0.000	0.0	0.0
SIA	switch limit	.	AUS	52	3.848			F		23	6.0	-	4.1	8.2
SIA		.	AUS	52	3.848				K	1	0.3	-	0.0	0.8
SI2	limit switch	.	AUS	6	0.444			F		2	4.5	-	0.8	10.7
SI2		.	AUS	6	0.444				B	4	9.0	-	3.1	17.5
SIE	switch limit electronic	.									-	-	-	-
SLA	switch level	.	CH	1		0.013			B	3	224.8	-	190.4	471.7
SLA		.	AUS	9	0.666			C		9	13.5	-	7.0	21.7
SLA	level switch	.	AUS	6	0.444			E		2	4.5	-	0.8	10.7
SMA	switch manual	.	VN	8		0.107			K	2	18.7	-	9.4	44.4
SMA		.	IN-B	13	1.571			F		12	7.6	-	4.4	11.6
SMA		.	IN-S	17	1.138			F		7	6.1	-	2.9	10.4
SPA	switch pressure	.	AUS	3	0.222			F		2	9.0	-	1.6	21.4
SPA		.	AUS	3	0.222				B	4	18.0	-	6.2	34.9
SPA		.	AUS	3	0.222				K	2	9.0	-	1.6	21.4
SQA	switch torque	.									-	-	-	-
STA	switch temperature	.									-	-	-	-
		.												-
TAA	transformer	.	CND	2	0.600					0	1.2	-	0.0	5.0
TA2	transformer 220/120 V	.									-	-	-	-

			Reactor	Components	Cummulative calendar time	Cummulative operating time	Demands	Failure modes		Failures	Failure rate	Failure probability	90% Confidence bounds	
code	component type description		code	#	Mill.h	Mill. h	#	crit	deg	#	1e-6/h	1/demand	5%	95%
TA6	transformer 6kV/380V	.	PRC-M	2		0.436		F		6	13.8	-	5.9	24.1
TEA	transformer 1000 kVa	.	CND	1	0.300			F		0	2.3	-	0.0	10.0
TEA	transformer 500 kVa	.	CND	2	0.600			F		0	1.2	-	0.0	5.0
TIC	transformer (instrument transformer, current transformer)	.	IN-S	431	28.860			F		2	0.1	-	0.0	0.2
TIP	transformer instrument potential	.									-	-	-	-
		.									-	-	-	-
		.									-	-	-	-
TVA	regulating transformer	.									-	-	-	-
		.									-	-	-	-
UCA	controller	.									-	-	-	-
UCE	controller electronic	.									-	-	-	-
UCF	flow controller	.									-	-	-	-
UCP	controller pneumatic	.									-	-	-	-
UEH	solid state devices high power application	.									-	-	-	-
UEL	solid state devices low power application	.									-	-	-	-
UEY	isolating diode assembly	.									-	-	-	-
UIA	analog display	.	IN-Y	46	3.242			F		4	1.2	-	0.4	2.4
UID	digital instrument	.	VN	2		0.027		F		1	37.5	-	24.1	112.2
UIE	indicating instrument electronic	.	IN-B	37	4.472			F		20	4.5	-	3.0	6.2
UIL	indication lamp	.									-	-	-	-
UIM	CRT screen, monitor	.									-	-	-	-
UIR	recorder	.	VN	5		0.067		F		20	299.7	-	259.9	417.7
UIR		.	IN-S	2	0.134			F		3	22.4	-	6.1	47.0
UIR		.	IN-B	1	0.121			F		1	8.3	-	0.4	24.8
UIR		.	IN-Y	4	0.282			F		1	3.5	-	0.2	10.6
UIX	other ind. instr.	.	VN	2		0.027			B	30	1123.8	-	900.0	1481.2
UIX		.	IN-S	2	0.134			F		14	104.5	-	63.2	154.3
UIX		.	PRC-M	6		0.439		F		1	2.3	-	0.1	6.8
		.									-	-	-	-
UMC	manual control device pushbutton	.	CH	1	0.014			X		1	72.0	-	3.7	215.6
UMC		.	VN	13		0.174			K	1	5.8	-	1.1	17.3
UNA	annunciator	.	CH	1	0.014			X		4	287.9	-	98.3	558.0
UNA		.	VN	1		0.013		F		1	74.9	-	55.2	224.4
UNS	annunciator module solid state, LED-, LCD-display	.									-	-	-	-
URS	reactor scram system	.	CH	1	0.014			K		1	72.0	-	3.7	215.6
URS		.	CH	1	0.014			X		1	72.0	-	3.7	215.6
		.									-	-	-	-
VA1	valve air operated	.	CND	2			560	E/O		4	-	0.004	0.0	0.0

			Reactor	Components	Cummulative calendar time	Cummulative operating time	Demands	Failure modes		Failures	Failure rate	Failure probability	90% Confidence bounds	
code	component type description		code	#	Mill.h	Mill. h	#	crit	deg	#	1e-6/h	1/demand	5%	95%
VA1			CND	2		0.560		E/O		4	7.1	-	2.2	13.8
VAR	valve air operated all systems except raw water return line	.									-	-	-	-
VCA	valve self operated check	.	PRC-M	7		0.509		F		2	3.9	-	0.4	9.3
VCA		.	PRC-H	3		0.224		F		5	22.4	-	12.3	40.9
VCA			CND	8		2.000		E/O		2	1.0	-	0.0	2.4
VCA			CND	8			512	E/O		2	-	0.0005	0.0	0.0
VDA	valve solenoid operated	.	AUS	15	1.110			F		5	4.5	-	1.8	8.2
VDA		.	AUS	15	1.110				K	1	0.9	-	0.0	2.7
VDA		.	AUS	15	1.110			Y		8	7.2	-	3.6	11.8
VD2		.	AUS	2	0.148			Y		1	6.8	-	0.3	20.2
VEA	valve explosive operated	.									-	-	-	-
VHA	valve hydraulic operated	.									-	-	-	-
VMA	valve motor operated	.	A	1	0.099			E		2	20.2	-	3.6	47.8
VMA		.	VN	6			1863	E		1	-	0.0001	0.0	0.0
VMA		.	VN	6			5589	O		3	-	0.0001	0.0	0.0
VMA		.	PRC-M	7		0.509		O		4	7.9	-	2.2	15.2
VMA		.	PRC-M	7		0.509		I		2	3.9	-	0.4	9.3
VMA		.	PRC-M	7		0.509		D		0	1.4	-	0.0	5.9
VMA		.	PRC-H	3		0.224		A		0	3.1	-	0.0	13.4
VMA		.	AUS	3	0.222				B	3	13.5	-	3.7	28.4
VMA	(30 cm diameter)		CND	16	2.100			F		1	0.5	-	0.0	1.4
VMA	(15 cm diameter) mech. fail.		CND	6		0.840	190	C		5	6.0	0.004	1.1	10.9
VMA	(15 cm diameter) electrical fail		CND	6		0.840	190	F		3	3.6	0.003	0.4	7.5
VPA	valve piston operated	.									-	-	-	-
VRA	valve relief	.									-	-	-	-
VSA	valve safety	.									-	-	-	-
VWA	valve angle valve	.									-	-	-	-
VWB	ball valve	.	AUS	6	0.444			K		2	4.5	-	0.8	10.7
VWB		.	AUS	6	0.444			Y		1	2.3	-	0.1	6.7
VWG	valve gate	.	CZ	20		0.126		F		7	55.6	-	39.0	94.0
VWG		.	CZ	20		0.126		Y		1	7.9	-	2.2	23.8
VWG		.	PRC-M	10		0.142		D		1	7.1	-	2.2	21.1
VWJ	valve plug valve	.									-	-	-	-
VWL	valve globe valve	.									-	-	-	-
VWN	valve needle valve	.									-	-	-	-
VWP	valve diaphragm	.									-	-	-	-
VWT	valve butterfly valve	.	AUS	5	0.370				B	58	156.7	-	124.5	192.1
VWT		.	AUS	5	0.370			F		17	45.9	-	29.3	65.7
VWT		.	AUS	5	0.370			Y		8	21.6	-	10.8	35.5
VWU	valve nozzle valve	.									-	-	-	-
VXA	valve manual	.	A	30	2.975			F		1	0.3	-	0.0	1.0

			Reactor	Components	Cummulative calendar time	Cummulative operating time	Demands	Failure modes		Failures	Failure rate	Failure probability	90% Confidence bounds	
code	component type description		code	#	Mill h	Mill h	#	crit	deg	#	1e-6/h	1/demand	5%	95%
VXA			PRC-M	5		0 363			B	2	5 5	-	1 1	13 1
VXA			PRC-H	76		5 668			B	26	4 6	-	0 7	6 2
VXA		.	AUS	2	0 148			F		2	13.5	-	2 4	32.0
VXA			AUS	2	0 148			Y		2	13 5	-	2 4	32.0
											-	-	-	-
WAA	*shielding general*	.									-	-		-
WFA	shielding irrad. fuel										-	-	-	-
											-	-	-	-
XAA	fuel element, general	.									-	-	-	-
XAM	*MTR fuel element, general*	.	CH	60	0 834			B		11	13 2	-	7 4	20 3
XAT	TRIGA fuel element, general										-	-	-	-
XBM	MTR stand. refl.element Be metal										-	-	-	-
XBN	MTR stand. refl.element Be oxid										-	-	-	-
											-	-	-	-
XCA	fuel element handling tool, gen										-	-	-	-
XCM	fuel element handling tool, manual		A	1	0 099			X		2	20.2	-	3 6	47.8
XCM			IN-B	2	0 242			F		1	4 1	-	0 2	12 4
XCR	*fuel element handling tool, remote*										-	-	-	-
XHA	fuel element HEU general										-	-	-	-
XHM											-	-	-	-
XHN											-	-	-	-
XHO											-	-	-	-
XHP											-	-	-	-
XHT	Fuel element TRIGA, stand. FLIP		A	9	0 892			Y		1	1 1	-	0 1	3 4
XMM		.									-	-	-	-
XMN		.									-	-	-	-
XMO		.									-	-	-	-
XMP		.									-	-	-	-
XMR	fuel element rod type MEU	.	PRC-M	195		3 566				0	0.2	-	0 0	0 8
XLA	fuel elm. LEU, general										-	-	-	-
XLM		.									-	-	-	-
XLN		.									-	-	-	-
XLO		.									-	-	-	-
XLP		.									-	-	-	-
XLT	Fuel element TRIGA, stand LEU	.	A	85	8 429			Y		4	0.5	-	0 2	0.9
XLT		.	IN-Y	143	10 080			Y		1	0.1	-	0 0	0.3
XLU	Fuel element TRIGA, instr. LEU	.									-	-	-	-
XPA	fuel element process tube, gen	.	PRC-H	81 71		6.094		J		9	1.5	-	0.0	2.4
XRM	Refl. element graphite, MTR	.									-	-	-	-
XRT	Refl. element graphite, TRIGA	.									-	-	-	-
XTM	Tail. element MTR standard	.									-	-	-	-
		.									-	-	-	-

			Reactor	Components	Cummulative calendar time	Cummulative operating time	Demands	Failure modes		Failures	Failure rate	Failure probability	90% Confidence bounds	
code	component type description		code	#	Mill.h	Mill. h	#	crit	deg	#	1e-6/h	1/demand	5%	95%
YAA	air filter	.									-	-	-	-
YFD	demineralizer	.	IN-Y	1	0.070			F		3	42.6	-	11.6	89.3
YFM	filter liquid, mechanical restriction	.	IN-Y	1	0.070			Q		3	42.6	-	11.6	89.3
YFM		.	IN-S	12	0.804			Q		27	33.6	-	23.7	44.9
YFM		.	IN-B	2	0.242			Q		4	16.5	-	5.7	32.1
YFX	Ion exchanger filter	.	CH	4	0.056			Y		1	18.0	-	0.9	53.9
YFX		.	IN-B	2	0.242			F		5	20.7	-	8.2	37.9
YFX		.	IN-S	10	0.670			Q		1	1.5	-	0.1	4.5
YSF	strainer / filter	.	IN-B	2	0.242			Q		1	4.1	-	0.2	12.4
YSF		.	IN-S	23	1.540			Q		11	7.1	-	4.0	11.0

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CONTRIBUTORS TO DRAFTING AND REVIEW

Böck, H.	Atominstitut der Österreichischen Universitäten, Austria
Dušek, J.	Nuclear Research Institute, Czech Republic
Hammer, J.	Paul Scherrer Institute, Switzerland
Li, Z.	China Institute of Atomic Energy, China
Mavko, B.	"Jozef Stefan" Institute, Slovenia
Suprawardhana, M.S.	Yogyakarta Nuclear Research Centre, Indonesia
Tomic, B.	International Atomic Energy Agency
Van Lam, P.	Dalat Nuclear Research Institute, Viet Nam
Winfield, D.	AECL Research, Canada
Witt, H.	Australian Nuclear Science and Technology Organization, Australia