IAEA TECDOC SERIES

IAEA-TECDOC-1922

IAEA-TECDOC-1922

Reliability Data for Research Reactor Probabilistic Safety Assessment

Final Results of a Coordinated Research Project

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RELIABILITY DATA FOR RESEARCH REACTOR PROBABILISTIC SAFETY ASSESSMENT

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IAEA-TECDOC-1922

RELIABILITY DATA FOR RESEARCH REACTOR PROBABILISTIC SAFETY ASSESSMENT

FINAL RESULTS OF A COORDINATED RESEARCH PROJECT

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2020

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FOREWORD

The need for a reliability database specifically for nuclear research reactors for use in probabilistic safety assessment (PSA) has been widely acknowledged since the mid-1980s. A past IAEA coordinated research project (CRP), carried out from 1989 to 1993, addressed this need and resulted in the publication of Generic Component Reliability Data for Research Reactor PSA (IAEA-TECDOC-930).

This publication is the result of a CRP to update and expand the IAEA's reliability data for research reactor PSAs, carried out from 2001 to 2004. The goal of this CRP was to update the information in IAEA-TECDOC-930 with the participation of additional research reactors and to provide a wider range of reliability data. The CRP had participants from 11 Member States — Argentina, Austria, Australia, Brazil, Canada, Czech Republic, India, Indonesia, Republic of Korea, Romania and Viet Nam — and covered a variety of research reactors in terms of type, size, design and utilization.

The current publication updates the information in IAEA-TECDOC-930 and provides information on a wider range of issues pertaining to reliability data for research reactor PSA. Accordingly, in addition to component reliability data, it provides information relating to the preparation and application of data on initiating events, human reliability, common cause failures and the reliability issues of digitalized systems.

The main focus of this publication is the component reliability database provided in the annexes, including the data collected by the CRP participants. Data provided in IAEA-TECDOC-930 by Member States that did not participate in the current CRP are also provided.

The IAEA would like to thank all the CRP participants for their valuable contributions to this publication. The IAEA officers responsible for this publication were D.V. Rao and A.M. Shokr of the Division of Nuclear Installation Safety.

CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

Probabilistic safety assessment (PSA) has been recognized as an effective tool for integrated safety assessment of nuclear installations since mid-1980s. Ref. [1] states “Probabilistic safety analysis may be used as a complementary tool for detecting potential weaknesses and improving the safety assessment.” A reliability database is a crucial element for facilitating the conduct of PSA. The IAEA carried out a Co-ordinated Research Project (CRP) during 1989 to 1993 to foster PSA utilization for research reactors and to prepare a generic component reliability database. A procedure for generating component reliability data from field operation experience and a generic component reliability database which had been collected and compiled based on field data were included in the IAEA-TECDOC-636 [2] and the IAEA-TECDOC-930 [3] respectively, which were published as the end products of the CRP.

In 2000, the necessity of updating the reliability database led to the launch of a new CRP entitled “To update and expand the IAEA reliability database for research reactor PSAs”. A total of eleven countries participated and contributed to the collection and compilation of component and system reliability data based on their operational experience. Three research co-ordination meetings took place; Korea (2001), Argentina (2003) and Indonesia (2004) to exchange and compile reliability data collected by the participant institutes.

1.2. OBJECTIVES

The current IAEA-TECDOC is the result of the CRP “To update and expand the IAEA reliability data for research reactor PSAs”, aimed at the following objectives:

- Expanding the target components and systems for which reliability data is provided;
- Enhancing the accuracy and the quality of the reliability data by taking into account the operating experience of the research reactors of member countries participating in the CRP; and
- Expanding the technical information provided on data preparation and on the use of data for research reactor psa and other applications.

1.3. SCOPE

This current TECDOC updates information in the TECDOC-930 and has a broader scope in that it provides information on a wider range of issues pertaining to reliability data for research reactor PSA. Accordingly, in addition to component reliability data, the TECDOC provides information related to preparation and application of data on initiating events, human reliability, common cause failures and the reliability issues of digitalized systems.

1.4. STRUCTURE

The TECDOC, in addition to this introductory section on the background, objectives and scope, includes two main thematic sections. The first one, section 2, provides detailed generic information on data preparation issues, application, and uses of research reactor reliability data. The second, section 3, provides detailed information on the specific collection methods of member state facilities and usage of the collected reliability data. Seven annexes provide the following supporting information:

Annex I Contributing research reactor facility information;
Annex II Component and failure parameter coding information;
Annex III Common cause failure examples;
Annex IV Human error data examples;
Annex V Statistical data analysis;
Annex VI Generic component reliability data for research reactor PSA;
Annex VII Examples of failure data algorithms used in database Table VI–1.

Annex VI provides the tabular listing of the final reliability data collected from the Member States contributing to the CRP. Annex VII provides a discussion of the algorithms used in Annex VI, to aid users wishing to setup their own facility-specific database.

2. INFORMATION ON PREPARATION AND APPLICATION OF RELIABILITY DATA FOR RESEARCH REACTORS

2.1. INTRODUCTION

Many different types of data are required for the conduct of a PSA. Ref. [4] para 5.121–5.139 provide recommendations on the required data for a level 1 PSA for nuclear power plants. Ref. [5] provides detailed information on PSA elements. Section 2.2 (below) and its subsections describe issues related to the preparation of reliability data for PSA of research reactors. Information is provided on the following topics, which form the elements of a PSA:

- Initiating events;
- Component reliability data;
- Human reliability data;
- Common cause failure data;
- Reliability issues of digitalized systems;
- Data collection programme requirements and problems; and
- Generic equipment reliability databases.

Section 2.3 describes issues related to the applications and use of reliability data.

2.2. RELIABILITY DATA PREPARATION ISSUES

Sections 2.2.1. to 2.2.5. discuss data preparation issues applicable to important aspects of a PSA. Section 2.2.6. discusses data collection programme requirements and typical problems encountered. Section 2.2.7. discusses generic reliability databases.

2.2.1. Initiating events

The identification, screening, grouping and frequency evaluation of initiating events (IEs) is one of the important tasks to be accomplished in a PSA study, and this section provides information on this issue. The general methodology is similar to that followed for nuclear power plants [4]. However, there are some aspects, which are specific to research reactors, and their experimental facilities. For example, the potential for reactivity insertion events and different potential modes of reactor operation, such as pulsed mode, may need to be included while formulating a list of initiating events. There are numerous definitions for IEs given in the PSA literature. However, in the context of research reactor safety the definition of an initiating event is taken from the IAEA Safety Glossary as:

"An identified event that leads to anticipated operational occurrences or accident conditions".

While it is intended to provide the reader with an overview of different approaches to defining, grouping and quantifying IEs, it is left to those performing the PSA to select the most appropriate approach for their application.

Information is provided on the following aspects:

- Identification of initiating events;
- Screening and grouping of initiating events;
- Determination of initiating event frequency, and
- Quality assurance programme for the selection, grouping and categorization of initiating events.

2.2.1.1 Identification of initiating events

The IEs can comprise hardware failures in the facility, mal-operation of facility hardware through human errors or due to man-machine interface problems, or events originating outside the facility that create extreme environments. Examples of the latter include earthquakes, external fire or flood and aircraft impact on the reactor structure. Ref. [4] para 5.11–5.39 provide detailed recommendations on selection of IEs for internal events. Section 6 of Ref. [5] provides detailed information on analysis of IEs.

Some of the methods that are used for the identification of IEs are:

(a) Analytical methods such as failure mode and effects analysis (FMEA) to predict component failure modes that can impose important initiating events with respect to system performance;
(b) Deductive analysis such as master logic diagram, Ref [6] provides details of the method;
(c) Comparison with the list of IEs for similar facilities;
(d) Analysis of facility operating experience;
(e) Review of the safety analysis report including design basis accident analysis and design extension conditions.

Reference to available IEs lists from generic sources, or from a previous PSA on the facility, are useful, as starting points in compiling an up-to-date list of facility-specific IEs.

Each of the above approaches allows potential IEs to be extracted from a different perspective, thus yielding a high degree of confidence that a comprehensive and complete list of IEs can be identified.

A list of selected postulated initiating events for research reactors is given in the IAEA Specific Safety Guide SSG-20, [7] for reference. Many lists of IEs used in PSAs for nuclear power plants are also available in the literature. The latter lists are particularly useful for determining initiating events originating outside the facility.

2.2.1.2 Screening and grouping of initiating events

The use of section 2.2.1.1. may generate a very large number of initiating events, which then may require some screening and grouping in order to make the subsequent analytical processes manageable. The screening process involves an assessment of the likelihood of the initiator and the probability of failure of the defences against propagation of the accident sequence, to make an informed judgement about whether or not a certain identified initiating event can be screened out. Ref. [4] para 6.14–6.25 provide recommendations on screening of hazards for PSA.

The grouping of initiating events is made in such a way that all events in the group impose the same success criteria on safety systems as well as the same special conditions and shall result in the same undesired event or some other defined end state. Ref. [4] para 5.32–5.39 provide recommendations on grouping of IEs.

2.2.1.3 Determination of initiating event frequency

Sometimes there are special features of the facility and its location, which must be considered. This approach has special significance for research reactors as the specific design and type of the facility makes it necessary to analyse special features and the possibility that these contribute to the initiating events. For example, loss of off-site power frequency will always be dependent on the particular site and the facility connection to the grid so that operational experience is essential for this particular type of event.

Other examples are experimental facilities, such as pressurized water loops, which could contribute to a radioactivity release. The pulsed power operational capability of some research reactors also has the potential for reactivity related accidents. These factors have to be considered in determining the IEs frequencies.

Some of the methods for the quantification of IEs frequencies are given below:

(a) Mean frequencies of frequent operational occurrences

Utilizing facility-specific mean values for the frequent operational occurrences is the classical approach for the estimation of failure frequency of an initiating event. This is a common approach used for quantification of anticipated transients, which have frequencies high enough that operational data actually exists. If the data available from facility specific sources is of high enough frequency, then this approach is a very reliable method of estimating the frequency of initiating events. The data for this approach is obtained from the facility's historical records of failures and abnormal occurrences.

(b) Bayesian updating methods

When facility-specific information is not available, for example for a new facility, and only generic data on the initiating events of similar facilities is available, a one-stage Bayesian analysis may be performed. In such analysis the number of failures and the duration of time in which the failures occurred are input evidence used to update a prior distribution. The resulting posterior distribution is a generic distribution of the IEs frequency that can be expected for the new facility. This approach can also be used if data from a facility of similar type/design is available**.**

When facility specific data of the number of failures and the observation time is available, a two-stage Bayesian analysis can be performed. The distribution obtained by the earlier described process is now taken to be the prior generic distribution and the facility specific data is new evidence used to update the generic distribution to obtain a facility specific distribution of the failure frequencies. Ref. [8] provides further information.

(c) Expert judgement

Expert judgement may be used to obtain an estimate of the frequency of an event that has not been observed from facility experience.

Large uncertainties are associated with expert judgement, so that the use of this approach requires careful planning and documentation to allow peer review. There are mathematical methods available in the literature for the conversion of expert judgement expressed in qualitative terms to the quantified estimates. Fuzzy logic is one of the methods that can be used to covert the qualitative terms, e.g., very low, low, medium and high, into probability estimates. Review of such methods is outside the scope of this TECDOC.

(d) Frequency estimation by evaluation of failure rates and mission times

This approach is used to evaluate the initiating event frequency resulting from failures of specific items of equipment in a facility. The cases of valve casing leaks and pipe breaks or leakages in a certain facility location and internal flooding are examples. In these cases, valves and pipe failure rates are searched for the applicable values for the particular facility, based on quality, type and size. In some cases, analytical or empirical engineering models may be used to derive failure rates of equipment, e.g., probabilistic fracture mechanics.

If a facility has not experienced a particular type of an initiating event, the frequency can be predicted using fault tree analysis, synthesising the event from logical combinations of other, lower level events, for which failure data could be found. A fault tree can in principle be constructed to include all equipment and human errors contributing to the initiating event. Using facility specific failure rate data on components and assessed human error probabilities, the frequency of the IEs can then be estimated. Generic component failure data given in this TECDOC or any other generic failure rate data could be used, if facility specific component failure data is not available.

2.2.1.4 Quality assurance programme

Given that the quality of initiating event data is of great importance, it is useful to implement an appropriate quality assurance programme. Para 3.13–3.14 and Para 10.70–10.75 of Ref. [4], and section 1.3 of Ref. [5] provide the attributes on a quality assurance programme for PSA. This sub-section provides some quality assurance guidelines for the selection of initiating events and their quantification.

(a) Initiating Event Identification Task

A reasonably complete set of initiating events may be compiled by a structured and systematic approach, as outlined in Section 2.2.1. This has to ensure that no significant initiating event is omitted.

Additionally, a quality assurance check has to then ensure that:

(i) Initiating events obtained from generic source are evaluated to check applicability to the facility being studied;
(ii) Experience from similar facilities are reviewed to check applicability to the facility being studied;
(iii) Facility-specific IEs experience are reviewed to ensure that root cause initiating events are valid;
(iv) IEs induced by human error are considered;
(v) IEs precursors are accounted for to help identify IEs, and
(vi) Different operational states of the facility are included in the identification of IEs.

(b) Initiating Event Grouping

Using a structured and systematic process the raw IEs are grouped according to similar characteristics, in terms of facility response, requirements and consequences.

(c) Initiating Event Frequency Assessment

Attributes associated with the IEs frequency assessment are:

(i) Facility specific and generic data are used in justifiable manner.
(ii) Initiating event precursors, to provide a partial basis for quantifying their frequencies, are considered.
(iii) For rare initiating events (frequency $<10^{-4}$ /reactor-year), industry generic data are used, augmented with specific probabilistic analysis, (e.g., fracture mechanics).
(iv) Initiating event frequencies are calculated on a reactor-year basis. For initiating events initiated only at power the frequency may have to be corrected by the fraction of time the reactor is at power.
(v) For frequent initiating events some time trend analysis has to be used to account for any quantifiable historic trend, e.g., reactor trip frequency change or loss of offsite power frequency change.
(vi) Initiating events dependent upon facility specific design features are subjected to fault tree modelling as the appropriate way to quantify them.
(vii) When using fault tree models for quantifying IEs frequency ensure that the fault tree models are such that the top event quantification is a failure frequency and not a failure probability (unavailability).

2.2.2. Component reliability data

Component reliability data is used in PSA for modelling of equipment failure probability, unavailability of safety systems and for estimating initiating event frequencies.

Component reliability data can be derived from either generic data or from facility specific data or a combination of both. Generic data derived from failure histories of other facilities though may reflect well the characteristics of a target reactor facility. Facility specific data is obtained from maintenance and failure records. Section 2.3.9. discusses some of the problems related to selection of data, i.e., facility specific or generic, for PSA.

Component reliability data include parameters such as failure rate, failure per demand, unavailability, maintenance and test intervals, average maintenance time, and average out-of-service time. The information needed to derive these parameters include: number of failures of each failure mode, the accumulated operation time or the number of demands over a period of interest, repair or maintenance outage times, and the population of items for which the data is collected.

This TECDOC provides (in Annex VI) generic failure rates for many component types based on the operational experience of a variety of research reactors of the participant countries, collected as part of the CRP. Relevant information of these reactors to specific data collection issues of the participant countries is given in Annex I. General data collection methods and related issues are discussed in Section 2.2.6. In most cases maintenance records formed the basic data from which the generic data have been derived. Section 2.2.6. covers the practical problems experienced by the CRP participants during the data collection and analysis process. Section 2.2.7. discusses sources of generic reliability data for PSA. Sections 2.3 provides information on the use and applications of reliability data.

2.2.3. Human reliability data

2.2.3.1 Introduction

The use of human reliability data is an important part of a research reactor PSA. In the following subsections, human reliability analysis (HRA) is briefly discussed. There are several methods that can be used. As example, the two frequently used general approaches to HRA are introduced below. Since a very important part of every HRA approach is quantification of human error probabilities, some of the most common quantification methods are summarized to provide the reader with a comparative understanding of how the various methods are implemented. The reader is referred to the HRA references for a detailed implementation of HRA. Some examples of human error data are described in Annex IV, but the scope of this publication does not include quantitative derivation of human error data.

2.2.3.2 General approaches to HRA

Two HRA methods are discussed in this section. The first method is ‘Systematic Human Acting Reliability Procedure’ (SHARP) and the second method is ‘A Technique for Human Event Analysis’ (ATHEANA).

SHARP

SHARP methodology [9, 10] provides a general framework for human reliability analysis. Although developed as first-generation method in the early 1980s, SHARP remains a very useful tool, which still covers current issues associated with HRA.

The approach consists of the seven steps listed below:

– Identification

At the beginning of the analysis, all human actions with a potentially significant impact on the risk are identified. The identification can be based on system analysis, on pre-defined basic human action taxonomies, or on operational experience.

– Screening

All identified human actions are included into the PSA model and conservatively quantified on the basis of pure expert judgement as part of an initial screening. Those actions that are found to be significant are then analysed further within the next steps of SHARP.

– Qualitative analysis

Detailed information about the external conditions (influencing factors) of human actions not screened out is gathered and treated qualitatively. This activity includes facility walk-downs and intensive communication with operating staff.

– Formal model development

A separate unique formal model is constructed for every human action, where the analysed action is split into very basic elements. This activity can include the development of a graphical representation or application of basic rules for combinations of probabilities.

– Integration

Potential changes in the facility model may be discussed on the basis of qualitative analysis of the given action. It may be necessary to include several variants of the action into the PSA model. Therefore, some fault trees or event trees may need to be modified or extended. A preliminary qualitative analysis of dependencies is performed in this step, as well.

– Quantification

Final quantification of all human actions is performed in this step. All dependencies among human actions are incorporated from the point of view of quantification.

– Documentation

The analysis results are comprehensively documented, with attention being paid to auditability of data.

ATHEANA

ATHEANA [11] belongs to the second generation of HRA methods. SHARP provides the basic framework for research reactor PSA, but some important aspects of HRA emphasised in ATHEANA need to be addressed. Specialists performing HRA analysis for research reactor PSAs are expected to be familiar with the different methods and use what is best suited for their research reactor.

ATHEANA introduces the concept of error forcing context (EFC), defined as combinations of facility conditions and other influences upon the likelihood of operator error. According to SHARP, a potential for human error is given by the characteristics of the given task. According to ATHEANA, the potential for human error is determined by the context of the given action. Performance Shaping Factors (PSFs) were used in SHARP in a similar, but simpler, application.

ATHEANA is applied in two different approaches: the retrospective approach (when analysing events that have already occurred) and the prospective approach (for anticipated events).

When used in its prospective approach, ATHEANA requires the use of EFCs. ATHEANA identifies the (unexpected) facility conditions that, coupled with relevant PSFs, can have significant impact on human actions, enabling a wide range of error types. By using EFCs quantification becomes an issue of calculating the likelihood of specific facility conditions, for which unsafe actions are much more likely than would be so under anticipated (expected) conditions.

An additional category of human errors is introduced in ATHEANA; errors of commission, i.e., errors caused by carrying out unintended human actions.

2.2.3.3 Methods of quantification of human error probability (HEP)

The major difference of HRA from component reliability analysis is that no unique, generally recommended method exists for the quantification of human failure probabilities. Ref. [4] Para 5.96–5.113 provide the recommendations on the human reliability aspects related to PSA. Section 10 of Ref. [5] provides detailed information on attributes of HRA. Ref. [12] provides a standard for the probabilistic assessment of nuclear power plants (NPPs). Although produced for NPP, the standard is also applicable for the evaluation of PSA of other nuclear facilities including research reactors. The standard provides a broad spectrum of subjects, which has to be addressed in a credible HRA.

There are many approaches and models used in the HRA, with various advantages and disadvantages. Table 1 lists some of the methods used for estimating HEP. The main features are briefly discussed, highlighting the advantages and disadvantages, with some comments provided with respect to their use for research reactor PSA.

TABLE 1. SOME HUMAN ERROR PROBABILITY QUANTIFICATION METHODS

HEP Method	Main Features of HEP Method	Comments Relevant to HRA for Research Reactors
Accident Sequence Evaluation Programme (ASEP) [13]	ASEP methodology represents a shortened, simplified and up-dated version of the Technique for Human Error-Rate Prediction (THERP) developed in the mid-1980s. The main simplification was a reduction of the spectrum of performance shaping factors taken. In ASEP there are two dominant factors: the level of dynamics of the human action and the level of stress. A disadvantage of the method is that it has a very simplified and conservative analysis of dependencies.	The ASEP method provides approximate quantification of the probabilities of human error in the operation of research reactors, when a limited amount of analytical resources is at disposal. It has been recommended by the ASME-RA-S-2002 code, [12].
Human Error Assessment and Reduction Technique (HEART) [14]	This method was developed in the UK in the late 1980s. It has common features with the ASEP method, but the spectrum of influencing factors taken into consideration is far broader. The method consists of two steps. In the first step, the type of activity is selected from a HEART pattern and a basic nominal value of HEP is specified. In the second step, a broad spectrum of influencing factors is considered, with the aim of potential modification of the nominal HEP value in a conservative direction.	The HEART method defines many, abstract, influencing factors and requires fairly low personnel resource requirements to utilize. For every factor, a maximum multiplicative coefficient for correction of nominal probability value is provided. The HRA analyst can choose the maximum, or an arbitrary lower, coefficient. The final HEP value is thus highly dependent on expert judgement.
Cognitive Reliability and Error Analysis Method (CREAM) [15]	This method discussed here belongs to the so-called second-generation HRA methods developed in the second half of the 1990s. CREAM is the only comprehensive HRA approach that includes cognitive aspects of human reliability. The CREAM quantification technique is independent of any other HEP quantification method.	Although the subject of analysis, quantification of cognitive aspects of human behaviour, is normally considered to be a difficult and comprehensive task, the methodology application requires only a moderate level of time resources. The analyst follows the individual parts of CREAM in a sequential manner, using detailed guidance provided in the CREAM manual. From the perspective of a research reactor PSA, CREAM can be very helpful in the quantification of selected individual human actions with substantial cognitive potential.

Table 10.2 of Ref. [5] provides the main tasks for HRA. Human error actions that are expected to be modelled in a research reactor PSA [12] are:

- Pre-initiator human errors;
- Post-initiator human errors;
- Recovery actions.

Modelling requirements of these human error actions [12] are:

- Estimation of HEPs using a systematic process;
- Analysis of the quality of written procedures, administrative controls (independent reviews) and human machine interfaces, including component configuration, instrumentation and control layout;
- Provide assessment of uncertainty in HEPs;
- Check quantitative results in the light of facility history, procedures, operational practices and experience;

- Screening values may be used for HEPs in non-dominant accident sequences. Otherwise, perform detailed analyses;
- Use a model to estimate HEPs of cognitive failures as well as failures of execution;
- Post-initiator HEPs have to consider the following attributes; quality of operator training and experience (classroom/simulator); quality of written procedures and administrative controls; availability of instrumentation; need to take corrective actions; degree of quality of alarm /monitoring indications; human machine interface; time available and time required to complete the response; complexity of the required response; environmental conditions (lighting, heat, radiation) under which the operator works; and the necessity, adequacy and availability of special tools;
- Time points at which operators are expected to receive relevant indications have to be specified;
- Consistency of HEP quantification has to be checked given the scenario context from facility history, procedures, operational practices and experience;
- For multiple human actions required in an event, the degree of dependence has to be assessed;
- Take into account recovery and self-recovery potential.

2.2.4. Common cause failure data

Common cause, or dependent failures, may be large contributors to the undesired event frequency risk in the PSA evaluation of research reactors. This is because most research reactors, as with power reactors, are typically designed with significant defence in depth and with redundancy in many of the layers of defence. A major accident is thus only likely to occur if there are multiple failures across the various layers of defence, or within groups of redundant items. The probability of these multiple failures occurring randomly and coincidentally is usually insignificant, but the probability increases if dependant failures are considered. It is therefore important to have common cause (dependent) failure data and to be able to quantify the dependent failure frequency if possible.

The nature of common cause failures (CCF) however makes them quite difficult to quantify, and the availability of failure frequency data for these failures is scarce, as failure frequencies are low. Therefore, uncertainties associated with the data used in of common cause failure quantification are also very large and, in many cases may only be subjective. Some of common cause failure data examples are provided in Annex III; no quantification of associated failure rates is however provided.

Different types of common cause failures are discussed in section 2.2.4.1. Section 2.2.4.2 discusses inter-component dependencies and section 2.2.4.3, common cause failure models.

2.2.4.1 Types of common cause failures

Ref. [4] Para 5.92 to 5.95 provide recommendations on the treatment of common cause failures. Ref. [16] provides information on procedures for conducting common cause failure analysis in PSA. Ref. [8] identified 3 main types (and their subtypes) of common cause failures and provides the following analysis methods.

TABLE 2. ANALYSIS METHOD OF COMMON CAUSE FAILURES [8]

Common Cause Failure Type	Analysis Method
1. Common cause initiators	Event specific models and qualitative search.
2. Inter-system dependencies	
2A Functional dependencies	Event tree analysis or fault tree analysis.
2B Shared equipment dependencies	Event tree analysis or fault tree analysis.
2C Physical interactions	Event specific models, fault tree analysis or qualitative search and human reliability analysis.
2D Human interactions	Event tree analysis, fault tree analysis and human reliability analysis.
3. Inter-component dependencies	
3A Functional dependencies	Fault tree analysis, beta factor or binomial failure rate.
3B Shared equipment dependencies	Fault tree analysis.
3C Physical interactions	Event specific models or fault tree analysis or qualitative search and human reliability analysis.
3D Human interactions	Event tree analysis and fault tree analysis and human reliability analysis.

The types of common cause failures identified in Table 2 are briefly discussed in the following sections.

a. Common cause initiators

Common cause initiator is an initiating event and at the same time degrading one or more safety functions that may be needed to mitigate consequences of the accident. Typical examples are events such as earthquakes, internal floods, or internal fires. These common cause initiating events can be predicted with appropriate methods usually applied to NPPs. The common cause is then treated as a potential initiator of an event tree and by modifying the failure probability of individual components by their susceptibility to a specified common cause initiating event [8].

b. Intersystem functional dependencies

These types of common cause failures refer to systems that are considered in a PSA, which depend on another common system for support or actuation. An example is two active systems (such as containment isolation system and post-accident cooling for example) which both depend on a common support system, (e.g., electrical power system).

Such dependencies can be easily incorporated in an event tree by an appropriate definition of the event tree models. If the dependence is complete, i.e., there is a definite failure or success of an event, given the occurrence of another event, there is no need for further analytical treatment. If the dependency is not complete, the dependency has to be modelled as for shared equipment dependencies.

c. Shared equipment dependencies

Shared equipment dependency refers to dependency between systems, which use common equipment, e.g., an electrical power supply transformer. Such dependencies can be treated by appropriate definition of a system fault tree model.

d. Physical interactions

Physical interaction failures can be incorporated as dependencies in a fault tree, and if these dependencies are complete, i.e., definite failure or success of an event, given the occurrence of another failure event, then the dependency can be handled by appropriate fault tree modelling and no further analytical treatment is needed. An example would be that of a component whose failure causes another component to fail (e.g., failure of the high voltage supply of an ion chamber; the lack of high voltage supply then causing the ion chamber to fail).

e. Human interactions

Human interactions are failures affecting several components or systems that depend on one or more operator actions to be successful. An example would be an operator requirement to close several redundant valves, but the switch handle position indication is misread and all the valves are opened simultaneously, in error.

These kinds of common cause failures can be analysed using standard techniques for human error assessment and quantification, as discussed in section 2.2.3, and can be explicitly modelled in the fault trees of a PSA.

Probability models for human interactions are based on task analysis and various studies of human failure in specific steps of a task. Methods such as SHARP, HEART and ATHENA are available, see section 2.2.3. This approach is based on modelling of identified human interaction events in the fault trees of a PSA as human error events, the probability of which are then quantified using Human Reliability Analysis (HRA) techniques using human error rates from internationally accepted generic databases. In summary, the method attempts to model explicitly the underlying causes of CCF events in the PSA.

This modelling covers such possible errors as “Operator inadvertently opens wrong valve” or “Operator inadvertently leaves system inoperable after test”, or “Instrument technician incorrectly calibrates all pressure transmitters after maintenance”.

f. Inter-component dependencies

These are event or failure causes that result in a common cause failure of multiple components or subsystems. The multiple failures of interest in risk analysis are usually within the same system or the same fault tree minimal cut set that has been identified for a system or an entire accident sequence, e.g., redundant equipment in a system. Dependent failure types 3A, 3B, 3C and 3D (for inter-component dependencies, see Table 2), are defined to correspond with failure types 2A, 2B, 2C and 2D, respectively (for inter-system dependencies), the difference being that multiple failures occur at the subsystem and component level instead of at the system level [8].

2.2.4.2 Common cause failure models for inter-component dependencies

There are several types of common cause failure models available to quantify inter-component dependencies. These can be grouped into two groups; traditional (parametric) models and so called innovative models. The traditional models are briefly described in this section. Innovative models are described in Section 2.2.4.3. The traditional models involve the quantification of CCF of a redundant system, without considering the physical causes of the dependencies. In general, the traditional models implicitly model CCF, using various quantitative parameters. The models vary from being simple to more complex in their use. For all models it is difficult to obtain objective CCF parameter data and may even be almost non-existent in practice for some CCF parameters.

(a) Basic Parameter Model

The most general of the commonly used parametric CCF models is the Basic Parameter Model (BPM), [16]. Other parametric models, see (b) to (e) below, can be characterized as re-parameterizations of this model. In the BPM model, a set of parameters $Q_k^{(m)}$ is defined as follows:

- $Q_k^{(m)}$ denotes the probability of a basic event involving *k* specific components (*1<= k <= m*) in a common cause component group of size *m*, i.e., the probability of *k* failures in CCF out of m items.
- The model is based on a symmetry assumption that the probabilities of similar basic events involving similar types of components are the same.

(b) Beta Factor Model (BFM)

In the *β*-factor method [14] the failure rate for each basic event can be expanded into independent and dependent (common cause failure) contributions.

$$\lambda = \lambda_{independant} + \lambda_{ccf} \quad (1)$$

The relationship between λ_{ccf} and λ is called β. Thus

$$\beta = \frac{\lambda_{ccf}}{\lambda} \quad (2)$$

then λ_{ccf} can be expressed as:

$$\lambda_{ccf} = \frac{\beta\, \lambda_{independant}}{1-\beta} \quad (3)$$

When the systems under consideration consist of more than dual redundancy, the β-factor method will provide conservative values. This is because the β-factor model does not distinguish between different numbers of multiple failures and the method does not produce any additional reliability credit for a redundant system, as the level of redundancy exceeds two.

Generic *β*-factors are available in the literature for types of components used in designs with redundant components (e.g., diesel generators, valves and instrumentation and controls). The available data is mostly based on nuclear power plant experience in the US in the early 1980's [28-31]. The application of generic *β*-factors may not be straightforward however as system designs and operating modes may not be comparable. Attention must be paid to the fact that the *β*-factors will in principle differ for different failure modes (e.g., failure to start, or failure to continue to run). Additionally, *β*-factors vary in principle according to the test scheme of the redundant components. Testing of redundant components may be either optimized staggered, random, or consecutive, or various combinations of these modes, with respect to the test interval. Data on generic *β*-factors however rarely provides any information on this aspect.

(c) Multiple Greek Letter Model (MGL)

The MGL model [17] is a generalized extension of the β-factor model. In this method, other parameters in addition to the *β*-factor, are introduced to distinguish among common cause events affecting different numbers of components in systems with two or more levels of redundancy. In principle, if parameter numerical values are available, the MGL model can provide a more accurate representation of system reliability than the *β*-factor model, as the extra conservatism of the β-factor method is removed, and the multiple redundancy levels are allowed for using additional parameters. The conditional probability that a CCF is shared by one or more components is designated by *β*; is *γ* if the CCF is shared by two or more components and is *δ* if the CCF is shared by three or more components. Ref. [17] provides further details.

Generic *β*-factors and the *γ*, *δ* parameters of the MGL model, are difficult to obtain because of the long periods required to collect CCF data with any statistical significance. As CCF data is inherently rare compared to individual component failure data, uncertainties on CCF data are also large and are rarely documented. Since there are more parameters in the MGL model than the *β*-factor model, and events with three or more common failures are quite rare, the uncertainties associated with MGL model data parameters are quite large, because an extensive data collection period is required to observe multiple failure events that have some statistical significance. The MGL model can be shown to reduce to the same as the β-factor model, in the case of a dual redundant system.

(d) Alpha Factor Model

The α-factor model [16] defines common cause failure probabilities from a set of failure frequency ratios and the total component failure probability. As with the MGL model the α-factor model provides a more rigorous reliability assessment of multiple redundant systems. The α-factor model parameters can all be shown to be related to the β, γ, δ parameters of the MGL model. In terms of the basic event probabilities, the alpha factor parameters are defined as:

$$a_k^{(m)} = \frac{\binom{m}{k} Q_k^{(m)}}{\sum_{k=1}^{m} \binom{m}{k} Q_k^{(m)}} \tag{4}$$

where $\binom{m}{k} Q_k^{(m)}$ is the probability of events involving k component failures in a common cause group of m components, and the denominator is the sum of all such probabilities, for k = 1 to m. In other words, $\alpha_k^{(m)}$ is equal to ratio of the probability of failure events involving any k components over the total probability of all failure events in a group of m components.

Details of the method are provided in Ref. [16] and Ref. [17]. The various α-factor model parameters are derived from historical data, i.e., by a count of the number of instances redundant components have failed individually and together in groups of 2, 3, 4 etc., over an observation period. The α factor model appears to be less used than the MGL model in the literature, probably because the parameter definitions are more complex than those of the MGL model.

(e) Binomial Failure Rate Model (BFR) [8, 17]

This model assumes the occurrence of a random shock that produces common cause failure with failure rate (μ) and that the resulting dependent failures are binomially distributed with parameter P. Thus, there are two parameters (μ and P) for BFR model. The BFR model, similar to the MGL and BFM models allows for several multiple unit failures in a system with more than two components:

$$P(M/N) = \binom{M}{N} \times P^M \times (1 - M)^{N-M} \tag{5}$$

where N is the redundancy level, M is the number of components failing at the same time and P is the failure probability of one component (due to a random shock) and may not be confused as the probability of independent failure of the item. The above formula gives the conditional probability of common cause failure of a group of M items (out of N redundant components), given that the common cause shock initiator (with failure rate μ) is present.

The parameters μ and P are required to be derived from observation of coincident failures over a time. Ref. [8], Annex B.4, provides further details of the method.

2.2.4.3 Innovative approaches for CCF modelling

Innovative models have been developed to overcome the lack of specific numerical data for CCF parameters in the traditional models listed in Section 2.2.4.2. In these innovative approaches, effort is directed at better understanding the physical nature of the CCF, the root causes, as well as the quantification of the root causes.

(a) Partial Beta Factor Method (PBF)

This semi-quantitative method has its basis in the β-factor model. The approach is to derive a β-factor by considering a set of CCF factors that contribute to the overall β-factor [18-20]. The method is known as the partial beta factor method and was developed by UK Atomic Energy Authority (UKAEA), around 1989.

Each of the factors that contribute to the overall β-factor corresponds to a specifically defined characteristic defence against dependent failure, e.g., simplicity, degree of redundancy, degree of physical separation. Subjective numerical judgements are assigned to each of the listed defence characteristics and the overall effect of these common cause contributors is then quantified using a simple empirical formula to derive an overall β-factor, derived from a subset of partial β-factors.

Even though subjective considerations exist in assigning the scores for the contributions, the method is considered to be a very useful extension of the beta factor method. The main advantage of the method is that it provides an auditable trail for the factors used in the derivation of the β-factor. Auditability is a feature that the purely parametric methods of Section 2.2.4.2 do not provide, if the data is derived from generic sources.

(b) Unified Partial Method (UPM)

This method, also developed by AEA Technology, 1996, [21], is a further development from the partial beta factor method. The method again provides an auditable approach and involves a structured and explicit assessment of the susceptibility of a system to dependent failures but requiring a more detailed approach than the partial beta factor model.

(c) Hidden Human Failure Root Cause Analysis (HFRCA)

The types of models used to treat human interactions have been also been used to treat inter-component dependencies. This approach [22] assumes that the root causes for inter-component dependency events are essentially human errors during design, manufacture, installation, maintenance and testing. Environmental factors could also be considered with respect to the failure of designers to foresee and adequately allow for such factors in the design.

The approach is based on modelling inter-component dependencies events in the fault trees as human error events. The probabilities are then quantified using Human Reliability Analysis (HRA) techniques with human error rates from generic databases. Basically, the method attempts to model explicitly the underlying causes of inter-component dependency events in the PSA and allows for an auditable analysis.

There are limitations in the model arising from the difficulty and subjectivity in assigning human error probabilities for certain activities (particularly the design tasks). However, for the human errors in design, manufacture, and installation, this model explicitly considers these factors, which the various parametric models do not.

2.2.5. Reliability issues of digitalized systems

Because of the very extensive changes and progress made in the use of digitalized systems for instrumentation and control (I&C) and because of some of their unique reliability issues, compared for example to mechanical components, a discussion section is provided on reliability issues associated with digitalized systems.

Research and power reactors rely on instrumentation and control (I&C) for monitoring, control, and protection. Analogue I&C systems have historically performed their intended monitoring and control functions satisfactorily. However, current concerns with the continued use of analogue systems are the effects of ageing, e.g., mechanical failure, environmental degradation, and obsolescence about replacement parts availability. The I&C industrial base has now largely moved to digital-based systems and vendors are gradually discontinuing user support and the stocking of spares for analogue systems. Digitalized systems are though now faced with more frequent obsolescence problems than analogue systems.

The reason for the transition to digital I&C systems lies in their important advantages over existing analogue systems, e.g., fault tolerance, self-testing, signal validation, and process system diagnostics. However, there are several outstanding safety and reliability issues regarding the use of digital I&C systems that have not been resolved to the same extent that analogue systems safety and reliability have historically demonstrated. Examples associated with commercial off-the-shelf hardware and software are software qualification, common mode software failure potential and safety and reliability assessment methods, analysis of human factors and human reliability analysis.

It is well known that the quantitative risk/safety analysis such as PSA plays a very important role in proving the safety of a system. However, methods for quantitative safety assessment of digital applications, in particular, are still not very well developed. This issue is briefly discussed below, by grouping the topic into three categories: hardware, software verification and validation, and reliability modelling.

About hardware, the factors that significantly affect the safety of digital systems have to be determined. For example, the long lifetime of I&C components, and failure mechanism due to electromagnetic fields needs to be evaluated. At the same time, the method of evaluating the component lifetime, especially for components in a reactor protection system has to be developed, to ensure a longer lifetime and higher reliability.

About software verification and validation used in I&C systems the issues that need to be considered are software quality, software configuration management, defence-in-depth and diversity, commercial off-the-shelf software dedication, and real-time performance analysis. For non-safety systems, digitalized components have already been widely utilized for many years. More recently, due to the problems of functional degradation, ageing, and spares availability of analogue system components, there is an increasing trend towards the utilization of digitalized components for safety systems as well. One of the important features of the new generation of nuclear facilities internationally is the use of digitalized I&C systems for both non-safety and safety systems. The selection of digitalized I&C in principle enables the simplification and standardization as well as maintainability in operation, although making software changes in safety applications can pose significant problems in a highly regulated environment. Despite the advantages of a digitalized I&C system, the regulatory bodies in many countries are taking a cautious approach and may raise many questions on the regulatory approval for safety system use of digitalized systems. One of the major reasons for this is that the methods of quantitative evaluation of digitalized component reliability including software have not yet been well developed. The difficulties of quantitative evaluation of digitalized components lie in the fact that such a system does not have continuous (time-based) performance characteristics. In other words, the performance of the digitalized component throughout a defined operating period cannot be deduced from a limited number of sample tests. Hence, about the software component, only qualitative evaluation is possible. Strict product specifications, a highly controlled and qualified development process, and practical tests have to be relied upon to verify the core functions of the final product.

About the reliability modelling of digitalized systems, a totally different approach to that of the existing analogue systems is required. Whereas a random defect is the major cause of failure in an analogue component, in a digitalized component, not only is there a possibility of a random defect in the hardware, but the possibility of a deterministic defect due to a design failure of the software has to be considered. It is a general conclusion of software engineering research that deterministic defects in software design cannot be entirely eliminated by testing.

The use of common hardware in digitalized systems also raises a concern about CCF. For software, the CCF concern becomes even more serious due to active sharing of codes and data. Since the spreading of this CCF over the facility will increase the possibility of negating redundancy that is essential to achieve high reliability for safety systems of the facility. It is therefore necessary to ensure diversity (of hardware and software) with an assurance of high quality to prevent CCF. Since, as mentioned above, quantitative methods that assure high software quality have not yet been fully developed, this problem cannot be dealt with effectively. Thus, digitalized systems are basically different from existing analogue systems because of the software component. This is not only because the reliability assessment of the software itself is inherently difficult, but also because a new situation that has not been considered previously could occur in the operational processes involving complex interactions of hardware and software. A new analytical approach is then required in the quantitative reliability evaluation to account for these factors.

The uncertainty that is inherent in the quantitative evaluation of reliability of digital technology has to be overcome if digital technology is to be applied to safety systems of nuclear facilities. The reliability evaluation of software, for example CCF modelling methods, failure endurance technology evaluation is each representative of such difficulties. In addition, there are other various problems, related to the quantitative methodology, such as evaluation of failure type, validity of reliability data, and modelling methods of dynamic digital technology that are still in the research stage of development.

Extensive research on quantitative safety evaluation of digital components is in progress internationally. The digital system consists of hardware and software. The fact that the failure types of these two are very different makes the analysis of digital systems difficult. While the quantitative methodology on hardware failure rates is already well established, there are issues regarding the definition/derivation of software error failure rates. Hence, there has been a tendency to deduce digital system reliability considering the hardware error based on the existing experience but not considering the software error problems. International standards, such as MIL-HDBK-217F, Bellcore Standard TR-332, and British Telecom HRD4 consider hardware only. This is because the data useful for statistical analysis of hardware reliability can be obtained easily from many existing applications. This is not the case with software because the research on the system failure due to software and operator errors has been in existence only for a relatively short term. Therefore, the extent of software data for analysis is insufficient and there is no consistency in the statistical methods used. Also, it is debatable whether software errors can in principle be treated statistically. It will take some time for the evaluation methodology to evolve into a generally acceptable standard.

Experience shows that software error is an important contributor to overall digitalized system failure. Also repair times for software errors are generally longer than for digital hardware. System unavailability can thus be dominated by software errors.

Historically, reliability of software and hardware were studied independently, and each failure rate was estimated separately. The failure rate of the whole system is then obtained by adding the hardware and software failure rates together. This assumes operation as a single specific system (a single component and a single function). In modern and complex systems, this assumption may not be valid. Often a single system may function in many ways and several systems may perform a common single function and the hardware and software failure rates cannot be independently estimated and summed. There are several methodologies applicable, e.g., Markov models and Bayesian networks. These methods however, have limitations and hence have difficulty in practical application. For example, data parameters required for the analyses for a large system become extensive and the modelling is difficult. Furthermore, for high reliability systems with low failure rates ($< 10^{-6}$/h), it is difficult to estimate such parameters using measured test values and hence analysis can be very subjective.

The system reliability estimates for digitalized systems to be included in PSA are usually based on the supplier’s guaranteed reliability figures, which in turn may be based on a combination of historical data from their customers and the hardware and software reliability prediction models. Detailed discussion of prediction methods is outside the scope of this TECDOC.

2.2.6. Data collection programme requirements and problems

This subsection provides information about the data collection process, about requirements and problems, which can appear during the data collection and information for overcoming difficulties. Problems in data collection exercises, such as those experienced by the participants of the IAEA CRP “To update and expand the IAEA reliability database for research reactor PSAs” are quite common. An understanding of the issues involved is therefore useful, as it helps to provide the user with an appreciation of the problems. With this appreciation the user of a database may then even be able to make some judgement of the quality of the contents of a database. Additionally, such information would help a database user, in the event, a facility-specific data collection programme is initiated.

Requirements and problems, which may arise during a data collection exercise, have been grouped into the following four issues:

- Resource commitment to the data collection programme;
- Definition of scope of data collection programme;
- Type and availability of facility data; and
- Quality problems affecting raw data.

These issues are discussed in the following subsections. The information is based mainly upon experience of the participants during the CRP data collection process.

2.2.6.1 Resource commitment to the data collection programme

The most essential requirement is a clear commitment by facility management to provide personnel resources, in terms of dedicated personnel, for the data collection process. The commitment may be initiated because a facility requires data for a very specific and focused purpose, (e.g., study of emergency diesel generator reliability, or the off-site power supply reliability) or it may be more general, forming part of the facility maintenance programme, or it may be for a PSA programme. There may be an external requirement, such as from a regulator or, as in the case of the CRP, an international collaborative programme is agreed to. The lack of adequate staff resources available for such a programme at research reactor facilities is usually one of the main reasons for the absence of a formal maintenance management system and with it, an attendant equipment reliability database.

Regardless of the reason for the personnel commitment, a data collection exercise has to require, at a minimum to be overseen by a technically qualified scientist or engineer. This individual has to have a wide general knowledge of process systems and related equipment, and possess a good understanding of basic statistics. Collection of data may sometime be viewed as a tedious, repetitious task and there may be reluctance of qualified professional staff to become involved. Nevertheless, component oversight is essential if good overall data quality is to be captured. A common practice, especially in smaller facilities such as research reactors, is to utilize science and engineering university students on short-term work contracts to perform most of the routine work. The professional can then oversee the on-going aspects of maintaining, updating and auditing the database. Depending upon the facility complexity, and hence the database size, the professional staff member may be able to do this type of work on a periodic regular basis, without requiring a commitment to full time database management, once the process for collection and documentation is established. For a large database, say for a power plant or a large commercial database, the business of data collection will invariably be managed and maintained by full time dedicated professional staff.

2.2.6.2 Definition of scope of data collection programme

While the personnel resources are committed, the scope of the data collection programme must be clearly defined. Generally, the decision will involve committing either to a long-term programme which is intended to be maintained continually, or it will be a short-term programme, perhaps with the intention of updating at a defined or even undefined, infrequent interval in the future.

In addition to the time scale of the programme it is vital to define the extent of the data collection programme, i.e., the systems and equipment to be included in the study. For the CRP programme the mandate discussed in Section 1 defined the scope of the programme. In general, a data collection programme could vary from focussing in detail on a few specific items, components of high safety significance for instance, to the other extreme of trying to capture information on most equipment used in a facility.

2.2.6.3 Type and availability of facility data

The type and availability of reliability data that can be gathered from the raw data sources in facilities generally, including research reactors will vary considerably. It can range from essentially being almost non-existent to being part of a well-maintained, extensive, long-term collection programme. Where a given facility fits in between these two extremes will depend on how well the two key requirements, discussed in sections 2.2.6.1 and 2.2.6.2, are defined, supported and monitored by facility management.

The potential type of raw data sources available in the CRP data collection process, which are also typical of other types of process facilities, are: facility logbooks, shift supervisor reports, maintenance work orders, equipment and alarm test records, abnormal events records and various types of internal technical and engineering reports. Examples of the various types of raw data sources of the participant countries of this CRP are provided in Annex II, Table II–1.

Not all the potential sources of data are easily useable to extract failure data. Some of the data sources, e.g., facility logs, are not provided for exclusively documenting all equipment failures, but rather to reflect the operational status of the facility. The comment in section 2.2.6.1, regarding the potential tedious nature of data collection arises because the analyst may have to consult large amounts of recorded data, from various sources, only a small fraction of which may reveal the specific type of information that is relevant. The most useful data sources are usually found in maintenance work orders and equipment and alarm test records. As a rule, the quality of the data in the various types of data sources often reflect the importance given by the producers of those documents. There may often be a perception by maintenance/operating staff that failure data information is not important to record. If staff producing the raw data, usually operations and maintenance staff, recognize that it is useful for them, the data is likely to be of high quality. If the staff rarely use the data directly or are not aware of how it is useful for the facility, then the data will tend to be of low quality.

If the reliability analyst can demonstrate, to maintenance and operations staff, that recording good quality information, whether it be in hard copy format or a computerized recording system, will be useful, then this is one of the most important factors in achieving good quality in the raw data. This type of problem is quite typical in many data collection programmes, unless good rapport is established between the data user and maintenance and operational staff.

A very typical example of low quality raw data statements, common in many data records, is to see notification that a component is unavailable because of failure, with little or no further detail being provided. For this type of failure record, the failure mode is simply assigned by the analyst as “fail to function” (F), see Annex II, Table II–2. Details of the specific mode would of course be much more revealing.

2.2.6.4 Quality problems affecting raw data

Some typical problems related to the data quality, experienced during the raw data collection of CRP participants, are listed and discussed below:

Incompleteness or errors of failure event recording

Database information on specific failure events may be incomplete, because of the uncertainty by the analyst regarding component identification, or regarding the type of failure event recorded. Components could be identified incorrectly in the records by the maintenance staff, unknown to the analyst. If the raw data information is incomplete, this will result in the analyst omitting a potential failure from the database. This type of error is fundamentally related to the recording process used by the maintenance staff. There may also be transcribing errors in the process of transferring information from raw data records into the failure database. The latter type of error is more common where there may be a significant number of failures or number of tests, e.g., diesel generator failure records.

Data on the time of its failure or the operating times of equipment may also be incomplete or poorly recorded. Fragments or entire volumes of raw data records may be missing. Generally, because of the potential for underreporting, failure rates tend to be underestimated, rather than overestimated.

The overall quality of failure data is thus usually highly dependent upon the quality of the raw data records of the testing and maintenance activities performed by maintenance and operations staff.

Deficiency of equipment design for failure indication

Design deficiencies may contribute to equipment failure not being indicated or not being indicated promptly. In turn this will lead to inaccuracies in recording failure times, operating times, and possibly the number of failures. For instance, poor ergonomic design in a control room could lead to certain alarms going unnoticed and hence unrecorded. Equipment failures may also be unrevealed because of the lack of adequate instrumentation, including alarms, to monitor satisfactory operation.

Deficiencies in equipment test and maintenance recording forms

The use of standardized fixed format failure report forms as opposed to the use of an open-format form has, in some facilities, found to result in failure information not being documented by maintenance and operating staff. A fixed format form may provide more consistent recording data, but on the other hand it has been found to contribute to a decrease in the details of failure related information, which would have been described in more detail if more space had been provided on a free format form.

The use of electronic database systems for recording maintenance/test data also may not always provide improvements in data collection compared to using hard copy records. For certain types of data, (e.g., diesel generator test and maintenance) a hand-written log book located in the field to record test information has been found to be more accurate than using computerized recording. The latter requires data to be entered remote from the equipment and possibly at times long after the equipment has been maintained and tested. While there is no substitute ultimately for a computerized database for long term historical record keeping, because of the size of facilities and equipment layout, the use of some type of hand-written field records for test and maintenance information is still essential. The accurate transcribing and archiving of the raw data to a computerized system is then a quality control issue. Electronic data storage allows easy data input, storage, retrieval, editing, verification and processing. The Australian DES data entry system for example was used by several CRP participants to input and record raw data for their facilities.

Maintenance and test documentation and procedural deficiencies

In many cases, for standby components, the number of demands and the number of failures to start, to change position or to function during testing or maintenance is not recorded. Similarly, for standby operating components it is often difficult to know from raw data records whether a failure has appeared in the operating time interval or in the standby period.

2.2.6.5 General information for improving reliability data quality

Some general information to improve the quality of the documents containing failure records to improve quality assurance in the recording of maintenance, test or repair information are listed below. This information follows from the discussions of Section 2.2.6.1 to 2.2.6.2:

(a) A commitment from facility management is essential to ensure adequate staff resources are provided to supply the equipment maintenance and test information data sources, from which a reliability database can be developed and maintained;

(b) Administrative requirements need to ensure that maintenance and test information is recorded and archived. Informal liaison and feedback between analysts and maintenance and operations staff is very helpful in this regard;

(c) Data for the reliability database is generally stored electronically, software such as Microsoft EXCEL spread sheets or Microsoft ACCESS have been used by some Member States for data storage and processing;

(d) Enhancing the quality and detail of written information of maintenance and test records is usually done through liaison and feedback with maintenance and operational staff and the data analysts. Provision of details by maintenance and operational staff on component failure, failure mode and the failure root-causes is particularly important.

2.2.6.6 Specific information for failure data analysis issues

Even if high quality raw failure data is not available the reliability analyst may still face some problems regarding failure data interpretation before data is entered into a final failure database. This section provides a list of a few of the issues that may arise in this regard, including some specific information:

(a) Failure event data may still be unclear and incomplete from the analyst's perspective and it may difficult to define the severity of a failure. In this case the analyst is confronted with the decision whether to document a failure event or not. The numerical effect of error in assigning a failure mode i.e. 'critical failure' or 'degraded' can be significant especially in the case of highly reliable components. For example, the difference between no failure and one failure in estimating failure rate is much more than the difference between eight and nine failures although in both cases the error is one failure. In the absence of sufficient information, the conservative approach is to count such events as a total failure;

(b) If a component has within its boundary some redundant parts, a failure of one of the redundant parts need not be considered as a failure of the component, as the component can still perform its function. In such case the database has to record the failure of the redundant part;

(c) The use of identification codes for components in the failure database has to be consistent with the design and operational documents of the facility;

(d) Successive failure of the same components over short time intervals from the same root cause has to be counted as a single failure. Generally, these types of failures are usually due to poor diagnosis of the cause of failure or inadequate repair or testing. The analyst has to be careful though not to exclude documenting potential common cause failures in redundant equipment, when such successive failures occur.

2.2.7. Generic equipment reliability databases

2.2.7.1 General

Many generic equipment reliability databases are available for use, on either a commercial basis, or in the public domain. These databases cover equipment in specific industries or may focus on specific types of equipment across different industries. This section discusses some of the general issues of concern for the reliability analyst when any type of generic database is utilized. Section 2.2.7.2 provides reference information for the widely used generic databases.

Most generic databases assume the failure rate, or failures per demand, are independent of time or demand, i.e., the constant failure rate model. Most failure rates quoted in more recent databases also include an upper and lower statistical bound on the failure rate, or on the failures per demand. The confidence bounds set by the interval between the bounds is assumed to be due only to statistical uncertainties in the operating time, the number of tests and the number of failures.

The assumption of constant failure rate, regardless of the failure data collection time interval, means that more accurate time-averaging methods, (e.g., the exponentially-weighted-mean-average or time-moving average methods) are not used. Effects such as wear in and wear out, which can be allowed for by suitable time-averaging techniques, may thus be hidden from the analyst with the use of generic failure rate data. Use of time averaging methods can change the 'average' failure rate quoted (usually the cumulative sum time average) significantly.

The confidence bound intervals quoted in generic databases may also not indicate a true spread of failure rates within one industry, let alone between different industries, because of varying operating and maintenance conditions and different equipment manufacturers of the same type of equipment. Therefore, it can be expected that uncertainty estimate intervals for the "same" item of equipment may not be representative for a specific application to a different facility. Some judgement of the suitability of each generic data source is thus required. For example, the US MIL Standard 217 quotes failure rate values for electronic equipment, together with scaling factors to take account of the most significant factors affecting the failure rates (e.g., operating temperature). The same level of detail for most mechanical engineering equipment is not practical, as particular environmental operating conditions are not usually available. However, operating environment conditions clearly do affect mechanical and instrumentation components, as is the case for electronic equipment.

Some additional factors are also quite important when considering whether to use generic estimates of failure rates for a specific item of engineering equipment.

Most generic databases provide data on 'all-modes' failure rates but not all provide failure-mode-specific failure data. In a given PSA or reliability study, application of only one type of failure mode may be relevant. Thus, the generic failure rate estimate has to be corrected, if possible, by the ratio of the failure rates of the relevant failure mode to the all-modes failures. This correction factor could be significant.

Facility specific information has to be taken into account if possible. Some generic database estimates may be based only on expert opinion, as opposed to actual operating experience. Facility operating modes, preventive maintenance and testing programmes may vary considerably and will influence the performance of equipment between different facilities, even if the same manufacturer requirements were used. This type of operating and maintenance information is not provided in many databases.

Standby-operated equipment operates differently from continually operating equipment. In this regard it is important to distinguish between the standby failure rate and the operating (running) failure rate. These two parameters are quite different. Only very rarely do databases distinguish the two. It is quite difficult to obtain quality data on standby failure rates, as information on test (and the normal starting) intervals is also required for the derivation of valid standby failure rates. Standby failure rates are often erroneously used as an operating or running failure rate. If the test interval is unknown, then application of standby failure rates to a different facility with different test intervals could be invalid.

In summary, the use of generic databases for reliability data has to recognize that large uncertainties are expected to be associated with the application to equipment in a different facility for a variety of reasons. Use of generic database sources is not expected to be representative unless the generic facility operations and maintenance is similar to the one the data is being for. Therefore, the analyst has to recognize that use of generic data generally serves more of a guide than an accurate representation, unless the facility differences and the details of the generic data collection and analysis are documented and well understood. Wherever possible the collection of facility-specific data has to be used if this is feasible.

2.2.7.2 Generic database sources

This section provides reference to a useful recent review article on the state-of-the-art and perspectives on reliability databases. A list of the generic database sources references in the review article is provided. Other relevant generic databases not included in the reference article are also listed and very briefly discussed.

Ref. [23] provides information on the reliability database review for any user of generic databases. The report gives a history of reliability database development and provides an overview of existing databases, equipment reliability handbooks and related software products. Various national standards set for the collection and exchange of reliability data are also discussed, as is the future direction of reliability data development. Of particular interest is an excellent historical review of database development. The review outlines the development of the first, second and third generation of reliability data. This continual development of database sources may not be evident to the casual user of generic databases. The review discussion helps to show how the improvement of data analysis techniques has evolved and how hardware and software tools have initiated the growth of database quality.

A list of generic databases is discussed in [23]. Reliability Information Analysis Centre has published several databases such as Non-electronic Parts Reliability Data (NPRD-2016), Electronic Parts Reliability Data (EPRD-2014), and other databases. Other relevant reliability database sources, not included in [23] are provided in Refs. [32-38].

2.3. USE AND APPLICATIONS OF RELIABILITY DATA

2.3.1. PSA application

This section discusses factors considered during the preparation of the generic component reliability database, to facilitate its application to PSA. Information on factors the user must take into consideration, when using the database is described in Sections 2.3.3 – 2.3.9.

A PSA for a research reactor involves quantifying the likelihood of various types of accident consequences, e.g., an overall core damage frequency or the failure frequency of individual reactor systems. The objective is to use such quantification to assess and demonstrate adequate safety of the facility and to use the results to identify improvements to the facility. A variety of quality reliability data (e.g., component failure rates, human error probabilities, CCF parameters, equipment inspection and test intervals, equipment repair times, and mission times for safety functions) are required for this purpose. Data on equipment repair times, test intervals and mission times are specific to the facility design and operation and maintenance regime as well as the PSA models used. Therefore, discussion of those factors is outside the scope of this TECDOC. The focus of this TECDOC is on reliability data on component failure rates, human error, initiating events and CCF. The analyst has to be aware however that some database failure data, e.g., failure per demand and standby failure rates, depend upon knowledge of the test or starting time intervals if the data is to be used correctly. These additional details are often not provided in generic databases.

Ideally, PSA reliability data has to be based on facility-specific failure data, provided good quality data, with reasonable uncertainty bounds, is available. Often such data is not available, and it is then necessary to use data from external sources (generic databases). In such cases, as far as possible reliability data used has to be based on data collected from equipment or facilities that are as similar as possible to the equipment and operating environment as the facility being analysed.

The failure data in the generic component database of this TECDOC has been collected from different types of research reactors of the participant countries of the CRP. The user has to carefully select the data that best matches his/her facility and equipment. To facilitate that process this TECDOC provides equipment information such as equipment ratings, size, and operational application. Several examples of the application of PSA and reliability data for a new research reactor facility and for developing competence for nuclear installation PSAs, by using an existing research reactor are provided in [24–26].

The focus of a PSA is primarily safety oriented, both in the design and operational aspects of the facility, although it may also be used for non-safety aspects such as support for operational availability and reliability centred maintenance, for example. A variety of equipment specific failure modes may be relevant for PSA and may be used in reliability, maintainability and availability studies of reactor equipment, as described in Section 2.3.2. and so, where available, failure modes are presented in the database.

To facilitate performing uncertainty analysis the generic database also provides confidence bounds of the failure rate estimates, see Annex V.

2.3.2. Other reliability analysis applications

There are many applications, other than PSA, where reliability data is utilized, e.g.:

(a) Reliability/maintainability/availability/safety analysis of individual process systems, safety systems or support systems;
(b) Performance of specifically-designated equipment (backup power, trip/scram systems)
(c) Reliability centred maintenance;
(d) Failure Mode and Effects Analysis (FMEA) and Failure Mode, Effects and Criticality Analysis (FMECA);
(e) Hazard and Operability Analysis (HAZOP);
(f) Spare parts management; and
(g) Design optimization and operability technical studies, as required.

The procedure involved in the collection of information/data from facility records towards generating the component reliability data for these applications is generally the same as for the PSA application, see Section 2.3.1. However, the specific objective of the analysis dictates the additional detailed requirements needed for the preparation and collection of data. For instance, if the objective is to have an assessment of operational availability of the equipment then data on safe as well as unsafe failures of the equipment is needed. Table 3 provides a summary list of typical requirements of reliability data, pertaining to the reliability-related applications listed above. While working on specific applications such as listed in Table 3, the analysts has to therefore determine any specific reliability data requirements, to achieve the necessary application objectives.

TABLE 3. APPLICATION OF DATA FOR RELIABILITY-RELATED APPLICATIONS

Application	Application Objective and Typical Data Requirements	Remarks
Reliability, maintainability, availability, and safety analysis of individual systems	The reliability data requirements are the same as required for a PSA study. However, the following has to be noted a) the data on demand failure probability has to be correlated to standby failure rate using the testing intervals for the components, b) the reliability analysis of safety systems has to be based on performance data of the equipment, c) spurious actions of safety systems have to be used for availability evaluation and d) common cause failure data has to be modelled in redundant safety systems, as this aspect has significant bearing on the insights obtained from the analysis.	Facility specific data is essential for applications for safety systems. Generic data has to be used only for comparative purposes, unless the generic equipment is essentially identical in design and operational mode.
Performance of specifically designated equipment	The method, model and criteria used for the generation of reliability data has to be consistent for the equipment being studied.	Facility specific data is essential for specifically designated equipment. Generic data has to be used only for comparative purposes.
Reliability centred maintenance (RCM)	In RCM there is an emphasis on collecting data pertaining to the identification of failure modes, and the type of maintenance activities performed on components. Hence, the reliability data has to be segregated depending on various failure modes, failure type and the typical maintenance action requirements.	Facility specific data is essential for this application.
Failure mode and effects analysis (FMEA) and failure mode, effects and criticality analysis (FMECA)	FMEA and FMECAs are primarily qualitative techniques. The objective is to assign a qualitative component failure probability (e.g., high, medium, low) for comparison, FMEA and to provide a similar ranking for failure criticality, (i.e., severity) rankings, FMECA. Expert opinion, based on operational and maintenance insights, sometimes forms the main input for qualitative data.	None.
Hazard and operability study (HAZOP)	HAZOP is basically a qualitative analysis and so the data requirement on for individual components is therefore mainly qualitative.	As qualitative data is utilized, the use of all generic data for this application may often be adequate.
Spare parts management	Failure data is required for failures, which will necessitate the replacement of a component. Data on mean times for replacement and repair are essential. Uncertainty related to potential delays in spare part procurement is also an important part of this application.	Facility specific and manufacturer specific information is essential.
Reactor trip/scram analysis	The data requirement is for quantitative or qualitative failure rates or failures per demand of components and associated repair and outage times.	Facility specific data from operational/maintenance reports is essential for this application.
Design optimization and operability studies	These studies are generally carried out during the facility design stage so that the generic data sources, manufacturer/vendor data on MTTF, and test performance results form the main data requirement for these applications.	Manufacturer specific, commissioning data or generic data will be used.

2.3.3. Use of Reliability Data

In studying reliability of systems, all relevant systems, subsystems and components must be considered as integral items of the facility. Sections 2.3.4. to 2.3.6. describe how to define the boundaries of systems, sub-systems, or components; see also IAEA TECDOC-478 [27], and IAEA TECDOC-636, [1]. Sections 2.3.7. to 2.3.9. then respectively discuss component group and component type coding, extracting data from databases and information for criteria of data selection.

2.3.4. System boundary

The definition of system boundary is important, as the functional intent may not otherwise be obvious. The boundary of a system includes all elements which are necessary to carry out its function. If there are interface or support systems that are essential for this function then these must be considered, but there has to be a boundary definition, so that functional failures can be clearly assigned to either the system, interface or support system.

For example, the controller and associated instrumentation of the controlled components such as motors, pumps and fans must be included. The electrical supply to a system may exclude external power supply (which might be separately considered) but may include incoming circuit breaker before the bus bars, the bus bars, other switch-gear and cabling. For a cooling system the heat exchanger, piping and valves must be included.

It is important that the schematics of the system, which indicate all interconnections, are available. Such schematics will facilitate the development of appropriate fault tree models used in PSA.

2.3.5. Subsystem boundary

A subsystem is a group of components and associated devices performing a primary or secondary function. The interfaces of sub system boundary must include relevant mechanical, electrical, and control equipment. For example, a pump subsystem may include the following components:

- Pump, centrifugal;
- Clutch, mechanical;
- Motor, AC Induction;
- Control equipment;
- Switchgear.

2.3.6. Component boundary

The component boundary defines clearly all interfaces of a specific component, with which it interfaces via hardware or software, (see Ref. 2). The component itself could be divided into sub components.

A clear definition of a component boundary is an important characteristic of generic component reliability data to be used in a PSA study. When selecting data for a PSA from a generic reliability database, the analyst has to know the component boundary in which historical failure data had been captured to ensure that the data used matches the failure event being modelled in the PSA. This boundary has to be provided in component reliability data so that the user could recognize what sub components are involved and what are excluded.

2.3.7. Component group and code

Detailed explanations of component group and component type code are provided in Ref. [27] and Ref. [2]. The same component groups and codes have been adopted for this TECDOC.

The user of the generic database of this TECDOC has to note that there is more than one way of coding a component and that problem could be reflected in the data records of the generic database.

For example, if a Motor Driven Pump (PMA), is treated as a sub system, its component type code could be PMA with its component boundary including the centrifugal pump (PWC), its mechanical clutch (JEM) and induction motor (MAI). If the pump is treated as a centrifugal pump PWC the component boundary would only include pump components such as casing, flange, bearing, impeller, gasket, and electric motor. However, not all data records may have strictly followed such a convention. Therefore, care must be exercised in the selection of appropriate data records for a PSA and detailed descriptions of the component boundary must be ascertained before a selection is made.

2.3.7.1 Component description

To facilitate the use of the generic data by PSA analysts each component used for data collection has to be described adequately. At a minimum the descriptions have to include: component name and coding, component type, manufacturer, some key technical characteristics, the system the component is used in, and the component boundary (see Table 4).

TABLE 4. EXAMPLE OF COMPONENT DESCRIPTION

Component Name	**Motor Driven Pump**
Component Code	PMA
Type	Centrifugal pump
System	Primary Cooling System
Sub system	Primary Pump
Component Boundary	Centrifugal pump (PWC), mechanical clutch (JEM) and induction motor (MAI).
Manufacturer	KSB

2.3.8. Extracting data

The data in the generic component database of this TECDOC have been collected from different types of research reactors of the participant countries of the CRP. The analyst must carefully select the data that best matches his/her facility and equipment. To facilitate that process this TECDOC provides details such as component boundary, equipment ratings, size, and application.

If there is more than one matching data record listed in the generic component reliability database, then the analyst can apply data pooling techniques to derive an appropriate mean value and confidence bounds. While this TECDOC has not attempted to use data pooling techniques to produce consolidated summary results for component failure data. The appropriate statistical methods for doing such an analysis are discussed in Ref. [39].

Uncertainty analysis forms an important integral part of PSA. To perform uncertainty analysis, the uncertainty in the data used in the PSA must be considered. The generic component reliability database provides a measure of the uncertainty of the failure rate data for each data record based as described in Section 2.2.6.3 and Annex V. However, it must be noted that the uncertainty of the data that the PSA analyst must use is not necessarily limited to the statistical uncertainty, as given in the database. There will be additional uncertainty associated with how well the generic data may match the facility/equipment operational conditions for which the data is used. Prudent engineering judgement is required to assign an appropriate level of uncertainty.

2.3.9. Criteria for data selection: generic/facility specific

From the point of view of the data analyst, there are two basic data categories: generic and facility specific. Facility specific data is preferred, compared to generic data, but there are often essential reasons for using generic data for development of quantitative inputs of system/facility reliability models.

There is no other option other than generic data, when there are no facility specific data, for example if a new facility is being designed and/or built. If facility specific data is of very low quality, or if the statistical accuracy is very low, in case of short data collection times, then use of generic data is valuable. Additionally, a large amount of effort and resources may be required to obtain facility specific data, whereas the generic data (assumed to be adequately representative) may be readily available in a suitable form.

Use of generic data may play an important role where specific data is sparse and/or of low quality. In the first case, the data taken from generic sources can increase the statistics and decrease statistical uncertainty connected with numerical values of estimated parameters. In the second case, generic data can be employed as a useful standard making it possible to define the level of deviation of the estimated parameter values from the normally expected values, due to the low quality of facility specific data.

The degree of additional uncertainty introduced into the reliability model with the application of generic data depends on factors such as the quality of generic data and the level of affinity of generic information to the facility under consideration. Both of these uncertainties may be difficult to assess even qualitatively. The applicability of generic information on component reliability to a specific facility is depends on factors connected to component design, and details of how the component is operated, maintained and tested. Prior to the use of generic data values, these attributes have to be checked carefully if possible and the generic data values need to be modified, to address the potential differences, when necessary and where possible. Quite often, several generic values could be candidates for application. Appropriate selection has to be made with the aim to choose the value representing highest level of similarity from point of view of design and operation. A strategy based on the selection of the "best" value is preferred to a simple averaging of several values. The main point is that the "independent" generic values may often be dependent (e.g., from the same original source), and therefore the approach based on enumeration of an average of any kind may not be appropriate from a statistical point of view as it would give biased results. The generic data developed during this CRP and included into the IAEA database does not have such a dependence.

Sometimes, Bayesian updating is a good way of improving facility specific reliability parameter estimation. When this method is applied, both generic and facility specific data are used and a lower quality of one type of data source can be compensated accordingly with better quality of other data. This variant of analysis may be also preferred when there is no good agreement on generic/facility specific data preference.

The overall conclusion is that direct use of generic data needs to be limited for research reactors PSAs. Even in the case of no failures recorded, the specific information (length of period without failure) may be combined with generic data by means of the Bayesian updating approach.

This overall conclusion does not mean that the generic data database development is of low importance. Such a database can be employed many ways in the research reactors PSA. It can provide good comparison of component reliability data reported from different research reactors. It can be used for many kinds of sensitivity analysis (hypothetical PSA for one research reactor) with the most conservative (or most optimistic) parameter values taken from the database to see the sensitivity of PSA results to component reliability.

3. RELIABILITY DATABASE INFORMATION

3.1. REACTOR FACILITIES AND DATA COLLECTION METHODS

A total of 11 countries (Argentina, Australia, Austria, Brazil, Canada, Czech Republic, Korea, Romania, India, Indonesia, and Vietnam participated in the CRP. Data from 16 research reactors from 10 countries contributing to the CRP are represented in the data of Annex VI of this TECDOC. India and Indonesia each with three facilities, Argentina and Brazil each with two facilities, Australia, Austria, Canada, Romania, Indonesia, and Vietnam with one facility. The maximum power of these facilities ranges from 100 kW(th) (Kartini, Yogyakarta) up to 135 MW(th), (NRU, Chalk River). Some data from the previous CRP is also included; from China with two facilities, and from Czech Republic, Slovenia and Switzerland with one facility. Among these facilities, the first criticality in the year1956 was at Apsara, India, the latest was in the year 2000 in Bandung. Indonesia. The main utilization for the larger facilities with maximum power greater than 10 MW is isotope production in addition to other utilization. The facilities with maximum power below 10 MW mainly use their reactor for training, education, basic and applied research including neutron activation analysis. The total number of component types monitored varies from 11 up to 116 per facility. The main raw data sources were maintenance records and logbooks. Information from the different reactor facilities and the data collection sources can be found in Table V–1.

3.2. USE OF THE COMPONENT RELIABILITY DATABASE

This section provides user information for the component reliability database of Annex VI, Table VI–1.

The various steps in the procedure needed to locate reliability data for a given component type are listed in Table 5. A gamma radiation monitor sensor is used as an example.

As noted in Section 2.4.4 all data records may not have followed the boundary labelling convention strictly, but the data description has to show more clearly what was included. Therefore, care must be exercised in the selection of appropriate data records and the detailed descriptions of component boundary checked, before a final selection is made.

TABLE 5. PROCEDURE TO LOCATE RELIABILITY DATA FOR A RESEARCH REACTOR COMPONENT

STEP	Action	Source of information
1	User determines the component category generic description of interest. e.g. sensor.	Component category description listing in Annex II, Table II-1, column 2. A single-item alphanumeric code in Table II-1, column 1, provides the general component category description (e.g., A for sensor).
2	User determines the component group within the generic component category, e.g., radiation sensor.	Component group description listing in Annex II, Table II-1, column 4. A double-item alphanumeric code in Table II-1, column 3 provides the general component category description (e.g., AR for radiation sensor).
3	User determines the three-item alphanumeric code representing the specific component type e.g. gamma radiation monitor.	Component type description listing in Annex II, Table II-1, column 6. A three-item alphanumeric code in Table II-1, column 5 provides the specific component type description (e.g., ARG for gamma radiation monitor).
4	The main component reliability database is then accessed, to obtain failure data for the failure mode required, the component code and the reactor code.	The user refers to the Annex VI, Table VI–2, column 1 component code to locate ARG alphabetically. Seventeen ARG gamma monitor failure types are listed in column 1. The required single digit alphanumeric failure mode is found in column 9; the codes being defined in Table II–2.
5	The facility-specific component information for the component is located so the user can then choose the component description, and hence failure data, that corresponds as closely as possible to that needed.	Facility-specific technical information on the component type found in STEP 3 is located alphabetically in Annex II, Table II–3, column 1. For the ARG example Table II–3 column 3 then provides 11 entries. Column 2 provides the country and reactor code*. Column 3 provides a description of the component. With the closest component description then found the user can then refer to Table VI–2, column 10, to choose the most appropriate failure rate to be used.

*For a given reactor facility the component code itself may not identify unique equipment for a facility. To do this a two-digit suffix has been added to the component code in Table II–3 column 1 for some data records, e.g., ARG01, ARG02, etc. The country/reactor component code with its numerical suffix will then uniquely identify the equipment. Where there is no numerical suffix added to the reactor component code, it is still possible to locate equipment uniquely, by matching it to the number of components in column 4 of Table VI–2.

3.2.1. Determination of failure parameter as a rate or a demand

The user then needs to check Table VI–2, columns 5, 6 or 7 to determine whether the failure parameter is a rate or a demand and which of these two parameters is suitable for his/her requirements. The particular failure mode, or modes, in Table VI–2, column 8 is then consulted. Annex II, Table II–1, column 1 provides an alphabetical reference list of failure codes, with the failure mode being described in column 2. The appropriate failure rate (failures per calendar time or failures per operating time), or the failure probability per demand, is found in Table VI–2, columns 10 or 11, respectively. Uncertainty bounds are given in Table VI–1, columns 12 and 13.

Before the user commits to the use of any particular failure data from a given reactor facility, a check has to be made on other reactor facility data for the same component type. This then will provide some idea of the spread of the failure data spread between similar components in different facilities, as discussed in Section 2.4.2. The user may wish to combine failure data from different facilities and calculate a mean value and an appropriate uncertainty range for the combined data. Finally, the user has to confirm the failure rate calculations provided in Table VI–2, for the data being extracted, to provide a verification check for the data, which is presented in the table.

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Annex I

CONTRIBUTING RESEARCH REACTOR FACILITY INFORMATION

Table I–1 lists features of the contributing research reactor facilities relevant to the reliability data collection process from 13 Member States. Three Member States: China, Slovenia and Switzerland were not members of this CRP, but had contributed to IAEA TECDOC-930 and some validated data from these Member States was also chosen to be included. Eleven Member States: Argentina, Australia, Austria, Brazil, Canada, Czech Republic, India, Indonesia, Korea, Romania and Vietnam participated in this CRP. More research reactor-related data can be found on the IAEA research reactor database: https://nucleus.iaea.org/RRDB.

TABLE I–1. FEATURES OF CONTRIBUTING RESEARCH REACTOR FACILITIES AND DATA COLLECTION PROCESS

Country	**Argentina**		**Australia**	**Austria**	**Brazil**
Country Code	**AR**		**AU**	**AT**	**BR**
Reactor Code	**AR3**	**AR6**	**HIFAR**	**TRIGA Mark-II**	**BR1**
Facility, Maximum Power, 1st Critical	RA-3 10 MW 1968	RA-6 500 kW 1982	HIFAR Lucas Heights 10 MW 1958	TRIGA Mark-II Vienna 250 kW 1962	Pool Type Sao Paulo 5 MW 1957
Approximate Operating Hours/Year	6000	1500	6500	2000	2400
Main Utilization	Isotope Production, Material Testing, Research	Teaching & Training, Material Testing, Research	Isotope Production, Neutron Activation Analysis (NAA), Silicon Doping, Basic & Applied Physics, Postdoc. Studies	University Training, Education Basic & Applied Research	Isotope Production, Basic & Applied Research, Neutron Activation Analysis, Academic Studies, Training
Period of Data Collection	1986–1998	1982–2002	1985–2002	11/1981–12/2002	1998–2002
Total Number of Component Types Investigated	42	39	30	38	69
Data Sources	Maintenance Records, Personnel Interview	Maintenance Records, Personnel Interview	Maintenance Records:	Log Books, Maintenance Records, Operating Experience	Log Books, Shift Books, Maintenance Records, Incident Reports
Main Systems of the Components Investigated	RCS & RSS, I&C, Research Reactor, Cooling System, Ventilation System	RCS & RSS, I&C, Research Reactor, Cooling System, Ventilation System, Electrical Power System	ECCS, Confinement Heat Removal System, Confinement Isolation System, Primary and Secondary Cooling, Standby Electrical Supply	RCS & RSS, I&C, Reactor, Sec. Cooling Ventilation System, Fuel, Electrical Power Systems	RCS & I&C, Reactor Protection System, Electrical Power Systems, Ventilation and A/C System

TABLE I–1. FEATURES OF CONTRIBUTING RESEARCH REACTOR FACILITIES AND DATA COLLECTION PROCESS (cont.)

Country	**Brazil**	**Canada**	**China (*)**		**Czech Republic(*)**
Country Code	**BR**	**CA**	**CN**		**CZ**
Reactor Code	**BR 4**	**NRU**	**M**	**H**	**CZ**
Facility, Maximum Power, 1st Critical	Critical Assembly Sao Paulo 100 W 1988	NRU Chalk River 135 MW 1957	MTR China Atomic Inst. Beijing MW 1965	HWRR China Atomic Inst. Beijing 15 MW 1980	LVR 15 Rez/Praha 15 MW 1990
Approximate Operating Hours/Year	400	7800	3200	2600	3500
Main Utilization	Basic Reactor, Physics Research, Instructional Laboratory System	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	1998–2002	1970–2000	1965–1993	1958–1993	1991–2002
Total Number of Component Types Investigated	72	73	19	14	63
Data Sources	Log Books, Maintenance Records, Incident Reports	Log Books, Maintenance Records, Operating Experience	Log Books, Maintenance Records	Log Books, Maintenance Records	Log Books, Operating Experience, Maintenance Database
Main Systems of the Components Investigated	Reactor Control System, I&C, Reactor Protection System, Electrical Power Systems, Instrument and Plant Air Supply System	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, Electrical Power Systems

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TABLE I–1. FEATURES OF CONTRIBUTING RESEARCH REACTOR FACILITIES AND DATA COLLECTION PROCESS (cont.)

Country		**India**		**Indonesia**	
Country Code		**IN**		**ID**	
Reactor Code	**D**	**C**	**A**	**S**	**B**
Facility, Maximum Power, 1st Critical	Dhruva 100 MW 1985	Cirus 40 MW 1960	Apsara 1 MW 1956	MPR-30 Serpong 30 MW 1987	TRIGA 2000 Bandung 2 MW 2000
Approx. Operating Hours/Year				3000	1500
Main Utilization	Isotope Production, NAA, Material Testing, Basic & Applied Physics	Isotope Production, NAA, Material Testing, Basic & Applied Physics	Isotope Production, NAA, Material Testing, Basic & Applied Physics	Isotope Production, Education & Training, Reactor Engineering, Materials Testing	Education & Training, Basic & Applied Physics
Period of Data Collection	1986–2002	1992–2002	1997–2002	1987–2003	2000–2003
Total Number of Component Types Investigated	72	21	17	92	60
Data Sources	Log Books, Maintenance Records, COR Reports	Incident Reports, Monthly Reports	Incident Reports, Monthly Reports	Log Books, Maintenance Records	Log Books, Maintenance Records
Main Systems of the Components Investigated	ECCS, Shutdown, Cooling, Protection System, Ventilation System, Electrical Power Supply	ECCS, Shutdown, Cooling, Protection System, Ventilation System, Electrical Power Supply	ECCS, Shutdown, Cooling, Protection System, Ventilation System, Electrical Power Supply	RCS & RSS, I&C, Reactor and Reactor Cooling Systems, Fuel, Ventilation, Electrical Power Supply	RCS & RSS, I&C, Reactor and Reactor Cooling Systems, Fuel, Ventilation, Electrical Power Supply

TABLE I–1. FEATURES OF CONTRIBUTING RESEARCH REACTOR FACILITIES AND DATA COLLECTION PROCESS (cont.)

Country	**Indonesia**	**Romania**	**Slovenia (*)**	**Switzerland (*)**	**Vietnam**
Country Code	**ID**	**RO**	**SI**	**CH**	**VN**
Reactor Code	**Y**	**TRIGA**	**SI**	**CH**	**DALAT**
Facility, Maximum Power, 1st Critical	KARTINI Yogyakarta 100 kW 1979	TRIGA Steady State Reactor 14 MW 1979	TRIGA Mark-II Ljubljana 250 kW 1966	MTR Würenlingen 10 MW 1957	IVV-9 Dalat 500 kW 1983
Approximate Operating Hours/Year	1000	2700	3000	6000	1300
Main Utilization	Education & Training Basic & Applied Physics	Material Testing, Basic & Applied Physics, NAA, Isotope Production	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	1993–2003	1979–2000	1985–1993	1991–1993	1984–2002
Total Number of Component Types Investigated	11	27	36	14	116
Data Sources	Log Books Maintenance Records	Log Books, Shift Supervisor Reports, Work Authorizations, Operating Experience	Log Books, Maintenance Records, Operating Experience	Log Books, Maintenance Records	Log Books, Maintenance Records
Main Systems of the Components Investigated	RCS & RSS, I&C, Reactor and Reactor Cooling Systems, Fuel, Ventilation, Electrical Power Supply	RCS, I&C, Sec. Cooling System, Ventilation System, Purification Systems, Radioactive Waste System, Radiation Monitoring System, Electrical Power System	RCS & RSS, I&C, Reactor and Reactor Cooling Systems, Ventilation, Radiation, Monitoring, Electrical Power Supply	RCS & RSS, I&C, Reactor and Reactor Cooling Systems, Ventilation, Radiation, Monitoring, Electrical Power Supply	RCS & RSS, I&C, Reactor and Reactor Cooling Systems, Ventilation, Electrical Power Supply Systems

* IAEA TECDOC-930.

Annex II

COMPONENT AND FAILURE PARAMETER CODING INFORMATION

This Annex forms part of the generic component reliability database. It is comprised of the following tables:

Table II–1 Component categories, groups and types and associated coding;
Table II–2 Failure mode code definitions.

Table II–1 gives a description of each component category, group and type along with their respective one, two and three letter coding system. To find a specific component type the user has to consult the component category descriptions of A to V and then search the component groups and component type listings. The coding system was developed, to a large extent, on that formulated in [1].

TABLE II–1. COMPONENT CATEGORIES, GROUPS AND TYPES AND ASSOCIATED CODING

Code	Component Category Description	Code	Component Group Description	Code	Component Type Description
A	Sensors	AA	Sensor general	AAA	Sensor general
				AAR	Sensor air
		AC	Sensor core flux	ACA	Sensor core flux
				ACF	Fission counter
				ACI	Ionisation chamber
				ACS	Self-powered detector
		AF	Sensor flow	AFA	Sensor flow
		AH	Sensor humidity	AHA	Sensor humidity
		AL	Sensor level	ALA	Sensor level
				ALR	Sensor pool water level
		AP	Sensor pressure	APA	Sensor pressure
				APD	Sensor pressure difference
		AQ	Sensor water chemistry	AQC	Sensor conductivity
				AQP	Sensor ph
		AR	Radiation monitors	ARA	Aerosol monitor
				ARG	Gamma monitor
				ARI	Iodine monitor
				ARN	Neutron monitor
				ARO	Off-gas monitor
				ARU	Radiation monitoring alarm unit
				ARW	Water monitor
		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
				BTV	Battery bank

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TABLE II–1. COMPONENT CATEGORIES, GROUPS AND TYPES AND ASSOCIATED CODING (cont.)

Code	Component Category Description	Code	Component Group Description	Code	Component Type Description
C	Conductors	CB	Bus	CB2	Bus 120 Vac, 220 VAC single phase
				CB3	Bus 220 Vac, 380 VAC three phase
				CB4	Bus conductor three phase 415 VAC
				CB6	Bus 6 kvac
				CBA	Bus general power distribution
				CBD	Bus dc
				CBH	Bus-3.3 kvac
				CBI	Bus-22 kvac
		CC	Cable	CCP	Cable power connection
				CCS	Cable signal (supervisory)
		CW	Wire	CWA	Wire
				CWC	Wire control circuit, several joints
D	Diesel generators, gas turbine driven generators	DE	Diesel engine	DEA	Diesel engine
		DG	Diesel generator AC	DGA	Diesel generator, emergency AC
		DT	Gas turbine driven generator		
E	Other electrical equipment, electrical part of experimental installations	EB	Panel board	EBA	Terminal board
				EBM	Panel board-electrical motor control centre
				EBS	Panel board-reactor cooling system
		EC	Converter	ECM	Static converter for main coolant pumps
		EE	Electrical equipment	EEL	Lamps
		EH	Heater electric	EHA	Air heater
				EHO	Oil heater
				EHP	Pressurizer 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 power supply instrumentation
				EPL	Low voltage power supply - I&C equipment
				EPU	Uninterruptible power supply < 1kva
		ER	Rectifier	ERS	Rectifier static
		EX	Electrical equipment for experiments	EXA	Electrical equipment for experiments, general

Text cont. on p. 43

TABLE II–1. COMPONENT CATEGORIES, GROUPS AND TYPES AND ASSOCIATED CODING (cont.)

Code	Component Category Description	Code	Component Group Description	Code	Component Type Description
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, 2.5 cm< diameter < 7.5 cm
				FSA	Piping straight section
				FSL	Stainless steel pipe 15 cm diameter, 142 m, 270 welds
				FSM	Piping large, >7.5 cm diameter
				FSS	Piping small, <2.5 cm 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, D_2O tank, storage containers for irradiated fuel and materials	GB	Beam ports, beam tubes	GBC	Thermal column
				GBR	Beam port, radial
				GBS	Storage and transport containers
				GBT	Beam port, tangential
		GC	Thermal column	GCB	Thermal column
		GH	Header	GHE	Header
		GP	Pool, open swimming pool	GPL	Pool liner
				GPS	Storage rack for fuel
		GS	Storage containers	GSF	Storage/transport container, irradiated 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
				HCV	cooling tower-fan
		HX	Heat exchanger	HXA	heat exchanger
				HXB	heat exchanger, straight tube, horizontal
				HXC	heat exchanger-evaporative condenser
				HXF	heat exchanger fuel storage
				HXH	heat exchanger, U-tube, horizontal shell and tube
				HXM	heat exchanger, straight tube, vertical shell and tube
				HXP	heat exchanger plate type
				HXR	heat exchanger pond heat removal
				HXT	heat exchanger cleaning system
				HXV	heat exchanger, U-tube, vertical shell and tube
I	Instrumentation (channels, reactor protection system)	IA	Instrumentation	IAA	instrumentation
				IAR	control rod position indication
I		IC	Instrumentation channel analogue	ICA	Instrument channel analogue general

Text cont. on p. 44

TABLE II–1. COMPONENT CATEGORIES, GROUPS AND TYPES AND ASSOCIATED CODING (cont.)

Code	Component Category Description	Code	Component Group Description	Code	Component Type Description
I	Instrumentation (channels, reactor protection system)	IC	Instrumentation channel analogue	ICC	Instr. Ch. Analogue core flux
				ICD	Instr. Ch. Protection logic
				ICF	Instr. Ch. Analogue flow
				ICL	Instr. Ch. Analogue level
				ICP	Instr. Ch. Analogue pressure
				ICS	Instr. Ch. Analogue seismic
				ICT	Instr. Ch. Analogue temperature
				ICZ	Instr. Ch. Analogue-parts
		ID	Instrumentation chan. 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 temperature
J	Other mechanical equipment, lifting gear, structures, experimental setup	JB	Brake Drum-Movable Reactor Bridge	JBM	Brake drum-movable reactor bridge
		JC	Core structure	JCA	Core structure, general
				JCG	Grid plate
				JCT	Fuel guide tube
		JE	Clutch	JEE	Clutch electrical
				JEM	Clutch mechanical
		JF	Pneumatic Fitting	JFT	Pneumatic fitting
		JG	Core tools	JGF	Floating core tools
		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
		JR	Crane bridge	JRB	Crane bridge
		JT	Tank	JTF	Tank resin flushing
				JTR	Tank storage, refuelling water storage tank
		JX	Tele-manipulator	JXT	Tele-manipulator
K	Circuit breakers	KA	Circuit breaker	KAA	Circuit breaker, general
				KAC	Circuit breaker AC
		KC	Circuit breaker moulded type	KCA	Circuit breaker moulded 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
		LT	Transmitter temperature	LTT	Transmitter temperature
		LP	Transmitter pressure	LPP	Transmitter pressure
				LPD	Transmitter pressure difference

Text cont. on p. 45

TABLE II–1. COMPONENT CATEGORIES, GROUPS AND TYPES AND ASSOCIATED CODING (cont.)

Code	Component Category Description	Code	Component Group Description	Code	Component Type Description
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 bi-stable
				NCB	Personal computer, pc
				NCD	Data acquisition system
				NCW	Work station computer
		ND	Printer	NDA	Printer, general
		NI	Interface	NIN	Computer network, general
		NK	Computational module	NKA	Computational module
		NM	Signal modifier	NMA	Signal modifier
				NMM	Signal modifier median selector
				NMO	Signal modifier voltage-pneumatic transducer
				NMP	Signal modifier current-pneumatic transducer
				NMR	Signal modifier resistance-voltage transducer
				NMS	Signal modifier square root extractor
				NMT	Signal modifier current-current transducer
				NMV	Signal modifier current-voltage transducer
				NMX	Signal modifier, multiplier
		NO	Input/output device	NOA	Input/output device
		NP	Programmable logic controller	NPA	Programmable logic controller
		NS	Signal conditioning system	NSA	Signal conditioning system for core flux, level, pressure, temperature, temperature general
				NSC	Sign. Cond. Sys. Core flux
				NSF	Sign. Cond. Sys. Flow
				NST	Sign. Cond. Sys. Temperature
O	Control rods and drive mechanism	OC	Control rod	OCC	Control rod cruciform, boron carbide control rods
				OCR	Control 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
				PMT	Pump motor & turbine driven
		PT	Pump turbine driven	PTA	Pump turbine driven
		PW	Pump without driver	PWB	Pump horizontal, 22-820 L/s
				PWC	Pump centrifugal
				PWE	Pump vertical, 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	QCH	Compressor diaphragm-helium circulation
				QCI	Compressor instrument air
				QCX	Freon compressor

Text cont. on p. 46

TABLE II–1. COMPONENT CATEGORIES, GROUPS AND TYPES AND ASSOCIATED CODING (cont.)

Code	Component Category Description	Code	Component Group Description	Code	Component Type Description
Q	HVAC and air handling equipment	QC	Compressor	QCY	Freon compressor-air dryer
		QD	Damper	QDA	Damper
				QDM	Damper manual (HVAC)
		QF	Fan cooler containment	QFB	Blower fan-critical cell vac
				QFR	Emergency exhaust fan-ventilation
				QFV	Fan containment ventilation fan
				QNA	Cooling fan centrifugal
		QV	HVAC unit annulus ventilation	QVA	HVAC unit auxiliary building
				QVB	HVAC unit battery room ventilation
				QVG	HVAC unit air ventilation, general
				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
				RRS	Switch relay
				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
		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	Transformer	TX	Transformer for main facility supply		
		TA2	Transformer	TA2	Transformer 220/120 VAC
				TA6	Transformer 6 kvac/380 VAC
				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

Text cont. on p. 47

TABLE II–1. COMPONENT CATEGORIES, GROUPS AND TYPES AND ASSOCIATED CODING (cont.)

Code	Component Category Description	Code	Component Group Description	Code	Component Type Description
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	Analogue display
				UID	Digital instrument
				UIE	Indicating instrument electronic
				UIL	Indication lamp
				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-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
				VAT	Valve air operated butterfly
		VC	Valve self-operated	VCA	Valve self-operated check
				VCF	Valve self-operated by floating device
		VD	Valve solenoid operated	VDA	Valve solenoid operated
		VM	Valve motor operated	VMA	Valve motor operated
				VMT	Valve motor operated butterfly
		VP	Valve piston operated	VPA	Valve piston operated
		VR	Valve relief	VRA	Valve relief
		VS	Valve safety	VSA	Valve safety
		VW	Valve without operator	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 equipment	WA	Shielding general	WAA	Shielding general
		WF	Shielding irradiated fuel	WFA	Shielding irradiated fuel
		WS	Shielded door	WSD	Shielded door
		WX	Shielding of experiments	WXA	Shielding of experiments
X	Fuel element, and fuel tubes, reflector elements, flux shaping elements	XA	Fuel, general	XAA	Fuel elements, general
				XAM	MTR fuel element, general
				XAT	TRIGA fuel element, general
		XB	Reflector, beryllium	XBM	MTR standard reference element Be metal
				XBN	MTR standard reference element Be oxide
		XC	Fuel element handling tool	XCA	Fuel element handling tool, general
				XCM	Fuel element handling tool, manual
				XCR	Fuel element handling tool, remote

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TABLE II–1. COMPONENT CATEGORIES, GROUPS AND TYPES AND ASSOCIATED CODING (cont.)

Code	Component Category Description	Code	Component Group Description	Code	Component Type Description
X	Fuel element, and fuel tubes, reflector elements, flux shaping elements	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, standard flip
		XL	Fuel element LEU	XLA	Fuel element LEU, general
				XLT	Fuel element TRIGA, standard LEU
				XLU	Fuel element TRIGA, instrumented LEU
				XMR	Fuel element rod type MEU
		XP	Fuel element process tubes	XPA	Fuel element process tube, general
		XR	Reflector element, graphite	XRM	Reflector element graphite, MTR
				XRT	Reflector element graphite, TRIGA
		XT	Flux shaping element	XTM	Flux shaping element, MTR
Y	Strainers, filters, demineralizer	YA	Air filter	YAA	Air filter
				YAC	HEPA/charcoal filter (ventilation)
		YD	Demineralizer	YDA	Demineralizer
		YE	Ejector H_2SO4, NaOH	YEN	Ejector H_2SO_4, naoh
		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

TABLE II–2. FAILURE MODE CODE DEFINITIONS

Failure Mode Code	Failure Mode
A	All Modes
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
N	Erroneous Signal

Note: Detailed definitions of most of the above failure modes (with associated examples) are provided in Ref. [2]. Failure Mode A has been added to be consistent with Ref. [27] and Failure Mode N has been subsequently added.

Table II–3 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 test or operational features that the contributors consider relevant. It is recognized that this information does not provide complete descriptions. Nevertheless, it provides information at more specific level than the component type descriptions of Table II–1.

TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY

Component Code	(Country) Reactor Code	Specific Information on Component Types
AAR	(AR) RA3	Component: Sensor air. Subsystem: Instrumentation and control system. Population: 3
ACA	(IN) A	Component: Sensor core flux. Population: 3
ACA	(VN) DALAT	Component: Sensor core flux; Manufacturer: Russia Type: KNK-15, KNK-3 Component boundary: Sensor only; Operating duty: Operating; System: Neutron flux control sub-system, Reactor control system; Population: 9
ACA 01	(ID) B	Component: Sensor core flux; Type: Compensated ionization chamber (CIC); System: Reactor instrumentation; Component boundary: Cables, Grommet, Housing extension watertight bolt flange, Lower seal; Operating duty: Operating; Manufacturer: GA, USA; Population: 2
ACA 01	(ID) S	Component: Sensor core flux; Type: CIC; System: Nuclear instrumentation; Component boundary: Detector tube, Cable connector, High voltage supply, Insulation resistance, Manufacturer: Hartmann & Braun; Operating duty: Operating; Population: 9
ACA 02	(ID) B	Component: Sensor core flux; Type: Fission Chamber (FC); System: Reactor instrumentation; Component boundary: Cables, Grommet, Housing extension watertight bolt flange, Lower seal; Operating duty: Operating; Manufacturer: GA, USA; Population: 2
ACA 02	(ID) S	Component: Sensor core flux; Type: FC; System: Nuclear instrumentation; Component boundary: Detector tube, Cable connector, High voltage supply, Insulation resistance, Manufacturer: Hartmann & Braun; Operating duty: Operating; Population: 2
ACA01	(ID) Y	Component: Sensor core flux; Type: Compensated ionization chamber (CIC); System: Reactor instrumentation; Component boundary: Cables, Grommet, Housing extension watertight bolt flange, Lower seal, Moisture proof welded seal, Neutron detector; Operating duty: Operating; Manufacturer: GA, USA; Population: 2
ACA02	(ID) Y	Component: Sensor core flux; Type: Fission Chamber (FC); System: Reactor instrumentation; Component boundary: Cables, Grommet, Housing extension watertight bolt flange, Lower seal, Moisture proof welded seal, Neutron detector; Operating duty: Operating; Manufacturer: GA, USA; Population: 2
ACF	(AR) RA6	Component: Fission chamber, Population: 3

Text cont. on p. 51

TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
ACF	(BR) BR01	Component: Fission chamber; System: Instrumentation and control system; Manufacturer: Westinghouse; Model: WL-6376-A; 93% enriched U; Operating duty: 1 fission chamber operating, 1 standby; Component boundary: Sensor and local power supply; Population: 2
ACF	(IN) D	Component: Fission chamber; Population: 2
ACF01	(AR) RA3	Component: Fission chamber mechanism; Subsystem: Instrumentation and control system; Component boundary: Sensor; Population: 2
ACF02	(AR) RA3	Component: Fission chamber; Subsystem: Instrumentation and control system; Component boundary: Sensor; Population: 2
ACI	(AR) RA6	Component: Fission chamber mechanisms; Subsystem: Instrumentation and control system; Population: 3
ACI	(AT) TRIGA MARK-II	Component: Compensated ionization chamber: RC6EB; Manufacturer: Centronix; Population: 3
ACI	(CA) NRU	Trip and control system ionization chambers, TQU, (6 x 10^{-14}A/n), 300 VDC input, Population: 8
ACI	(IN) D	Component: Ion chamber. Population: 9
ACI	(CZ)	Ionization chamber, Population : 12
ACI01	(AR) RA3	Component: running chain; Component boundary: Sensor, Population: 3
ACI02	(AR) RA3	Component: Compensated ionisation chamber, lineal chain; Subsystem: Instrumentation and control system, Population: 1
ACS	(CH)	Component: self-powered detector; Population: 3
AFA	(AR) RA3	Component: Flow meter; Subsystem: Primary cooling system; Population: 1
AFA	(CA) NRU	Differential pressure cell for flow trips (three), Taylor Electronics, Model 1304T, 0-300” water column, 4-20 mA; Population: 3
AFA	(ID) Y	Component: Sensor Flow; Type: Venture and magnetic Flow meter MK 309; System: Primary cooling system; Component boundary: Cables, Electronic interface, Connectors, Supporting case; Specification: 0-530 L/min; Operating duty: Operating; Manufacturer: GA, California USA; Population: 2

Text cont. on p. 52

TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
AFA 01	(ID) S	Component: Sensor flow; Type: Orifice; System: Rabbit system, Make-up water system, Chilled water system, Raw water system, Stack monitoring, Low activity waste, drainage, Primary water system; Component boundary: Metal box, Control rod, Pressure tank, Vacuum room, Metal membrane, Differential converter, Electronic oscillator, Power supply 24 VDC, Cable connector; Manufacturer: Siemens; Operating duty: Operating; Population: 60
AFA 02	(ID) S	Component: Sensor flow; Type: Orifice; System: Primary and secondary cooling system; Component boundary Metal box, Control rod, Pressure tank, Vacuum room, Metal membrane, Differential converter, Electronic oscillator, Power supply 24 VDC, Cable connector; Detail/Specification: Measuring range: 1-10 bar; Output signal: 4-20 mA; Manufacturer: Siemens; Population: 10
AFA01	(VN) DALAT	Component: Sensor flow in primary coolant flow meter; Manufacturer: Russia, Hartmann & Braun; Type: DK-6-100-1-B-2, ARK500; Component boundary: Sensor only; Operating duty: Operating; System: Primary coolant flow meter, Reactor instrumentation system; Population: 1
AFA02	(VN) DALAT	Component: Sensor flow in secondary coolant flow meter; Manufacturer: Russia, Hartmann & Braun; Type: DK-6-100-1-A/G-2, ASK800; Component boundary: Sensor only; Operating duty: Operating; System: Secondary coolant flow meter, Reactor instrumentation system; Population: 1
ALA	(AR) RA6	Component: Floating water level; Subsystem: Instrumentation and control system; Population: 4
ALA	(CA) NRU	Differential pressure cell for level trips, Foxboro 13A, 20-100 kPa(d), range 0 to 150 cm water column; Population: 3
ALA	(CH)	Component: Sensor level; Population: 12
ALA	(ID) B	Component: Sensor level; Type: Wire; System: Control level air primer; Component boundary: Liquid level control, Relay, Magnet; Specification: Cu, Operating duty: Operating; Manufacturer: Batan; Population: 1
ALA	(ID) B	Component: Sensor level; Type: Capacitive; System: Reactor pool and spent fuel storage pool; Component boundary: Probe rod, Seal and boss, Earth connection in probe head, Electronic insert EC37 Z, Connection to terminal block: Power Supply +24 VDC; Manufacturer: Endress + Hausser Ltd.; Operating duty: Operating; Population: 31
ALA	(ID) Y	Component: Sensor level; Population: 2
ALR	(BR) BR01	Component: Sensor pool water level; System: Instrumentation and control system; Type: LCD-580; Manufacturer: NIVETEC; Component boundary: Sensor and local power supply; Population: 1

Text cont. on p. 53

TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
ALR	(VN) DALAT	Component: Sensor pool water level; Manufacturer: Russia, Hartmann & Braun; Type: ARK 200; Component boundary: Sensor only; Operating duty: Operating; Population: 1
APA	(CA) NRU	Pressure switch for high pressure trip (three), United Electric controls, 0-340 kPag; Population: 3
APA	(ID) S	Component: Sensor of control pressure; Type: Bourdon tube; System: Process control system, Reactor protection system; Component boundary: Metal box, Control rod, Pressure tank, Metal membrane, Differential converter, power supply 24 VDC.; Detail/ Specification: Measuring range: 30-300 mbar, 60-600 mbar, 400-4000 mbar, 1000-10000 mbar; Output signal 4-20 mA; Manufacturer: Siemens; Operating duty: Operating; Population: 42
APD	(ID) S	Component: Sensor Pressure Difference; Type: Bourdon tube; System: Process control system, Reactor protection system.; Component boundary: Metal box, Control rod, Pressure tank, Metal Membrane, Differential converter, Electronic oscillator, power supply +24 VDC; Detail/ Specification: 3000 mbar, 1000-10,000 mbar, 500 mbar; Output signal: 0-20 mA. Measuring range: 30-300 mbar; Manufacturer: Siemens; Operating duty: Operating; Population: 29
AQC	(AR) RA6	Component: Sensor conductivity, 4-20 mA; Population: 5
AQC	(BR) BR04	Component: Sensor-Conductivity; System: Moderator Water Treatment System; Type: electronic, 110 V; Operating duty: Operating; Component boundary: Sensor and power supply, Population: 5
AQC	(VN) DALAT	Component: Sensor conductivity of the primary cooling water; Manufacturer: Russia, JEWAY (UK); Type: KT10, JEWAY; Component boundary: Sensor only; Operating duty: Operating; Population: 2
AQC 01	(ID) S	Component: Sensor conductivity; Type: Bourdon Tube; System: Process control system; Component boundary: Box, Control rod, Pressure Tank, Metal membrane, Differential converter, Electronic oscillator, power supply +24 VDC; Specification: Measuring ranges: 30-300 mbar, 50-500 mbar, 300-3000 mbar, 1000-10,000 mbar; Output signal: 4-20 mA, Operating duty: Operating; Manufacturer: Siemens; Population: 29
AQC 02	(ID) S	Component: Sensor conductivity; Type: Capacitive; System: Secondary cooling System; Component boundary: Sensor Shielding, Transmission system, Wiring terminal, Connection system to the transmitter; Specification: Range: 1-1000 µS/cm, 0-50 ohm; output current: 0-0 mA; power supply: +24 VDC; Operating duty: Operating; Manufacturer: Siemens; Population: 2
AQP	(RO) TRIGA	Component: pH Sensor, System: Purification Circuit; Details: Sensor is located on the inlet water pool pipe of the pool purification circuit, used for automatic chemical control of the primary cooling water; Component boundary: Sensor itself; Population: 1

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
ARA	(AR) RA3	Component: Aerosol monitor; Subsystem: Instrumentation and control system, Population: 1
ARA	(AT) TRIGA MARK-II	Component: GM counter with filter; Manufacturer: Hartmann & Braun (1975); Population: 1
ARA	(CH)	Component: aerosol monitor; Berthold; Population: 1
ARA	(ID) S	Component: Alpha–Beta measuring channel; Type: IC; System: Working area protection system, Stack Monitoring System; Component boundary: Unit of Detectors, Power supply Voltage from external source of HVDC Module, 3-Channel Amplifier with anti-coincident module, pseudo-coincident module indicators, Pump, Flow meter, Filter; Operating duty: Operating; Manufacturer: Berthold; Population: 8
ARA	(SI)	Component: aerosol monitor; Population: 1
ARA01	(RO) TRIGA	Component: Aerosol Monitor, Type: Berthold; System: Fission Product Monitoring System; Component boundary: the monitor including all component mentioned above (pump, detector, preamplifier, electronic unit); Operating duty: Operating; Population: 7
ARA02	(RO) TRIGA	Component: Aerosol Monitor, Type: Berthold with movable filter, type FHT 72; System: Fission Product Monitoring System; Component boundary: the monitor boundary including all components mentioned above (pump, flow-meter, detectors, electronic unit); Population: 1
ARG	(AT) TRIGA MARK-II	Component: Gamma Monitor; Manufacturer: Berthold; Population: 1
ARG	(AU) HIFAR	Component: Gamma Monitor; Subsystem: Containment Isolation System; Component boundary: Sensing head, cabling from the head to the electronic amplifier, power supply connections and the trip unit; Population: 17
ARG	(CH)	Component: gamma monitor; Population: 12
ARG	(ID) S	Component: Gamma Ionization Chamber; Type: IC; System: Local Area protection system, Environment protection system.; Component boundary: Detector tube, Cable connector, High Voltage supply, Insulation resistance; Manufacturer: Hartmann and Braun; Operating duty: Operating; Population: 15
ARG	(ID) Y	Component: Gamma Ionization Chamber; Type: RMS II; System: Area monitoring system; Component boundary: HV, Connector, Cables; Detail/Specification: Operating duty: Operating; Manufacturer: Eberlyn; Population: 6

Text cont. on p. 55

TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
ARG	(IN) D	Component: Gamma monitor – ventilation; Population: 2
ARG01	(CA) NRU	Gamma motor, actuates emergency filter system, AEP 5180 type. Population: 1
ARG01	(RO) TRIGA	Component: Gamma Monitor, Type: Berthold; System: Fission Product Monitoring System. Ten gamma Berthold monitors are located in reactor hall, personnel lock chamber, lock chamber for auto, main circulating pumps hall, heat exchanger hall, ventilation towers, purification circuit, radioactive waste collecting system, irradiation devices hall, beam room; Component boundary: counter, electronic unit, remote signal output; Operating duty: Operating; Population: 10
ARG02	(CA) NRU	Gamma monitor, actuates emergency filter system, Eberline type. Population: 3
ARG02	(RO) TRIGA	Component: Gamma Monitor, Manufacturer: Russia, Type: Actinia; System: Fission Product Monitoring System; Component boundary: counters, electronic unit; Operating duty: both operating. Population: 2
ARI	(RO) TRIGA	Component: Iodine Monitor, Type: Berthold; System: Fission Product Monitoring System: One iodine monitor located at the air exhaust stack; Component boundary: iodine monitor including all components as noted for ARG01 (RO) above; Population: 1
ARN	(ID) S	Component: Neutron monitor; Type: IC; System: Portable equipment; Component boundary: High Voltage Supply to the detector, Detector, Pre- Amplifier and Amplifier, Display; Specification: Type: Dineutron, portable; Detector: Gas filled; Operating duty: Operating; Manufacturer: Nardeux; Population: 3
ARN	(ID) Y	Component: Neutron monitor; Population: 1
ARO	(RO) TRIGA	Component: Gas Monitor, Type: Berthold, System: Fission Product Monitoring System. There are six gas monitors located in reactor hall, ventilation system, ventilation evacuating tower, purification circuit, radioactive waste collect system, beam tubes hall; Component boundary: the monitor including all component mentioned above (pump, flow meter, preamplifier, electronic unit); Operating duty: Operating; Population: 6
ARU	(AR) RA3	Component: area monitor; Subsystem: Radiation Monitoring System, Population: 1
ARU	(AR) RA6	Component: area monitor; Subsystem: Radiation Monitoring System, Population: 22
ARU	(BR) BR04	Component: Radiation Monitoring Alarm Unit; System: Radiation Monitoring System; Type: radiation monitor; Operating duty: Operating; Component boundary: monitor, vacuum pump motor, vacuum pump, paper and coal air filter, detector and associated electronics, alarms and power supply; Population: 4

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
ARU01	(BR) BR01	Component: Radiation monitoring alarm unit – duct monitor; System: Instrumentation and control system; Type: 942-A; Manufacturer: VICTOREEN – Model 942-A; Component boundary: detector, monitor; Population: 4
ARU02	(BR) BR01	Component: Radiation monitoring alarm unit, area monitor; System: Instrumentation and control system; Type: 956-A; Manufacturer: VICTOREEN–Model 956 A; Component boundary: detector and cabling; Population: 9
ARW	(RO) TRIGA	Component: Water Activity Monitor, Type: Berthold, System: Fission Product Monitoring System; Details: The monitor measures the water activity from TRIGA reactor primary circuit, type Berthold (the symbol used is RL01). It is a multi-channel analyzer (NaI scintillation counter) with two channels linear and logarithmic. Component boundary: scintillation counter, electronic unit; Population: 1
ASA	(ID) S	Component: Sensor speed; Type: Rotary; System: Primary cooling System, Secondary cooling System; Component boundary: Voltage Supply 15 V DC, Rotary anchor, Electronic transmitter; Specification; Output signal: 0-20 mA; Operating range: 0-2000 rev./min; Operating duty: Operating; Manufacturer: Siemens; Population: 6
ASA	(ID) Y	Component: Sensor speed; Population: 1
ATA	(AR) RA6	Component: thermocouple; Component boundary: Thermocouple body, Population: 10
ATA	(AT) TRIGA MARK-II	Component: Sensor temperature, Population: 1
ATA	(BR) BR01	Component: Sensor temperature; System: Instrumentation and control system; Type: thermocouple; Manufacturer: ECIL; Component boundary: Sensor and local power supply: Population: 24
ATA	(CA) NRU	Temperature trip instrument, resistance to current transducer, Foxboro, Model 694-P, 0-1 mA, 20°-65°C; Population: 8
ATA	(ID) B	Component: Sensor temperature; Type: RTD; System: Primary cooling system; Component boundary: Water, Pipe, Detail/Specification: 4-20 mA, 220 VAC; Operating duty: Operating; Manufacturer: Amerika; Population: 3
ATA	(ID) B	Component: Temperature Sensor; Type: Resistive; System: Process System, Reactor Protection; Component boundary: Wire and tube, cable connector, Supply voltage +24VDC, connection between sensor and transmitter; Specification: Probe: PT 100; Output signal: 0-20 mA; Operating duty: Operating; Manufacturer: Heraeus GmBH, Germany; Population: 12
ATA	(IN) D	Component: Thermocouple; Population: 130

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
ATA	(ID) Y	Component: Sensor temperature; Population: 4
ATA	(SI)	Component: Sensor temperature; Population: 4
ATA	(VN) DALAT	Component: Sensor temperature; Manufacturer: Russia, Hartmann & Braun; Type: TCP-5076, TCM-5071, PT-100; Component boundary: Sensor only; Operating duty: Operating; System: Reactor Temperature Instruments, Reactor Instrumentation System; Population: 9
BCA	(ID) S	Component: Battery charger; Type: Electronic control system; System: Uninterruptible Power supply, Diesel Emergency Sets; Component boundary: Input Fuse Isolator, Input Transformer, Rectifier Fuse, Thyristor, Rectifier Bridge, Capacitor, Battery Terminal.; Detail/Specification: Capacity: 150 Ah; Voltage: 24 VDC; Operating duty: Operating; Manufacturer: Germany; Population: 6
BCA	(ID) Y	Component: Battery charger; Population: 1
BCS	(ID) S	Component: Battery charger solid state; Population: 6
BCS	(ID) Y	Component: Battery charger solid state; Population: 1
BTA	(AT) TRIGA MARK-II	Component: Battery; Population: 1
BTA	(ID) S	Component: Battery Lead acid; System: Uninterruptible power supply, Diesel Emergency Sets; Component boundary: Box Fuses, Cells, Positive rod plates, negative grid plates, Plastic covers, Ground battery racks, Cables, Connecting Clamps; Specification: Hoppecke: 11 OSP 1100, 3 OSP 150; Voltage: 1.87 V/Cell; Quantity: 13 cells (output 24 VDC), 13 cells (output-24 VDC), 111 cells (for output 220 VAC), 102 cells (for output 220 VDC); Operating duty: Operating; Manufacturer: Germany; Population: 402
BTA	(ID) Y	Component: Battery; Population 4
BTA	(CZ)	Component: Battery; Population 4
BTL	(BR) BR04	Component: Battery (Auxiliary Diesel Engine); System: Electrical power supply System; Type: Lead acid accumulator; Operating duty: Standby; Component boundary: battery, terminal connections and starting button. Population: 2

Text cont. on p. 58

TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
BTL	(CA) NRU	DC lead acid battery bank, 120 x 2.15 VDC cells, Gould, discharge tested once per year for a 3-hour mission, (degraded failure is failure to complete mission test specification, failure to run is failure to operate on demand, with required amperage; Population: 2 banks of 60 cells
BTL	(ID) Y	Component: battery lead acid accumulator; Population: 2
BTL	(CN) M	Component: battery lead acid accumulator, Population: 1
BTL	(ID) S	Component: battery lead acid accumulator; Population: 22
BTV01	(IN) D	Component: Battery bank 240 VDC; Population: 2
BTV02	(IN) D	Component: Battery bank 48 VDC; Population: 2
CB2	(CH)	Component: bus 120 VAC, 220VAC single phase; Population: 1
CB3	(VN) DALAT	Component: Bus 220 VAC, 380 VAC three phase; Manufacturer: Russia; Type: Bus AC; Component boundary: Bus AC of electric power supply system; Operating duty: Operating; System: Electric Power supply system; Population: 3
CB4	(IN) C	Component: Bus conductor 3 phase 415 VAC; Population: 1
CB4	(IN) D	Component: Bus 415 VAC 3 phase; Population: 10
CBA	(CA) NRU	Electrical distribution bus 600 VAC, Population: 1
CBD	(IN) D	Component: Bus 240 VDC, Population: 4
CBD	(VN) DALAT	Component: Bus DC; Manufacturer: Russia; Type: Bus DC; Component boundary: Bus DC of electric power supply system; Operating duty: Operating; System: Electric Power supply system; Population: 2
CBH	(IN) D	Component: Bus 3.3 kV; Population: 3
CBI	(IN) D	Component: Bus 22 kV; Population: 2

Text cont. on p. 59

TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
CCP	(VN) DALAT	Component: Cable power; Manufacturer: Russia; Type: ACBOZ-1000, AAB1-1000; Component boundary: Cable power of electric power supply system; Operating duty: Operating; System: Electric Power Supply system; Population: 10
CCS	(BR) BR04	Component: Conductor; System: Radiation Monitoring System-Panel board; Type: alarm cable signal (supervisory); Operating duty: Operating; Component boundary: instrument, cable and power supply; Population: 16
CCS	(IN) D	Component: Signal Cable (~3,000 m length)
DGA	(AU) HIFAR	Component: Diesel Generator; System: Electrical power supply system (standby); Engine Manufacturer: Dorman Model 6PTCR2; Engine Type: Four stroke, turbo charged water-cooled diesel rated at 311 kW continuous operation; Alternator: Stamford AC Alternator Type: SC434E, 300 kVA, 435 V, 3 phase, 50 Hz at 1500 rev./min; Component boundary: Complete plant including engine, alternator, starter, fuel system; Operating duty: Standby. Test run for 1 hour every week except during shutdown (every 4-5 weeks) when they are run for 2 hours; Population: 2
DGA	(BR) BR04	Component: Diesel Generator Emergency AC; System: Electrical power supply system - Essential Power; Details: Diesel Motor, 220 kW, 250 kVA, 380 VAC, 3 phase, 60 Hz; Fuel supply: 1 daily tank-500 L; 1 storage tank: 6000 L; Operating duty: Standby; Component boundary: diesel engine, fuel supply, electric generator unit, control unit, lubrication system, cooling system (excludes starting auxiliary battery); Population: 1
DGA	(CZ)	Component: Diesel Generator Emergency AC; Population: 1
DGA	(ID) B	Component: Diesel Generator Emergency AC; Type: Diesel; System: Emergency System; Component boundary: Diesel Engine, generator; Detail/Specification: 310 kVA, 380/220 VAC, 3 phase; Operating duty: Standby; Population: 1
DGA	(ID) S	Component: Diesel Generator Emergency AC; Type: Diesel; System: Diesel Emergency Sets; Component boundary: Diesel engine, generator, stator, rotor, exciter, rectifier, yoke ring, fuel pump water pump, oil cooler, control equipment, logic and instrumentation; Specification: Brushless synchronous generator; Capacity per unit: 525 kVA; Voltage/Phase: 400 VAC, 3 phase; frequency 50 Hz; Power factor 0.8; Rotation: 1500 rev./min; Diesel; Type: VTA28G1; Capacity: 500 kW at 1500 rev./min; Operating duty: Standby; Manufacturer: Siemens (Generator), Cummins (Engine); Population: 3
DGA	(ID) Y	Component: Diesel Generator Emergency AC; Type: OM 355 V; System: Emergency Power Supply; Component boundary: Generator, Motor diesel, Cooling system, Battery, Panel; Specification: 3 phase; 100 kVA; 262 A, 1500 rev./min. Operating duty: Operating; Manufacturer: Mercedes Benz Germany; Population: 1
DGA	(VN) DALAT	Component: Diesel generator emergency AC; Manufacturer: Russia, Germany; Type: DGA-2-48M1, 30RFOZJ; Component boundary: Diesel engine, generator and generator output breaker, control equipment, logic and instrumentation, service systems; Operating duty: 1 in operation and 1 in standby; System: Electric Power supply system. Diesel generator details: Power: 50 kW; Output voltage: 380/220 VAC; Frequency: 50 Hz; Population: 2

Text cont. on p. 60

TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
DGA01	(BR) BR01	Component: Diesel Generator–emergency AC (220VAC); System: Electrical Power supply system. Engine: MWM, four-stroke, 8 cylinders, turbo charged, water cooled diesel;160 kW; continuous operation at 1800 rev./min; Alternator: Toshiba, synchronous, 3 phase, 160 kVA, 220/127 VAC, 60 Hz at 1800 rev./min; Operating duty: Standby; Component boundary: complete plant - including starting system, diesel motor, electric generator unit, control unit, lubrication system, cooling system. Population: 1
DGA01	(CA) NRU	Emergency diesel generator, 125 to 200 kVA, 6 cylinders, Cummins & GM, tested once per month; Population: 10
DGA02	(BR) BR01	Component: Diesel Generator – emergency 440 VAC; System: Electrical Power supply system; Engine: MWM, four-stroke, 12 cylinders, turbo charged, water cooled diesel; rated at 245 kW continuous operation at 1800 rev./min; Alternator: Toshiba, synchronous, 3 phase, 250 kVA, 440/380 VAC, 60 Hz at 1800 rev./min; Operating duty: Standby; Component boundary: complete plant - including starting system, diesel motor, electric generator unit, control unit, lubrication system, cooling system; Population: 1
DGA02	(CA) NRU	Emergency diesel generator, 250 kVA, 6 cylinders, Cummins, tested once per week; Population: 1
DGA03	(BR) BR01	Component: Diesel Generator-emergency AC (No-Break 440 VAC); System: Electrical power supply system; Motor generator: Motor: Anel, asynchronous, 3 phase; rated at 187 kW continuous operation at 1800 rev./min; Alternator: Anel, synchronous, 3 phase, 205 kVA, 440 V, 60 Hz at 1800 rev./min.; Diesel motor: Caterpillar, four-stroke, 12 cylinders, turbo charged, water cooled diesel; rated at 160 kW continuous operation at 1800 rev./min; Operating duty: Standby; Component boundary: starting system, motor generator, flywheel, electromagnetic clutch, diesel motor, control unit, lubrication system, fuel supply, cooling system; Population: 1
DGA04	(BR) BR01	Component: Diesel Generator – emergency 220 VAC); System: Electrical power supply system; Motor generator: Motor DC: Negrine, 230/310 VAC; rated at 25 kW continuous operation at 1800 rev./min.; Alternator: Negrine, synchronous, 3 phase, 25 kVA, 220/127 VAC, 60 Hz at 1800 rev./min; Diesel generator: Diesel motor: Magirus-Deutz, Four-stroke, 6 cylinders, Turbo charged, Water cooled diesel; rated at 80 kW continuous operation at 1800 rev./min; Alternator: Negrine, Synchronous, 3 phase, 60 kVA, 220 V, 60 Hz at 1800 rev./min; Operating duty: Standby; Component boundary: Starting system, Motor generator, Flywheel, Static converter, Battery charger, Batteries, Diesel generator, Control unit, Lubrication system, Fuel supply, Cooling system; Population: 1
EBA	(ID) B	Component: Switch Gear Panel; System: Control panel system; Component boundary: Body, Fuse, Switch, box; Specification: 200 A, 100 A; Operating duty: Operating; Manufacturer: Indonesia, Germany; Population: 4
EBA	(CZ)	Component: Switch Gear Panel; Population: 12

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
EBA	(ID) S	Component: Terminal; Type: Normally Open (NC-NO); System: Venting System Intermediate Radiation Zone, Secondary cooling System, Control rod, Material Access, SGR 01; Component boundary: Relay, Wire, Fuse; Specification: NYY 4 x 6 mm^2, Cu, PVC; Operating duty: Operating; Manufacturer: Siemens, Germany; Population: 2340
EBA	(ID) Y	Component: Electric terminal; System: Control panel system; Component boundary: Body, Fuse, Switch, box; Detail/ Specification: 200 A, 100 A; Operating duty: Operating; Manufacturer: Indonesia, Germany; Population: 4
EBM01	(BR) BR01	Component: Panel board-electric motor control centre; System: Electrical power supply system – Vital Power; Manufacturer: CAEG; Component boundary: Cooling pump (primary and secondary circuit) command and local power supply; Cooling tower fans command and local power supply; Population: 1
EBM02	(BR) BR01	Component: Panel board-electric motor control centre; System: Electrical power supply system – Essential Power; Manufacturer: Termoplan; Component boundary: Ventilation fan motor command and local power supply, Damper local power supply; Population: 1
EBM03	(BR) BR01	Component: Panel board-electric motor control centre; System: Electrical power supply system – Normal Power; Manufacturer: CAEG; Component boundary: compressor (air conditioning) cooling pump command and local power supply; Population: 1
EBS	(BR) BR01	Component: Panel board – Reactor cooling system command – control room; System: Reactor cooling system – Primary circuit; Manufacturer: IPEN; Component boundary: Cooling pump (primary and secondary circuit) command; Cooling tower fans command; Population: 1
EEL	(AR) RA3	Component: 1500-2000 W lamps (pool reflectors); Population: 5
EHO	(ID) S	Component: Oil heater; Type: Electric; System: Chilled water intermediate radiation zone, Chilled water low radiation zone, Compress air system, Venting system intermediate radiation zone; Component boundary: Wire, Trafo, Ceramic; Specification: 200 W, 220 VAC; Operating duty: Operating; Manufacturer: Germany; Population: 12
EHO	(ID) Y	Component: Oil heater; Population: 2
EHW	(ID) S	Component: Water heater; Type: Electric; System: Diesel emergency sets, Reactor pool purification system; Component boundary: Wire, Trafo, Fuse, Ceramic, Relay detail/specification: 1000 W, 220 VAC and 3 Phase, 380 VAC; Operating duty: Operating; Manufacturer: Germany; Population: 12

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
EIZ	(CA) NRU	Inverter, SAB NIFE, Model 120 PW7-5-107, input 120 VDC, 84 A, 7.5 kW, output 120 VAC, 60 cps, Single phase; Population: 3
EIX	(RO) TRIGA	Component: Inverter, Manufacturer: ASEA – SWEDEN, Type: Three stages, YRHA 200-60, 60 kVA, System: Electrical power supply system. Component boundary: Inverter assembly, Cooling fan, Rectifier, control circuit, Status indication; Population: 1
EIZ	(ID) S	Component: Inverter static single phase; Type: Electronic; System: Uninterruptible power supply; Component boundary: Input fuse isolator, Input transformer, Rectifier fuse, Thyristor, Rectifier bridge, Smoothing choke, DC link capacitor, Transistor bridge (inverter), Output filter, Capacitor, Battery terminal; Detail/specification: Rated supply voltage: 220 VDC; Rated power: 20 kVA; Power factor: 0.8; Rated frequency: 50 Hz Operating duty: Operating; Manufacturer: Siemens; Population: 3
EIZ	(ID) Y	Component: Inverter static single phase; Population: 6
EPA	(AT) TRIGA MARK-II	Component: Power Supply HR Series; Manufacturer: Hartmann & Braun (1968); Population: 1
EPA	(BR) BR01	Component: Power supply system: Instrumentation and control system; Type: local power supply (high/low voltage); Manufacturer: Technipower; Model: PL. 25, 7-0750; Component boundary: magnets (control rod drive mechanism) power supply; Population: 4
EPA	(BR) BR04	Component: Power Supply (Instrumentation and Control Equipment); System: Nuclear Instrumentation; Type: Control rod drive mechanism local power supply; Operating duty: Operating; Component boundary: Control rod drive mechanism local power supply, Cables and connectors; Population: 2
EPA	(CH)	Component: Outdoor 220 VAC, 50 Hz; Population: 1
EPA	(CZ)	Component: Power Supply (Instrumentation and Control Equipment); Population: 12
EPA	(ID) S	Component: Power supply; Type: AC/DC; System: Venting system intermediate radiation zone, Demineralized water supply, Fuel storage pool purification system, Gamma dose rate monitoring system, Radiation monitoring system; Component boundary: Transformer, Fuse, Cable, Breaker, Over load; Detail/specification: 3TB4117-OA, 6A; 3 FE1010-2D, 0.25-0.40 A; Operating duty: Operating; Manufacturer: Siemens; Population: 24
EPA	(ID) Y	Component: Power Supply I&C Equipment; Population: 6

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
EPA01	(AR) RA3	Component: Power Supply; Subsystem: Instrumentation and control system; Type: 24 VAC; Population: 1
EPA01	(VN) DALAT	Component: Power supply blocks 5 VDC and 24 VDC; Manufacturer: Russia; Type: BNN-150, BNN-152; Component boundary: Power supply block; Operating duty: Operating; System: Control logic sub-system, Reactor control system; Details: Output voltage regulator: 5 VDC and 24 VDC; Maximum load current: 10A with 5V and 5 A with 24V; Input Voltage: 180 VAC-250 VAC, Population: 7
EPA02	(AR) RA3	Component: Power Supply; Subsystem: Instrumentation and control system; Type: High voltage; Population: 6
EPA02	(VN) DALAT	Component: 48 VDC power supply; Manufacturer: Russia; Type: rectifier; Component boundary: Power supply; Operating duty: Operating; System: Control logic sub-system, Reactor control system; Details: Output voltage regulator: 48 VDC; Maximum load current: 50 A; Input Voltage: 150-250 VAC; Population:1
EPH	(BR) BR01	Component: High voltage power supply - Instrumentation and control equipment; System: Instrumentation and control system; Type: Local power supply, Input 105 VAC to 125 VAC (2.5 A); Output +15 VAC (3.5A) to –15 VAC (1.5A); Manufacturer: Gulf Electronic System; Model: V-008; Population: 2
EPH	(VN) DALAT	Component: High voltage source for sensor core flux; Manufacturer: Russia; Type: BNV-26; Operating duty: Operating; Details: Output Voltage Regulator: +400 VDC and -250 VDC; Maximum of load current: 2mA; Input Voltage: 12 VDC; Population: 9
EPH01	(AR) RA6	Component: High voltage power supply; Subsystem: Instrumentation and control system; Type: 520 VAC; Population: 3
EPH01	(BR) BR04	Component: High Voltage Power Supply (Instrumentation and Control Equipment); System: Nuclear Instrumentation; Type: High voltage power supply – analogue core flux – power channel; Operating duty: Operating; Component boundary: High voltage local power supply, Cables and connectors; Population: 8
EPH02	(AR) RA6	Component: High Voltage Power Supply; Subsystem: Instrumentation and control system; Type: 0-1000 VAC; Population: 16
EPH02	(BR) BR04	Component: High Voltage Power Supply (Instrumentation and Control Equipment); System: Nuclear Instrumentation; Type: High voltage power supply – analogue core flux – start-up and safety channel; Operating duty: Operating; Component boundary: high voltage local power supply, Cables and connectors; Population: 4
EPH03	(BR) BR04	Component: High Voltage Power Supply, Instrumentation and Control Equipment; System: Nuclear Instrumentation; Type: High voltage power supply – analogue core flux – start-up and safety channel; Operating duty: Operating; Component boundary: High voltage local power supply, Cables and connectors; Population: 4

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
EPH04	(BR) BR04	Component: High Voltage Power Supply, Instrumentation and Control Equipment; System: Nuclear Instrumentation; Type: high voltage power supply – analogue core flux – start-up and safety channel; Operating duty: Operating; Component boundary: high voltage local power supply, Cables and connectors; Population: 4
EPH05	(BR) BR04	Component: High Voltage Power Supply, Instrumentation and Control Equipment; System: Nuclear Instrumentation; Type: High voltage power supply - analogue core flux - start-up and safety channel; Operating duty: Operating; Component boundary: High voltage local power supply, Cables and connectors; Population: 4
EPL	(AR) RA6	Component: Power Supply; Subsystem: Instrumentation and control system; Type: 12 VAC, 24 VAC; Population: 18
EPL01	(BR) BR04	Component: Low voltage power supply (Instrumentation and Control Equipment); System: Nuclear instrumentation; Type: Low voltage power supply - analogue core flux - safety (start-up) channel; Operating duty: Operating; Component boundary: Low voltage local power supply, Cables and connectors; Population: 4
EPL02	(BR) BR04	Component: Low voltage power supply (Instrumentation and Control Equipment); System: Nuclear Instrumentation; Type: Low voltage power supply - analogue core flux - safety (power) channel; Operation duty: Operating; Component boundary: Low voltage local power supply, Cables and connectors; Population: 4
EPL03	(BR) BR04	Component: Low voltage power supply (Instrumentation and control equipment) - SCRAM Alarms; System: Nuclear instrumentation; Type: Low voltage power supply – analogue core flux – safety (power) channel; Operating duty: Operating; Component boundary: Low voltage local power supply, Cables and connectors; Population: 5
EPU	(VN) DALAT	Component: Uninterruptible power supply; Manufacturer: Malaysia; Italy; USA; Type: S/N US2200, MOD-TW30, C3KS; Component boundary: Uninterruptible power supply Operating duty: Operation; System: Electric power supply system; Population: 3
ERS	(CA) NRU	Silicon diode static rectifier, Statvolt, 150 kW, 600 VAC, 3 phases, output 120 VDC, air convention cooled; Population; 2
ERS	(ID) S	Component: Rectifier static; Type: Electronic; System: Uninterruptible power supply; Component boundary: Input fuse isolator, Input transformer, Rectifier fuse, Thyristor, Rectifier bridge, Smoothing choke, DC link capacitor, Transistor bridge (Rectifier), Output filter, Capacitor, Battery terminal; Detail/specification: Rated supply voltage: 220 VDC; Rated power: 20 kVA; Power factor: 0.8, 50 Hz; Operating duty: Operating; Manufacturer: Siemens, Germany; Population: 2
ERS	(ID) Y	Component: Rectifier static; Population: 3
FEA	(CA) NRU	Component: Piping expansion bellows, 304 stainless steel, (15 cm diameter), main coolant system; Population 26

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
FEA	(ID) S	Component: Piping expansion joint; Type: Carbon steel with flange; System: Secondary cooling system; Component boundary: Stud bolts, Pipe with flange; Specification: 80 cm; Stainless steel; Operating duty: Operating; Manufacturer: Tuflin Armaturen, Xomox International GmbH Germany; Population: 40
FEA	(ID) Y	Component: Piping expansion joint; Type: Cast iron; System: Secondary cooling system; Component boundary: Piping, Component support; Operating duty: Operating; Manufacturer: Indonesia (Local); Population: 2
FEA	(IN) A	Component: Expansion joint aluminium; Population:1
FNA	(ID) S	Component: Piping nozzle; Type: Carbon steel; System: Secondary cooling System; Component boundary: Reducing pipe 40 cm to 10 cm dia.; Specification: Male connector, Stainless steel, Maximum pressure 10 MPa, 10 cm dia.; Operating duty: Operating; Manufacturer: Swagelok, USA; Population: 17.
FNA	(ID) Y	Component: Piping nozzle; Population: 5
FRA	(AU) HIFAR	Component: Bursting discs (Rupture diaphragms); Subsystem: Emergency core cooling system; Bursting discs are on the D_2O delivery line of the scavenge pumps. The bursting discs contain the helium blanket above the D_2O in the reactor tank. Manufacturer: Marston NPG 4171/E. Rating: 82.73 kPa in both directions; Material: Aluminium (99.5% pure). Dimensions: Outside diameter - 127 mm. Bore diameter: 76 mm; Component boundary: Only the bursting disc itself and excludes associated heater and alarm; Population: 2
FS3	(CA) NRU	Carbon steel piping, 5 cm diameter, Process water lines, 700 kPag service
FS3	(ID) S	Component: Piping medium; Type: Piping; System: Secondary cooling system, Venting system intermediate radiation zone, Non active waste water, Storage; Component boundary: Piping, Elbow, Tee; Detail/specification: Stainless steel, Carbon steel, Carbon steel and bronze, 2.5 cm to 7.5 cm dia.; Operating duty: Operating; Manufacturer: Ferrostahl, GmbH, Germany; Population: 2378 m
FS3	(ID) Y	Component: Piping medium, 2.54 cm to 7.5 cm dia.; Type: Cast iron; System: Secondary cooling system; Component boundary: Piping; Specification: Diameter 5 cm, 6.3 cm and 13 cm; Operating duty: Operating; Population: 123 m
FSA01	(BR) BR04	Component: Piping straight section; System: Instrument Air Supply System; Type: pipeline, carbon steel, 5 cm, 100 psi; Operating duty: Operating; Component boundary: Pipeline, Joints and Bends
FSA02	(BR) BR04	Component: Piping straight section; System: Instrument air supply system; Type: connectors, brass, 0.6 cm, 200 kPa; Operating duty: Operating; Component boundary: Pipeline, Joints and Bends

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
FSA03	(BR) BR04	Component: Piping straight section; System: Chilled water system - Condensed water circuit; Population: Type: pipeline – water; 7.5 cm, carbon steel, 3 kgf/cm^2; Operating duty: Operating; Component boundary: Pipeline, Joints and Bends
FSL	(CA) NRU	Stainless steel piping, 15 cm diameter, 142 m total length, 700 kPAg service, Main coolant system, 270 welds
FSL	(IN) C	Component: Pipe line 900 mm sea water carbon steel 1000 m length
FSL01	(IN) D	Component: Piping SS 304, 30 cm dia., 107 m length, ≈100 welds
FSL02	(IN) D	Component: Piping SS 304 L 15 cm dia, 67 m length, ≈80 welds
FSL03	(IN) D	Component: Piping SS < 10 cm dia., 109 m length
FSM	(BR) BR01	Component: Piping - Primary cooling piping; System: Reactor cooling system – Primary Circuit; Type: 304 stainless steel austenitic piping, 30 cm and 40 cm dia., 6.9 bar; Component boundary: Piping only and excludes valves
FSM	(ID) B	Component: Piping large, >7.5 cm dia.; Type: Pipe; System: Secondary cooling system; Component boundary: Pipe; Operating duty: Operating; Population: 175
FSM	(ID) S	Component: Piping; Type: Carbon Steel; System: Primary component drainage; Component boundary: Seamless pipe welding connection, DN 100, DN 150, DN 200, DN 300, DN 400, Stainless steel; Detail/specification: Pressure nominal 15 bar; Medium: Primary water; Operating duty: Operating: Manufacturer: Ferrostahl, GmbH, Germany; Population: 1230
FSM	(IN) A	Component: Piping aluminium, 15 cm dia. 37 m length
FSM	(IN) C	Component: Piping carbon steel, 15 cm dia., 600 m length
FSM01	(AU) HIFAR	Component: Secondary cooling piping (large); Subsystem: Secondary cooling system; Normal flowrate: 355 kg/s; Max flowrate: 390 kg/s; Design stress: 220 MPa @ 100°C. Pipe diameters: 45 cm, 25 cm, 10 cm, 5 cm. Component boundary: Pipelines only and excludes valves
FSM01	(CA) NRU	Carbon steel secondary system piping 120 cm dia., 0.95 cm thick, 536 m length, 700 kPag service
FSM01	(IN) D	Component: Piping carbon steel 90 cm dia., 225 m length
FSM01	(VN) DALAT	Component: Piping >7.5 cm diameter in reactor primary cooling circuit; Manufacturer: Russia. Component boundary: Pipe sections only; Operating duty: Operating; System: Reactor primary cooling system; Population: 4

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
FSM02	(AU) HIFAR	Component: Inlet Header; System: Secondary cooling system; Diameter: 500mm nominal bore with 250 mm lines to the three heat exchangers. Component boundary: Pipes only excluding valves
FSM02	(CA) NRU	Carbon steel process water system piping, 46 cm diameter, 60 m total length, 700 kPag service
FSM02	(IN) D	Component: Piping carbon steel <40 cm dia., 200 m length
FSM02	(VN) DALAT	Component: Piping >7.5 cm dia. in reactor secondary cooling circuit; Manufacturer: Russia; Component boundary Pipe sections only; Operating duty: Operating; System: Reactor secondary cooling system; Population: 5
FSS	(BR) BR01	Component: Piping small, 2.5 cm dia.; System: Reactor cooling system - Secondary circuit - corrosion test circuit; Type: 2.5 cm diameter plastic pipeline; Manufacturer: DEGANI_VADUZ; Component boundary: Pipelines only and excludes valves
FSS	(CA) NRU	Carbon steel piping, 5 cm diameter process water lines, 700 kPa(g) service
FSS	(ID) S	Component: Piping small, <2.5 cm dia.; Type: Carbon steel and plastic; System: Cooling water chemical treatment; Component boundary: Seamless pipe, Welding connection for carbon steel material, Flange and glue connection for PVC material; Detail/specification: Pressure nominal 10 bar; Operating duty: Operating; Manufacturer: Ferrostahl, GmbH, Germany and George Fisher Aktiengesellschaft (PVC Pipe Material); Population: 1144
FSS	(ID) Y	Component: Piping small <2,5 cm dia.; Population: 28
FTA	(ID) Y	Component: Piping tee; Type: Cast iron, & Al; System: Primary & Secondary cooling system; Component boundary: Piping; Specification: 5, 6.3 and 12 cm dia.; Operating duty: Operating; Manufacturer: Indonesia; Population: 22
FXA	(IN) D	Component: Sensor flow - orifice < 90 cm dia. Population: 2
FYA	(CA) NRU	Main coolant system, Stainless steel piping flange gaskets (148 gasket and flange assemblies), 25 cm diameter
FYA	(ID) S	Component: Gasket; Type: Asbestos; System: Secondary cooling system, Non active waste water storage, Flooding pump; Component boundary: Pipe, Valves, Specification: 3 mm thickness; Operating duty: Operating; Manufacturer: Tombo, Japan; Population: 393
FYA	(ID) Y	Component: Gasket; Type: Metal rubber; System: Secondary cooling system; Component boundary: Valve, Piping, Pumps; Detail/ specification: Thickness 0.5 cm; 14 and 24 cm dia.; Operating duty: Operating; Manufacturer: Indonesia; Population: 136

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
FYA	(IN) D	Component: Flange stainless steel 30 cm dia.; Population: 15
GBC	(IN) D	Component: Thermal column; Population: 1
GBR	(CA) NRU	Calandria beam hole radial re-entrant tubes; Population: 15
GBR	(CH)	Component: beam port, radial; Population:1
GBR	(ID S	Component: Beam tube; Type: Tangential and radial; System: Beam tube flooding system; Component boundary: Hollow tube, Shield, Heavy concrete, Injector, Fill line pipe, Cover, Seal, Bolts; Detail/ specification: Safety class: Class-1; Quantity: 6 Facilities; Material: Al Mg3 F18 ; Manufacture: Interatom GmbH, Germany; Operating duty: Operating; Population: 4
GBR	(ID) Y	Component: Beam tube; Type: Tangential; Population: 3
GBR	(IN) A	Component: Beam tubes; Population: 9
GBR	(IN) C	Component: Beam tubes; Population: 20
GBR	(IN) D	Component: Re-entrant cans - beam port; Population: 18
GBT	(CA) NRU	Calandria elliptical through tube; Population: 1
GCB	(CA) NRU	Graphite thermal column, outside calandria (2.4m x 3.2m x 3.7m); Population: 1
GHE	(BR) BR01	Component: Header; System: Reactor cooling system – Primary Circuit; Population: 1; Type: Convection valve; Manufacturer: Babcock & Wilcox; Component boundary: Valve body and interiors, Operating mechanism; Population: 1
GPL	(IN) A	Component: Pool liner – SS; Population: 1
GTA	(CA) NRU	Calandria vessel, Alcan 57SASTM 5052, leaks sufficiently large for replacement; Population:3
GTA	(CH)	Component: Tank, Reactor vessel; Population: 3
GTA	(ID) B	Component: Tank, Reactor vessel; Type: Open; System: Reactor; Specification: Al 6061 T6; Operating duty: Operating; Manufacturer: Batan; Population: 1
GTA	(IN) C	Component: Reactor vessel - Aluminium; Population: 1
GTA	(VN) DALAT	Component: Reactor tank; Manufacturer: General Atomic, USA; Component boundary: Reactor tank; Population: 1; Operating duty: Operating; System: Reactor Tank; Population: 1

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
GTE	(ID) S	Component: Expansion tank; Type: Cylindrical tank with membrane; System: Demineralized water supply, Chilled water intermediate radiation zone, Chilled water low radiation zone Component boundary: Manhole, Hook, Pressure gauge, Diaphragm, Body, Leg, Plate, Flange; Detail/ specification: Safety Class: Class-3; Quantity: 1 pc; Volume of N_2: 550 L; Volume of water: 250 L; Operating Pressure/Temperature: 10 bar/45°C; Water fill pressure: 6 bar; Manufacture: Otto KG Abt. Heizungstechnik, Germany; Operating duty: Operating; Population: 3
HCA	(AR) RA3	Component: Cooling tower; Subsystem: Secondary cooling system; Component boundary: Spray arms, Piping, Screens, Catch basin, includes Cooling fans; Population: 3
HCA	(AR) RA6	Component: Cooling tower; Subsystem: Secondary cooling system; Component boundary: Spray arms, Piping, Screens, Catch basin, includes Cooling fans; Population: 1
HCA	(AU) HIFAR	Component: Cooling Towers; Manufacturer: Budge-Ellis/Liang-Chi; Type: Evaporative counter flow design; System: Secondary cooling system; Tower Height: 500 cm; Tower diameter: 760 cm; Component boundary: Spray arms, Piping, Screens, Catch basin, includes Cooling fans; Population: 6
HCA	(ID) B	Component: Cooling tower general; Type: LBT 350; System: Secondary cooling system; Component boundary: Motor, Fan guard, Sprinkler pipe, Filling, Tension device, Eliminator, Automatic filter water sump, Drain; Detail/ specification: High 3.3 m; Diameter 4.6 m; Inlet 10 cm; Outlet 10 cm; Power 1000 kW; Voltage 220 VAC; Flow rate 75 L/s; Operating duty: Operating; Population: 2
HCA	(ID) Y	Component: Cooling tower general; Type: LBC 80; System: Secondary cooling system; Component boundary: Motor, Fan guard, Sprinkler pipe, Filling, Tension device, Eliminator, Automatic filter water sump, Drain; Specification: High 1925 mm; Diameter 2175 mm; over flow 25 mm; Inlet 100 mm; Outlet 100 mm; Power 1.5 kW; 220 VAC; Flow rate 540 m^3/min; Operating duty: Operating; Manufacturer: Liang Chi Cooling Tower Industrial Co, Ltd, Taipei; Population: 2
HCA01	(BR) BR01	Component: Cooling tower - general; System: Reactor cooling system - Secondary circuit; Type: Fibreglass; Manufacturer: Alpina; Motor: 2X180/4-A19-I; Component boundary: Spray arms, Piping, Screens, Catch basin, includes Cooling fans; Population: 1
HCA02	(BR) BR01	Component: Cooling tower - general; System: Reactor cooling system - Secondary Circuit; Type: concrete; Manufacturer: Garcia & Bassi; Motor: C53SRSF-2C; Component boundary: Spray arms, Piping, Screens, Catch basin (excludes cooling fans); Population: 1
HCV 01	(BR) BR01	Component: Cooling tower - fan; System: Reactor cooling system – Secondary circuit (Cooling tower A); Type: 8 blades; Coupled motor (aligned with fan shaft); Manufacturer: Alpina; Motor: WEG; 22 kW; Component boundary: Motor, Fan, Gear box; Population: 2

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
HCV02	(BR) BR01	Component: Cooling tower - fan; System: Reactor cooling system – Secondary circuit (Cooling tower B); Population: 4; Type: 5 blades; Motor (perpendicular to fan shaft); Manufacturer: Garcia & Bassi; Motor: WEG; 22 kW; Component boundary: Motor, Fan, Gear box; Population:1
HXA	(AR) RA3	Component: Heat exchanger; Subsystem: Primary cooling system; Component boundary: Heat Exchanger only; Population: 2
HXA	(AR) RA6	Component: Heat exchanger; Subsystem: Primary cooling system; Component boundary: Heat Exchanger only; Population: 2
HXA	(AU) HIFAR	Component: D_2O Heat Exchangers; Manufacturer: Head Wrighton Processes Ltd. System: Primary cooling system. Design pressure: 310 kPa (shell), 620 kPa (tubes). Design temp: 70°C (shell), 70°C (tubes); Component boundary: Heat Exchanger only; Population: 3
HXA	(ID) B	Component: Heat exchanger; Type: Plate; System: Primary system; Specification: 2 MW; Material SS 304, SS 306 and Titanium; Flow rate 60 L/s primary and 75 L/s secondary; Operating duty: Operating; Population: 8
HXA	(VN) DALAT	Component: Heat exchanger, reactor primary cooling system; Manufacturer: Russia; Type: 600TNV-I-10-M8/20G4-2; Component boundary: Heat exchanger; Operating duty: Operating; Population: 1
HXB	(BR) BR01	Component: Heat exchanger – straight tube, horizontal shell and tube (H_2O Heat Exchanger); System: Reactor cooling system; Type: horizontal shell and tube, double pass counter-current; Manufacturer: Cia. Brasileira de Caldeiras; Design Details: carbon steel (shell) and 304 stainless steel (tube), 5 MW; Nominal diameter: 94 cm; Tube diameter: 1.3 cm; Component boundary: Heat Exchanger only; Population: 1
HXB	(CN) H	Component: Heat exchanger, straight tube, horizontal shell/tube; Population: 2
HXB	(CN) M	Component: Heat exchanger, straight tube, horizontal shell/tube; Population: 2
HXB	(IN) D	Component: Heat exchanger, carbon steel shell & Cu-Ni tubes; Population: 5
HXC	(AU) HIFAR	Component Evaporative Condenser; Subsystem: Space Conditioning System (containment heat removal system). Manufacturer: Baltimore Aircoil; Component boundary: Condenser vessel, spray pump, motors, fan, electrical controls; Population: 3
HXH 01	(ID) Y	Component: Heat exchanger, U tube, horizontal shell and tube; Type: NATL BD 10576; System: Primary & Secondary cooling system; Component boundary: Shell and tube, Piping, Supports; Detail/ Specification: Pressure 520 kPa; Temperature 70°C; Operating duty: Operating; Manufacturer: Paterson Kelley Co. Inc; Population: 1
HXH 02	(ID) Y	Component: Heat exchanger; Type: Plate EC4-075-IM; System: Primary & Secondary cooling system; Component boundary: Body, Pipe, supports; Specification: Pressure 100 Psi; Temp 200°C; Plate pack width 22 cm, Operating duty: Operating; Manufacturer: Texas Inc. US; Population: 1

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
HXM	(CA) NRU	Heat exchanger main coolant system, 304 stainless steel, 25 MW, single pass, counter-current, shell and tube, Andale Company, vertical, 5.0 m long; Population: 8
HXM	(ID) S	Component: Heat exchanger straight tube type vertical shell and tube; Population 2
HXM	(IN) D	Component: Heat exchanger heavy water shell & tube type carbon steel shell and stainless steel tubes; Population 3
HXP	(ID) B	Component: Heat exchanger plate type; System: Primary cooling system; Operating duty: Operating; Population: 2
IAA	(AT) TRIGA MARK-II	Component: Instrumentation; Manufacturer: Hartmann & Braun; Population: 5
IAA	(CN) H	Component: instrumentation; Population: 60
IAA	(ID) S	Component: Instrumentation; Type: Modular, electronic; System: Rabbit System; Component boundary: Rabbit; Operating duty: Operating; Population: 1
IAA	(ID) Y	Component: Instrumentation; Population: 1
IAA	(IN) D	Component: Amplifier-rectifier unit; Population: 3
IAA01	(VN) DALAT	Component: Control and Averaging Block; Manufacturer: Russia; Type: BM-14R; Component boundary: Range selection block, failure identification block, digital-analogue converter, averaging block, blockade block, galvanic buffer block; Operating duty: Operating; System: Neutron Flux Control Sub-system, Reactor control system; Population: 3
IAA02	(VN) DALAT	Component: Automatic regulating block; Manufacturer: Russia; Type: BUM-21R; Component boundary: Input block, comparator, code to frequency; converter, DAC, unbalance signal amplifier, period signal amplifier; Operating duty: 1 in operation and 1 in standby; System: Control Logic Sub-system, Reactor control system; Population: 2
IAA03	(VN) DALAT	Component: AR regulating logic block; Manufacturer: Russia; Type: BAR; Component boundary: Logic processing blocks, 2 out of 3 selection block, amplifier, power amplifier, intermediate relay block; Operating duty: Operating; System: Control Logic Sub-system, Reactor control system; Population: 1
IAA04	(VN) DALAT	Component: Shim rod control logic block; Manufacturer: Russia; Type: BKS; Component boundary: Logic processing blocks, 2 out of 3 selection block, Amplifier, power amplifier, intermediate relay block; Operating duty: Operating; System: Control Logic Sub-system, Reactor control system; Population: 1

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
IAA05	(VN) DALAT	Component: KC rod drive control relay block; Manufacturer: Russia; Type: CPU; Component boundary: Feeder switch, resistances, relay time delay, relays auxiliary, current relay, contactors; Population of blocks: 4; Operating duty: Operating; System: Control Logic Sub-system, Reactor control system
IAA06	(VN) DALAT	Component: Safety rod (AZ) control logic block; Manufacturer: Russia; Type: BAZ; Component boundary: Logic processing blocks, 2 out of 3 selection block, amplifier, power amplifier, intermediate relay block; Operating duty: Operating; System: Control Logic Sub-system, Reactor control system; Population: 1
IAA07	(VN) DALAT	Component: AZ rod drive control relay block; Manufacturer: Russia; Type: CPU; Component boundary: Feeder switch, resistances, relay time delay, relays; auxiliary, current relay, contactors; Operating duty: Operating; System: Control Logic Sub-system, Reactor control system; Population: 2
IAR	(BR) BR01	Component: Control rod position indication - control console; System: Instrumentation and control system; Type: indicating digital instrument; Manufacturer: DDC; Component boundary: control console instrument; Population: 4
IAR	(SI)	Component: control rod position indication; Population: 1
IAR	(VN) DALAT	Component: Position indicator (for KC and AP); Manufacturer: Russia, Hartmann & Braun; Type: UK36.000; Component boundary: Position indicator; Operating duty: Operating; System: Control Logic Sub-system, Reactor control system; Population: 5
IAR01	(BR) BR04	Component: Control rod Absolute Position Indication; System: Instrumentation and control system; Type: digital display; Operating duty: Operating; Component boundary: instrument, signal, cables, connectors and power supply; Population: 4
IAR02	(BR) BR04	Component: Safety/Control rod Relative Position Indication; System: Nuclear Instrumentation; Type: digital display; Operating duty: Operating; Component boundary: instrument, signal, cables, connectors and power supply; Population: 4
ICA	(CN) M	Component: reactor regulating system; Population 1.
ICA01	(CA) NRU	Linear power neutronic amplifier and power supplies, analogue, AEP-5313, Population: 5
ICA02	(CA) NRU	Linear rate neutronic amplifier and power supplies, analogue, AEP-5314; Population: 5
ICA03	(CA) NRU	Log power neutronic amplifier and power supplies, analogue, AEP-5315, Population: 5.
ICA04	(CA) NRU	Log rate neutronic amplifier and power supplies, analogue, AEP-5316, Population: 4
ICA01	(IN) D	Component: Function generator; Population: 3
ICA02	(IN) D	Component: Campbell Unit; Population: 3
ICA03	(IN) D	Component: Function generator; Population: 3

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
ICA04	(IN) D	Component: Linear power amplifier; Population: 3
ICA05	(IN) D	Component: Pre-amplifier; Population: 3
ICA06	(IN) D	Component: Mean Power Trip Unit; Population: 3
ICA07	(IN) D	Component: Set point unit; Population: 3
ICC	(AT) TRIGA MARK-II	Component: Linear Channel, Instrumentation Manufacturer: Hartmann & Braun; Populations: 3, 16 and 4
ICC	(BR) BR01	Component: Linear Channel; System: Instrumentation and control system; Type: Liner amplifier multi-range and pico-ammeter NMP-4; Model: ELD239-3200-2F; Manufacturer: General Atomic; Component boundary: ionisation chamber, signal, cabling from the chamber to electronic amplifier, connectors and power supply; Population: 1
ICC	(BR) BR04	Component: Instrumentation Channel Analogue Core Flux Comparator Module; System: Nuclear Instrumentation; Type: analogue instrument; electronic instrument; Operating duty: Operating; Component boundary: instrument, signal, cables, connectors and power supply; Population: 4
ICC	(CH)	Component: Merlin, Gerin, transistorized equipment, linear DC-channels; Population: 7
ICC	(CN) H	Component: Instrumentation Channel Analogue core flux; Population: 6
ICC	(CN) M	Component: Instrumentation Channel Analogue core flux ; Population : 2
ICC	(CZ)	Component: Instrumentation Channel Analogue core flux ; Population : 12
ICC	(RO) TRIGA	Component: Core Flux Indicating Instrument, Manufacturer: Honeywell-SUA; Type: NIM-2, System: Control & Monitoring System; Details: One logarithmic (10 decade) analogue core flux channel instrumentation (period), three linear analogue core flux channel instrumentation (overpower scram channel). Component boundary: Sensor (fission chamber), power supply electronics and associated signal amplifiers Operating duty: logarithmic analogue core flux instrumentation and 2 linear analogue core flux instrumentation, operating, 1 linear analogue core flux instrumentation in standby; Population: 4
ICC	(SI)	Components: a) Compensated ion chamber (Log channel) sensitivity: 2 x 10^{-14} amp/nv; Manufacturer: H&B (Hartman & Brown); b) Uncompensated ion chamber (Lin channel) sensitivity 7.7 x 10^{-15} amp/nv; Manufacturer: H&B (Hartman & Brown); c) Compensated ion chamber (start-up) 5 x 10^{-5} W to 50 W; Manufacturer: H&B (Hartman & Brown); Population: 3
ICC01	(AR) RA3	Component: start channel; Component boundary: Sensor; Population: 2

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
ICC01	(AR) RA6	Component: Instrumentation channel analogue core flux; Subsystem: Instrumentation and control system; Population: 3
ICC01	(IN) A	Component: Log power amplifier; Population: 1
ICC01	(VN) DALAT	Component: Channel of source power measurement; Manufacturer: Russia; Type: BIK 01; Component boundary: Input block, counting block, count-rate blocks, logarithmic amplifiers, differential amplifiers, buffer blocks, power threshold block, period threshold block; Operating duty: Operating; System: Neutron Flux Control Sub-system, Reactor control system; Population: 3
ICC02	(AR) RA3	Component: instrumentation channel operating neutron flux; Component boundary: Sensor; Population: 3
ICC02	(AR) RA6	Component: instrumentation channel analogue source power neutron flux; Subsystem: Instrumentation and control system; Population: 3
ICC02	(IN) A	Component: Safety Channel, Population: 2
ICC02	(VN) DALAT	Component: Channel of power measurement at intermediate range; Manufacturer: Russia; Type: BIK 02; Component boundary: Input block, counting block, count-rate blocks, logarithmic amplifiers, differential amplifiers, buffer blocks, power threshold block, period threshold block; Operating duty: Operating; System: Neutron Flux Control Sub-system, Reactor control system; Population: 3
ICC03	(AR) RA3	Component: instrumentation channel analogue linear regulation chain; Subsystem: Instrumentation and control system; Population: 1
ICC03	(IN) A	Component: Servo power regulating channel; Population: 1
ICC03	(VN) DALAT	Component: Channel of power measurement at power range; Manufacturer: Russia; Type: BIK 03; Component boundary: Input block, counting block, count-rate blocks, logarithmic amplifiers, differential amplifiers, buffer blocks, power threshold block, period threshold block; Operating duty: Operating; System: Neutron Flux Control Sub-system, Reactor control system; Population: 3
ICC04	(IN) A	Component: Start-up/pulse channel; Population: 1
ICC05	(IN) A	Component: Linear power channel; Population: 1
ICD	(IN) D	Component: Instrumentation channel - protection logic; Population: 3
ICF	(AR) RA3	Component: Instrumentation channel analogue flow; Subsystem: Instrumentation and control system; Population: 2
ICF	(CH)	Component: Fischer & Porter - magneto-dynamic flow meter channel, 5 L/s; Population: 2
ICF	(CN) H	Component: Flow rate measuring system with indicator; Population: 1

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
ICF	(CN) M	Component: Flow rate measuring system with indicator; Population: 6
ICF	(ID) S	Component: Instrumentation channel analogue flow; Type: Modular, electronic; System: Primary cooling system, Secondary cooling system, Cooling Water Purification System, Emergency Core cooling system; Component boundary: Power supply of 5, 15 and 24VDC, Amplifier, isolation transformer, buffer amplifier; Specification: Range of limit adjustment: 0-10 V Output signal of the transformer: 0-10 V; Output signal of the transmitter: 0-20 mA; Operating duty: Operating; Manufacturer: Siemens; Population: 20
ICF	(IN) Y	Component: Instrumentation channel analogue flow; Population: 4
ICF	(IN) C	Component: Flow monitoring fuel channels; Population: 190
ICF	(IN) D	Component: Instrumentation - channel flow monitoring; Population: 390
ICF01	(AT) TRIGA MARK-II	Component: Analogue flow of the Instrumentation; Details: Flow channel for primary cooling circuit, up to 30 m^3/h; Population: 1
ICF01	(RO) TRIGA	Component: Instrumentation Channel Analogue Minimum Flow - in Primary Circuit, Manufacturer: Instrumentation for one channel - Romanian, for the other channel USA, System: Control & Monitoring System; Component boundary: each channel consists of detector, transducer, relays (intermediate and final); Operating duty: 1 operating, 1 standby; Population: 2
ICF02	(AT) TRIGA MARK-II	Component: Instrumentation Channel Analogue flow; Details: Flow channel for purification flow, up to 3 m^3/h; Population: 2
ICF02	(RO) TRIGA	Component: Instrumentation Channel Analogue Differential Flow Inlet-Outlet Pool, Manufacturer: Instrumentation for one channel - Romanian, for the other channel USA, System: Control & Monitoring System; Component boundary: each channel consists of detector, transducer, relays (intermediate and final); Operating duty: 1 operating, 1 standby; Population: 2
ICF03	(RO) TRIGA	Component: Instrumentation Channel Analogue Minimum Flow - emergency pump, Manufacturer: Instrumentation for one channel - Romanian, for the other channel USA, System: Control & Monitoring System; Component boundary: each channel consists of detector, transducer, relays (intermediate and final); Operating duty: 1 operating, 1 standby; Population: 2
ICL	(AU) HIFAR	Component: RAT level Measurement; Manufacturer: Rosemount Inc.; System: Emergency Core cooling system; Type: Pressure Transmitter with stainless steel electric housing Model: 1152 Alphaline Nuclear Pressure transmitter; Component boundary: Includes level sensor and instrumentation; Population: 3
ICL	(CN) H	Component: Instrument analogue level; Population: 1

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
ICL	(ID) S	Component: Instrument channel analogue level; Type: Modular Electronic; System: Primary cooling system, Secondary cooling system, Cooling Water Purification System, Waste Storage System; Component boundary: Power supply of 5, 15 and 24 VDC, amplifier, isolation transformer, buffer amplifier, limit value generator; Specification: Range of limit adjustment: 0-10 V; Output signal of the transformer: 0-10 V; Output signal of the transmitter: 0-20 mA; Operating duty: Operating; Manufacturer: Siemens; Population: 17
ICL	(ID) Y	Component: Instrument channel analogue level; Population: 1
ICL01	(RO) TRIGA	Component: Instrumentation Channel Analogue Level; System: Liquid Radioactive Waste; Details: Level instruments located on 8 liquid radioactive waste tanks; Component boundary: Sensor, transducers, and indicator; Population: 8
ICL02	(RO) TRIGA	Component: Analogue Level Channel Instrumentation; Manufacturer: Instrumentation for one channel - Romanian, for the other channel USA, Type: Minimum pool water level channel instrumentation; System: Control & Monitoring System; Details: Component boundary: detector, transducer, relays intermediate and final scram initiator; Operating duty: 1 operating, 1 standby; Population: 2
ICL03	(RO) TRIGA	Component: Analogue Level Channel Instrumentation; Manufacturer: Instrumentation for one channel Romanian, for the other channel USA, Type: Maximum pool water level channel instrumentation; System: Control & Monitoring System; Component boundary: detector, transducer, relays intermediate and final scram initiator; Operating duty: 1 operating, 1 standby; Population: 2
ICP	(CN) H	Component: instrument channel analogue pressure; Population: 2
ICP	(ID) S	Component: Instrument channel pressure; Type: Modular Electronic; System: Primary Cooling system, Secondary cooling system, Cooling Water Purification System, Emergency Core cooling system; Component boundary: Power supply of 5, 15 and 24 VDC, amplifier, isolation transformer, buffer amplifier, limit value generator. Specification: Absolute pressure and differential pressure; Range of limit adjustment: 0-10 V; Output signal of the transformer: 0-10 V; Output signal of the transmitter: 0-20 mA; Operating duty: Operating; Manufacturer: Siemens; Population: 24
ICP	(ID) Y	Component: Component: instrument channel a. Pressure; Population: 1
ICT	(AT) TRIGA MARK-II	Component: Water temperature of reactor pool, analogue channel; Manufacturer: Hartmann & Braun (1968); Population: 6
ICT	(CN) H	Component: Temperature measuring system with thermocouple sensor and recorder, Population: 5
ICT	(CN) M	Component: Temperature measuring system with thermocouple sensor and recorder, Population: 1

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
ICT	(ID) S	Component: Instrument channel temperature; Type: Modular Electronic; System: Primary cooling system, Secondary cooling system, Cooling Water Purification System, Emergency cooling system; Component boundary: Power supply of 5, 15 and 24 VDC, amplifier, isolation transformer, buffer amplifier, limit value generator; Specification: PT 100; Range of limit adjustment: 0-10 V; Output signal of the transformer: 0-10 V; Output signal of the transmitter: 0-20 mA; Operating duty: Operating; Manufacturer: Siemens; Population: 12
ICT	(IN) Y	Component: Instrument channel, temperature; Population 6
ICT	(IN) C	Component: Instrumentation channel temperature, Population: 190
ICT01	(RO) TRIGA	Component: Fuel Temperature Channel Instrumentation; Manufacturer: USA, System: Control & Monitoring System; Component boundary: Each channel includes two thermocouples, amplifier, measure device and reactor scram bistable; Operating duty: 2 operating, 1 standby; Population: 3
ICT02	(RO) TRIGA	Component: Difference Inlet–Outlet Water Temperature Channel Instrumentation, Manufacturer: Instrumentation for one channel - Romanian, for the other channel USA, System: Control & Monitoring System; Component boundary: Each channel includes two thermocouples, amplifier, Sensor and reactor scram bistable; Operating duty: 1 operating, 1 standby; Population: 2
ICT03	(RO) TRIGA	Component: Outlet pool Temperature Channel Instrumentation; Manufacturer: Instrumentation for one channel - Romanian, for the other channel USA, System: Control & Monitoring System; Component boundary: Each channel includes two thermocouples, amplifier, Sensor and reactor scram bistable; Operating duty: 1 operating, 1 standby; Population: 2
ICT04	(RO) TRIGA	Component: Pool Temperature Channel Instrumentation; Manufacturer: Instrumentation for one channel – Romanian, for the other channel USA, System: Control & Monitoring System; Component boundary: Each channel includes two thermocouples, amplifier, measure device and reactor scram bistable; Operating duty: 1 operating, 1 standby; Population: 2
IDT	(BR) BR04	Component: Instrumentation Channel Digital - Temporizer Counter; System: Nuclear Instrumentation; Type: digital instrument; Operating duty: Operating; Component boundary: instrument, signal, cables, connectors and power supply; Population: 4
JBM	(BR) BR04	Component: Brake; System: Movable Reactor Bridge; Type: brake drum; Operating duty: Operating; Component boundary: wheel disk, brake drum, brake disc facing and electromagnetic drive; Population: 8
JEE	(IN) D	Component: Clutch - Shut off rod electrical; Population: 9
JEM	(ID) S	Component: Clutch mechanical; Type: Hydraulic Clutch; System: Secondary cooling system; Component boundary: Drum, Ball Bearing. Thrust, Hydraulic Chamber, Spooling Friction Plate, Security Bolt, Flange, Shock Absorber; Detail/Specification: Type: MKWN 315, Speed 1400-1500 rev./min; Power 160-250 kW; Delay Time 5-7 sec. Operating duty: Operating; Manufacturer: Flender Amolix, Germany; Population: 48

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
JFT	(RO) TRIGA	Component: Pneumatic Fitting, Manufacturer: Romania, Component boundary: pneumatic fitting; Operating duty: There are two pneumatic fittings to the transfer gate, which isolate the reactor pool and transfer channel. Operating duty: Operating; Population: 2
JGF	(AR) RA3	Component: floating core tools; Population: 5
JIA	(CH)	Component: irradiation container; Population: 15
JIP	(AT) TRIGA MARK-II	Component: Pneumatic transfer system; Population: 3
JIP	(CA) NRU	Component: Pneumatic transfer system piping installation, in-core and out-of-core, failures are piping failures and do not refer to stuck capsules; Population: 1
JIP	(CH)	Component: Pneumatic transfer system, Population: 1
JIP	(ID) Y	Component: Pneumatic Transfer System; Component boundary: Hand loader, Sensor, micro switch, auto loader, compressor; Specification: Pressure 6 bar; Capacity 100 capsules; transfer time 3 s; Pipe diameter 3.2 cm, Operating duty: Operating; Manufacturer: USA; Population: 1
JIP 01	(ID) S	Component: Pneumatic transfer system; Type: Hydraulic Fluid; System: Rabbit System; Component boundary: Nitrogen Bottle, Tubing, Valve, Solenoid Valve, Non-return Valve, Dispatching and Receiving Station, Decay and Box, Filter, Ion Exchange, Resin Filter and Irradiation Station, Logic Circuit, Water Pump; Specification: Inside diameter 3.6 cm; Transport Medium: Water; Sample velocity: 0.6 m/s; Minimum Dwell Time: 0.2 s; Sample Size 2.5 cm dia. 7.0 cm length; Weight 70 g; Thermal rating: 15 W/g; Operating duty: Operating; Manufacturer: HWM Hans Wallischmiller GmbH, Germany; Population: 4
JIP 02	(ID) S	Component: Pneumatic transfer system; Type: Pneumatic fluid; System: Rabbit system; Component boundary: Nitrogen bottle, Tubing, Valve, Solenoid Valve, Non-return Valve, Dispatching and Receiving Station, Decay and Degasifying Box, Filter, Fan, Exhaust Air, Irradiation Station, Control Logic Circuit; Detail/Specification: Inside diameter 2.0 cm; Transport Medium: Water; Operating Pressure: 1.5 bar; Sample velocity: 10 m/s; Minimum Dwell Time: 0.2 s; Sample Size: Spheres up to 2 cm; Weight 0.01-0.05 g; Thermal rating: 5 W/g; Operating duty: Operating; Manufacturer: HWM Hans Wallischmiller, GmbH, Germany; Population: 1
JLC	(ID) Y	Component: Lube oil cooler; Population: 3
JLC 01	(ID) S	Component: Lube oil cooler; Type: Oil chamber; System: Compressed Air System, Primary Cooling; System, Chilled Water Low radiation zone, Secondary cooling system, Secondary; Component boundary: Input Shaft, Output Shaft, Oil Lubricant, Spherical Roller Bearing, Roller Bearing, Pinion Gear, Wheel Gear, Gasket, Oil Seal Key, Hub, Cover Ring, Securing Bolt; Manufacturer: Flender-Himmel Werk GmbH & Co. KG., Germany; Operating duty: Operating; Population: 21
JLC 02	(ID) S	Component: Lube oil cooler; Type: Lubricant chamber; System: Emergency cooling system; Component boundary: Input Shaft, Output Shaft, Oil Lubricant, Spherical Roller Bearing, Cylindrical Roller Bearing, Pinion Gear, Wheel Gear, Gasket, Oil Seal, Key, Hub, Cover Ring, Securing Bolt; Operating duty: Operating; Manufacturer: Flender-Himmel Werk GmbH & Co. KG., Germany; Population: 3

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
JPP	(ID) S	Component: Penetration piping; Type: Rubber Moulded; System: Venting System Auxiliary Building; Component boundary: Rubber Moulded Profile, Securing Bolts; Specification: Wear resistance, Slipper, Type: K01-08; Operating duty: Operating; Manufacturer: Henrich Wagner, Germany; Population: 15
JPP	(ID) Y	Component: Penetration piping; Population: 2
JPP	(IN) D	Component: Penetration for piping <40 cm; Population: 9
JRB	(AR) RA6	Component: Crane bridge main, System: Crane bridge system, Population: 1
JRB	(RO) TRIGA	Component: Crane bridge, Manufacturer: Romania, System: Crane bridge system, Details: Located in reactor hall, 2 hooks: 20 tonnes and 5 tonnes; Population: 1
JRB01	(AR) RA3	Component: Crane bridge main, Population: 1; Subsystem: Crane bridge system, Details: Located in reactor hall, 1 hook of 7 tonnes; Population: 1
JRB02	(AR) RA3	Component: Crane bridge decay pool, Subsystem: Crane bridge system, Details: Located in reactor hall, 1 hook of 7 tonnes; Population: 1
JRB03	(AR) RA3	Component: Crane bridge hot cell; Subsystem: Crane bridge system; Population: 1
JRB04	(AR) RA3	Component: Crane bridge reactor hall floor; Subsystem: Crane bridge system; Population: 1
JTR	(BR) BR04	Component: Storage Tank; System: Feedwater treatment system; Type: steel fibre, 5 m^3; Component boundary: Tank and associated instrumentation; Population: 1
JTR	(RO) TRIGA	Component: Tank, Manufacturer: I.U.C. Fagaras, Romania, System: Liquid radioactive waste system; Component boundary: Vessel including inlet and outlet lines up to the first flange, Population: 8
JXT	(AR) RA3	Component: Tele-manipulator; Population: 2
KAA	(AT) TRIGA MARK-II	Component: Circuit breaker, Population: 10
KAA	(ID) S	Component: Circuit breaker; Type: Air Type; System: Secondary cooling system, Venting system intermediate radiation zone; Component boundary: Cable, Fuse, Contactor, Relay; Specification: 25-350 A, 220/380 VAC, 600 VAC; Operating duty: Operating; Manufacturer: Germany; Population: 300
KAA	(ID) Y	Component: Circuit breaker; Population: 126
KAA	(VN) DALAT	Component: Circuit breaker 600VAC; Manufacturer: Russia; Type: ABM15N, A3144, A3134; Component boundary: Circuit breaker; Operating duty: Operating; System: Electric power supply system; Population: 13

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
KAC	(BR) BR04	Component: Circuit breaker, Critical cell ventilation and air conditioning system; System: Electrical power supply system; Type: Protection circuit breaker, AC; Operating duty: Operating; Component boundary: Circuit breaker, contacts and Power supply; Population: 1
KAC	(ID) S	Component: Circuit breaker AC generator; Type: Air type; System: Diesel emergency sets; Component boundary: Bars, Switch, Fuse; Specification: Voltage 380 VAC, current 0-500 A; Operating duty: Operating; Manufacturer: Siemens; Population: 3
KAC	(ID) Y	Component: Circuit breaker indoor AC; Population: 68
KIA	(ID) S	Component: Circuit breaker indoor AC Application; Type: Air type; System: ECR Ventilator; Component boundary: Bars, Switch, Fuse; Detail/Specification: Voltage 220/380 V, current 0-25 A; Operating duty: Operating; Manufacturer: Siemens; Population: 3
KIA	(ID) Y	Component: Circuit breaker indoor AC; Population: 24
KIA01	(IN) D	Component: Circuit Breaker 22 kV Oil; Population: 8
KIA02	(IN) D	Component: Circuit Breaker 3.3 kV Oil; Population: 11
KIA03	(IN) D	Component: Circuit Breaker 415 VAC Air Cooled, Population: 16
KIS	(ID) S	Component: Circuit breaker isolation ground fault interrupter; Type: Air type; System: Chilled water low radiation zone; Component boundary: Thermistor, Overload fuse; Specification: Normal current 100-160 A, Starting current 1000-1900 A; Operating duty: Operating; Manufacturer: Klockner Moeller; Population: 8
KIS	(ID) Y	Component: Circuit Breaker isolation ground fault; Population: 2
KRP	(AT) TRIGA MARK-II	Component: Circuit breaker reactor protection; Population: 15
KSF	(ID) S	Component feeder (junction box); Population: 1
KTA	(AT) TRIGA MARK-II	Component: Fuses for all voltage levels in each in each circuit of RSS, IC system; Population: 20
KTA	(ID) B	Component: Fuse all voltage levels; System: Reactor instrumentation; Component boundary: Terminal, Relay, Cable; Operating duty: Operating; Manufacturer: Omron, Telemechanic; Population: 63
KTA	(ID) S	Component: Fuse all voltage levels; Type: Melting fuse; System: Demineralized water supply, Control rod, Primary cooling system, Cooling tower, Chilled water intermediate radiation zone, Venting system intermediate radiation zone, Diesel emergency demineralized water plant, Personal lock, Secondary cooling system, Compressed air system, Pool warm layer system, Venting system radiation zone, Ultrasonic; Component boundary: Wire, Terminal, Ceramic; Detail/Specification: 220 VAC/380 VAC, Operating duty: Operating; Manufacturer: Germany; Population: 180

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
KTA	(ID) Y	Component: Fuse all voltage levels; Population: 43
KTA	(VN) DALAT	Component: Fuse 6 kV; Manufacturer: Russia; Type: PK4-10-160/160/-20IZ; Component boundary: Fuse only; Operating duty: Operating; System: Electric power supply system; Population: 3
LAA	(ID) S	Component: Transmitter general; Type: Current Signal; System: Reactor protection system, Process control system; Operating duty: Operating; Population: 425
LAA	(ID) Y	Component: Transmitter general; Population: 15
LAA	(VN) DALAT	Component: Magnetic amplifier; Manufacturer: Russia; Type: UVAP-19; Component boundary: Magnetic amplifier only; Operating duty: Operating; System: Control Logic Sub-system, Reactor control system; Details: Control Voltage: 0-6.5V DC; Power: 500 W; Input Voltage: 190; Automatic control rod motor, Population: 1
LCA	(VN) DALAT	Component: Preamplifier for sensor core flux; Manufacturer: Russia; Type: BUI-06R, BPNZ-06; Component boundary: Preamplifier only; Operating duty: Operating; System: Neutron flux control sub-system, Reactor control system; Population: 9
LFF	(SI)	Component: transmitter flow, Population: 1
LFF01	(VN) DALAT	Component: Transmitter flow in primary coolant flowmeter; Manufacturer: Russia, Hartmann & Braun; Type: DMER, ARK-500; Component boundary: Transmitter only; Operating duty: Operating; System: Primary coolant flowmeter, Reactor instrumentation system; Population: 1
LFF02	(VN) DALAT	Component: Transmitter flow in secondary coolant flowmeter; Manufacturer: Russia, Hartmann & Braun; Type: DMER, ARK-800; Component boundary: Transmitter only; Operating duty: Operating; System: Secondary coolant flowmeter, Reactor instrumentation system; Population: 1
LLL	(SI)	Component: transmitter level, Population: 1
LLL	(VN) DALAT	Component: Transmitter reactor water level; Manufacturer: Russia, Hartmann & Braun; Type: DME, ARK-200; Component boundary: Transmitter only; Operating duty: Operating; System: Water level instruments, Reactor instrumentation system; Population: 1
LTT	(ID) S	Component: Transmitter temperature; Type: Current Signal; System: Process control system (Primary, Secondary cooling system, Emergency cooling system), Reactor protection system; Component boundary: Transmitter; Operating duty: Operating; Population: 124
LTT	(ID) Y	Component: Transmitter temperature; Population: 4
LPD	(BR) BR01	Component: Transmitter pressure difference; System: Instrumentation and control system; Location: Reactor core, primary circuit piping, secondary circuit piping; Manufacturer: SMAR; Model: LD 301; Component boundary: Transmitter, cabling; Population: 4

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
MAA	(ID) Y	Component: Motor; Population: 8
MAA01	(ID) S	Component: Motor; Type: Induction; System: Venting system intermediate radiation zone, Venting system building, Venting system radiation zone; Component boundary: Motor, Shaft, Gear, Limit Switch; Specification: 3 Phase motor; type: 1 LA 50 80 4AA70 Z; 1400 rev./min; 50 Hz; 220/380 VAC; 1.47/0.85 A; Connection: Δ-Y; Power Factor 0.8; Power: 0.55 kW; Type of Protection: IMB3 IP54 ICL F; Operating duty: Operating; Manufacturer: Germany; Population: 135
MAA02	(ID) S	Component: Motor; Type: Induction; System: Primary cooling system, Secondary cooling system, Reactor pool purification system, Pool warm layer system, Demineralized water supply; Component boundary: Motor, Shaft, Gear, Limit Switch; Specification: 3 Phase motor; type MD 71-2-60; 2800 rev./min, 50 Hz; 220/380 VAC; 3.3/1.9 A; Connection: Δ-Y; Power Factor 0.8; Power: 0.55 kW; type of Protection: IP67 ISKL F, VDE 0530/72; Operating duty: Operating; Manufacturer: AUMA, Germany; Population: 110
MAA01	(ID) B	Component: Motor; Type: Induction motor; System: Primary cooling system; Component boundary: Rotor, Stator, Pipe; Specification: 3 Phase, 1450 rev./min, 220/380/440, Power Factor 0.8; Operating duty: Operating; Manufacturer: Baldor, USA; Population: 2
MAA02	(ID) B	Component: Motor; Type: Induction motor; System: Secondary cooling system; Component boundary: Rotor, Stator, Pipe; Specification: 3 phase, 1475 rpm, 380/660 VAC, 80 kW; Operating duty: Operating; Manufacturer: GE, USA; Population: 2
MAC	(ID) S	Component: Motor AC; Type: Induction; System: Secondary cooling system, Radiation monitoring system, Venting system intermediate radiation zone, Chilled water low radiation zone, Chilled water intermediate radiation zone; Component boundary: Motor, Shaft, Gear, Limit Switch; Specification: Motor for E-Actuator; Type: AS 25; rotation: 1400 rev./min; 50 Hz; 220/380 VAC; Power: 0.04 kW; Type of protection: IP65 ICL F; Operating duty: Operating; Manufacturer: DEUFRA, Germany; Population: 140
MAC	(ID) Y	Component: Motor AC; Population: 8
MAC01	(IN) D	Component: Motor AC for shutdown cooling pump, Population: 3
MAC02	(IN) D	Component: Motor AC 3.3 kV, 540 kW for primary cooling pump, Population: 3
MAC03	(IN) D	Component: Motor AC 3.3 kV, 450 kW for secondary cooling pump, Population: 5
MAD	(CA) NRU	Motor generator set, Westinghouse, shunt wound, 75 kW, 125 VDC supply, 1200 rev./min, output 600 VAC, Operating duty: 1 Operating, 1 standby; Population 2
MAI	(ID) Y	Component; Motor AC induction: Population: 9

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
MAI	(ID) S	Component: Motor AC induction; Type: Induction; System: Floor drains active areas, Primary cooling system, Pool cooling system, Venting system intermediate radiation zone, Secondary cooling system, Storage pool purification system; Component boundary: Motor, Shaft, Gear, Limit Switch; Specification: 3 Phase; Type: KA1 1375 AB 050-Z; Rotation: 2925 rev./min; 50 Hz; 380 VAC; 11 A; Connection: Δ-Y; Power Factor: 0.81; 5.5 kW; Type of Protection: IP54 ICL B; Operating duty: Operating; Manufacturer: SHORCH, Germany; Population: 48
MSS	(ID) S	Component: Motor servo; Type: Induction; System: Crane, Venting system intermediate radiation zone; Component boundary: Motor, Shaft, Gear, Limit switch; Specification: Motor for E-Actuator; Type: AS 25, 1400 rev./min; 50 Hz; 220/380 VAC; 0.04 kW; Type of Protection: IP65 ICL F; Operating duty: Operating; Manufacturer: DEUFRA, Germany; Population: 8
NCA	(AR) RA6	Component: Signal comparator bi-stable subsystem: Instrumentation and control system; Population: 21
NCA	(CN) H	Component: Signal comparator bi-stable, Population: 1
NCA	(CZ)	Component: Signal comparator bi-stable; Population: 17
NCB	(ID) Y	Component: Personal computer; Type: IPC-610; System: Reactor Instrumentation; Component boundary: Monitor, Hard disk, CPU, Keyboard; Detail/ Specification: 100-240 V, 60/50 Hz, 1.25 A; Operating duty: Operating; Manufacturer: PT. Pembina Galindro Electro Co. Indonesia; Population: 2
NCB01	(AT) TRIGA MARK-II	Component: Personal computer, PC: Manufacturer: IBM; Population 1
NCB02	(AT) TRIGA MARK-II	Component: Personal computer, PC: Manufacturer: IBM; Population 2
NCD	(BR) BR01	Component: Data Acquisition System; System: Instrumentation and control system; Manufacturer: IPEN; Component boundary: Personal computer and panel board; Population: 1
NCD	(BR) BR04	Component: Data Acquisition Module; System: Data Acquisition System; Type: analogue and digital device; Operating duty: Operating; Component boundary: Analogue and digital device, Field signal, Power supply and Monitor; Population:1
NCD	(RO) TRIGA	Component: Data Acquisition System, Manufacturer: Romania, System: Data Acquisition System; Details: Data acquisition system is a centralized system, using a mainframe computer CORAL 4030 (family PDP 11/34, 10MHz), with a multi-tasking, multi-users operating system. Component boundary: analogue scanner multiplexer, HP-IB interface, mainframe computer CORAL 4021, graphical terminals, database acquisition; Population:1
NCH	(CZ)	Component: High quality computer; Population: 1
NKA	(AR) RA6	Component: computational module; Type: Spec 200; Population: 27

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
NKA	(BR) BR01	Component: Computational module (equipment actuation controller); System: Air Conditioning and Ventilation System; Location: Control Room; Manufacturer: HONEYWELL; Model: XI58IAH; Component boundary: Processor, Personal computer; Population: 2
NKA	(ID) S	Component: Computational module; Type: Electronic; System: Reactor protection system Train 2; Component boundary: Computer; Operating duty: Operating; Manufacturer: Siemens; Population: 3
NKA	(ID) Y	Component: Computational module; Type: IRO1994sSI; System: Reactor Instrumentation; Component boundary: Electronic interface, Switch, Data acquisition & control; Operating duty: Operating; Manufacturer: BATAN; Population: 2
NKA01	(AT) TRIGA MARK-II	Component: Computational module; Manufacturer: GA; Population 33
NKA02	(AT) TRIGA MARK-II	Component: Computational module; Manufacturer: GA; Population 5
NMA	(AT) TRIGA MARK-II	Component: Signal modifier; Manufacturer GA; Population: 1
NMA	(ID) S	Component: Signal modifier, general; Type: Isolated; System: Reactor pool, Secondary cooling system; Operating duty: Operating; Population: 3
NMA	(SI)	Component: signal modifier, Population: 1
NMM	(AR) RA6	Component: signal modifier median selector; Type: 2AP+MSL; Population: 3
NMR	(AR) RA6	Component: resistance-voltage transducer; Population: 6
NMS	(AR) RA6	Component: Signal modifier square root extractor; Type: 2AX-SQE; Non-nuclear system; Population: 4
NMV	(ID) B	Component: Signal modifier current-voltage transducer; Type: I-V Transducer; System: Reactor instrumentation; Component boundary: Transducer; Operating duty: Operating; Population: 17
NMX	(AR) RA6	Component: signal modifier, multiplier; Type: 2AP+MUL; Non-nuclear system; Population: 1
NSA	(ID) S	Component: Signal conditioning system, general; Type: Current; System: Venting system intermediate radiation zone; Operating duty: Operating; Population: 2
NSA01	(AT) TRIGA MARK-II	Component: Signal conditioning system for core flux, level pressure, temperature general; Population 2
NSA02	(AT) TRIGA MARK-II	Component: Signal conditioning system for core flux, level pressure, temperature general; Population 3

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
NSC	(ID) B	Component: Signal conditioning system, flux; Type: NP 1000, NLW-2; System: Reactor instrumentation; Operating duty: Operating; Manufacturer: GA; Population: 2
NSC	(ID) S	Component: Signal conditioning system, flux; Type: Electronic current; System: Process system, Reactor protection system, Radiation protection system; Component boundary: Supply voltage 24, 15 and 5 VDC, Amplifier unit, Transformer module, Distribution module; Operating duty: Operating; Manufacturer: Siemens; Population: 12
NSC	(ID) Y	Component: Signal conditioning system, flux; Type: NP 1000, NLW-2; System: Reactor Instrumentation; Operating duty: Operating; Manufacturer: GA; Population: 2
NSC	(VN) DALAT	Component: Indication subsystem for NFCS; Manufacturer: Russia, Hartmann & Braun; Component boundary: Information treatment block, Analogue monitor, Digital indicator of power and period, Power recorder, Period recorder; Operating duty: Operating; System: Neutron flux control sub-system, Reactor control system; Population: 1
NSF	(ID) Y	Component: Signal conditioning system, flow; Type: IRO194 FM; System: Reactor Instrumentation; Component boundary: Cables, Electronic interface; Operating duty: Operating; Manufacturer: BATAN; Population: 2
OCC	(ID) S	Component: Control rod cruciform boron; Population: 8
OCR	(AT) TRIGA MARK-II	Component: Control rod, single control rod assembly; Manufacturer: GA; Population: 3
OCR	(CN) M	Component: Control rod, single control rod assembly, Population: 11
OCR	(IN) A	Component: Control rod, Population: 4
OCR	(IN) C	Component: Shutoff rod, boron; Population: 6
OCR	(IN) D	Component: Snubber, shutoff rod; Population: 9
OCR	(IN) D	Component: Clutch - shutoff rod electrical - slippage; Population: 9
OCR	(RO) TRIGA	Component: Control rod, Manufacturer: USA, Type: TRIGA; System: Control & Monitoring System; Component boundary; Control rod, Associated assembly, Bolted connections for control rod and control rod drive ends and containing shroud; Population: 8/6
OCR01	(BR) BR01	Component: Safety rod - single rod assembly; System: Instrumentation and control system; Manufacturer: American Machine & Foundry Co., Model: 89-113-6000-4-1; Component boundary: Control rod and control rod drive mechanism; Population: 3
OCR01	(VN) DALAT	Component: Stainless steel control rod; Manufacturer: Russia; Component boundary: Control rod only; Operating duty: Operating; System: Control logic sub-system, Reactor control system; Population: 1

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
OCR02	(BR) BR01	Component: Control rod - single rod assembly; System: Instrumentation and control system; Manufacturer: General Atomic, Model ESD319-8010; Component boundary: Control rod and control rod drive mechanism; Population: 1
OCR02	(VN) DALAT	Component: Boron carbide control rod; Manufacturer: Russia; Component boundary: Control rod only; Operating duty: Operating; System: Control logic sub-system, Reactor control system; Population: 6
OCS	(CA) NRU	Shut off rod magnets, mechanical failure to drop on demand, Population: 18
OCS	(CN) M	Component: Control rod clustered silver, indium, cadmium control rod, Population: 1
OCS	(CZ)	Component: Control rod clustered silver, indium, cadmium control rod, Population: 12
ORA	(AR) RA3	Component: Control rod drive; Subsystem: Control system; Component boundary: Motor, Rack and Pinion gear system, Electromagnet, and Console position indication and command system; Population: 4
ORA	(AR) RA6	Component: Control rod drive; Subsystem: control system; Component boundary: Motor, Rack and Pinion gear system including the Electromagnet, and Console position indication and command system; Population: 5
ORA	(AT) TRIGA MARK-II	Component: Control rod drive; Manufacturer: Bodine Motor, General Atomic; Details: Rod drives for shim, regulation and transient rod; Population: 3
ORA	(CA) NRU	Control rod weight 211 kg, 12 cm dia., speed 15 cm/s, Diehl induction motor, 200 W, 115 VAC, Population: 18
ORA	(CN) H	Component: Control rod drive; Population: 12
ORA	(CN) M	Component: Control rod drive; Population: 11
ORA	(CZ)	Component: Control rod drive mechanism; Population: 12
ORA	(ID) B	Component: Control rod drive; Type: Rack and pinion; System: Reactor control system; Component boundary: AC Servo motor, magnetic, switch, cables, connectors; Operating duty: Operating; Manufacturer: GA; Population: 4
ORA	(ID) S	Component: Control rod drive; Type: Rack & Pinion; System: Control rod Drive Mechanism; Component boundary: Motor drive, Motor brake, Spindle rod, Micro switches, Electrical supply, Magnet holding; Specification: Aluminium; Number of micro switches in each driver 8; motor brake 220 VAC; motor drive: 380 VAC; Operating duty: Operating; Manufacturer: Westinghouse; Population: 9
ORA	(ID) Y	Component: Control rod drive; Type: Rack and pinion; System: Reactor control system; Component boundary: AC Servo motor, Magnet, Switch, Cables, Connectors; Operating duty: Operating; Manufacturer: GA; Population: 3

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
ORA	(RO) TRIGA	Component: Control rod Drive, Manufacturer: USA, Type: TRIGA; System: Control & Monitoring System; Details: standard TRIGA rack and pinion control rod drives. Component boundary: Motor, Rack and pinion gear, Electromagnet, Console position indication and command system; Population: 8/6
ORA01	(VN) DALAT	Component: AR control rod drive; Manufacturer: Russia; Type: ADP-362, 500 W; Component boundary: Motor 6.5 VDC, drums, Counter-weight, End position contactor, Position potentiometer, Speed-generator, Steel wire; Operating duty: Operating; Population: 1
ORA02	(VN) DALAT	Component: KC control rod drive; Manufacturer: Russia; Type: D-500MF; Component boundary: DC-motor, Magnet, Position potentiometer, Drum, end position Contactor, Friction gear, Steel wire; Operating duty: Operating; System: Control logic sub-system, Reactor control system; DC-motor details: Power Supply: 48 V DC; 500 W; 3A; Population: 4
ORA03	(VN) DALAT	Component: AZ control rod drive; Manufacturer: Russia; Type: D-500MF; Component boundary: DC-motor, Magnet, Position potentiometer, Drum, end position contactor, Friction gear, Steel wire; Operating duty: Operating; System: Control Logic Sub-system, Reactor control system; DC-motor details: Power Supply: 48 VDC; 500 W; 3A; Population: 2
PDA	(ID) S	Component: Pump diesel drive; Type: Centrifugal; System: Venting System Intermediate Radiation Zone; Component boundary: Pump, Motor, Electric, Control; Specification: 1750 rev./min; Head 68 m; 35 kW; Operating duty: Operating; Manufacturer: Torishima GAE, Tokyo Japan; Population: 3
PMA	(CN) M	Component: Feed water make-up pump, horizontal motor drive, low flow rate; Population: 2
PMA	(CZ)	Component: Pump motor driven; Population: 9
PMA	(ID) B	Component: Pump motor driven; Type: AM 1602V2; System: Primary cooling system; Component boundary: Pump, Motor, Power Supply, Control Logic Circuit; Specification: 40 kW; 75 kW; 60 L/s; Pressure 1.5 bar, Operating duty: Operating/Standby; Manufacturer: JAPAN; Population: 4
PMA	(ID) Y	Component: Motor driven; Type: AM 1602V2; System: Primary, Secondary cooling system; Component boundary: Rotor, Stator, Terminal, Capacitor; Specification: 3 phase; 36 A; 2900 rev./min; 18, 5 kW; Operating duty: Operating; Manufacturer: JAPAN; Population: 5
PMA	(SI)	Component: Water tower pump; Details: Flow 23 m^3/min, discharge line diameter: 10 cm; Operating duty: Operating; Population: 1
PMA01	(AR) RA3	Component: Main circulating pump; Type: Split Case centrifugal; Discharge flow 500 m^3/h; Subsystem: Primary System; Component boundary: Pump, Motor, Gaskets, Control circuits; Population: 2
PMA01	(AT) TRIGA MARK-II	Component: Motor driven pump; Details: Primary pump, 11 kW, 30 m^3/h; Population: 1

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
PMA01	(AU) HIFAR	Component: D_2O Main Pumps; System: Primary cooling system; Manufacturer: Haywood Tyler; Type: Single Stage low-pressure water circulator; Pump details: 52 kW, Vertical; Motor details: 42 kW, 1460 rev./min, 415 VAC, 3 phase; Component boundary: Pump, Motor, Starter, Control circuits, and Local power supply connection; Operating duty: 2 operating, 1 standby; Population: 3
PMA01	(BR) BR01	Component: Pump motor driven, Primary Cooling water pump; System: Reactor cooling system; Type: Centrifugal, motor driven, helicoidal rotor, horizontal shaft; Manufacturer: KSB do Brasil; Model: SPK 250/31; Pump details: 681 m^3/h, 19 to 27 m H_2O (head), 1760 rev./min, flywheel, 57 kW; Motor details: Arno DC motor, AR-315, 74 kW, 440 VAC, 60 Hz, 111 A; Operating duty: 1 operating, 1 standby; Component boundary: Pump, Motor, Gaskets, Control circuits (excludes electrical command panel board); Population: 2
PMA01	(BR) BR04	Component: Pump Motor Driven; System: Chilled Water System - Condensed Water Circuit; Population: 2; Type: centrifugal; Engine: 76 m^3/h, 30 meters H_2O, inlet water temperature: 35ºC; outlet water temperature: 30ºC; model: A-30; type: UND; manufacturer: OMEL; Driver: motor - electric; Operating duty: 1 operating, 1 standby; Component boundary: Pump, Motor and Gaskets; Population: 2
PMA01	(CA) NRU	Main circulating coolant pump DC motors, Westinghouse, 15 kW, DC shunt, 690 rev./min, 115 VDC; Population: 4
PMA01	(ID) S	Component: Pump unit; Type: Dosing pump; System: Cooling water chemical treatment; Component boundary: Pump, Motor, Power Supply, Control Logic Circuit; Specification: Flow rate: 64-77 L/hr; Pressure: 6.5 bar; Power: 0.1 kW; Power Supply: 220 VAC, 50 Hz, 0.8 A; Type: VAMB07063PVT000A000; Manufacturer: Pro Minent Dosiertechnic GmbH, 69123 Heidelberg, Germany; Operating duty: Operating; Population: 7
PMA01	(RO) TRIGA	Component: Emergency cooling pump, Manufacturer: Aversa, Romania; Type: EPET, vertical pump, System: Primary circuit; Details: Submersible pump set in primary cooling pipe. 67 m^3/hr); Component boundary: Pump, Motor, Power supply, Control equipment, Logic and Instrumentation; Operating duty: Operating; Population: 1
PMA01	(VN) DALAT	Component: Primary cooling pump; Manufacturer: Russia; Type: 4KG-12K-14-2; Component boundary: Pump; System: Reactor Primary cooling system; Pump details: 90 m^3/h, 1.6 MPa; Operating duty: 1 operating, 1 standby; Population: 2
PMA02	(AT) TRIGA MARK-II	Component: Motor driven pump; Details: Purification pump, 2 kW, 3 m^3/h; Population: 1
PMA02	(AU) HIFAR	Component: D_2O Shutdown pumps; System: Primary cooling system Manufacturer: Hydraulic and Mechanical Developments Ltd. (HMD); Type: Magnet drive (glandless); Pump details: 3.75 kW, Vertical, Magnet drive glandless, Motor details: 4 kW, 960 rev/min, 415 VAC, 3 phase, No mechanical coupling between motor and pump, which eliminates the possibility of D_2O leaks; Component boundary: Pump, Motor, Starter, Control circuits, Local power supply; Operating duty: Operates only when the reactor is shutdown; Population: 2

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
PMA02	(BR) BR01	Component: Pump motor driven, Secondary cooling water pump; System: Reactor cooling system; Type: Centrifugal, motor driven, horizontal shaft, radius rotor; Manufacturer: Worthington; Model: 8-LN-10; Pump details: 432 to 590 m^3/h, 20 to 24 meters H_2O (head), 1760 rev./min; Motor details: CS-BOM-01: General Electric DC motor, 37 kW, 440 VAC, 60 Hz, 1800 rev./min; CS-BOM-02: Arno DC motor, 644 kW, 440 VAC, 60 Hz, 1800 rev./min; Operating duty: 1 operating, 1 standby; Component boundary: Pump, Motor, Gaskets, Control circuits (excludes electrical command panel board); Population: 2
PMA02	(BR) BR04	Component: Pump Motor Driven; System: Chilled Water System, Intermediary System; Type: centrifugal, 43 m^3/h, 10 m H_2O head; model: A-70; type: UND; manufacturer: OMEL; Manufacturer: WEG; Operating duty: 1 operating, 1 standby; Component boundary: Pump, Motor and Gaskets; Population: 2
PMA02	(CA) NRU	Main circulating coolant pump AC motors, Westinghouse, 187 kW, 2 speed AC, 30 and 60 rev./min, 3 phase; Population: 8
PMA02	(ID) S	Component: Pump Unit; Type: Diffusion pump; System: Radiation monitoring system; Component boundary: Pump, Motor, Power supply, Control logic circuit; Specification: 2 m^3/hr, 2 bar; 0.3 kW; 220 VAC, 50 Hz, 1.9 A; Manufacture: KNF Neuberger, Germany; Operating duty: Operating; Population: 10
PMA02	(RO) TRIGA	Component: Main circulating pump, Manufacturer: Aversa, Romania; Type: Centrifugal pump, Details: 7 kg/cm^2, stainless steel, operating temperature: 44 °C, 0.25 m^3/s, pumping head 42 m H_2O, NPSH: 5.4 m, motor electrical MEB-400 – M-100-4,1475 rev./min, 6 kW; Component boundary: Pump, Motor, Power supply, Control equipment, Logic and instrumentation; Operating duty: 2 operating (full power) and 2 standby; Population: 4
PMA02	(VN) DALAT	Component: Primary cooling pump; Manufacturer: Russia; Component boundary: Motor, Power supply, Control equipment, Logic and instrumentation; System: Reactor Primary cooling system; Motor details: Type: asynchronous; 380 VAC, 50 Hz; 14 kW, 27 A, power factor 0.8; Operating duty: 1 operating, 1 standby; Population: 2
PMA03	(AU) HIFAR	Component: D_2O Scavenge Pumps; Type: Flygt Submersible pump (model B2102); System: Emergency Core cooling system; Pump details: Impeller: high head, low flow version, operating temperature 40°C, 12 L/s; Motor details: 5 kW, 2850 rev./min, 415 VAC, 3 Phase; Component boundary: Pump, Motor, starter, Control circuits, Local power supply; Operating duty: Standby. Run for short periods during periodic tests. Failure rate is estimated per calendar time; Population: 2
PMA03	(BR) BR01	Component: Pump motor driven; System: Air conditioning and ventilation system; Location: External area - cooling towers; Manufacturer: KSB do Brazil; Model: 65-26; Pump details: 51 m^3/h, 28 m H_2O (head), 1750 rev./min; Component boundary: Pump, Motor, Gaskets, Control circuits (excludes electrical command panel board); Population: 2
PMA03	(BR) BR04	Component: Pump motor driven; System: Chilled water system – Chilled water distribution circuit; Type: Centrifugal; Engine: 34 m^3/h, 25 m H_2O head; model: A-30; type: UND; manufacturer: OMEL; Driver: Motor, electric, 3 phase, 380 VAC; Operating duty: 1 operating, 1 standby; Component boundary: Pump, Motor and Gaskets; Population: 2
PMA03	(CA) NRU	Purification system pump motors, Canadian Westinghouse, 20 kW, 550 VAC, 60 Hz, 3 phase, 3500 rev./min; Population: 2

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
PMA03	(ID) S	Component: Pump unit; Type: Submersible pump; System: Floor drains active areas, Primary drainage System; Component boundary: Pump, Motor, Power Supply, Control logic circuit; Detail/ Specification: Safety Class: Class-3; Flow rate: 8 m^3/hr, Head: 6 bar; 0.55 kW, 2800 rev./min; Type: Ama Drainer 32-3 SE; Manufacture: KSB Pumpen Aktiengesellschaft; Operating duty: Operating; Population: 4
PMA03	(RO) TRIGA	Component: Secondary pump, Manufacturer: Aversa, Romania, Type: Siret, centrifugal pump, System: Secondary circuit; Details: pump, type: 14 NDS with rotor, 860 m^3/hr, pumping height: 33 m pressure head, 960 rev./min. Pump motor, type: MAB 2 x 400 VAC 100-4 asynchronous, 200 kW, 1000 rev./min, 6 kW; Component boundary: Pump, Motor, Power supply to the motor, Control equipment, Logic and instrumentation; Operating duty: Operating, Population: 3
PMA03	(VN) DALAT	Component: Secondary cooling system pump; Manufacturer: Russia; Type: KM-90/55, flow rate: 90 m^3/h; Operating duty: 1 operating,1 standby; Population: 2
PMA04	(AU) HIFAR	Component: H_2O Main Pumps; Manufacturer: APE; Type: Horizontal Split Case centrifugal. Model 7KL; System: Secondary cooling system; Motor details: Brook 30 kW, 415 VAC, 1500 rev./min Soft starters for on-line starting; Component boundary: Pump, Motor, Starter, Control circuits, Local power supply: Operating duty: 3 operating, 1 standby; Population: 4
PMA04	(BR) BR04	Component: Pump motor driven; System: Feedwater treatment system; Type: Centrifugal, 2 m^3/h, 35 m H_2O head; stainless steel 316; model: ALFA-32; type: 2103; manufacturer: ALBRIZZI-PETRY; Details: Electric motor, 380 VAC, 3 phase, 3500 rev./min; seal: graphited asbestos; Manufacturer: WEG; Component boundary: Pump, Motor and Gaskets; Operating duty: Operating; Population: 1
PMA04	(ID) S	Component: Pump unit; Type: Centrifugal pump; System: Fuel storage pool cooling and purification system; Component boundary: Pump, Motor, Power Supply, Control logic circuit, Elastic coupling; Detail/Specification: Type: CPK-Cm 32 200; Flow rate: 10 m^3/hr, Head: 48 m, 4 kW/2800 rev./min; Manufacturer: KSB Pumpen Aktiengesellschaft; Operating duty: Operating; Population: 2
PMA04	(RO) TRIGA	Component: Purification system pump; Manufacturer: Pump Aversa, Romania and motor Poland; Type: Centrifugal pump TERMA 65-22 II/212 –Ox 39T 109 B and pump motor CELMA; Component boundary: Pump, Motor, Power supply to the motor, Control equipment, Logic and instrumentation; Operating duty: Operating; Population: 3
PMA04	(VN) DALAT	Component: Secondary cooling pump motor; Manufacturer: Russia; Type: 4A160M2; Component boundary: Motor; System: Reactor secondary cooling system; Motor details: Type: asynchronous; 380 VAC; Frequency: 50 Hz; 19 kW; 35 A, power factor: 0.8; Operating duty: 1 operating, 1 standby; Population: 2
PMA05	(AU) HIFAR	Component: H_2O Shutdown Pumps; Manufacturer: Lee, HOWL & Co; Type: End Suction centrifugal; System: Secondary cooling system; Pump details: Centrifugal, 2.2 kW; Motor details: Brook 2.2 kW, 415 VAC, 3 phase, 1500 rev./min; Component boundary: Pump, Motor, Starter, Control circuits, Local power supply; Operating duty: Each pump operates for one day (24 hours) every shutdown; Population: 2
PMA05	(BR) BR04	Component: Pump motor driven; System: Critical cell drain system; Type: Centrifugal; 13 m^3/h, 15 meters H_2O head; model: AA, UND; seal: mechanical; manufacturer: OMEL; Driver: electric, 3 CV; manufacturer: WEG; Operating duty: Operating; Component boundary: Pump only (excludes driver); Population: 1

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
PMA05	(ID) S	Component: Pump unit; Type: Vertical-multi stage pump; System: Reactor pool purification system; Component boundary: Pump, Elastic coupling, Motor, Power supply, Control logic circuit; Detail/Specification: Type CPK-Cm 50 250; 20 m^3/hr; head 50 m; 7.5 kW; Manufacture: KSB Pumpen Aktiengesellschaft; Operating duty: Operating; Population: 2
PMA05	(RO) TRIGA	Component: Liquid radioactive waste pump, Manufacturer: Germany; Type: Hermetic Gr CAM 2/3 H.m.Fl.s; Details: 10 m^3/hr, motor type A.G.X. 90L-2; Component boundary: Pump, Motor, Power supply, Control equipment, Logic and instrumentation; Operating duty: One pump operating, 3 pumps standby; Population: 4
PMA06	(VN) DALAT	Component: Purification system pump for spent fuel storage; Manufacturer: Russia; Type: XM2/25-K-2V; Component boundary: Pump, Motor, Power supply, Control equipment, Instrumentation; Details: 2 m^3/h; asynchronous motor; 380 VAC; 50 Hz; 1.1 kW, 2.5 A, 2610 rev./min; Operating duty: Operating; Population: 1
PMA07	(ID) S	Component: Pump unit; Type: Vertical-submersible pump; System: Low active waste water storage; Component boundary: Pump, Motor, Power supply, Control logic circuit; Details: 56 m^3/hr, head: 1.8 bar; 5.5 kW, 1450 rev./min; Manufacturer: KSB Pumpen Aktiengesellschaft; Operating duty: Operating; Population: 3
PMT	(IN) D	Component: Pump motor & turbine driven, 10 kW; Population: 3
PTA	(IN) D	Component: Hydraulic turbine for shutdown cooling pump; component boundary: Turbine only; Population: 1
PWB	(AT) TRIGA MARK-II	Component: pump horizontal, 22 - 820 L/s, Population: 1
PWB	(CH)	Component: pump horizontal, 22 - 820 L/s, Population: 2
PWB	(CN) M	Component: pump horizontal, 22 - 820 L/s; Population: 1
PWB	(ID) S	Component: Pump centrifugal, horizontal, flow 22-820 l/s; Type: Centrifugal pump; System: Primary cooling system, Secondary cooling system; Component boundary: Pump, Motor, Electric control; Manufacturer: KSB; Operating duty: Operating; Population: 3
PWC	(CA) NRU	Main circulating coolant pumps, Ingersoll Rand, 230 kg/s, 57 m head; Population: 8
PWC	(CH)	Component: motor driven pump, vertical 20 L/s, 4 kW; Population: 1
PWC	(CN) M	Component: Pump motor drive centrifugal, horizontal low head; Population: 4
PWC	(ID) B	Component: Pump; Type: Centrifugal pump, ETA 50-20R,65 X50FS8HM; System: Primary and Secondary cooling system; Component boundary: Pump, Motor, Power supply, Control logic circuit; Detail/Specification: 3450 rev./min; Total head 15 m; 30 m^3/h; 2 kW; Operating duty: Operating; Manufacturer: FLOMAX USA; Population: 2

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
PWC	(ID) S	Component: Main Pump; Type: Centrifugal Pump; System: Primary cooling system; Component boundary: Pump, Motor, Power supply, Control logic circuit; Details: Head 28 m; 220 kW; 1950 m^3/hr; Manufacture: KSB Aktiengesellschaft, Germany; Operating duty: Operating; Population: 6
PWC	(ID) Y	Component: Pump; Type: Centrifugal pump, ETA 50-20R,65 X50FS8HM; System: Primary and secondary cooling system; Component boundary: Standard crank shaft engine, Bearing, Impeller, Drive clamp; Details: 3450 rev./min, head 15 m; 380 L/min; 2 kW; Operating duty: Operating; Manufacturer: FLOMAX USA; Population: 5
PWC01	(AR) RA6	Component: Primary cooling system centrifugal pump; Type: Centrifugal, 150 m^3/h, head 30 m, 2,900 rev./min; Component boundary: Pump, Motor, Gaskets, Control circuits; Population: 2
PWC02	(AR) RA6	Component: Demineralizer system centrifugal pump; 5 m^3/h, head 35m, 2,900 rev./min; Component boundary: Pump, Motor, Gaskets, Control circuits; Population: 2
PWC03	(AR) RA6	Component: Secondary cooling system centrifugal pump, 100 m^3/h, 2,900 rev./min; Component boundary: Pump, Motor, Gaskets, Control circuits; Population: 2
PWC04	(AR) RA6	Component: Demineralizer make up water system pump; Type: Centrifugal, 5 m^3/h, head 35m, 2,900 rev./min; Component boundary: Pump, Motor, Gaskets, Control circuits; Population: 1
PWC05	(AR) RA6	Component: Buffer tank demineralization pump; Type: Centrifugal, 2 m^3/h, head 35 m, 2900 rev./min; Component boundary: Pump, Motor, Gaskets, Control circuits; Population: 1
PWC06	(AR) RA6	Component: Effluent pump; Type: Centrifugal, 20 m^3/h, head 13 m, 2,900 rev./min; Component boundary: Pump, Motor, Gaskets, Control circuits; Population: 2
PWE	(CH)	Component: pump vert. 70-1900 L/s; Operating duty: Operating; Population: 2
PWE	(CN) H	Component: pump vert. 70-1900 L/s; Operating duty: Operating; Population: 3
PWE	(CN) M	Component: Pump vertical 70-1900 L/s; Operating duty: Operating; Population: 2
PWS	(CA) NRU	Purification system pumps, Allis-Chalmers, 21 kg/s, 64 m head, centrifugal, vertical; Operating duty: Operating; Population: 2
QAA	(ID) S	Component: Air dryer unit; Type: Fin & tube; System: Venting system emergency diesel building, Compressed air system, Chilled water radiation zone, Component boundary: Compressor evaporator unit, Condenser unit, Exhaust fan; Dew point temperature: 16 bar/50 °C; Inlet/Outlet Air temperature 2°C, 290 m^3/h, 220 mbar; Refrigerant: R-12; Manufacturer: Newtech, Druckluftaufbereitung; Operating duty: Operating; Population: 3
QBF	(AU) HIFAR	Component: Cooling tower fans; System: Secondary cooling system, Diameter 360 cm; Material: Aluminium alloys; Motor: 2-speed electric: Component boundary: Motor, Fan, and Gear box; Operating duty: Operating; Population: 6

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
QBF	(ID) B	Component: Blower fan; Type: ETA 50-20; System: Ventilation; Component boundary: Propeller, Motor, Universal joint; Details: 85 W; 240 VAC; 50/60 Hz; Manufacturer: Sulzer, Switzerland; Operating duty: Operating; Population: 2
QBF	(ID) S	Component: Fan unit; Type: Axial; System: Venting system intermediate radiation zone; Component boundary: Blade, Shaft, Bearing, Pulleys; Details: Type: DM 83-1 M3-ET3; 28,000 m^3/hr; 25 kW; 2,900 rev./min; Manufacturer: Solyvent Ventec; GmbH, Germany; Operating duty: Operating; Population: 33
QBF	(ID) Y	Component: Blower fan; Type: ETA 50-20; System: Ventilation; Component boundary: Propeller, Motor, Universal joint; Details: 85 W; 240 VAC; 50/60 Hz; Manufacturer: Sanyo electric Co. Ltd JAPAN; Operating duty: Operating; Population: 12
QBF01	(VN) DALAT	Component: Cooling tower ventilator fan; Manufacturer: Russia; Type: 1VG-25; Details: Asynchronous motor; 380 VAC; 50 Hz; 11 kW; 29 A; Power factor: 0.8; 365 rev./min; Operating duty: Operating; Population: 2
QBF02	(VN) DALAT	Component: Control circuit for cooling tower ventilator; Manufacturer: Russia; Component boundary: Power supply to the motor, Control equipment for the ventilator, Logic and instrumentation; Operating duty: Operating; Population: 2
QCH	(IN) D	Component: Compressor diaphragm, helium circulation system; Operating duty: Operating; Population: 3
QCI	(BR) BR04	Component: Compressor, Instrument air supply system; Type: reciprocating, electric motor driven; Engine: 70 Nm^3/h; 7.0 kgf/cm^2; Model: BV-80DA; manufacturer: BARIONKAR; Driver: motor – electric; 20 CV, 3 phase, 15 kW, 380/660 VAC, 1750 rev./min; shafting: belt drive; manufacturer WEG; Component boundary: Compressor, Motor and Belt; Operating duty: 1 operating, 1 standby; Population: 2
QCI	(RO) TRIGA	Component: Compressor instrument air system, Manufacturer: GRASSO-NAMI (Holland), Type: Water cooled, one stage 6 bars, Component boundary: Compressor body, Supply breaker, Control circuitry, Cooling components, Seals, Lubrication, Motor, Status indication; Operating duty: 1 operating, 1 standby; Population: 2
QCI01	(BR) BR01	Component: Compressor instrument air system: Type: 30 Series, reciprocating, electric-driven, two-stage; Manufacturer: Ingersoll Hand; Model: 242; Driver: motor AC, General Electric, Model 25-1064-405; Component boundary: Starting system, Driver, Power transmission (belt), Compressor unit (including tank), Control and monitoring, Lubrication system; Operating duty: Standby; Population: 1
QCI01	(CA) NRU	Air compressor, Worthington Company reciprocating, 17 m^3/s, 520 kPag discharge pressure, 75 kW motor, 600 Vac, 3 phase, 60 cps. Operating duty; 2 operating, 1 standby; Population: 3
QCI02	(BR) BR01	Component: Compressor instrument air system; Location; Type: HBB 1 cylinder, reciprocating, single stage; Manufacturer: Worthington; Model: HBB-25-125, 1.3 m^3/min, 7 kgf/m^2, 675 rpm; Driver: Motor electric, 11 kW, 220V/440VAC, 1760 rev./min; Component boundary: Starting system, Driver, Power transmission (belt), Compressor unit, Storage tank, Control and monitoring, Lubrication system; Operating duty: Operating; Population: 1

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
QCI02	(CA) NRU	Air compressor, Joy Manufacturing Company, 3-stage centrifugal, 57 m^3/s, 700 kPag discharge pressure, 336 kW Reliance motor, 2,300 VAC, 3 phase, 60 rev./min; Operating duty: Operating; Population: 1
QCX	(AU) HIFAR	Component: Freon Compressor; Manufacturer: Carrier System: Space Conditioning System; Motor details: Crompton Parkinson 19 kW, 415 VAC, 3 phase, 1,440 rev./min, Component boundary: Compressor, Motor, Belt, Electrical connections, Switchgear and Controls; Population: 3
QCX01	(BR) BR01	Component: Freon compressor; System: Air conditioning and ventilation system; Type: Semi-hermetic reciprocating; Manufacturer: BITZER; Model: 6G-40/2; Compressor unit, 180 m^3/h, 80 TR; Driver: Motor electric, 30 kW, 1,750 rev./min; Component boundary: Starting system, Driver, Power transmission, Fan coil, Compressor unit, Control and monitoring, Lubrication system; Operating duty: Operating; Population: 2
QCX01	(BR) BR04	Component: Chiller freon compressor - air conditioning; Type: SG-40, shielded; Engine: 4 stages; Freon type: R22 (gas); Driver: Electric motor, manufacturer: Coldex Frigor, Model: CGWA-080 NSA; Component boundary: Compressor only Operating duty: 2 compressors operating per circuit; 2 standby; Population: 4 (2 per chiller)
QCX02	(BR) BR04	Component: Self container compressor - air conditioning; System: Ventilation and air conditioning system; Type: Shielded; Engine: 2 stages; Freon type: R22 (gas); Driver: Electric motor, manufacturer: Coldex Frigor, Model: 125-25H; Operating duty: Operating; Component boundary: Compressor only; Population: 3
QCY	(BR) BR04	Component: Freon compressor-air dryer, Instrument air supply system; Type: Air cooling; Engine: Model: S4; Freon type: R-12; Manufacturer: Barionkar; Driver: electric motor, 380 VAC, 3 phase, belt drive; Manufacturer - WEG; Operating duty: 1 operating, 1 standby; Component boundary: Compressor, Motor, Belt and power supply; Population: 2
QDA	(BR) BR04	Component: Damper - Automatic control – air exhausting; System: Critical cell ventilation and air conditioning system; Type: Shut off, automatic control, air operated, two position parallel blade, 60x75 cm, 12,000 m^3/h; Operating duty: 4 operating; open (reactor operation); closed (reactor shutdown); Component boundary: Damper and Actuator; Population: 5
QDA	(ID) B	Component: Damper; Type: Mechanical, Handle; System: Ventilation; Component boundary: Handle, Plat open/close; Detail/Specification: 85x85 cm; Operating duty: Operating; Manufacturer: Domestic; Population: 2
QDA	(ID) S	Component: Damper; Type: Fire brick and melting fuse; System: Venting system intermediate radiation zone; Component boundary: Damper; Operating duty: Operating; Population: 86
QDA	(ID) Y	Component: Damper; Type: Mechanical; System: Ventilation; Manufacturer: Indonesia; Component boundary: Handle, Plat open/close; Detail/ Specification: 85x85 cm; Operating duty: Operating; Population: 2
QDA01	(CA) NRU	Ventilation system fan dampers butterfly, double acting, electric solenoid for dampers, monthly test, flow 6 m^3/s; Population: 6

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
QDA02	(CA) NRU	Emergency filter ventilation system dampers, 90 cm diameter, pneumatic, 6 m^3/s; Population 4
QDM01	(BR) BR04	Component: Damper - Local manual control - Air exhausting; system: Critical cell ventilation and air conditioning system; Type: Modulating, manual control, 80 x 75 cm, 12,000 m^3/h; Operating duty: 3 operating; 3 standby; Component boundary: Damper and Actuator; Population: 6
QDM02	(BR) BR04	Component: Damper - Remote manual control - air recirculating; System: Critical cell ventilation and air conditioning system; Type: On-off, two position parallel blade, 80x75 cm, 13,000 m^3/h; Operating duty: 4 operating; 4 standby; Component boundary: Damper and Actuator; Population: 8
QFB	(BR) BR04	Component: Blower fan; Critical cell ventilation and air conditioning system; Type: Centrifugal; Engine: Model: SISW; manufacturer: HIGROTEC; Driver: electric motor; 380 VAC, 3 phase; pulley drive; Manufacturer: WEG; Operating duty: 1 blower fan operating per circuit, 1 standby; Component boundary: Blower fan and Motor; Population: 2
QFV	(BR) BR04	Component: Containment ventilation fan - Air Recirculating System: Type: centrifugal; Engine: model: SISW; manufacturer: HIGROTEC; Driver: electric motor; 15 CV; 380 VAC, 3 phase; pulley drive; manufacturer: WEG; Component boundary: Fan and Motor; Operating duty: 1 operating, 1 standby; Population: 2
QFV01	(BR) BR01	Component: Containment ventilation fan; System; Manufacturer: GEMA; Model: CHL-1190; Motor: WEG, 37 kW, 1,180 rev./min; Component boundary: Fan, Motor; Population: 1
QFV01	(CA) NRU	Ventilation fans, Canadian Sirocco company, 6 m^3/s, 56 kW; Population: 5
QFV02	(CA) NRU	Electrical I&C controls for ventilation fan motors, 56 kW, 600 VAC, 395 rev./min fan, 1,800 rev./min motor, 3 phase, double V-belt. Population: 5
QFV03	(BR) BR01	Component: Containment ventilation fan; Manufacturer: SUR-REFRICON; Model: LLS-224; 11,400 m^3/h, 30 cm H_2O head, 2,450 rev./min; Motor: WEG; Model TE-160M; 19 kW, 3,520 rev./min; Component boundary: Fan, Motor; Population: 1
QFV04	(BR) BR01	Component: Containment ventilation fan; Manufacturer: SUR-REFRICON; Model: LLS-224; 1,400 m^3/h, 8 cm H_2O head, 3,090 rev./min; Motor: WEG, 0.4 kW, 3,410 rev./min; Component boundary: Fan, Motor; Population: 1
QFV05	(BR) BR01	Component: Containment ventilation fan; Manufacturer: SUR-REFRICON; Model: LLS-224; 1,400 m^3/h, 38 mm head H_2O, 3,090 rev./min; Motor: WEG, 0.4 kW, 3,380 rev./min; Component boundary: Fan, Motor; Population: 1
QNA01	(RO) TRIGA	Component: Cooling Fan, Manufacturer: Independenta, Sibiu, Romania, Type: axial, vertical, System: Secondary Circuit; Details: Diameter: 470 cm, 30 kW, 130-180 m^3/s, double rotation speed: 750 rev./min or 1500 rev./min; Component boundary: Mechanical and electrical parts, including commands, Motor and power supply to the motor, Operating duty: 3 operating, 3 standby; Population: 6

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
QNA02	(RO) TRIGA	Component: Cooling Fan, Manufacturer: Fisher and Langer - Austria; Type: centrifugal, type VLE19, System: Ventilation System; Details: fan double rotation speed: 750 rev./min or 1500 rev./min; Component boundary: Mechanical and electrical parts, including commands, Motor and power supply to the motor; Operating duty: Four pairs of fans, one operating, one standby in each pair. Population: 8
QVA	(BR) BR01	Component: HVAC unit - auxiliary building; System: Air Conditioning and Ventilation System - Cold Area; Type: air conditioning "self-contained"; Manufacturer: Springer Carrier; Model: 50BZ006; Component boundary: HVAC unit comprising blower fans and Freon compressors; excludes other associated components such as condenser, piping and valves; Population: 3
QVG	(RO) TRIGA	Component: Air Conditioning Unit, Manufacturer: O.K.G. Austria; System: Ventilation System, Details: located in different ventilation unit, Component boundary: Heating battery, Cooling battery, not include fan, which was analysed separately; Operating duty: 3 pairs of units, operating alternating, one from each pair, on calendar time; Population: 6
QVR	(ID) S	Component: HVAC Unit control room; Type: Water cooler, Storage pool purification; System: Fuel storage pool purification system; Component boundary: High voltage, Cable; Operating duty: Operating; Population: 3
QVS	(AU) HIFAR	Component: Space Conditioner Unit; System: Space Conditioning System Component boundary: HVAC unit comprising the blower fans and excludes other associated components - Freon compressor, Condenser, Piping and Valves; Population: 6
RAA	(ID) S	Component: Relay Auxiliary; Type: NC/NO; System: Secondary cooling system, Venting System Intermediate Radiation Zone, Chilled Water Low Radiation Zone, Primary cooling system; Component boundary: Coil, Input terminal, Output terminal; Detail/Specification: 220 VAC, 220 VDC, 24 VDC, 36 VDC; Operating duty: Operating; Manufacturer: Siemens; Population: 1500
RCA	(ID) S	Component: Relay control AC; Type: NC /NO; System: Crane, Venting system low radiation zone, Venting system intermediate radiation zone, Chilled water intermediate radiation zone, Venting system auxiliary building, Chilled water low radiation zone, Demineralized water supply, Compressed air system, Diesel emergency Sets, Secondary cooling system, Primary cooling system, System rabbit, Spent fuel storage pool, Reactor pool; Component boundary: Coil, Input terminal, Output terminal; Detail/Specification: 220 VAC; Operating duty: Operating; Manufacturer: Siemens, Dold, Syrelec; Population: 568
RCA	(VN) DALAT	Component: Relay block VB-73; Manufacturer: Russia; Type: VB-73; Component boundary: rectifier, relays: System: Neutron flux control sub-system, Reactor control system; Power Supply: 24 VDC; Contact current: 2A; Population: 6
RCD	(ID) S	Component: General relay control DC; Type: NC/NO, 24 VDC; Manufacturer: Siemens; Population: 96
RCL	(ID) S	Component: General relay control; Type: NC/NO; Component boundary: Coil, Input terminal, Output terminal; Detail/Specification: 220 VAC, 220 VDC, 24 VDC, 36 VDC; Manufacturer: Siemens; Population: 200

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
RPH	(ID) S	Component: Relay, power 300-460 A; Type: NC/NO; System: Secondary cooling system, Pool Warm Layer System, BHC 01; Component boundary: Coil, Input terminal, Output terminal; Detail/Specification: 220/380 VAC, 300-460 A; Manufacturer: Siemens, Mitsubishi; Population: 45
RPL	(ID) S	Component: Relay, power 40-60 A; System: Secondary system, Venting system low radiation zone, Pool warm layer system, Chilled water intermediate radiation zone, Chilled water radiation zone; Component boundary: Coil, Input terminal, Output terminal; Details: 220/380 VAC, 40-60 A; Manufacturer: Siemens; Population: 180
RRA	(BR) BR04	Component: Relay - Protective; System: Instrumentation and control system; Type: all types; Component boundary: Power supply; Population: 210
RRS	(IN) D	Component: Switch Relay, 15 VDC; Population: 24
RTA	(VN) DALAT	Component: Relay time delay; Manufacturer: Russia; Type: EMRV-27B-1; Component boundary: Relay; System: Electric power supply system; Details: delay time: 0-10 s, contact current: 2A; Population: 6
RWA	(BR) BR04	Component: Relay; System: Instrumentation and control system, 24 VAC; Component boundary: Contacts, Coil, Power supply; Population: 726
RWA	(ID) B	Component: Relay, general; Component Code: RWA; Type: NC/NO; System: Ventilation, Primary cooling system, Secondary cooling system; Component boundary: Cable terminal, Circuit breaker; Detail/Specification: LC1 D4001, LC1 D2501; Operating duty: Operating; Manufacturer: Omron, Telemechanic; Population: 24
RWA	(ID) S	Component: Relay, general; Population: 939
RXA	(ID) B	Component: Relay contacts; Type: NA; System: Ventilation, secondary cooling system; Component boundary: Relay; Detail/Specification: NA; Operating duty: NA; Manufacturer: Omron, Telemechanic; Population: 12
SAA	(BR) BR04	Component: Nuclear channels test and calibration switch – Signal simulator amplifier – Reactor control console switch; System: Nuclear instrumentation; Type: on-off; Operating duty: Demanded on instrumentation test only; Component boundary: Contacts and Power supply; Population: 10
SCC	(ID) B	Component: Switch contacts; Type: S-80, S-K95, K-125; System: Primary, Secondary and Blower; Component boundary: Magnet, Timer; Operating duty: Operating; Manufacturer: Mitsubishi electric corporation JAPAN; Population: 26
SCC	(ID) Y	Component: Switch contacts; Type: S-80, S-K95, K-125; System: Primary, Secondary and Blower; Component boundary: Magnet, Timer; Operating duty: Operating; Manufacturer: Mitsubishi electric corporation JAPAN; Population: 9
SDA	(CH)	Component: Switch digital channel pressure/vacuum, pressure, level; Population: 2
SFA01	(VN) DALAT	Component: Switch, flow, in primary coolant system flow meter; Manufacturer: Russia, Hartmann & Braun; Type: Threshold switch; Operating duty: Operating; Instrumentation system; Population: 2

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
SFA02	(VN) DALAT	Component: Switch, flow, in primary coolant system flow meter; Manufacturer: Russia, Hartmann & Braun; Type: Threshold switch; Operating duty: Operating; Instrumentation system; Population: 2
SLA	(VN) DALAT	Component: Switch, reactor water level; Manufacturer: Russia, Hartmann & Braun; Type: Threshold switch; Component boundary: Switch; Operating duty: Operating; Population: 2
SMA	(VN) DALAT	Component: Switch manual; Manufacturer: Russia, Hartmann & Braun; Type: P1T2-2, P2T-1, P2T-5, PGK-3P3N, PGK-5P2N; Operating duty: Operating; System: Control logic sub-system, Reactor control system; Population: 8
SMA01	(BR) BR04	Component: Switch Manual; System: Instrument Air Supply System; Operating duty: demand operated; Component boundary: Switch, Contacts and Power supply; Population: 1
SMA02	(BR) BR04	Component: Switch Manual, Nuclear Instrumentation System; Operating duty: Operating; Component boundary: Switch, Contacts and Power supply; Population: 1
STA	(VN) DALAT	Component: Switch temperature; Manufacturer: Russia, Hartmann & Braun; Type: Threshold switch; Operating duty: Operating; System: Reactor temperature instruments, Reactor instrumentation system; Population: 2
TA2	(IN) C	Component: transformer 22 VAC/415 VAC; Population: 7
TA6	(CN) M	Component: transformer 6 kVAC/380 VAC; Population: 2
TA6	(VN) DALAT	Component: Transformer 6kVAC/380VAC; Manufacturer: Russia; Type: TM-1000/10; Component boundary: Transformer; Operating duty: Operating; System: Electric power supply system; Details: Power: 1000 kVA, 50 Hz, 3 phase; Diagram and group connection: Δ/Y; HV side: 6.6 kVAC, 187.5A; LV side: 400 kVAC, 1445 A; Population: 1
TAA02	(ID) S	Component: Transformer; Component boundary: Primary winding, Secondary winding, Isolation, Oil; Details: Power transformer, 1,600 kVA, 3 phase, 50 Hz; Primary connection: D; Secondary connection: YN 5; Primary (20 kVAC, 46A), Secondary (400 VAC, 2.300 A); Type of Cooling: ESSO-80; weight: 3,750 kg; Operating duty: Operating; Manufacturer: UNINDO (oil); Population: 1
TIC	(ID) S	Component: Transformer instrumentation; Population: 431
TUA01	(CA) NRU	Transformer substation, English Electric, 500 kVA, 2400/600 VAC, 3 phase, 60 Hz, delta primary, star secondary; Population: 2
TUA02	(CA) NRU	Transformer substation, English Electric, 1000 kVA, 2400/600 VAC, 3 phase, 60 Hz, delta primary, star secondary; Population: 1
TUT01	(IN) D	Component: Transformer sub-station 22/3.3 kVAC, 3 phase liquid filled, 10 MVA; Population: 2
TUT02	(IN) D	Component: Transformer sub-station 22/415 kV, 3 phase liquid filled, 2 MVA; Population: 4

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
UCA	(ID) S	Component: Controller electronic; System: Process control system, Chilled water low radiation zone, Lift, Reactor protection system, Radiation protection system, Control rod drive mechanism; Component boundary: Power supply, Transmission signal from sensors, Electronic modules, Drivers, Sensors; Details: Supply voltages: 5, 15 and 24 VAC; Type: Hard wired programming; Operating duty: Operating; Population: 30
UCE	(ID) S	Component: Controller electronic; Type: Programmable; System: Primary cooling system, Secondary cooling system, Cooling water purification system, Waste storage system Component boundary: Supply voltage from the external source +24 V DC, Central processing unit of Simatic S5, Unit power supply for Simatic S5, RAM module, EPROM module, Input/output modules, Transducer, Signal converter I/U, Limit value transmitter, Decoupling relays, Push Button switches; Details: Type: Simatic S5 110 A; CPU: Siemens, Simatic S5, Module 902; RAM: Siemens, Simatic S5, Module 340; EPROM: Siemens, Simatic S5, Submodule 911; Power Supply: Siemens, Simatic S5, Unit 932; Input voltage: 0-24 VAC; Output voltage: 0-24 VAC; Power supply; voltage: 24 VDC; Software: Special tools STEP 5; Program editor: type PG 675, Siemens; Unit capacity: Max 512 Inputs and 512 Output; Operating duty: Operating; Manufacturer: Siemens; Population: 11
UCE01	(BR) BR01	Component: Controller electronic - temperature; System; Air conditioning; Type: Electronic thermostat; Manufacturer: Honeywell; Model: T775; Component boundary: Temperature sensor, Control circuit; Population: 2
UCE01	(BR) BR04	Component: Controller - Reactor power automatic control (flux control); system: Nuclear instrumentation; Type: Electronic controller - reactor automatic control; Operating duty: Operating; Component boundary: Module and Power supply; Population: 1
UCE2	(BR) BR01	Component: Automatic Reactor Power Control; System: Instrumentation and control system; Type: Pre- amplifier; Model: C113-614; Manufacturer: General Atomic; Component boundary: module and power supply; Population: 1
UCF	(ID) S	Component: Flow controller; Type: PLC; System: Primary system, Secondary system, Waste management system, Water purification system, Emergency cooling system; Component boundary; Module and Power supply 24 VDC, Operating duty: Operating; Manufacturer: Siemens; Population: 20
UIA	(ID) Y	Component: Analogue display; Type: NP 1000, NW2, RMS-II; System: Reactor instrumentation and control system; Component boundary: Connector, Cables, Supports; Details: 0.5 A, 120 VAC, 50/60 Hz; Operating duty: Operating; Manufacturer: GA; Population: 4
UIA	(RO) TRIGA	Component: Indicating instrument, Type: Flow meter, System: Purification system, Details: Indicating instruments on NaOH, H_2SO_4 tanks, flow 6,300 L/hr, pressure 6 bar; Component boundary: Flow meter assembly; Population: 4
UIA01	(BR) BR04	Component: Indicating instrument - Analogue display; System: Nuclear instrumentation; Type: Analogue display; Operating duty: Operating; Component boundary: Instrument and Power supply; Population: 2
UIA02	(BR) BR04	Component: Indicating instrument - Analogue display; System: Nuclear instrumentation; Type: Analogue display; Operating duty: Operating; Component boundary: Instrument and Power supply; Population: 4

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
UIA03	(BR) BR04	Component: Indicating instrument - Water level; System: Water temperature control and fast filling water system; Type: Analogue display; Operating duty: Operating; Component boundary: Instrument and Power supply; Population: 1
UIA03	(BR) BR04	Component: Indicating instrument - Water level; System: Water temperature control and fast filling water system; Type: Analogue display; Operating duty: Operating; Component boundary: Instrument and Power supply; Population: 1
UID01	(VN) DALAT	Component: Indicator temperature; Manufacturer: Russia, Hartmann & Braun; Type: KVM1-507; DPM7; Component boundary: Indicator; Operating duty: Operating; System: Reactor temperature instruments, Reactor instrumentation system; Population: 1
UID01	(VN) DALAT	Component: Indicator temperature; Manufacturer: Russia, Hartmann & Braun; Type: KVM1-507; DPM7; Component boundary: Indicator; Operating duty: Operating; System: Reactor temperature instruments, Reactor instrumentation system; Population: 1
UID02	(VN) DALAT	Component: Indicator level reactor water level; Manufacturer: Russia, Hartmann & Braun; Type: KVU1-503; DPM7; Component boundary: Indicator; Operating duty: Operating; System: Water level instruments, Reactor instrumentation system; Population: 1
UIE	(BR) BR04	Component: Indicating Instrument; System: Nuclear Instrumentation; Type: digital and analogue instrument; Operating duty: Operating; Component boundary: Instrument and Power supply; Population: 2
UIE	(ID) B	Component: Indicating instrument. Electronic; Type: IRP1994, IRO1994PBK; System: Reactor instrumentation; Component boundary: Water level, Control rod position; Operating duty: Operating; Manufacturer: BATAN; Population: 37
UIE	(ID) S	Component: Indicator lamp; Type: DC Signal; System: Main control room, Emergency control room, Local panel; Component boundary: Connection cable, Supply voltage, lamps, Terminals/port; Details: Supply voltage: 24 VDC; Lamp manufacturer: KEN, JAPAN; Red, Green, Clear; Type: T 10X28 mm E10, current 110 mA; Operating duty: Operating; Manufacturer: Siemens; Population: 1,200
UIE	(ID) Y	Component: Indicating instrument. Electronic; Type: IRP1994, IRO1994PBK; System: Reactor instrumentation; Component boundary: Water level, Control rod position; Operating duty: Operating; Manufacturer: BATAN; Population: 4
UIL	(BR) BR01	Component: Indication lamp; System: Instrumentation and control system; Type: 12 VAC, 40 mA; Manufacturer: Sadokin; Component boundary: Console; Population: 78
UIR	(ID) B	Component: Recorder; Type: Micro servo; System: Reactor instrumentation; Component boundary: Power supply, Connector, Cables; Detail/ Specification: 120 VAC, 4-20 mA, 12-60 mm/min.; Operating duty: Operating; Manufacturer: Graphtec, USA; Population: 1
UIR	(ID) S	Component: Universal servo multipoint recorder; Type: Analogue; System: Recorder; Component boundary: Analogue DC, Step motor drives; Details: Non - contact servo, plunger coil system with stepping motor; Number of channel: 6, electrically isolated; Power supply 24 VDC; Input signal range: 0-24 mA; Manufacturer: Siemens; Operating duty: Operating; Population: 21

Text cont. on p. 101

TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
UIR	(RO) TRIGA	Component: Core flux indicating instrument - power recorder; Manufacturer: Honeywell-SUA, Type: Linear and logarithmic scales, System: Control & monitoring system, Component boundary: Recorder assembly (recorder and command electronics), Two pens; Population: 1
UIR01	(VN) DALAT	Component: Recorder, primary coolant flowmeter; Manufacturer: Russia, Hartmann & Braun; Type: KCU2-004; SK12; Component boundary: Recorder; Operating duty: Operating; System: Primary coolant flowmeter, Reactor instrumentation system; Population: 1
UIR02	(VN) DALAT	Component: Recorder secondary coolant flowmeter; Manufacturer: Russia, Hartmann & Braun; Type: KCU2-004; SK-12; Component boundary: Recorder; Operating duty: Operating; System: Secondary coolant flowmeter, Reactor instrumentation system; Population: 1
UIR03	(VN) DALAT	Component: Recorder, temperature; Manufacturer: Russia, Hartmann & Braun; Type: KCN2-028, KCM2-021; SK-12; Component boundary: Recorder; Operating duty: Operating; System: Reactor temperature instruments, Reactor instrumentation system; Details: Power Supply: 220 VAC; Response time: 1s switchable to 2, 5, 10, 15 and 60 s; 4-20 mA DC; Population: 3
UIX	(AT) TRIGA MARK-II	Component: Data recorder; Manufacturer: AEG (1968); Details: Type CL 20 and CL 21; Population: 2
UIX01	(VN) DALAT	Component: Indicators (normal operation); Manufacturer: Russia; Component boundary: Input amplification modules, Intermediate relay blocks, Time relay block, Power amplification block, Diodes, Bulbs; Operating duty: Operating; System: Control logic sub-system, Reactor control system; Population: 1
UIX02	(VN) DALAT	Component: Indicators (safety); Manufacturer: Russia; Component boundary: Input signal module, Input amplification modules, Intermediate relay blocks, Time relay block, Power amplification block, Horn, Bell, Buttons, Bulbs; Operating duty: Operating; System: Control logic sub-system, Reactor control system; Population: 1
UMC	(BR) BR01	Component: Manual control device pushbutton - Reactor SCRAM; System: Instrumentation and control system; Manufacturer: General Atomic; Component boundary: Cabling from pushbutton to control console; Population: 3
UMC	(VN) DALAT	Component: Manual control drive push button; Manufacturer: Russia; Type: K-1-1, K-2-2, K-3-1, K-3-2, K-4-1, K-4-2, PKE222-1; Component boundary: Push button; Operating duty: demand operated; System: Control logic sub-system, Reactor control system; Population: 13
UMC01	(BR) BR04	Component: Manual Control Device Pushbutton; System: Nuclear Instrumentation; Type: pushbutton; Operating duty: Demand operated; Component boundary: Pushbutton switch, Cables, Connections and Power supply; Population: 21
UMC02	(BR) BR04	Component: Manual Control Device Pushbutton; System: Movable Reactor Bridge; Type: Pushbutton; Manufacturer: MAUSA; Operating duty: 6 demands per operation; Component boundary: Pushbutton Switch, Cables, Connections and Power supply; Population: 8

Text cont. on p. 102

TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
UNA	(AR) RA6	Component: alarm; Type: Absolute alarm; Population: 19
UNA	(VN) DALAT	Component: Annunciator; Manufacturer: Russia; Type: Accident annunciator; Component boundary: Control equipment, Horn; Population: 1; Operating duty: Operating; System: Control logic sub-system, Reactor control system
URS	(CH)	Component: Reactor scram system channel; Population: 1
URS	(IN) A	Component: Reactor scram system channel; Population: 1
VA1	(CA) NRU	Tilting disc emergency process water check valve, pneumatic operation, Dominion Engineering Works, 30 cm diameter; Population: 2
VA1	(RO) TRIGA	Component: Air operated valve, Manufacturer: Xorela, Swiss, Population: 4; System: Primary circuit, Details: diameter 35 mm, 6.5 bar instrument air, non-return valves on the outlet of primary circuit pumps; Component boundary: Valve and adjacent mechanical components, Logic and instrumentation, Control equipment, not including instrumental air lines; Operating duty: Operational with pumps; Population 4
VA101	(BR) BR04	Component: Valve - air operated; System: Water temperature control and fast filling water system; Type: Butterfly, 2 positions (on-off); Operating duty: closed (reactor operation), open (reactor shutdown); Component boundary: Valve, Actuator and Power supply; Population: 2
VA102	(BR) BR04	Component: Valve - Air Operated; System: Chilled Water System; Type: 85-02-2-250-FR; three-way valve; manufacturer: HITER; Operating duty: normally open; Component boundary: Valve, Actuator and Power supply; Population: 3
VAR	(IN) D	Component: Control valve moderator; Population: 3
VAT	(IN) D	Component: Valve air operated butterfly, 15 cm diameter; Population: 4
VCA	(AR) RA3	Component: Valve self-operated check; Subsystem: Demineralizer. System; Component boundary: Valve body and internal parts; Population: 2
VCA	(AR) RA6	Component: Valve self-operated check; Subsystem: Demineralization cont. system; Component boundary: Valve body and interiors, Operating mechanism; Population: 2
VCA	(BR) BR04	Component: Valve – self operated; System: Moderator water treatment system; Type: Check valve; Operating duty: 2 operating per circuit; 2 standby; Component boundary: Valve only; Population: 4
VCA	(CA) NRU	Pump discharge tilting disc check valves, horizontal swing, Dominion Engineering Works, 25 cm diameter; Population 8
VCA	(IN) C	Component: Check valve 15 cm diameter; Population: 2
VCA01	(IN) D	Component: Check valve 15-30 cm diameter; Population 9

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
VCA01	(VN) DALAT	Component: Check valve in reactor primary cooling circuit; Manufacturer: Russia; Type: 16NZ10BK; Operating duty: 2 Operating and 1 Standby; System: Reactor primary cooling system; Population: 3
VCA02	(IN) D	Component: Check valve, 40 cm diameter; Population: 2
VCA02	(VN) DALAT	Component: Check valve, reactor secondary cooling circuit; Manufacturer: Russia; Type: 19TL16BR; Component boundary: Check valve; Operating duty: 1 Operating and 1 Standby; System: Reactor secondary cooling system; Population: 2
VCF	(AR) RA3	Component: Valve operated by floating device; Subsystem: Secondary cooling system; Component boundary: Valve body and operating mechanism; Population: 1
VCF	(AR) RA6	Component: Valve operated by floating device; Component boundary: Valve body and interiors, operating mechanism; Population: 4
VDA	(BR) BR04	Component: Valve - solenoid operated; System: Instrument air supply system; Type: Needle valve; automatic control; Operating duty: alternating; Component boundary: Valve and Power supply; Population: 2
VDA	(ID) S	Component: Solenoid valve: Beam tube flooding system: Fire damper system: Venting system intermediate radiation zone; Component boundary: Solenoid, Solenoid attachment, Assembly sleeve, Bushing, Hollow screw, Spring plunger, Hollow screw, Seal, Washer, Bushing, Piston, Ring, Spindle, Valve seat, Valve body; Details; Normally open; Manufacturer: Herion-Werke KG, Germany; Operating duty: Operating; Population: 36
VDA01	(AU) HIFAR	Component: Solenoid operated valve; Type: 240 VAC; System: Containment isolation system; Description: Valves are used to flood/drain water seals for containment isolation; Component boundary: Valve body and interiors, Operating mechanism, excludes water supply system for sealing or draining; Population: 12
VDA02	(AU) HIFAR	Component: Solenoid operated valve for drain valves of effluent and lavatory lines; Type: 240 VAC; System: Containment isolation system; Component boundary: Valve body and interior, Operating mechanism; Population: 3
VMA	(AR) RA6	Component: Valve motor operated; Subsystem: Cooling Towers; Component boundary: Valve body and interiors, Operating mechanism; Population: 1
VMA	(AT) TRIGA MARK-II	Component: Motor operated valve; Details: Motor operated valve to close secondary water supply, pipe diameter 8 cm; Population: 1
VMA	(AU) HIFAR	Component: Motor operated valve; System: Secondary cooling; Type: Inlet header valves (all motorized gate valves); Sizes: 25 cm diameter, (6), and 5 cm diameter, (2); Component boundary: Valve body and interiors, and Motor; Population: 8

Text cont. on p. 104

TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
VMA	(BR) BR01	Component: Valve motor operated; System: Reactor cooling system - Primary circuit; Type: Isolation valve - ball (CP-VIS-01/04); gate (CP-VIS-02/03); Component boundary: Valve body and internals, Operating mechanism; Population: 4
VMA	(CN) H	Component: Motor operated valve, 200 cm diameter; Population: 3
VMA	(CN) M	Component: Motor operated valve, 200 cm diameter; Population; 7
VMA	(ID) S	Component: Actuator valve; Type: Motor drive; System: Secondary cooling system, Demineralized water plant, Demineralize water supply, Reactor pool, Purification system, Floor drains active areas, Low active waste water storage, Beam tube flooding system, Venting system intermediate radiation zone, Primary cooling system, Venting system, Low radiation zone, Pool warm layer system, Fuel storage pool purification system, Resin flushing system; Component boundary: Electric motor, Housing, Worm gear shaft, Bearing, Sun wheel, Housing, Pinion shaft, Actuator mounting flange; Manufacturer: AUMA Riester KG., Germany; Operating duty: Operating; Population: 136
VMA	(RO) TRIGA	Component: Motor Operated Valve, Manufacturer: Xorela, Swiss, Type: Gate valve; System: Primary circuit, Details: Valve motor operated, diameter 35 cm, electrical motor operated valve, acting as pump isolation valve. Component boundary: Valve and adjacent mechanical components, Motor, Motor power supply and Overload protection circuitry, Logic and instrumentation, Control equipment, Operating duty: Operating; Population: 4
VMA01	(AR) RA3	Component: Butterfly valve; 25 cm diameter; Subsystem: Primary system; Component boundary: Valve body and internals, Operating mechanism; Population: 4
VMA01	(CA) NRU	Main coolant system isolating electrically-operated gate valves, McAvity, Limitorque motors, 30 cm diameter; Population: 16
VMA01	(VN) DALAT	Component: Motor operated valve; Manufacturer: Russia; Type: IAO1009; Component boundary: Valve, Motor, Power supply, Control equipment, Logic and instrumentation; Operating duty: 1 Operating and 1 Standby; System: Reactor hall ventilation system; Motor details: Type: Asynchronous; 380 VAC; 180 W; Power factor: 0.6, 1,400 rev./min; Population: 2
VMA02	(CA) NRU	Main coolant system isolating electrically-operated gate valves, Jenkins, Limitorque motors, 15 cm diameter; Population: 6
VMA03	(CA) NRU	Main coolant system electrically-operated gate dump valves, McAvity (4) and Powell (2), Limitorque motors, 9 cm diameter; Population: 6
VMT01	(IN) D	Component: Valve motor operated butterfly 15 cm diameter; Population: 2
VMT02	(IN) D	Component: Valve motor operated butterfly 15-40 cm diameter; Population: 8
VRA	(CA) NRU	Pneumatically-actuated loop pressure relief valve, Norriseal Uniflow, Series 8111, stainless steel, right angle body style, 11 MPa, 340°C, 2.5 cm diameter, capacity 2.5 kg/s, spring loaded. Failures to reseat after actuation only. Test interval semi-annual; Population:2

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	(Country) Reactor Code	Specific Information on Component Types
VRA	(ID) S	Component: Air release valve; Type: Dual chamber with spring drive; Component boundary: Outlet, Lantern ring, Air trap, Bushing follower, Pin, cam, Ball, Diaphragm, Guide plate, Inlet; Details: 25-50 cm diameter, 2 bar; Manufacture: Gustav Mankenberg Armaturenfabrik, GmbH, Germany; Operating duty: Operating; Population: 96
VSA	(ID) S	Component: Safety valve; Type: Spring adjusted; System: Compressed air system, Chilled water low radiation zone, Chilled water intermediate radiation zone; Component boundary: Lifting cap, Spindle, Locking nut, Lifting, Axial needle bearing, Spring, Securing ring, Body; Detail/ Specification: Diameter: 20-50 cm; Fluid: Water; Manufacturer: Gustav Mankenberg Armaturenfabrik, GmbH, Germany; Operating duty: Operating; Population: 42
VWB	(AU) HIFAR	Component: Ball valve; System: Pneumatic carrier system radioisotopes; Carrier penetrations are sealed by solenoid actuated pneumatic/spring driven ball valves; Component boundary: Valve body and internals, Operating mechanism i.e. the 4-way solenoid actuated change over valve and the Pneumatic actuator, but excludes water traps and filters; Population: 6
VWG	(IN) D	Component: Gate valve >15 cm diameter, isolation valve; Population: 6
VWG	(CZ)	Component: Gate valve; Population: 20
VWG01	(AR) RA6	Component: Valve gate; System: Primary cooling system; Component boundary: Valve body and internals, Operating mechanism; Population: 2
VWG02	(AR) RA6	Component: Valve gate; System: Secondary cooling system; Component boundary: Valve body and internals, Operating mechanism; Population: 2
VWJ	(ID) S	Component: Plug valve combination with hand wheel; Type: Ball; System: Chilled water low radiation zone; Component boundary: Hand wheel, Gearbox, Spindle, Lockable cam, Details: Diameter 25 and 80 cm; Manufacturer: Tuflin Armaturen Xomox International, GmbH, Germany; Operating duty: Operating; Population: 72
VWN	(ID) S	Component: Thermo expansion valve; Type: Bulb of the gas fluid; System: Compressed air system, Radiation monitoring system, Chilled water intermediate radiation zone; Component boundary: Power assembly, Adjuster, Flange gasket, Spring, Flange, Inlet connection, Outlet connection, Bleed connection, Remote bulb; Manufacturer: Alco Controls Division - Emersion Electric Co. USA; Operating duty: Operating; Population: 36
VWP	(ID) Y	Component: Valve; Type: Diaphragm valve; System: Primary cooling system; Component boundary: Body, Bearing plate, Bonnet, Ball, Spring, Gasket, Gland flange stem; Operating duty: Operating; Population: 3
VWP01	(AR) RA3	Component: Diaphragm valve 7.5 cm diameter; Component boundary: Valve body and internals, Operating mechanism; Population: 1
VWP02	(AR) RA3	Component: Diaphragm valve 5 cm diameter; Component boundary: Valve body and internals, Operating mechanism; Population: 1

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
VWT	(AU) HIFAR	Component: Butterfly valve; System: Containment isolation system; Diameter: 20-30 mm; Component boundary: Valve body and internals, Operating mechanism includes a 4-way solenoid valve that reverses the air supply to the pneumatic actuator. Pressure and position switches are not included; Population: 3
VWT	(BR) BR01	Component: Butterfly valve; System: Air conditioning and ventilation system - compressor cooling system; Manufacturer: VV; Component boundary: Valve body and internals, Operating mechanism; Population: 8
VWT	(ID) S	Component: Butterfly valve; System: Secondary cooling system; Component boundary: Disc position indicator and Stop follower gland, Packing/Seal, Body, Bushing, Securing bolt, Disc, Seat, Retainer, Cap screw; Details: 30-80 cm diameter; Fluid: Water; Manufacturer: Tuflin Armaturen Xomox International, GmbH, Germany; Operating duty: Operating; Population: 150
VXA	(AT) TRIGA MARK-II	Component: Manual valve; Details: Manual valves in primary and secondary coolant, pipe diameter 8 cm; Population: 30
VXA	(CN) H	Component: Manually operated valve, 20 to 40 cm diameter; Population: 76
VXA	(CN) M	Component: Manually operated valve, 20 to 40 cm diameter; Population: 5
VXA01	(AU) HIFAR	Component: Manual valves, Secondary cooling system; Includes valves in the outlet header, inlet side of the cooling towers, isolating valves of the secondary cooling pumps; 30-50 cm diameter; Population: 20
VXA01	(VN) DALAT	Component: Manual valve in reactor primary cooling circuit; Manufacturer: Russia; Type: 14NZ17P28-1; Operating duty: 3 operating, 2 standby; Population: 5
VXA02	(VN) DALAT	Component: Manual valve in reactor secondary cooling circuit; Manufacturer: Russia; Type: 30T6BR, 31T6NZ, 5T14BR; Component boundary: valve; Operating duty: 6 operating, 2 standby; System: Reactor secondary cooling system; Population: 8
VXA03	(AR) RA3	Component: Butterfly valve; Secondary cooling system; Component boundary: Valve body and internals, Operating mechanism; Population: 6
VXA03	(VN) DALAT	Component: Manual valve in reactor purification system; Manufacturer: Russia; Type:14NZ17P28-1; Component boundary: valve; Operating duty: 4 operating, 2 standby; Population: 6
VXA04	(AR) RA3	Component: Cooling tower block valve; Subsystem: Secondary cooling system; Component boundary: Valve body and internals, Operating mechanism; Population: 3
VXA04	(VN) DALAT	Component: Manual valve, Purification system of spent fuel storage Manufacturer: Russia; Type:14NZ17P28-1; Component boundary: Valve; Operating duty: Operating; Population: 2
WSD	(AR) RA3	Component: Shielded door; Population: 1

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
XAA	(IN) C	Component: Fuel element - natural uranium; Population; 190
XAC	(IN) C	Component: Calandria tubes; Population: 190
XAM	(CH)	Component: MTR fuel element, general; Population 60
XCM	(AT) TRIGA MARK-II	Component: Fuel element handling tool, manual; Manufacturer: General Atomic; Population: 1
XCM	(ID) B	Component: Fuel element handling tool, manual; Manufacturer General Atomic; Population: 2
XHA	(VN) DALAT	Component: Fuel element; Manufacturer: Russia; Type: VVR-M; Component boundary: Fuel element; Operating duty: Operating; Population: 100
XHO	(IN) A	Component: Fuel element; Population: 34
XHT01	(AT) TRIGA MARK-II	Component: Fuel element; Manufacturer: General Atomic, Type: TRIGA FLIP fuel element, Details: 70% enrichment, cladding SST, Population: 9
XHT02	(AT) TRIGA MARK-II	Component: Fuel element; Manufacturer: General Atomic, Type: TRIGA standard LEU fuel element, Details: 19.8% enrichment, cladding Al or SST Population; 85
XLT	(ID) Y	Component: Fuel element TRIGA, standard, LEU; Type: General Atomic: 102, 104, 204 Al clad; Details: Enrichment 20%; Manufacturer: GA USA; Population: 147
XMR	(CN) M	Component: 16 rod fuel element assembly; Population: 195
XPA	(CN) H	Component: Fuel element process tube, general; Population: 82
XRT	(VN) DALAT	Component: Reflector; Manufacturer: General Atomic; Type: TRIGA standard; Component boundary: Reflector; Operating duty: Operating; Population: 1
YAC	(IN) D	Component: Emergency filter (HEPA+Charcoal) – ventilation; Population: 2
YDA	(ID) Y	Component: Demineralizer; Type: AT 18 X B 360; System: Primary cooling system; Component boundary: Filter, Basket, Motor, Resin; Operating duty: Operating; Manufacturer: California USA; Population: 1
YEN	(RO) TRIGA	Component: Ejector, Type: NaOH and H_2SO4 ejectors, System: Purification system, Details: 2 ejectors for each NaOH/H_2SO4 tank lines. Operate periodically on filter regeneration periods; Component boundary: Ejector assembly; Operating duty: 1 operating, 1 standby for both NaOH and H_2SO_4 ejectors; Population: 4
YFM	(AR) RA3	Component: Filter, liquid; Demineralization system; Population: 1
YFM	(AR) RA6	Component: Filter liquid; Secondary cooling system; Population: 1

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TABLE II–3.SPECIFIC INFORMATION ON COMPONENT TYPES FOR EACH FACILITY (cont.)

Component Code	**(Country) Reactor Code**	**Specific Information on Component Types**
YFM	(AT) TRIGA MARK-II	Component: Filter liquid; Population: 1
YFM	(ID) B	Component: Filter liquid mechanical restriction; Population: 2
YFM	(ID) S	Component: Oil and water separator; Type: Primary cooling system Tank; Component boundary: Tank, Oil, Oil filter cartridge, O-Ring, Safety valve; Operating duty: Operating; Manufacture: Sebroe Kältetechnik GmbH, Germany; Population: 12
YFM	(ID) Y	Component: Oil and water separator; System: Secondary cooling system; Operating duty: Operating; Population:1
YFX	(BR) BR04	Component: Filter; System: Moderator water purification system; Type: Ion exchange filter; Operating duty: Operating; Component boundary: Filter only; Population:1
YFX	(CH)	Component: Ion exchange filter; Population: 4
YFX	(ID) B	Component: Ion exchange filter; Population: 2
YFX	(ID) S	Component: Ion exchange filter; Population: 10
YFX	(VN) DALAT	Component: Ion exchange, Spent fuel storage purification system; Manufacturer: Russia; Type: I14144; Operating duty: Operating; Population: 1
YSF	(ID) B	Component: Strainer filter; Population: 2
YSF	(VN) DALAT	Component: Mechanical filter; Spent fuel storage purification system; Manufacturer: Russia; Type: I14144; Operating duty: Operating; Population: 2
YTS	(ID) S	Component: Intake screen service water system; Type: Mechanical, Screen mesh 110, Material: Stainless steel; System: Secondary cooling system; Operating duty: Operating; Population: 4

Annex III

COMMON CAUSE FAILURE EXAMPLES

Thirteen examples of common cause failures (CCF) are provided below. While this information is inadequate to perform quantitative CCF analysis, it helps PSA analysts to identify typical situations leading to CCF in their PSA models.

EXAMPLE 1

System/Item function and redundancy: four Excess Flux Trip Channels (EFTC), at least two of which must signal for a reactor trip to occur (2 out of 4).

Event description: a restricted trip of the reactor occurred, due to 2 out of 4 EFTCs signalling a trip.

Failure mode: (of EFTC) spurious trip.

Immediate cause of failure: excessive drift in the reference voltages.

How discovered: during testing of the EFTCs the fault recurred.

Root cause: inadequate testing.

EXAMPLE 2

System/Item function and redundancy: three resistance-temperature detectors (RTDs) in three heat exchangers of the primary cooling system used for monitoring primary coolant temperature.

Event description: discrepancies in the three temperature readings were noted during a test.

Failure mode: (of RTDs) indicating high readings.

Immediate cause of failure: incorrect installation in two of the RTDs resulted in a lag in their response to temperature changes.

How discovered: fault investigation.

Root cause: human error by maintenance staff.

EXAMPLE 3

System/Item function and redundancy: quadruplicated reactor neutronics, amplifiers and amplifier power supplies.

Event description: water sprayed inside cabinet of electronics, potentially disabling neutronic instrumentation and causing electrical short circuit on some amplifiers.

Failure mode: (of instrumentation) failure to function.

Immediate cause of failure: piping weld failure.

How discovered: water seen exiting from bottom of cabinet. Some neutronic channels tripped out.

Root cause: location of a process water line very close to cabinet.

EXAMPLE 4

System function and redundancy: duplicated battery banks for emergency power, in dedicated battery room.

Event description: water entered battery room from outside door due to a water pipe break, with potential for disabling all battery supply. Batteries not affected as located on a raised table support.

Failure mode: (of battery) potentially low or no voltage.

Immediate cause of failure: piping failure.

How discovered: water seen entering battery room through door.

Root cause: battery room not flood proof.

EXAMPLE 5

System function and redundancy: duplicate electrical control transformers for main coolant pumps.

Event description: both control transformers failed, and main pumps became unavailable. Power factor changed in the main power supply line, affecting 2,300 V AC power supply to pump motor, damaging control transformers, which failed to operate with the changed power factor.

Failure mode: (of main coolant pumps) failure to run.

Immediate cause of failure: electrical power factor change.

How discovered: main coolant pumps stopped and reactor tripped.

Root cause: lack of recognition that power factor change could fail pump control transformers, no power factor phase protection for power supply to the pumps.

EXAMPLE 6

System function and redundancy: quadruplicated log rate neutronic instrumentation.

Event description: portable radio walkie-talkie interfered with log rate signals in control room, tripping reactor.

Failure mode: (of log rate signals) fail high.

Immediate cause of failure: use of portable radio in control room.

How discovered: reactor tripped on high log rate signals.

Root cause: inadequate radio frequency interference screening of control room neutronic instrumentation.

EXAMPLE 7

System function and redundancy: duplicated emergency diesel fuel tanks.

Event description: common vent line to outside environment connecting both fuel tanks, presenting possible source of water ingress, and affecting both diesel fuel tanks simultaneously.

Failure mode: (of fuel tanks) potentially contaminated fuel.

Immediate cause of failure: possible water ingress via common vent line.

How discovered: periodic design safety review.

Root cause: no consideration for CCF in design of fuel tanks.

EXAMPLE 8

System function and redundancy: triplicated emergency Class 2 power DC/AC power inverters.

Event description: all three inverters tripped upon loss of offsite power.

Failure mode: failed to provide standby power on demand.

Immediate cause of failure: inadequate operational performance of inverters during a power transient from loss of offsite power.

How discovered: all three inverters tripped, losing Class 2 power, when off site (Class 4) power failed.

Root cause: lack of complete commissioning testing during installation.

EXAMPLE 9

System function and redundancy: Triplicate ion chambers

Event description: All three ion chambers giving false signal due to rise in the shielding water level.

Failure mode: failure to provide a valid ion chamber signal.

Immediate cause of failure: Rise in the shielding water level.

How discovered: unexpected signal change in all three ion chambers during reactor power manoeuvre.

Root cause: inadequate design review of water shielding effect on ion chambers.

EXAMPLE 10

System function and redundancy: eight main coolant pumps.

Event description: cracks found in concrete base supports of all main coolant pumps, which could have led to severe vibration of pumps, if pump mounting to base became weakened.

How discovered: routine operational inspections.

Root cause: ageing effects of concrete base, possibly with a long-term contribution from pump vibration.

EXAMPLE 11

System function and redundancy: main circulating pumps. There are four primary circuit pumps; a single pump allowing 7 MW operation and two pumps allowing 14 MW operation.

Event description: two pumps failed (overheating) within a short period during reactor operation at power.

Failure mode: fail to run.

Immediate cause of failure: motor/pump misalignment.

How discovered: inspection.

Root cause: inadequate operation and maintenance procedures.

EXAMPLE 12

System function and redundancy: pneumatic operated valves in the primary cooling circuit. There are four of these valves one each for each of the primary circuit pumps.

Event description: two pneumatic valves on the primary discharge lines failed to open when required, within a period of 15 minutes.

Failure Mode: fail to open

Immediate Cause of failure: possibly human error in maintenance. The CCF occurred 2 days after performing maintenance work.

How discovered: inspection

Root cause: human error. Coupling factors included same operational staff, same operating procedure, same maintenance/test/calibration schedule and same maintenance procedures and staff.

EXAMPLE 13

System function and redundancy: secondary cooling pumps. There are three secondary cooling pumps. For 0 to 7 MW operation one secondary pump provides adequate cooling. For 7 to 14 MW two secondary pumps are required.

Event description: one pump was running when there was a leak in one of its discharge valves and the pump was shut down. The operator tried to start one of the other pumps and it failed to start. The operator then tried to start the third pump available. That also failed to start.

Failure Mode: fail to start

Immediate Cause of failure: possibly due to hardware fault in the control equipment.

How discovered: failed on demand.

Root cause: internal to control equipment including hardware related causes and internal environmental causes. Coupling factors included same operational staff, same operating procedure, same maintenance/test/calibration schedule and same maintenance procedures and staff.

Annex IV

HUMAN ERROR DATA EXAMPLES

The participants of the CRP contributed the following eleven examples of human error data in research reactor operation and maintenance. These examples may help prospective PSA analysts to identify possible opportunities for human error in their facilities and allow for such events in the PSA models.

EXAMPLE 1

Event description: A maintenance worker accidentally touched a stop button and caused a secondary cooling pump to shut down. The incident occurred when the reactor was in a shutdown state.

Type of human error: An error of commission.

EXAMPLE 2

Event description: During a changeover of a log period neutronic channel a maintenance worker dropped a cable that was being connected. This caused a short circuit and a local power supply failure. The incident occurred when the reactor was in a shutdown state.

Type of human error: An error of commission.

EXAMPLE 3

Event description: During a calibration of differential reactivity worth of coarse control rod arms, at low power operation, an operator caused a trip of the reactor due to a skill-based error in the fine control adjustment.

Type of human error: An error of commission (skill based).

EXAMPLE 4

Event description: During routine cleaning of cooling tower ponds (at shutdown) the water level was allowed to drop below an allowable limit. This created insufficient suction head for shutdown pumps to operate.

Type of human error: Failure to follow procedures.

EXAMPLE 5

Event description: An incorrect temperature setting in a trip amplifier caused a controlled insertion of control arms to reduce reactor power to zero. The error by the operator was caused due to the difficulty of reading the trip settings. A new design of trip amplifiers was installed subsequently.

Type of human error: An error of commission.

EXAMPLE 6

Event description: After completing resin replacement for the ion-exchanger of the primary purification system, a maintenance worker omitted to close a manual valve in the ion-exchanger. The following day a loss of pool water occurred when the primary cooling pump was operated.

Type of human error: Maintenance error.

EXAMPLE 7

Event description: An operator inadvertently closed a manual valve of the primary cooling pump while the pump was operating. This caused a decrease of primary cooling flow and the reactor was scrammed by a low primary coolant flow rate.

Type of human error: A cognitive based operational error.

EXAMPLE 8

Event description: The reactor was operating at 200 kW for a reactor physics experiment. During the operation at this power, the primary cooling pump is to be shut down and the secondary cooling pump is to be kept operating. The primary cooling pump was switched on in error and the reactor scrammed on an overpower signal due to colder water entering the core.

Type of human error: An error of commission (failure to follow procedure).

EXAMPLE 9

Event description: After finishing maintenance work on a motor operated valve used to supply water to the reactor pool, maintenance staff omitted to close a normally closed manual valve in the primary cooling piping. This resulted in the occurrence of a bubble in the reactor pool and the increase of water conductivity while the primary cooling pump was operating the next day.

Type of human error: Maintenance error.

EXAMPLE 10

Event description: The reactor scrammed at 5 kW on fast period scram signal because of loading an irradiation sample having a large reactivity worth in the neutron trap.

Type of human error: Failure to follow procedures.

EXAMPLE 11

Event description: Incorrect calibration of the threshold switch setting of the core outlet temperature recorder occurred when the recorder was replaced by a new one.

Type of human error: Maintenance error.

Annex V

STATISTICAL DATA ANALYSIS

This Annex describes statistical data analysis topics relevant to the derivation of component failure rates applicable to reliability data in the CRP and as used in PSA.

Section V–1 presents definitions of terms related to the reliability and statistical topics involved in the development of the reliability database. Some of these definitions were extracted from Ref. [V–1].

Section V–2 presents the main assumptions adopted in the statistical modelling of component failure events.

Section V–3 provides a discussion of the equations used to calculate the uncertainties associated with the numerical results contained in the database.

Section V–4 presents and gives examples of the statistical procedures used to derive the reliability parameters and associated uncertainties.

V-1. DEFINITIONS

V-1.1. Component Operating Modes

Three different types of component operational modes are defined:

(a) Continuous Operation

A running component is one that operates continually during the period of normal operation of the system and this operating mode is called operating in Table I–3 data. For static components performing their specified function during the entire period of system operation, this operational mode is similarly called operating in Table I–3 data.

(b) Standby Operation

Components operating in the standby mode are normally inactive, but are intermittently called upon to perform some function, in case of a test, or an actual demand. This operational mode is called standby in Table I–3 data.

(c) Alternating (or Intermittent) Operation

In the alternating mode a component may be in either continuous operation or on standby. This happens if two or more components are available to perform a single function and only one is required at any one time to provide the system requirements. Table I–3 data specifies this type of operational mode, where appropriate.

V-1.2. Failure

A failure is defined as the loss of the ability of an item (e.g. component, equipment, sub-system, or system) to perform its required function. A failure is generally a subset of a fault. It represents an irreversible state of an item, so that it must be replaced or repaired to perform its designated function. An item or component failure is always defined in relation to the system in which the item or component is installed.

Failures can be classified as announced (revealed) or unannounced (unrevealed), depending on the detection mode; as primary or secondary failures, according to the induced cause; and as catastrophic, degraded or incipient by degree of damage. These definitions are also discussed in [V–1].

V-1.3. Failure Modes and Failure Mechanisms

Failure modes describe the way in which a component fails, usually from a functional or sub-functional point of view. It becomes necessary to distinguish failure modes when the consequences of a failure depend on the way in which a component fails. For example, a pump may fail to start or fail to stop. The consequences of these two types of failure may be quite different. Some failure modes resemble failure mechanisms. Failure mechanisms describe the actual physical processes leading to a failure. Corrosion, abrasive wear, vibrations, crack and oxidation are typical processes that can play a role in the physics of failure.

Table II–1 of Annex II provides a failure mode listing for components. Detailed definitions of each failure mode and examples are given in [V–1]. Further information on methods for assessing failure rates for various competing failure modes is provided in Ref. [V–2]. Ref. [V–3] provides methods of reliability data collection for offshore drilling and production equipment, which can be also used for reliability data collection for research reactors.

V-1.3.1. Time-Related versus Demand-Related Failures

Failures can be grouped into two broad categories: time-related failures and demand-related failures. A failure revealed at the time instant when the component is called into service from a standby mode is classified as demand-related. Failures occurring while the component is in continuous operation are classified as time-related. Since the same component type may operate continuously or in standby, this component may have both demand-related and time-related failures. In some cases, a root cause analysis of a failure event is performed. This may result in classifying certain failures as time-related even though they are only discovered/revealed when the component is called into service from a standby mode. Often it is difficult to determine if a failure of a standby component has occurred during the standby period, when it may be time related, or has occurred due to the stress of start-up conditions, occurring only at the instant of start-up. A time related failure for a standby component is referred to as a standby failure; see Section V–1.3.2, whereas a failure during continuous operation is a running failure. These two parameters are quite different. To determine the standby failure rate, information on the test interval, or start interval, of the component is required.

V-1.3.2. Time-Related Failures

For the modelling of time-related failures concepts of reliability theory need to be introduced. The statistical models underlying the treatment of time-related failure data are more complex than those for demand-related failures; the latter are presented in Section V–1.3.3.

a) Failure Rate Concept

The failure rate function tells us how likely it is that an item that has survived up to time *t*, will fail during the next unit of time *Δt*. If the item is deteriorating, this likelihood will increase with age. Therefore, the failure rate function will usually be a function of the time, or the age of the item.

To provide a mathematical definition of the failure rate function, it is necessary to present the definition of the time to failure, *T*, of an item, i.e., the time from which the item is put into operation until the first failure occurs. It is generally impossible to predict the exact value of the time to failure of the item, and *T* will therefore be a random variable with some probability distribution. The failure rate function, *λ(t)*, may be now defined as:

$$\lambda(t).\Delta t \ = Pr(t \ < T \ \leq t \ + \frac{\Delta t}{T > t}) \qquad \text{(V-1)}$$

(Note that:/denotes “given that”)

The right-hand side of Equation (V–1) denotes “the probability that the item will fail in the time interval *(t, t + Δt)*, given that the item is still functioning at time *t*”, or in other words: “the probability that an item that has reached age *t* will fail in the next interval *(t, t + Δt)*”. The approximation is sufficiently accurate when *Δt* is the length of a very short time interval. In this case, the failure rate can be defined as:

$$\lambda(t) \ = \frac{f(t)}{1-F(t)} \ t \geq 0 \qquad \text{(V–2)}$$

where:

f(t) is the probability density function of the time to failure of the item, and

F(t) is the probability that the item will fail up to time t (cumulative distribution function).

The failure rate function is sometimes called the hazard rate. The probability that the item will not fail up to time *t*, that is *1 - F(t),* is called the reliability function of the item calculated at time t. This means that:

$$R(t) = 1 - F(t) \qquad \text{(V–3)}$$

and

$$\lambda(t) = \frac{f(t)}{R(t)} \; t \geq 0 \qquad \text{(V–4)}$$

The life of an item/equipment may generally be split into three different phases: the burn-in (or infant mortality) phase, the useful life phase, and the wear-out phase. The failure rate function will usually have different shapes in these three phases. The failure rate function may follow the classic bathtub curve: decreasing in the burn-in phase, essentially constant in the useful life phase, and increasing in the wear-out phase. The bathtub curve is often claimed, with justification, to be a realistic model for mechanical equipment.

b) Further definitions related to the failure rate concept:

(i) The "all modes" failure rate of an item is an aggregate of failure rates summed over relevant failure modes.

(ii) Two types of time-related failure rates can be defined:
- Operating failure rate (or running failure rate): the failure rate for a continuously operated item is the expected number of failures per time unit (failures per hour or per year), while the item is continuously in use, and
- Standby failure rate: the standby failure rate is the expected number of failures per time unit for those items, which are in standby state until tested or required to operate. Data representing standby failure rates are often not available in practice, as the required test data see Section V–1.3.1 is often not available, or is difficult to analyse.

(iii) According to Ref. [V–4], the observed failure rate of an item is estimated via the rate of occurrence of breakdowns, i.e., calculating the number of failures divided by the total time in operation, the observed failure rate represents the rate at which failures befall the item despite its preventive maintenance; the naked failure rate is the rate of failures when no maintenance is performed. Current data processing methodologies do not take into account the distinction between these two concepts and they effectively assume that the rate of occurrence of critical failures is unaffected by the rate of occurrence of preventive maintenance.

V-1.3.3. Demand-Related Failures

Failure on demand is relevant to failures occurring on periodically or cyclically operated items. The failure occurs when the item is required to start, to change state, or to function.

Non-deteriorating components: When components subject to demand do not deteriorate while in standby or dormant state, the statistical analysis of the failure data is quite simple. In this case each demand can be modelled as a flip with a coin. It is assumed that, for each component type, the probabilities of failure on demand are independent and identical. If the probability of failure on demand is denoted as *p*, then the probability of observing n_d failures in *d* demands is given by the binomial distribution:

$$Pr(n_d \, failures \, in \, d \, trials/p) = \frac{d}{n_d} \, p^{n_d}(1-p)^{d-n_d} \; n_d \; = 0{,}1 \ldots\ldots \qquad \text{(V–5)}$$

Deteriorating components: Some failure mechanisms, notably those associated with wear, are disengaged during standby, while others, notably those associated with environmental temperature changes, corrosion, oxidation or embrittlement, continue during standby. Therefore, components on standby are usually subjected to maintenance. For components on standby, the probability of failure on demand is modelled as the unavailability at time *t*; that is, the probability that the component is in a failed state at t. When t is far from the time of component initial operation, it is common to use the steady-state unavailability, which is the limiting time-average unavailability.

According to the approach given in [V–1], the probability of failure on demand or the unavailability, is made up of two components called the "demand unavailability" Q_d and the "standby unavailability" Q_s respectively.

The demand unavailability is given by:

$$Q_d = \frac{n_d}{d} \tag{V–6}$$

where:

n_d is the total number of failures to start, to change state or to function on demand of the item (attributable to the stresses placed by the demands), and

d is the number of demands, changes of state or functions.

If the component is in a standby state and is subject to a "test-and-replace" maintenance regime, it means that the component is tested at a regular interval τ, and if found in a failed state it is replaced immediately by a new component of the same type. If λ_s is the standby failure rate, assumed constant, the probability of failure on demand or standby unavailability for uniformly distributed demands is

$$Q_s = 1 - \frac{1-e^{-\lambda_s\tau}}{\lambda_s\tau} \cong \frac{\lambda_s\tau}{2}\ \lambda_s\tau \ \le 0.1 \tag{V–7}$$

In practice, however, it is rare that standby failure rates $\boldsymbol{\lambda_s}$ are available. The factor of 2 indicates that, on average, the item is likely to be in a failed state equal to half the average demand/test interval. The two unavailability contributions Q_d and Q_s together are combined to provide the total unavailability Q (failures on demand)

$$Q = Qd\ +\ Qs \tag{V–8}$$

$$Q = \frac{n_d}{d} + \frac{\lambda_s\tau}{2} \dots\dots \tag{V–9}$$

of a standby item.

The above treatment recognises that there are two separate failure mechanisms applicable to demand-related failures i.e., a failure mechanism related to the operation on demand and another related to the time in standby mode.

Generic reliability databases usually provide Q the observed probability of failure on demand, which may comprise both components of Q_d and Q_s. The use of Q, the failure on demand parameter from a generic reliability database requires some caution, as the test interval that would have been applicable to the item in the generic database may not necessarily correspond to the test interval applicable to the facility used by the analyst. Ideally, the analyst requires Q_d, λ_s and τ, applicable to the item in the database for an appropriate correction to be applied. If the database does not provide the relevant data, i.e., the standby failure rate λ_s and the test interval τ, (which is usually the case), then there is an uncertainty associated with the use of the data, quoted as failures on demand Q, as it may represent predominantly Q_d or Q_s. Or, it may be that both components are present in some equal measure. This has to be recognised by the user. It is also to be noted that for some PSA applications, for example time dependent analysis, it is necessary to model demand failures in terms of λ_s and τ.

Repairable component: Suppose a component with failure rate λ is allowed to operate until failure and is then taken off line and repaired. This is a 'breakdown maintenance' strategy, sometimes called "run-to-failure'. During repair the component is unavailable and would lead to a failure if demanded during outage. Suppose that the repair process is exponential with repair rate μ. In this case, the probability of failure on demand is calculated as the steady-state unavailability, that is:

$$Q = \frac{\lambda}{\lambda+\mu} \quad \text{(V–10)}$$

Equation (IV–10) remains valid even when the variables are not exponentially distributed, when the rates λ and μ are interpreted as the inverse (the reciprocals) of expected lifetime (mean time to failure) and expected repair time (mean time to repair) of the component, respectively.

From the results presented in the previous topics it is apparent that identical components subject to standby degradation will not yield the same demand probabilities when they are maintained and repaired in different ways. For such components, the user cannot interpret a probability of failure on demand, unless he/she is told the testing interval (when using "test-and-replace" regime) or the repair rate (when using a "run-to-failure" regime). Additional complications arise if a hybrid maintenance policy is pursued; for example, components tested regularly and taken off-line for repairs.

V-2. CONSTANT FAILURE RATE ASSUMPTION

In this section the basic assumption normally used in PSA regarding random equipment failures, i.e. the constant failure rate assumption is briefly discussed [V–3]. Assuming that the failure rate function is constant during the useful life phase of an item, means that the item is not deteriorating during this phase. It also means, in statistical terms, that the time to failure of the item*, T,* is a random variable and is exponentially distributed.

In practice, deterioration will start when, or if, the item enters the wear-out phase. Many of the items covered in the generic database are subject to some maintenance or replacement policy. It is reasonable to assume that these items would have been replaced or refurbished before they reached the wear-out phase.

The so-called burn-in problems (infant mortality) may be caused by problems of quality assurance/control in the manufacture, installation or commissioning. Such quality problems are usually identified and rectified during the initial installation, commissioning and test run periods. Therefore, failure data collected during a burn in period has to be disregarded. This type of data is not to be included in a database, unless it is specifically being quoted for commissioning purposes, and it has to be assumed that data collection is carried out during the useful life phase.

If the main part of the failure events considered in the database come from the useful life phase, then it is reasonable to suppose that the failure rate is approximately constant. Even so, the statistical tests have to be performed during the data collection process, such as a trend analysis, in order to verify the assumption of a constant failure rate function. The use of a trend analysis technique, for instance an exponential-weighted-moving-average (EWMA) may provide quite different values for the current 'mean' failure rate, for data over a given observational period. So, the choice of how failure averaging is performed itself can provide uncertainty. Databases usually use the simple cumulative sum method of failure averaging, equivalent to a constant failure rate, so the user has no possibility of knowing what the effect of some other time-averaging technique would be. The constant failure rate assumption is not necessarily more rigorous than other time-averaging methods, but the user has to be aware that it is, nevertheless, an assumption.

An important underlying assumption of the constant failure rate assumption is that an item is considered to be "as good as new" as long as it is functioning and also after any repair or replacement following a failure. All failures are considered random and independent of the age of the item.

The estimation methods described in Section V–4. are therefore based on the assumption that the failure rate function is constant and independent of time, in which case:

$$f(t) = \lambda e^{-\lambda t} t \geq 0 \quad \text{(V–11)}$$

and

$$\lambda(t) = \lambda(t) \quad \text{(V–12)}$$

V-3. UNCERTAINTIES

The results of a PSA invariably contain uncertainties arising from a variety of different sources [V-5]. Uncertainties regarding data are one of the main issues to be considered during the preparation and application of the reliability data. Such uncertainties concern data for component failures, accident initiating events, common cause failures and failures resulting from human actions. Statistical uncertainties, from the low the frequency of rare initiating events, as well as from data related to human factors are particularly large.

The method to generate uncertainty bounds for the reliability parameters is not standardized in all databases. Most databases however now provide classical statistical confidence intervals for the parameters. In some cases, Bayesian statistical inference is applied and the uncertainty bounds are derived from the posterior distribution of the parameter in question. Some databases provide lower and upper bounds, without providing information on the method of derivation.

In most databases, statistical uncertainty due to the limited sample size is calculated as described in Sections V–4.2 and V–4.4. The 90% confidence range with 5% and 95% confidence limits around the mean value is defined. These involve the use of the chi-square distribution for time-related failures and the use of the F-distribution for demand-related failures.

V-3.1. Error Factor

The error factor represents a quantitative measure of the uncertainty associated with failure rate data. For our application, the error factor is defined as the ratio of the 95th percentile of the parameter probability distribution, λ_{95} or n_{d95}, to the average failure rate λ or the average number of failures in d demands n_d:

$$EF\ (failure\ rate) = \frac{\lambda_{95}}{\lambda} \qquad \text{(V–13)}$$

or

$$EF\ (failure\ on\ demand)\ = \frac{n_{d95}}{n_d} \qquad \text{(V–14)}$$

The error factor as represented above assumes a lognormal distribution for the uncertainty of failure rate data.

It must be noted that the uncertainty of failure rate data used in a PSA (represented by the Error Factor) need not necessarily be the same as that derived from statistical uncertainty (5% and 95% confidence limits) related to the sample size discussed in the previous subsection. This is because the uncertainty of failure rate data used in PSA are not only related to the statistical uncertainty due to the sample size but also due to other factors:

- Data collection errors during the compilation of the generic database;
- Mismatch of generic data with the facility/equipment for which data is required, and
- Mismatch of maintenance, and testing regimes between the equipment in generic database and the equipment in the facility being analysed.

Prudent engineering judgement is required to assign an appropriate level of uncertainty to the generic data used in a PSA, see also Section 2.4.5.

V-4. RELIABILITY PARAMETERS, CLASSICAL STATISTICAL ESTIMATION PROCEDURES

V-4.1. Mean Failure Rate for the Constant (Time-Related) Failure Rate; Homogeneous Sample

The constant failure rate is denoted by λ, and the Mean Time To Failure (MTTF) of an item may be calculated as;

$$MTTF = \frac{1}{\lambda} \dots \dots \qquad \text{(V–15)}$$

When data is available from identical items that have been operating under the same operational and environmental conditions we have a so-called homogeneous sample. The only data then needed to estimate the mean failure rate (sometimes also called the maximum likelihood estimator), λ, from in this case, are the observed number of failures, n, and the total time in service, T.

The mean, or maximum likelihood estimator, of λ is then given by:

$$\hat{\lambda} = \frac{number\ of\ failures}{total\ time\ in\ service} = \frac{n}{T} \qquad \text{(V–16)}$$

The total time in service, T, may be measured either as calendar time or operating time. This calculation is strictly valid only in the following situations:

(a) Failure times for a specified number of items, with the same failure rate λ, are available (all items come from the same population).

(b) Data (several failures) is available for one item over a period, and the failure rate λ is constant during this period.

(c) A combination of the two above situations, i.e., there are several items where each item might have several failures.

V-4.2. Uncertainty Interval for the Constant (Time-Related) Failure Rate; Homogeneous Sample

The uncertainty of the mean failure rate may be presented within a *(1-α). 100%* confidence range. This range defines lower and upper confidence limits (λ_L, λ_U), such that the "true value" of λ satisfies:

$$\Pr\,(\lambda_L \leq \hat{\lambda} < \lambda_U = (1-\alpha)100\% \qquad \text{(V–17)}$$

With n failures during a total time in service T, the *(1 - α). 100%* confidence range then gives lower and upper confidence limits (λ_L, λ_U), [V–1 and V–6], as:

$$\left(\frac{1}{2T}x^2{}_{\frac{\alpha}{2},2n}\,,\ \frac{1}{2T}x^2{}_{\frac{\alpha}{2},(2n+1)}\right) \qquad \text{(V–18)}$$

where $\alpha = 0.10$ for a 90% confidence range and $\chi^2_{0.05,v}$ *and* $\chi^2_{0.95,v}$ denote the 5% and 95% values respectively of the chi-square (χ^2) distribution with v degrees of freedom.

Using the Microsoft Excel function CHIINV (probability fraction, degrees of freedom v) and entering the probability value (0.95 or 0.05) and the number of degrees of freedom v, will provide the 95% or 5% value of the chi-square distribution, respectively. Some examples of chi-square values calculated by the Excel algorithm CHIINV are given in Table V–1.

TABLE V–1 EXAMPLES OF CHI-SQUARE VALUES CHIINV FROM EXCEL

n (# failures)	**CHIINV (0.95, ν)** $\chi^2_{(0..95,\ 2n)}$	**CHIINV (0.05, ν)** $\chi^2_{(0.05,\ 2n+2)}$
1	0.103	9.488
2	0.711	12.592
3	1.635	15.507
4	2.733	18.307
5	3.940	21.026

V-4.3. Mean Value for the Probability of Failure on Demand (Demand-Related Failures); Homogeneous Sample

If data for the number of demands is available, it is possible to estimate the probability of failure on demand. The probability of failure on demand is always related to one specific failure mode, i.e., failure to start.

The mean, or maximum likelihood estimator, of the probability of failure on demand (or demand failure probability) $\hat{p}$ is:

$$\hat{p} = \frac{n_d}{d} \qquad \text{(V–19)}$$

where n_d is the number of failures with the appropriate failure mode, and d is the number of demands.

V-4.4. Uncertainty Interval for the Probability of Failure on Demand

The binomial distribution is the probability distribution used to describe the component demand failures when either of two outcomes, a successful start or a failure-to-start may occur. The binomial probability function describes the probability p of obtaining n_d failures from a sample size (in this case, number of demand starts) of d as:

$$\text{P}(n_d \text{ failures in } d \text{ trials}/p)\ P\left(n_d \frac{failures\ in\ d\ trials}{p}\right) = \binom{d}{n_d} p^{n_d}(1-p)^{d-n_d} =$$

$$\frac{d!}{n_d!(d-n_d)!} p^{n_d}(1-p)^{d-n_d}, \text{ for } n_d=0,\ 1, \ldots,\ d \qquad \text{(V–20)}$$

One method to calculate a confidence interval for $\hat{p}$ involves tabulated percentiles of the F-distribution, [V–1, V–6]. The lower confidence limit P_L for $\hat{p}$ is given by:

$$P_L = \frac{1}{1+\left[{(d-n_d+1)}/{n_d}\right] \cdot F_L({\alpha}/{2}, 2(d-n_d+1),\ 2n_d)} \qquad \text{(V–21)}$$

where F_L is the value of the F-distribution for a fractional range of confidence (α) and degrees of freedom $\nu_1 = 2(d - n_d + 1)$ and $\nu_2 = 2n_d$.

The upper confidence limit P_U for $\hat{p}$ is given by:

$$P_U = \frac{1}{1+\frac{(d-n_d)}{(n_d+1)} \cdot \frac{1}{F_U[{\alpha}/{2}, 2(n_d+1), 2(d-n_d)]}} \qquad \text{(V–22)}$$

where F_U is the value of the F-distribution for degrees of freedom $\nu_1 = 2(n_d+1)$ and $\nu_2=2(d-n_d)$.

Using the Microsoft Excel function FINV (probability fraction of cumulative F-distribution, degrees of freedom ν_1, degrees of freedom ν_2) and entering the probability fraction (0.05) and the number of degrees of freedom ν_1 and ν_2, will provide the 5% value of the F-distribution, required for the 5% and 95% confidence limits (P_L and Pu) given by Equations (V–21) and (V–22). The same examples of the F-distribution values calculated in Table V–1 are calculated by the Excel algorithm FINV and given as reference examples in Table V–2.

TABLE V–2 EXAMPLES OF F-DISTRIBUTION VALUES FINV FROM EXCEL

Probability Value of Cumulative F-distribution (fraction)	Degrees of Freedom (ν_1)	Degrees of Freedom (ν_2)	FINV (0.05, ν_1, ν_2)
0.05	2660	122	1.257
0.05	124	2658	1.224

V-4.5. Estimation of Failure Rate and Probability of Failure on Demand in Case of Zero Observed Failures

In the case of zero failures the mean failure rate $\hat{\lambda}$ and the mean failure per demand probability $\hat{p}$ cannot be found from Equations (V–16.) and (V–19.) respectively.

The statistical approach used for zero failures is given in [V–1, Section 9.1.1 and V–6, p.256]. If there are no failures, then the mean failure rate, $\hat{\lambda}$, or the failure on demand probability, $\hat{p}$, are respectively given by:

$$\hat{\lambda} = \frac{x^2(0.5,2)}{2T} = \frac{0.693}{T} \quad \text{(V–23)}$$

and

$$\hat{p} = \frac{x^2(0.5,2)}{2d} = \frac{0.693}{d} \quad \text{(V–24)}$$

where $\hat{\lambda}$ is the mean failure rate and $\hat{p}$ is the mean probability of failure per demand and $\chi^2(0.5, 2)$ is the chi-square distribution value, 50th percentile with 2 degrees of freedom.
The interpretation of Equations (V–23) and (V–24) is that the 50% zero failure estimate means that the value for $\hat{\lambda}$ or $\hat{p}$ represents the likelihood of zero failures occurring 50% of the time.

V-4.6. Uncertainty Interval for Failure Rate and Probability of Failure on Demand in Case of Zero Observed Failures

For zero failures a lower confidence bound is not usually quoted as the interpretation of a lower bound lacks a firm statistical basis, from Equations (V–18) or (V–21). Only an upper limit is usually quoted which, from Equation (V–18), for the failure rate upper limit is given by:

$$\lambda_U = \frac{1}{2T} x^2{}_{\alpha/2, 2} \quad \text{(V–25)}$$

and, from Equation (IV–22.), for the failure probability per demand upper limit, as:

$$P_U = \frac{1}{1+\frac{d}{F_U[\alpha/2, 2, 2d]}} \quad \text{(V–26)}$$

where $\chi^2_{\alpha/2, 2}$ denotes the *(α/2 x 100)th* percentile of the chi-square (χ^2) distribution with 2 degrees of freedom and F_U is the *(α/2 x 100)th* percentile of the F-distribution for degrees of freedom 2 and 2d.

V-4.7. Estimation of the Error Factor for Failure Rate and Probability of Failure per Demand

Error factors are defined for the failure rates and probabilities of failure on demand respectively as the ratio of the 95th percentile, $\hat{\lambda}_{95\%}$ or $\hat{p}_{95\%}$, to the average failure rate $\hat{\lambda}$ or average probability of failure on demand $\hat{p}$:

$$EF\ (failure\ rate) = \frac{\hat{\lambda}_{95\%}}{\hat{\lambda}} \quad \text{(V–27)}$$

or

$$EF\ (probability\ of\ failure\ on\ demand) = \frac{\hat{p}_{95\%}}{\hat{p}} \quad \text{(V–28)}$$

Section IV–3.1. provides further information on the significance of the error factor.

V-4.8. Estimation of the Mean Time To Repair (MTTR)

The MTTR of a component is calculated as:

$$MTTR = \frac{t_1+t_2+t_3+\cdots t_k}{k} \quad \text{(V–29)}$$

where t_i is the observed repair time of the *i-th* failure and k is the number of failures for which the repair times are recorded. Thus, the repair rate μ can be estimated as:

$$\mu = \frac{1}{MTTR} = \frac{k}{t_1 + t_2 + t_3 + \cdots t_k} \quad \text{(V–30)}$$

V-4.9. Parameter Estimation Using Data from Different Sources

When generic databases are utilized it has to be recognized by the analyst that the data is derived from a number of similar, but not identical, sources. This CRP provides the analyst with data from a variety of different reactor types, (i.e., ‘similar’ types of sources). Of these reactors some of them may be of an ‘identical’ reactor type to that of interest to the analyst.

Even if the reliability data is collected in accordance with strict definitions and rules, and analysed using the same statistical methods, reliability data for similar components, even in nominally identical reactor facilities, may vary due to design changes, operating mode, environmental conditions and maintenance practices, for instance.

If the database is used to provide aggregated data for a component derived from all, or some, of the different reactor facilities then some method of data merging is required as the various data sources will invariably have different failure rate estimates, and varying amounts of data with different confidence intervals.

To merge data from different sources, and estimate the “average” failure rate as the total number of failures divided by the aggregated time in service may not always give a representative result, because the data from the different facilities are not homogenous. The resultant confidence interval found from a simple aggregate in particular may also not be rigorously valid. A detailed description of parameter estimation, using data from different sources, is beyond the scope of this CRP. A comprehensive treatment is however provided in [V–7] and this reference discusses several methods, which also includes Bayesian techniques.

REFERENCES FOR ANNEX V

[V–1] INTERNATIONAL ATOMIC ENERGY AGENCY, Manual on Reliability Data Collection for Research Reactor PSA, IAEA-TECDOC-636, IAEA, Vienna (1992).

[V–2] COOKE, R.M., The Design of Reliability Databases, Part I: Review of Standard Design Concepts, Reliability Engineering and System Safety 51 (1996).

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[V–4] SWEDISH NUCLEAR POWER INSPECTORATE, Review of SKi Data Processing Methodology, SKi Report 95:2, Stockholm (1995).

[V–5] NUCLEAR ENERGY AGENCY, Probabilistic Safety Assessment: An Analytical Tool for Assessing Nuclear Safety, Brief No. 8, January 1992, (www.nea.fr/brief/brief-08.html).

[V–6] KAPUR K.C., LAMBERSON L.R., Reliability in Engineering Design, John Wiley & Sons (1977).

[V–7] US NUCLEAR REGULATORY COMMISSION, Handbook of Parameter Estimation for Probabilistic Risk Assessment. Sandia National Laboratories, NUREG/CR-6823, SAND-2003-3348P, Office of Nuclear Regulatory Research Washington, DC 20555-0001 (2003).

Annex VI

GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA

Table VI–1 lists the various component reliability data parameters collected and the associated definitions of the parameters used in Table VI–2.

Table VI–2 provides the final generic component reliability data for the research reactors of the CRP.

TABLE VI–1. RELIABILITY PARAMETER DEFINITIONS

Code	3-letter component type code from Table I–1 reference listing, sometimes followed by a 2-digit suffix
Component type description	A description of the component type
Reactor Code	The alphanumeric code given in Table V–1, row 1, which identifies the reactor facility for the component type
Component population	The total number of components from which the failure data has been collected for the data record
Cumulative calendar time	The cumulative calendar time of the component population
Cumulative operating time	The cumulative operating time of the component population
Demands	The cumulative number of demands on the component population
Failure Mode	The failure mode code (single alphabetic code) from Table I–2
Failures	The number of failures of the given failure mode, corresponding to the cumulative calendar time, cumulative operating time or the cumulative number of demands
Failure rate	The failure rate per hour (based on calendar or operating time)
Failure probability	Calculated failure probability per demand
90% confidence bounds, (5% and 95% limits)	The 5% and 95% confidence bound limits for either the failure rate or the per-demand failure probability, based on the statistical data analysis described in Annex V

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
AAR	Sensor air (moving air)	AR3	3	2.89E+05	n.a.[a]	n.a.[a]	F	2	6.92E-06	n.a.[a]	1.23E-06	2.18E-05
ACA	Sensor core flux	A	3	2.90E+05	n.a.[a]	n.a.[a]	B	0	2.39E-06	n.a.[a]	-	1.03E-05
ACA	Sensor core flux	DALAT	9	n.a.[a]	2.58E+05	n.a.[a]	B	1	3.88E-06	n.a.[a]	1.99E-07	1.84E-05
ACA	Sensor core flux	DALAT	9	n.a.[a]	2.58E+05	n.a.[a]	F	1	3.88E-06	n.a.[a]	1.99E-07	1.84E-05
ACA	Sensor core flux	DALAT	9	n.a.[a]	2.58E+05	n.a.[a]	X	2	7.76E-06	n.a.[a]	1.38E-06	2.44E-05
ACA01	Sensor core flux	B	2	5.94E+04	n.a.[a]	n.a.[a]	F	10	1.68E-04	n.a.[a]	9.13E-05	2.85E-04
ACA01	Sensor core flux	Y	2	1.88E+05	n.a.[a]	n.a.[a]	–[b]	1	5.31E-06	n.a.[a]	2.72E-07	2.52E-05
ACA02	Sensor core flux	B	2	5.94E+04	n.a.[a]	n.a.[a]	F	10	1.68E-04	n.a.[a]	9.13E-05	2.85E-04
ACA02	Sensor core flux	Y	2	1.88E+05	n.a.[a]	n.a.[a]	–[b]	1	5.31E-06	n.a.[a]	2.72E-07	2.52E-05
ACA01	Sensor core flux	S	9	1.16E+06	n.a.[a]	n.a.[a]	F	4	3.44E-06	n.a.[a]	1.17E-06	7.87E-06
ACA02	Sensor core flux	S	2	2.58E+05	n.a.[a]	n.a.[a]	F	7	2.71E-05	n.a.[a]	1.27E-05	5.09E-05
ACF	Fission chamber	AR6	3	n.a.[a]	5.00E+04	n.a.[a]	F	1	2.00E-05	n.a.[a]	1.03E-06	9.48E-05
ACF	Fission counter	BR01	2	n.a.[a]	1.09E+04	n.a.[a]	F	10	9.21E-04	n.a.[a]	5.00E-04	1.56E-03
ACF	Fission counter	BR01	2	n.a.[a]	1.09E+04	n.a.[a]	B	2	1.84E-04	n.a.[a]	3.27E-05	5.80E-04

Text cont. on p. 129

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
ACF	Fission counter	D	3	4.47E+05	n.a.[a]	n.a.[a]	B	1	2.24E-06	n.a.[a]	1.15E-07	1.06E-05
ACF01	Fission chamber	AR3	2	2.45E+05	n.a.[a]	n.a.[a]	F	5	2.04E-05	n.a.[a]	8.03E-06	4.29E-05
ACF02	Fission chamber	AR3	2	2.45E+05	n.a.[a]	n.a.[a]	F	8	3.26E-05	n.a.[a]	1.62E-05	5.88E-05
ACI	Sensor core flux	TRIGA MARK-II	3	2.97E+05	n.a.[a]	n.a.[a]	F	2	6.73E-06	n.a.[a]	1.20E-06	2.12E-05
ACI	Ionization chamber	AR6	3	n.a.[a]	8.76E+04	n.a.[a]	B	4	4.57E-05	n.a.[a]	1.56E-05	1.04E-04
ACI	Ionization chamber	NRU	8	2.23E+06	n.a.[a]	n.a.[a]	F	0	3.11E-07	n.a.[a]	–[b]	1.34E-06
ACI	Ionization chamber	CZ	12	n.a.[a]	7.6E+04	n.a.[a]	C	4	5.29E-06	n.a.[a]		
ACI	Ionization chamber	D	9	1.34E+06	n.a.[a]	n.a.[a]	B	6	4.48E-06	n.a.[a]	1.95E-06	8.84E-06
ACI01	Compensated ionisation chamber	AR3	3	3.68E+05	n.a.[a]	n.a.[a]	F	6	1.63E-05	n.a.[a]	7.10E-06	3.22E-05
ACI02	Compensated ionisation chamber	AR3	1	1.23E+05	n.a.[a]	n.a.[a]	F	1	8.15E-06	n.a.[a]	4.18E-07	3.87E-05
ACS	Self-powered detector	CH	3	4.17E+04	n.a.[a]	n.a.[a]	X	2	4.80E-05	n.a.[a]	8.52E-06	1.51E-04
AFA	Sensor flow (flow meter)	AR3	1	1.23E+05	n.a.[a]	n.a.[a]	F	5	4.08E-05	n.a.[a]	1.61E-05	8.57E-05
AFA	DP cell flow	NRU	3	1.54E+06	n.a.[a]	n.a.[a]	F	5	3.25E-06	n.a.[a]	1.28E-06	6.83E-06
AFA	Sensor flow	Y	2	1.88E+05	n.a.[a]	n.a.[a]	F	10	5.31E-05	n.a.[a]	2.88E-05	9.01E-05

Text cont. on p. 130

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
AFA01	Sensor flow	S	60	7.75E+06	n.a.[a]	n.a.[a]	F	9	1.16E-06	n.a.[a]	6.05E-07	2.03E-06
AFA01	Sensor flow	S	60	7.75E+06	n.a.[a]	n.a.[a]	R	1	1.29E-07	n.a.[a]	6.61E-09	6.12E-07
AFA01	Sensor flow	S	60	7.75E+06	n.a.[a]	n.a.[a]	S	1	1.29E-07	n.a.[a]	6.61E-09	6.12E-07
AFA01	Sensor flow	S	60	7.75E+06	n.a.[a]	n.a.[a]	Y	1	1.29E-07	n.a.[a]	6.61E-09	6.12E-07
AFA01	Sensor flow	DALAT	1	n.a.[a]	4.40E+04	n.a.[a]	F	0	1.58E-05	n.a.[a]	-	6.81E-05
AFA02	Sensor flow	S	10	1.29E+06	n.a.[a]	n.a.[a]	F	5	3.87E-06	n.a.[a]	1.52E-06	8.13E-06
AFA02	Sensor flow	S	10	1.29E+06	n.a.[a]	n.a.[a]	O	1	7.74E-07	n.a.[a]	3.97E-08	3.67E-06
AFA02	Sensor flow	DALAT	1	n.a.[a]	4.33E+04	n.a.[a]	F	2	4.62E-05	n.a.[a]	8.22E-06	1.46E-04
ALA	Sensor level	AR6	4	n.a.[a]	3.50E+05	n.a.[a]	F	40	1.14E-04	n.a.[a]	8.62E-05	1.49E-04
ALA	DP cell level	NRU	3	5.51E+05	n.a.[a]	n.a.[a]	F	14	2.54E-05	n.a.[a]	1.54E-05	3.97E-05
ALA	Sensor level	CH	12	1.67E+05	n.a.[a]	n.a.[a]	B	1	6.00E-06	n.a.[a]	3.08E-07	2.84E-05
ALA	Sensor level	CH	12	1.67E+05	n.a.[a]	n.a.[a]	K	7	4.20E-05	n.a.[a]	1.97E-05	7.88E-05
ALA	Sensor level	CH	12	1.67E+05	n.a.[a]	n.a.[a]	X	1	6.00E-06	n.a.[a]	3.08E-07	2.84E-05
ALA	Sensor level	B	1	2.97E+04	n.a.[a]	n.a.[a]	F	1	3.37E-05	n.a.[a]	1.73E-06	1.60E-04
ALA	Sensor level	S	31	4.01E+06	n.a.[a]	n.a.[a]	E	2	4.99E-07	n.a.[a]	8.87E-08	1.57E-06
ALA	Sensor level	S	31	4.01E+06	n.a.[a]	n.a.[a]	F	33	8.24E-06	n.a.[a]	6.03E-06	1.10E-05
ALA	Sensor level	S	31	4.01E+06	n.a.[a]	n.a.[a]	O	1	2.50E-07	n.a.[a]	1.28E-08	1.18E-06

Text cont. on p. 131

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
ALA	Sensor level	S	31	4.01E+06	n.a.[a]	n.a.[a]	Y	2	4.99E-07	n.a.[a]	8.87E-08	1.57E-06
ALA	Sensor level	Y	2	1.88E+05	n.a.[a]	n.a.[a]	–[b]	0	3.68E-06	n.a.[a]	-	1.59E-05
ALR	Sensor pool water level	BR01	1	4.38E+04	n.a.[a]	n.a.[a]	K	4	9.13E-05	n.a.[a]	3.12E-05	2.09E-04
ALR	Sensor pool water level	DALAT	1	n.a.[a]	5.41E+04	n.a.[a]	F	0	1.28E-05	n.a.[a]	-	5.54E-05
APA	Pressure switch	NRU	3	1.54E+06	n.a.[a]	n.a.[a]	F	2	1.30E-06	n.a.[a]	2.31E-07	4.09E-06
APA	Sensor pressure	S	42	5.43E+06	n.a.[a]	n.a.[a]	F	16	2.95E-06	n.a.[a]	1.85E-06	4.48E-06
APA	Sensor pressure	S	42	5.43E+06	n.a.[a]	n.a.[a]	Y	3	5.53E-07	n.a.[a]	1.51E-07	1.43E-06
APD	Sensor pressure difference	S	29	3.75E+06	n.a.[a]	n.a.[a]	C	1	2.67E-07	n.a.[a]	1.37E-08	1.27E-06
AQC	Sensor conductivity	AR6	5	8.76E+05	n.a.[a]	n.a.[a]	F	7	7.99E-06	n.a.[a]	3.75E-06	1.50E-05
AQC	Sensor conductivity	BR04	5	n.a.[a]	1.91E+04	n.a.[a]	F	2	1.05E-04	n.a.[a]	1.86E-05	3.30E-04
AQC	Sensor conductivity	DALAT	2	n.a.[a]	1.08E+05	n.a.[a]	F	1	9.25E-06	n.a.[a]	4.74E-07	4.39E-05
AQC01	Sensor conductivity	S	29	3.75E+06	n.a.[a]	n.a.[a]	F	10	2.67E-06	n.a.[a]	1.45E-06	4.53E-06
AQC02	Sensor conductivity	S	2	2.58E+05	n.a.[a]	n.a.[a]	F	10	3.87E-05	n.a.[a]	2.10E-05	6.56E-05
AQP	Sensor pH-vale	S	2	2.58E+05	n.a.[a]	n.a.[a]	–[b]	0	2.68E-06	n.a.[a]	–[b]	1.16E-05
AQP	Sensor pH-value	TRIGA	1	1.75E+05	n.a.[a]	n.a.[a]	F	3	1.71E-05	n.a.[a]	4.67E-06	4.43E-05

Text cont. on p. 132

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
ARA	Aerosol monitor	AR3	1	5.26E+04	n.a.[a]	n.a.[a]	F	4	7.61E-05	n.a.[a]	2.60E-05	1.74E-04
ARA	Aerosol monitor	TRIGA MARK-II	1	9.90E+04	n.a.[a]	n.a.[a]	F	2	2.02E-05	n.a.[a]	3.59E-06	6.36E-05
ARA	Aerosol monitor	CH	1	1.39E+04	n.a.[a]	n.a.[a]	F	1	7.20E-05	n.a.[a]	3.69E-06	3.41E-04
ARA	Aerosol monitor	CH	1	1.39E+04	n.a.[a]	n.a.[a]	R	20	1.44E-03	n.a.[a]	9.54E-04	2.09E-03
ARA	Aerosol monitor	S	8	1.03E+06	n.a.[a]	n.a.[a]	F	1	9.67E-07	n.a.[a]	4.96E-08	4.59E-06
ARA	Aerosol monitor	S	8	1.03E+06	n.a.[a]	n.a.[a]	F	35	3.39E-05	n.a.[a]	2.50E-05	4.49E-05
ARA	Aerosol monitor	S	8	1.03E+06	n.a.[a]	n.a.[a]	R	4	3.87E-06	n.a.[a]	1.32E-06	8.85E-06
ARA	Aerosol monitor	S	8	1.03E+06	n.a.[a]	n.a.[a]	X	1	9.67E-07	n.a.[a]	4.96E-08	4.59E-06
ARA	Aerosol monitor	S	8	1.03E+06	n.a.[a]	n.a.[a]	S	1	9.67E-07	n.a.[a]	4.96E-08	4.59E-06
ARA	Aerosol monitor	SI	1	4.35E+04	n.a.[a]	n.a.[a]	F	2	4.60E-05	n.a.[a]	8.17E-06	1.45E-04
ARA	Aerosol monitor	SI	1	4.35E+04	n.a.[a]	n.a.[a]	K	1	2.30E-05	n.a.[a]	1.18E-06	1.09E-04
ARA01	Aerosol monitor	TRIGA	7	1.75E+05	n.a.[a]	n.a.[a]	F	4	2.29E-05	n.a.[a]	7.81E-06	5.23E-05
ARA01	Aerosol monitor	TRIGA	7	1.75E+05	n.a.[a]	n.a.[a]	K	2	1.14E-05	n.a.[a]	2.03E-06	3.60E-05
ARA02	FHT aerosol monitor	TRIGA	1	1.23E+06	n.a.[a]	n.a.[a]	F	11	8.97E-06	n.a.[a]	5.03E-06	1.49E-05
ARA02	FHT aerosol monitor	TRIGA	1	1.23E+06	n.a.[a]	n.a.[a]	K	7	5.71E-06	n.a.[a]	2.68E-06	1.07E-05
ARG	Gamma monitor	TRIGA MARK-II	12	1.19E+06	n.a.[a]	n.a.[a]	F	2	1.68E-06	n.a.[a]	2.99E-07	5.29E-06

Text cont. on p. 133

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
ARG	Gamma monitor	HIFAR	17	1.97E+06	n.a.[a]	n.a.[a]	B	11	5.59E-06	n.a.[a]	3.14E-06	9.25E-06
ARG	Gamma monitor	HIFAR	17	1.97E+06	n.a.[a]	n.a.[a]	F	8	4.07E-06	n.a.[a]	2.02E-06	7.34E-06
ARG	Gamma monitor	HIFAR	17	1.97E+06	n.a.[a]	n.a.[a]	K	14	7.11E-06	n.a.[a]	4.30E-06	1.11E-05
ARG	Gamma monitor	CH	12	1.67E+05	n.a.[a]	n.a.[a]	X	5	3.00E-05	n.a.[a]	1.18E-05	6.30E-05
ARG	Gamma monitor	CH	12	1.67E+05	n.a.[a]	n.a.[a]	K	61	3.66E-04	n.a.[a]	2.92E-04	4.53E-04
ARG	Gamma monitor	CH	12	1.67E+05	n.a.[a]	n.a.[a]	B	3	1.80E-05	n.a.[a]	4.90E-06	4.65E-05
ARG	Gamma monitor	CH	12	1.67E+05	n.a.[a]	n.a.[a]	F	1	6.00E-06	n.a.[a]	3.08E-07	2.84E-05
ARG	Gamma monitor	S	15	1.94E+06	n.a.[a]	n.a.[a]	F	6	3.10E-06	n.a.[a]	1.35E-06	6.11E-06
ARG	Gamma monitor	S	15	1.94E+06	n.a.[a]	n.a.[a]	X	1	5.16E-07	n.a.[a]	2.65E-08	2.45E-06
ARG	Gamma monitor	Y	6	5.65E+05	n.a.[a]	n.a.[a]	F	1	1.77E-06	n.a.[a]	9.08E-08	8.40E-06
ARG	Gamma monitor-ventilation	D	2	2.98E+05	n.a.[a]	n.a.[a]	F	5	1.68E-05	n.a.[a]	6.61E-06	3.53E-05
ARG01	Gamma monitor	NRU	1	3.50E+04	n.a.[a]	n.a.[a]	F	4	1.14E-04	n.a.[a]	3.90E-05	2.62E-04
ARG01	Gamma monitor	TRIGA	10	1.75E+06	n.a.[a]	n.a.[a]	F	7	4.00E-06	n.a.[a]	1.88E-06	7.51E-06
ARG01	Gamma monitor	TRIGA	10	1.75E+06	n.a.[a]	n.a.[a]	K	1	5.71E-07	n.a.[a]	2.93E-08	2.71E-06
ARG02	Gamma monitor, type ACTINIA	TRIGA	2	3.50E+05	n.a.[a]	n.a.[a]	F	2	5.71E-06	n.a.[a]	1.02E-06	1.80E-05

Text cont. on p. 134

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
ARG02	Gamma monitor	NRU	3	2.60E+04	n.a.[a]	n.a.[a]	F	0	2.67E-05	n.a.[a]	–[b]	1.15E-04
ARI	Iodine monitor	TRIGA	1	1.75E+05	n.a.[a]	n.a.[a]	K	3	1.71E-05	n.a.[a]	4.67E-06	4.43E-05
ARN	Neutron monitor	S	3	3.88E+05	n.a.[a]	n.a.[a]	F	1	2.58E-06	n.a.[a]	1.32E-07	1.22E-05
ARN	Neutron monitor	Y	1	9.42E+04	n.a.[a]	n.a.[a]	–[b]	0	7.36E-06	n.a.[a]	–[b]	3.18E-05
ARO	Off-gas monitor	S	3	3.88E+05	n.a.[a]	n.a.[a]	–[b]	0	1.79E-06	n.a.[a]	–[b]	7.73E-06
ARO	Off-gas monitor	Y	2	1.88E+05	n.a.[a]	n.a.[a]	–[b]	0	3.68E-06	n.a.[a]	–[b]	1.59E-05
ARO	Gas monitor	TRIGA	6	1.05E+06	n.a.[a]	n.a.[a]	F	21	2.00E-05	n.a.[a]	1.34E-05	2.88E-05
ARO	Gas monitor	TRIGA	6	1.05E+06	n.a.[a]	n.a.[a]	K	3	2.85E-06	n.a.[a]	7.78E-07	7.38E-06
ARU	Area monitor	AR3	1	1.23E+05	n.a.[a]	n.a.[a]	K	10	8.15E-05	n.a.[a]	4.42E-05	1.38E-04
ARU	Area monitor	AR3	1	1.23E+05	n.a.[a]	n.a.[a]	F	12	9.78E-05	n.a.[a]	5.65E-05	1.59E-04
ARU	Area monitor	AR6	22	n.a.[a]	8.76E+04	n.a.[a]	F	24	2.74E-04	n.a.[a]	1.89E-04	3.85E-04
ARU	Radiation monitoring alarm unit	BR04	4	n.a.[a]	5.11E+04	n.a.[a]	F	2	3.91E-05	n.a.[a]	6.95E-06	1.23E-04
ARU	Radiation monitoring alarm unit	S	14	1.81E+06	n.a.[a]	n.a.[a]	–[b]	0	3.83E-07	n.a.[a]	–[b]	1.66E-06

Text cont. on p. 135

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
ARU	Radiation monitoring alarm unit	Y	1	9.42E+04	n.a.[a]	n.a.[a]	–[b]	0	7.36E-06	n.a.[a]	–[b]	3.18E-05
ARU01	Radiation monitoring alarm unit-duct monitor	BR01	4	1.75E+05	n.a.[a]	n.a.[a]	F	11	6.28E-05	n.a.[a]	3.52E-05	1.04E-04
ARU02	Radiation monitoring alarm unit-area monitor	BR01	9	3.94E+05	n.a.[a]	n.a.[a]	K	1	2.54E-06	n.a.[a]	1.30E-07	1.20E-05
ARU02	Radiation monitoring alarm unit-area monitor	BR01	9	3.94E+05	n.a.[a]	n.a.[a]	F	2	5.07E-06	n.a.[a]	9.01E-07	1.60E-05
ARW	Water monitor	TRIGA	1	1.75E+05	n.a.[a]	n.a.[a]	F	1	5.71E-06	n.a.[a]	2.93E-07	2.71E-05
ARW	Water monitor	TRIGA	1	1.75E+05	n.a.[a]	n.a.[a]	K	2	1.14E-05	n.a.[a]	2.03E-06	3.60E-05
ASA	Sensor speed	S	6	7.75E+05	n.a.[a]	n.a.[a]	F	1	1.29E-06	n.a.[a]	6.61E-08	6.12E-06
ASA	Sensor speed	S	6	7.75E+05	n.a.[a]	n.a.[a]	R	2	2.58E-06	n.a.[a]	4.58E-07	8.12E-06
ASA	Sensor speed	Y	1	9.42E+04	n.a.[a]	n.a.[a]	–[b]	0	7.36E-06	n.a.[a]	–[b]	3.18E-05
ATA	Sensor temperature	AR6	10	n.a.[a]	1.67E+05	n.a.[a]	F	0	4.16E-06	n.a.[a]	–[b]	1.80E-05
ATA	Sensor temperature	TRIGA MARK-II	1	3.13E+04	n.a.[a]	n.a.[a]	I	1	3.19E-05	n.a.[a]	1.64E-06	1.51E-04
ATA	Sensor temperature	BR01	24	n.a.[a]	2.51E+05	n.a.[a]	F	5	1.99E-05	n.a.[a]	7.86E-06	4.19E-05

Text cont. on p. 136

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
ATA	Temperature resistance current transducer	NRU	8	2.10E+06	n.a.[a]	n.a.[a]	F	7	3.33E-06	n.a.[a]	1.56E-06	6.26E-06
ATA	Sensor temperature	B	3	8.91E+04	n.a.[a]	n.a.[a]	F	1	1.12E-05	n.a.[a]	5.75E-07	5.32E-05
ATA	Sensor temperature	S	12	1.55E+06	n.a.[a]	n.a.[a]	F	14	9.03E-06	n.a.[a]	5.46E-06	1.41E-05
ATA	Sensor temperature	Y	4	3.77E+05	n.a.[a]	n.a.[a]	–[b]	0	1.84E-06	n.a.[a]	-	7.95E-06
ATA	Sensor-temperature	D	130	1.90E+07	n.a.[a]	n.a.[a]	F	1	5.26E-08	n.a.[a]	2.70E-09	2.50E-07
ATA	Sensor temperature	SI	1	n.a.[a]	2.00E+04	n.a.[a]	K	1	5.00E-05	n.a.[a]	2.56E-06	2.37E-04
ATA	Sensor temperature	DALAT	9	n.a.[a]	3.85E+05	n.a.[a]	F	1	2.59E-06	n.a.[a]	1.33E-07	1.23E-05
BCA	Battery charger	S	6	7.75E+05	n.a.[a]	n.a.[a]	F	1	1.29E-06	n.a.[a]	6.61E-08	6.12E-06
CA	Battery charger	S	6	7.75E+05	n.a.[a]	n.a.[a]	R	1	1.29E-06	n.a.[a]	6.61E-08	6.12E-06
BCA	Battery charger	Y	1	9.42E+04	n.a.[a]	n.a.[a]	–[b]	0	7.36E-06	n.a.[a]	–[b]	3.18E-05
BCS	Battery charger	S	6	7.75E+05	n.a.[a]	n.a.[a]	–[b]	0	8.94E-07	n.a.[a]	–[b]	3.86E-06
BCS	Battery charger	Y	1	9.42E+04	n.a.[a]	n.a.[a]	–[b]	0	7.36E-06	n.a.[a]	–[b]	3.18E-05
BTA	Battery	TRIGA MARK-II	1	2.74E+04	n.a.[a]	n.a.[a]	F	1	3.65E-05	n.a.[a]	1.87E-06	1.73E-04
BTA	Battery	S	402	5.20E+07	n.a.[a]	n.a.[a]	F	2	3.85E-08	n.a.[a]	6.84E-09	1.21E-07

Text cont. on p. 137

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
BTA	Battery	CZ	4	2.5E+04	n.a.[a]	n.a.[a]	–[b]	–[b]	2.75E-05	n.a.[a]	–[b]	–[b]
BTA	Battery	S	402	5.20E+07	n.a.[a]	n.a.[a]	R	2	3.85E-08	n.a.[a]	6.84E-09	1.21E-07
BTA	Battery	S	402	5.20E+07	n.a.[a]	n.a.[a]	S	1	1.92E-08	n.a.[a]	9.87E-10	9.13E-08
BTA	Battery	Y	4	3.77E+05	n.a.[a]	n.a.[a]	–[b]	0	1.84E-06	n.a.[a]	-	7.95E-06
BTL	DC battery 130 Vdc (failure to maintain 80% capacity for 2-hour test)	NRU	2 x 60 cells	1.40E+05	n.a.[a]	n.a.[a]	B/R	3	2.14E-05	n.a.[a]	5.83E-06	5.53E-05
BTL	DC battery 130 Vdc (demand failure to supply 80% capacity for 2-hour test)	NRU	2 x 60 cells	n.a.[a]	n.a.[a]	8	B	0	n.a.[a]	8.66E-02	–[b]	3.12E-01
BTL	Battery lead acid accumulator	M	1	7.31E+04	n.a.[a]	n.a.[a]	F	4	5.47E-05	n.a.[a]	1.87E-05	1.25E-04
BTL	Battery lead acid accumulator	S	22	2.84E+06	n.a.[a]	n.a.[a]	–[b]	0	2.44E-07	n.a.[a]	–[b]	1.05E-06
BTL	Battery lead acid accumulator	Y	2	1.88E+05	n.a.[a]	n.a.[a]	–[b]	0	3.68E-06	n.a.[a]	–[b]	1.59E-05
BTL	Battery-diesel engine start	BR04	2	n.a.[a]	1.42E+02	n.a.[a]	F	1	7.04E-03	n.a.[a]	3.61E-04	3.34E-02
BTV01	Battery bank 240 VDC	D	2	3.00E+05	n.a.[a]	n.a.[a]	F	2	6.67E-06	n.a.[a]	1.18E-06	2.10E-05

Text cont. on p. 138

[a] n.a.: not applicable

[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
BTV02	Battery bank 48 VDC	D	2	3.00E+05	n.a.[a]	n.a.[a]	F	0	2.31E-06	n.a.[a]	–[b]	9.99E-06
CB2	Bus 120 Vac, 220 Vac sing. Phase	CH	1	1.39E+04	n.a.[a]	n.a.[a]	I	1	7.20E-05	n.a.[a]	3.69E-06	3.41E-04
CB3	Bus 220Vac, 380 Vac three phase	DALAT	3	n.a.[a]	4.97E+05	n.a.[a]	F	0	1.40E-06	n.a.[a]	n.a.[a]	6.03E-06
CB4	Bus conductor 3 phase 415 V	C	1	1.75E+05	n.a.[a]	n.a.[a]	–[b]	0	3.96E-06	n.a.[a]	n.a.[a]	1.71E-05
CB4	Bus conductor 3 phase 415 V	D	10	1.75E+06	n.a.[a]	n.a.[a]	F	1	5.71E-07	n.a.[a]	2.93E-08	2.71E-06
CBA	600 Vac power distribution bus	NRU	1	3.00E+05	n.a.[a]	n.a.[a]	F	0	2.31E-06	n.a.[a]	n.a.[a]	9.99E-06
CBD	Bus -240 VDC	D	4	7.00E+05	n.a.[a]	n.a.[a]	F	1	1.43E-06	n.a.[a]	7.33E-08	6.78E-06
CBD	Bus DC	DALAT	2	n.a.[a]	2.91E+04	n.a.[a]	F	0	2.38E-05	n.a.[a]	n.a.[a]	1.03E-04
CBH	Bus-3.3 kv	D	3	4.47E+05	n.a.[a]	n.a.[a]	F	1	2.24E-06	n.a.[a]	1.15E-07	1.06E-05
CBI	Bus-22 kv	D	2	3.50E+05	n.a.[a]	n.a.[a]	F	1	2.85E-06	n.a.[a]	1.46E-07	1.35E-05
CCP	Cable power connection	DALAT	10	n.a.[a]	1.66E+06	n.a.[a]	G	1	6.04E-07	n.a.[a]	3.10E-08	2.86E-06
CCS	Signal cable (~3,000 m length)	D	n.a.[a]	n.a.[a]	1.05E+05	n.a.[a]	F	1	9.52E-06	n.a.[a]	4.89E-07	4.52E-05

Text cont. on p. 139

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
CCS	Conductor-alarm cable signal (supervisory)	BR04	16	n.a.[a]	2.04E+05	n.a.[a]	X	1	4.89E-06	n.a.[a]	2.51E-07	2.32E-05
DGA	Diesel generator	HIFAR	2	n.a.[a]	2.84E+03	n.a.[a]	B	128	4.51E-02	n.a.[a]	3.87E-02	5.22E-02
DGA	Diesel generator	HIFAR	2	n.a.[a]	2.84E+03	n.a.[a]	F	3	1.06E-03	n.a.[a]	2.88E-04	2.73E-03
DGA	Diesel generator	HIFAR	2	n.a.[a]	2.84E+03	n.a.[a]	R	5	1.76E-03	n.a.[a]	6.94E-04	3.70E-03
DGA	Diesel generator	HIFAR	2	n.a.[a]	2.84E+03	n.a.[a]	Y	3	1.06E-03	n.a.[a]	2.88E-04	2.73E-03
DGA	Diesel generator	HIFAR	2	n.a.[a]	n.a.[a]	1.45E+03	S	11	-	7.60E-03	4.27E-03	1.25E-02
DGA	Diesel generator-emergency AC	BR04	1	n.a.[a]	7.10E+01	n.a.[a]	F	1	1.41E-02	n.a.[a]	7.22E-04	6.68E-02
DGA	Diesel generator-emergency AC	BR04	1	n.a.[a]	7.10E+01	n.a.[a]	R	2	2.82E-02	n.a.[a]	5.01E-03	8.87E-02
DGA	Diesel generator-emergency AC	BR04	1	n.a.[a]	n.a.[a]	71	S	3	n.a.[a]	4.23E-02	1.16E-02	1.06E-01
DGA	Diesel generator-emergency AC	CZ	1	n.a.[a]	6 E+03	n.a.[a]	–[b]	–[b]	1.1 E-04	–[b]	–[b]	–[b]
DGA	Diesel generator emergency AC	B	1	–[b]	–[b]	–[b]	–[b]	–[b]	–[b]	–[b]	–[b]	–[b]
DGA	Diesel generator emergency AC	S	3	n.a.[a]	3.90E+03	n.a.[a]	F	6	1.54E-03	n.a.[a]	6.70E-04	3.04E-03

Text cont. on p. 140

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
DGA02	Diesel generator 250 kva	NRU	1	n.a.[a]	6.83E+02	n.a.a	R	5	7.32E-03	n.a.a	2.88E-03	1.54E-02
DGA03	Diesel generator-emergency AC	BR01	1	n.a.[a]	6.33E+02	n.a.[a]	R	5	7.89E-03	n.a.[a]	3.11E-03	1.66E-02
DGA04	Diesel generator-emergency AC	BR01	1	n.a.[a]	1.06E+01	n.a.[a]	R	1	9.42E-02	n.a.[a]	4.83E-03	4.47E-01
EBA	Switchgear panel	CZ	12	n.a.[a]	7.6E+04	n.a.[a]	I	2	2.65E-05	n.a.[a]	–[b]	–[b]
EBA	Switchgear panel	B	4	1.19E+05	n.a.[a]	n.a.[a]	F	1	8.41E-06	n.a.[a]	4.32E-07	3.99E-05
EBA	Switchgear panel	S	2340	3.02E+08	n.a.[a]	n.a.[a]	F	8	2.65E-08	n.a.[a]	1.32E-08	4.77E-08
EBA	Switchgear panel	S	2340	3.02E+08	n.a.[a]	n.a.[a]	G	1	3.31E-09	n.a.[a]	1.70E-10	1.57E-08
EBA	Switchgear panel	S	2340	3.02E+08	n.a.[a]	n.a.[a]	T	2	6.61E-09	n.a.[a]	1.18E-09	2.08E-08
EBA	Switchgear panel	Y	4	3.77E+05	n.a.[a]	n.a.[a]	R	4	1.06E-05	n.a.[a]	3.63E-06	2.43E-05
EBA	Switchgear panel	Y	4	3.77E+05	n.a.[a]	n.a.[a]	L	1	2.65E-06	n.a.[a]	1.36E-07	1.26E-05
EBM01	Panel board-motor control centre	BR01	1	n.a.[a]	1.03E+04	n.a.[a]	F	5	4.86E-04	n.a.[a]	1.92E-04	1.02E-03
EBM01	Panel board-motor control centre	BR01	1	n.a.[a]	1.03E+04	n.a.[a]	K	3	2.92E-04	n.a.[a]	7.95E-05	7.54E-04

Text cont. on p. 141

[a] n.a.: not applicable

[a] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
EBM02	Panel board-motor control centre	BR01	1	4.38E+04	n.a.[a]	n.a.[a]	F	1	2.28E-05	n.a.[a]	1.17E-06	1.08E-04
EBM03	Panel board-motor control centre	BR01	2	2.19E+04	n.a.[a]	n.a.[a]	F	1	4.57E-05	n.a.[a]	2.34E-06	2.17E-04
EBS	Panel board-reactor cooling system	BR01	1	n.a.[a]	1.03E+04	n.a.[a]	F	1	9.72E-05	n.a.[a]	4.99E-06	4.61E-04
EEL	Lamp 1500W-2000W (pool reflectors)	AR3	5	3.07E+05	n.a.[a]	n.a.[a]	F	32	1.04E-04	n.a.[a]	7.60E-05	1.40E-04
EHA	Air heater	S	11	1.42E+06	n.a.[a]	n.a.[a]	F	4	2.81E-06	n.a.[a]	9.61E-07	6.44E-06
EHO	Oil heater	S	12	1.55E+06	n.a.[a]	n.a.[a]	C	1	6.45E-07	n.a.[a]	3.31E-08	3.06E-06
EHO	Oil heater	S	12	1.55E+06	n.a.[a]	n.a.[a]	F	3	1.93E-06	n.a.[a]	5.27E-07	5.00E-06
EHO	Oil heater	S	12	1.55E+06	n.a.[a]	n.a.[a]	Y	25	1.61E-05	n.a.[a]	1.12E-05	2.25E-05
EHO	Oil heater	Y	2	1.88E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	3.68E-06	n.a.[a]	n.a.[a]	1.59E-05
EHW	Water heater	S	12	1.55E+06	n.a.[a]	n.a.[a]	F	1	6.45E-07	n.a.[a]	3.31E-08	3.06E-06
EIX	Inverter 3 phase	TRIGA	1	6.50E+04	n.a.[a]	n.a.[a]	F	12	1.85E-04	n.a.[a]	1.07E-04	2.99E-04
EIX	Inverter 3 phase	TRIGA	1	6.50E+04	n.a.[a]	n.a.[a]	R	16	2.46E-04	n.a.[a]	1.54E-04	3.74E-04
EIX	Inverter 3 phase	TRIGA	1	6.50E+04	n.a.[a]	n.a.[a]	S	8	1.23E-04	n.a.[a]	6.12E-05	2.22E-04
EIZ	115 vac inverter	NRU	3	2.67E+05	n.a.[a]	n.a.[a]	F	1	3.74E-06	n.a.[a]	1.92E-07	1.77E-05

Text cont. on p. 142

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
EIZ	Inverter single phase	S	3	3.88E+05	n.a.[a]	n.a.[a]	I	1	2.58E-06	n.a.[a]	1.32E-07	1.22E-05
EIZ	Inverter single phase	Y	6	5.65E+05	n.a.[a]	n.a.[a]		0	1.23E-06	n.a.[a]	–[b]	5.30E-06
EPA	Power supply (instrumentation and control equipment)	TRIGA MARK-II	1	8.66E+03	n.a.[a]	n.a.[a]	F	1	1.15E-04	n.a.[a]	5.92E-06	5.48E-04
EPA	Power supply-instrumentation and control equipment	BR01	4	n.a.[a]	4.34E+04	n.a.[a]	K	3	6.91E-05	n.a.[a]	1.88E-05	1.79E-04
EPA	Power supply (I&C)	BR04	2	n.a.[a]	7.63E+03	n.a.[a]	M	1	1.31E-04	n.a.[a]	6.72E-06	6.22E-04
EPA	Power supply (I&C)	CZ	12	n.a.[a]	7.6E+04	n.a.[a]	B	4	5.29E-05	n.a.[a]		
EPA	Power supply (I&C)	CH	1	5.50E+03	n.a.[a]	n.a.[a]	F	1	1.82E-04	n.a.[a]	9.33E-06	8.63E-04
EPA	Power supply (I&C)	CH	1	1.39E+04	n.a.[a]	n.a.[a]	B	1	7.20E-05	n.a.[a]	3.69E-06	3.41E-04
EPA02	Power supply (I&C)	DALAT	1	n.a.[a]	2.86E+04	n.a.[a]	B	5	1.75E-04	n.a.[a]	6.88E-05	3.67E-04
EPA02	Power supply (I&C)	DALAT	1	n.a.[a]	2.86E+04	n.a.[a]	B	5	1.75E-04	n.a.[a]	6.88E-05	3.67E-04
EPA02	Power supply (I&C)	DALAT	1	n.a.[a]	2.86E+04	n.a.[a]	F	3	1.05E-04	n.a.[a]	2.86E-05	2.71E-04
EPH	High voltage power supply (I&C)	BR01	2	n.a.[a]	2.17E+04	n.a.[a]	F	1	4.61E-05	n.a.[a]	2.36E-06	2.18E-04

Text cont. on p. 143

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
EPH	High voltage power supply (I&C)	DALAT	9	n.a.[a]	2.58E+05	n.a.[a]	B	2	7.76E-06	n.a.[a]	1.38E-06	2.44E-05
EPH	High voltage power supply (I&C)	DALAT	9	n.a.[a]	n.a.[a]	15939	F	2	n.a.[a]	1.25E-04	2.23E-05	3.95E-04
EPH 01	High voltage power supply-(I&C)	BR04	8	n.a.[a]	3.05E+04	n.a.[a]	F	1	3.28E-05	n.a.[a]	1.68E-06	1.55E-04
EPH 02	High voltage power supply-I&C	BR04	4	n.a.[a]	1.53E+04	n.a.[a]	F	1	6.55E-05	n.a.[a]	3.36E-06	3.11E-04
EPH 03	High voltage power supply-I&C	BR04	4	n.a.[a]	1.53E+04	n.a.[a]	F	1	6.55E-05	n.a.[a]	3.36E-06	3.11E-04
EPH 04	High voltage power supply-I&C equipment	BR04	4	n.a.[a]	1.53E+04	n.a.[a]	F	1	6.55E-05	n.a.[a]	3.36E-06	3.11E-04
EPH 05	High voltage power supply-I&C equipment	BR04	4	n.a.[a]	1.53E+04	n.a.[a]	F	1	6.55E-05	n.a.[a]	3.36E-06	3.11E-04
EPH01	High voltage power supply 520V	AR6	3	n.a.[a]	8.76E+04	n.a.[a]	F	2	2.28E-05	n.a.[a]	4.06E-06	7.19E-05
EPH02	High voltage power supply 0-1000V	AR6	16	n.a.[a]	1.40E+06	n.a.[a]	F	6	4.28E-06	n.a.[a]	1.86E-06	8.45E-06
EPL	Low voltage power supply-I&C equipment	AR6	18	3.15E+06	n.a.[a]	n.a.[a]	F	3	9.51E-07	n.a.[a]	2.59E-07	2.46E-06

Text cont. on p. 144

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
EPL01	Low voltage power supply-I&C equipment	BR04	4	n.a.[a]	1.53E+04	n.a.[a]	F	1	6.55E-05	n.a.[a]	3.36E-06	3.11E-04
EPL02	Low voltage power supply-I&C equipment	BR04	4	n.a.[a]	1.53E+04	n.a.[a]	F	1	6.55E-05	n.a.[a]	3.36E-06	3.11E-04
EPL03	Low voltage power supply-I&C equipment-SCRAM alarms	BR04	5	n.a.[a]	1.91E+04	n.a.[a]	K	1	5.24E-05	n.a.[a]	2.69E-06	2.49E-04
EPU	Uninterruptible power supply	DALAT	3	n.a.[a]	7.94E+04	n.a.[a]	F	6	7.56E-05	n.a.[a]	3.29E-05	1.49E-04
ERS	Rectifier static	NRU	2	n.a.[a]	1.75E+05	n.a.[a]	F	2	1.14E-05	n.a.[a]	2.03E-06	3.60E-05
ERS	Rectifier static	S	2	2.58E+05	n.a.[a]	n.a.[a]	F	2	7.74E-06	n.a.[a]	1.37E-06	2.44E-05
ERS	Rectifier static	Y	3	2.83E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	2.45E-06	n.a.[a]	n.a.[a]	1.06E-05
FEA	Piping expansion bellows	NRU	26	7.50E+06	n.a.[a]	n.a.[a]	Y/J	0	9.24E-08	n.a.[a]	n.a.[a]	3.99E-07
FEA	Piping expansion joint	S	40	5.17E+06	n.a.[a]	n.a.[a]	F	4	7.74E-07	n.a.[a]	2.64E-07	1.77E-06
FEA	Piping expansion joint	S	40	5.17E+06	n.a.[a]	n.a.[a]	Y	8	1.55E-06	n.a.[a]	7.70E-07	2.79E-06
FEA	Piping expansion joint	Y	2	1.88E+05	n.a.[a]	n.a.[a]	F	1	5.31E-06	n.a.[a]	2.72E-07	2.52E-05
FEA	Piping expansion joint	Y	2	1.88E+05	n.a.[a]	n.a.[a]	R	1	5.31E-06	n.a.[a]	2.72E-07	2.52E-05
FEA	Expansion joint aluminium	IN-A	1	3.50E+05	n.a.[a]	n.a.[a]	Y	1	2.86E-06	n.a.[a]	1.47E-07	1.36E-05

Text cont. on p. 145

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
FNA	Piping nozzle	S	17	2.20E+06	n.a.[a]	n.a.[a]	F	1	4.55E-07	n.a.[a]	2.33E-08	2.16E-06
FNA	Piping nozzle	Y	5	4.71E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	1.47E-06	n.a.[a]	n.a.[a]	6.36E-06
FRA	Bursting disc	HIFAR	2	2.32E+05	n.a.[a]	n.a.[a]	B	2	8.62E-06	n.a.[a]	1.53E-06	2.71E-05
FRA	Bursting disc	HIFAR	2	2.32E+05	n.a.[a]	n.a.[a]	Y	2	8.62E-06	n.a.[a]	1.53E-06	2.71E-05
FS3	Carbon steel piping 5 cm diameter	NRU	–[b]	2.70E+05	n.a.[a]	n.a.[a]	Y/J	0	2.57E-06	n.a.[a]	n.a.[a]	1.11E-05
FS3	Piping medium. > 1" diameter	S	2378	3.07E+08	n.a.[a]	n.a.[a]	F	4	1.30E-08	n.a.[a]	4.45E-09	2.98E-08
FS3	Piping medium. > 1" diameter	S	2378	3.07E+08	n.a.[a]	n.a.[a]	Y	16	5.21E-08	n.a.[a]	3.27E-08	7.91E-08
FS3	Piping medium. > 1" diameter	Y	123	1.16E+07	n.a.[a]	n.a.[a]	R	1	8.63E-08	n.a.[a]	4.43E-09	4.10E-07
FSA01	Piping-straight section-2"-100 psi-air	BR04	–[b]	n.a.[a]	1.29E+04	n.a.[a]	Y	1	7.77E-05	n.a.[a]	3.99E-06	3.69E-04
FSA02	Piping-straight section-connector-1/4"-30 psi-air	BR04	–[b]	n.a.[a]	1.29E+04	n.a.[a]	Y	1	7.77E-05	n.a.[a]	3.99E-06	3.69E-04
FSA03	Piping-straight section-connector-3"-3 kgf/cm2-water	BR04	–[b]	n.a.[a]	3.81E+03	n.a.[a]	Y	1	2.62E-04	n.a.[a]	1.34E-05	1.24E-03

Text cont. on p. 146

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
FSL	Stainless steel piping 15 cm diameter, 142 m, 270 welds	NRU	n.a.[a]	2.70E+05	n.a.[a]	n.a.[a]	Y/J	0	2.57E-06	n.a.[a]	n.a.[a]	1.11E-05
FSL	Pipe line 900 mm sea water CS 1000 meters	C	n.a.[a]	3.67E+05	n.a.[a]	n.a.[a]	Y	1	2.72E-06	n.a.[a]	1.40E-07	1.29E-05
FSL01	Piping SS 304 L 300 mm 107 meter >100 welds	D	n.a.[a]	1.83E+05	n.a.[a]	n.a.[a]	Y	0	3.79E-06	n.a.[a]	n.a.[a]	1.64E-05
FSL02	Piping SS 304 L 150 mm 67 meter >80 welds	D	n.a.[a]	1.83E+05	n.a.[a]	n.a.[a]	Y	0	3.79E-06	n.a.[a]	n.a.[a]	1.64E-05
FL03	Piping SS <= 100 mm 109 meter	D	n.a.[a]	1.83E+05	n.a.[a]	n.a.[a]	Y	0	3.79E-06	n.a.[a]	n.a.[a]	1.64E-05
FSM	Piping large, > 3" diameter	BR01	n.a.[a]	n.a.[a]	1.03E+04	n.a.[a]	Y	1	9.72E-05	n.a.[a]	4.99E-06	4.61E-04
FSM	Piping large, > 3 " diameter	B	175	5.20E+06	n.a.[a]	n.a.[a]	Y	1	1.92E-07	n.a.[a]	9.86E-09	9.12E-07
FSM	Piping large, > 3 " diameter	S	1230	1.59E+08	n.a.[a]	n.a.[a]	F	1	6.29E-09	n.a.[a]	3.23E-10	2.98E-08
FSM	Piping large, > 3 " diameter	S	1230	1.59E+08	n.a.[a]	n.a.[a]	Y	1	6.29E-09	n.a.[a]	3.23E-10	2.98E-08

Text cont. on p. 147

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
FSM	Piping large, > 3 " diameter	Y	216	2.03E+07	n.a.[a]	n.a.[a]	n.a.[a]	0	3.41E-08	n.a.[a]	n.a.[a]	1.47E-07
FSM	Piping 6" Aluminium 37 meter	A	n.a.[a]	4.00E+05	n.a.[a]	n.a.[a]	Y	0	1.73E-06	n.a.[a]	n.a.[a]	7.49E-06
FSM	Pipe line 150 mm CS 600 meters	C	n.a.[a]	3.50E+05	n.a.[a]	n.a.[a]	Y	2	5.71E-06	n.a.[a]	1.02E-06	1.80E-05
FSM01	Water piping Large	HIFAR	1	1.16E+05	n.a.[a]	n.a.[a]	B	1	8.62E-06	n.a.[a]	4.42E-07	4.09E-05
FSM01	Water piping Large	HIFAR	1	1.16E+05	n.a.[a]	n.a.[a]	Y	1	8.62E-06	n.a.[a]	4.42E-07	4.09E-05
FSM01	Carbon steel, 120 cm diameter, 536 m	NRU	n.a.[a]	2.90E-05	n.a.[a]	n.a.[a]	Y/J	0	2.39E+04	n.a.[a]	n.a.[a]	1.03E+05
FSM01	Piping carbon steel 900 mm 225 meter	D	n.a.[a]	1.83E+05	n.a.[a]	n.a.[a]	Y	1	5.46E-06	n.a.[a]	2.80E-07	2.59E-05
FSM01	Piping large, >3" diameter	DALAT	4	n.a.[a]	1.27E+05	n.a.[a]	Y	0	5.46E-06	n.a.[a]	n.a.[a]	2.36E-05
FSM02	Water pipes-Inlet Header	HIFAR	1	1.16E+05	n.a.[a]	n.a.[a]	Y	1	8.62E-06	n.a.[a]	4.42E-07	4.09E-05
FSM02	Carbon steel, 46 cm diameter, 60 m	NRU	n.a.[a]	2.90E+05	n.a.[a]	n.a.[a]	Y/J	0	2.39E-06	n.a.[a]	n.a.[a]	1.03E-05
FSM02	Piping carbon steel <= 400 mm 200 meter	D	n.a.[a]	1.83E+05	n.a.[a]	n.a.[a]	Y	0	3.79E-06	n.a.[a]	n.a.[a]	1.64E-05

Text cont. on p. 148

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	5%	**95%**
FSM02	Piping large, >3" diameter	DALAT	5	n.a.[a]	1.55E+05	n.a.[a]	Y	2	1.29E-05	n.a.[a]	2.30E-06	4.07E-05
FSS	Piping small, <= 1" diameter	BR01	–[b]	n.a.[a]	1.03E+04	n.a.[a]	Y	1	9.73E-05	n.a.[a]	4.99E-06	4.62E-04
FSS	Piping small, <= 1" diameter	NRU		2.90E+05	n.a.[a]	n.a.[a]	J	0	2.39E-06	n.a.[a]	n.a.[a]	1.03E-05
FSS	Piping small, <= 1" diameter	S	1144	1.48E+08	n.a.[a]	n.a.[a]	F	1	6.76E-09	n.a.[a]	3.47E-10	3.21E-08
FSS	Piping small, <= 1" diameter	S	1144	1.48E+08	n.a.[a]	n.a.[a]	T	1	6.76E-09	n.a.[a]	3.47E-10	3.21E-08
FSS	Piping small, <= 1" diameter	S	1144	1.48E+08	n.a.[a]	n.a.[a]	Y	6	4.06E-08	n.a.[a]	1.77E-08	8.01E-08
FSS	Piping small, <= 1" diameter	Y	28	2.64E+06	n.a.[a]	n.a.[a]		0	2.63E-07	n.a.[a]	n.a.[a]	1.14E-06
FTA	Piping tees	Y	22	2.07E+06	n.a.[a]	n.a.[a]	F	1	4.83E-07	n.a.[a]	2.48E-08	2.29E-06
FTA	Piping tees	Y	22	2.07E+06	n.a.[a]	n.a.[a]	Y	1	4.83E-07	n.a.[a]	2.48E-08	2.29E-06
FXA	Sensor flow-orifice <= 900 mm	D	2	3.70E+05	n.a.[a]	n.a.[a]	F	0	1.87E-06	n.a.[a]	n.a.[a]	8.10E-06
FYA	Gasket	NRU	148	2.22E+07	n.a.[a]	n.a.[a]	J	1	4.51E-08	n.a.[a]	2.31E-09	2.14E-07

Text cont. on p. 149

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
FSS	Piping small, <= 1" diameter	S	1144	1.48E+08	n.a.[a]	n.a.[a]	T	1	6.76E-09	n.a.[a]	3.47E-10	3.21E-08
FSS	Piping small, <= 1" diameter	S	1144	1.48E+08	n.a.[a]	n.a.[a]	Y	6	4.06E-08	n.a.[a]	1.77E-08	8.01E-08
FSS	Piping small, <= 1" diameter	Y	28	2.64E+06	n.a.[a]	n.a.[a]	n.a.[a]	0	2.63E-07	n.a.[a]	n.a.[a]	1.14E-06
FTA	Piping tees	Y	22	2.07E+06	n.a.[a]	n.a.[a]	F	1	4.83E-07	n.a.[a]	2.48E-08	2.29E-06
FTA	Piping tees	Y	22	2.07E+06	n.a.[a]	n.a.[a]	Y	1	4.83E-07	n.a.[a]	2.48E-08	2.29E-06
FXA	Sensor flow-orifice <= 900 mm	D	2	3.70E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	1.87E-06	n.a.[a]	n.a.[a]	8.10E-06
FYA	Gasket	NRU	148	2.22E+07	n.a.[a]	n.a.[a]	J	1	4.51E-08	n.a.[a]	2.31E-09	2.14E-07
FYA	Gasket	S	393	5.08E+07	n.a.[a]	n.a.[a]	F	2	3.94E-08	n.a.[a]	7.00E-09	1.24E-07
FYA	Gasket	S	393	5.08E+07	n.a.[a]	n.a.[a]	R	3	5.91E-08	n.a.[a]	1.61E-08	1.53E-07
FYA	Gasket	S	393	5.08E+07	n.a.[a]	n.a.[a]	Y	13	2.56E-07	n.a.[a]	1.51E-07	4.07E-07
FYA	Gasket	Y	136	1.28E+07	n.a.[a]	n.a.[a]	R	10	7.81E-07	n.a.[a]	4.24E-07	1.32E-06
FYA	Flange SS 300 mm	D	15	2.76E+06	n.a.[a]	n.a.[a]	Y	3	1.09E-06	n.a.[a]	2.96E-07	2.81E-06
GBC	Thermal column	C	1	3.50E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	1.98E-06	n.a.[a]	n.a.[a]	8.56E-06
GBR	Beam port radial	NRU	13	3.82E+06	n.a.[a]	n.a.[a]	n.a.[a]	0	1.81E-07	n.a.[a]	n.a.[a]	7.84E-07

Text cont. on p. 150

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
GBR	Beam port, radial	CH	1	1.39E+04	n.a.[a]	n.a.[a]	Y	6	4.32E-04	n.a.[a]	1.88E-04	8.52E-04
GBR	Beam port, tangential	S	4	5.17E+05	n.a.[a]	n.a.[a]	F	3	5.80E-06	n.a.[a]	1.58E-06	1.50E-05
GBR	Beam port, tangential	Y	3	2.83E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	2.45E-06	n.a.[a]	n.a.[a]	1.06E-05
GBR	Beam tube	A	9	–[b]	n.a.[a]	n.a.[a]	Y	1	–[b]	n.a.[a]	–[b]	#NUM!
GBR	Beam tube	C	20	n.a.[a]	7.01E+07	n.a.[a]	Y	0	9.89E-09	n.a.[a]	n.a.[a]	4.27E-08
GBR	Re-entrant cans-beam port	D	18	2.70E+06	n.a.[a]	n.a.[a]	Y	0	2.57E-07	n.a.[a]	n.a.[a]	1.11E-06
GBT	Beam port tangential	NRU	1	2.63E+05	n.a.[a]	n.a.[a]	Y/J	1	3.80E-06	n.a.[a]	1.95E-07	1.80E-05
GCB	Thermal column	NRU	1	2.63E+05	n.a.[a]	n.a.[a]	F	0	2.64E-06	n.a.[a]	n.a.[a]	1.14E-05
GHE	Header	BR01	1	n.a.[a]	1.03E+04	n.a.[a]	X	2	1.95E-04	n.a.[a]	3.46E-05	6.12E-04
GPL	Pool liner-SS	A	1	1.75E+05	n.a.[a]	n.a.[a]	Y	0	3.96E-06	n.a.[a]	n.a.[a]	1.71E-05
GTA	Tank reactor vessel	NRU	3	7.63E+05	n.a.[a]	n.a.[a]	Y	1	1.31E-06	n.a.[a]	6.72E-08	6.22E-06
GTA	Tank reactor vessel	NRU	3	7.63E+05	n.a.[a]	n.a.[a]	J	0	9.08E-07	n.a.[a]	n.a.[a]	3.93E-06
GTA	Tank, reactor vessel	CH	2	2.78E+04	n.a.[a]	n.a.[a]	F	1	3.60E-05	n.a.[a]	1.85E-06	1.71E-04
GTA	Tank, reactor vessel	B	1	2.97E+04	n.a.[a]	n.a.[a]	X	2	6.73E-05	n.a.[a]	1.20E-05	2.12E-04

Text cont. on p. 151

[a] n.a.: not applicable

[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
GTA	Reactor vessel-aluminium	C	1	3.76E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	1.84E-06	n.a.[a]	n.a.[a]	7.97E-06
GTA	Tank, reactor vessel	DALAT	1	n.a.[a]	2.86E+04	n.a.[a]	n.a.[a]	0	2.42E-05	n.a.[a]	n.a.[a]	1.05E-04
GTE	Expansion tank	S	3	3.88E+05	n.a.[a]	n.a.[a]	F	1	2.58E-06	n.a.[a]	1.32E-07	1.22E-05
GTE	Expansion tank	S	3	3.88E+05	n.a.[a]	n.a.[a]	Y	29	7.48E-05	n.a.[a]	5.35E-05	1.02E-04
HCA	Cooling tower	AR3	3	n.a.[a]	2.25E+05	n.a.[a]	F	11	4.90E-05	n.a.[a]	2.75E-05	8.11E-05
HCA	Cooling tower	AR6	1	n.a.[a]	1.67E+04	n.a.[a]	n.a.[a]	0	4.16E-05	n.a.[a]	n.a.[a]	1.80E-04
HCA	Cooling tower	HIFAR	6	6.95E+05	n.a.[a]	n.a.[a]	B	31	4.46E-05	n.a.[a]	3.23E-05	6.02E-05
HCA	Cooling tower	HIFAR	6	6.95E+05	n.a.[a]	n.a.[a]	Y	19	2.73E-05	n.a.[a]	1.79E-05	4.01E-05
HCA	Cooling tower general	B	2	5.94E+04	n.a.[a]	n.a.[a]	D	1	1.68E-05	n.a.[a]	8.63E-07	7.98E-05
HCA	Cooling tower general	S	7	9.05E+05	n.a.[a]	n.a.[a]	–[b]	–[b]	7.66E-07	n.a.[a]	–[b]	3.31E-06
HCA	Cooling tower general	Y	2	1.88E+05	n.a.[a]	n.a.[a]	O	5	2.65E-05	n.a.[a]	1.05E-05	5.58E-05
HCA	Cooling tower general	Y	2	1.88E+05	n.a.[a]	n.a.[a]	B	1	5.31E-06	n.a.[a]	2.72E-07	2.52E-05
HCA	Cooling tower general	Y	2	1.88E+05	n.a.[a]	n.a.[a]	Y	1	5.31E-06	n.a.[a]	2.72E-07	2.52E-05
HCA	Cooling tower general	Y	2	1.88E+05	n.a.[a]	n.a.[a]	R	3	1.59E-05	n.a.[a]	4.34E-06	4.12E-05
HCA01	Cooling tower-general	BR01	1	n.a.[a]	3.59E+03	n.a.[a]	B	2	5.58E-04	n.a.[a]	9.91E-05	1.76E-03

Text cont. on p. 152

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
HCA02	Cooling tower-general	BR01	1	n.a.[a]	6.69E+03	n.a.[a]	B	1	1.49E-04	n.a.a	7.66E-06	7.09E-04
HCA02	Cooling tower-general	BR01	1	n.a.[a]	6.69E+03	n.a.[a]	Y	1	1.49E-04	n.a.[a]	7.66E-06	7.09E-04
HCV01	Cooling tower-fan	BR01	2	n.a.[a]	3.46E+03	n.a.[a]	B	1	2.89E-04	n.a.[a]	1.48E-05	1.37E-03
HCV01	Cooling tower-fan	BR01	2	n.a.[a]	n.a.[a]	138	S	1	n.a.[a]	7.25E-03	3.72E-04	3.39E-02
HCV02	Cooling tower-fan	BR01	2	n.a.[a]	9.76E+03	n.a.[a]	B	1	1.02E-04	n.a.[a]	5.26E-06	4.86E-04
HCV02	Cooling tower-fan	BR01	2	n.a.[a]	9.76E+03	n.a.[a]	R	7	7.17E-04	n.a.[a]	3.37E-04	1.35E-03
HCV02	Cooling tower-fan	BR01	2	n.a.[a]	n.a.[a]	670	S	2	n.a.[a]	2.99E-03	5.31E-04	9.37E-03
HXA	Heat exchanger	AR3	2	1.40E+05	n.a.[a]	n.a.[a]	B	1	7.13E-06	n.a.[a]	3.66E-07	3.38E-05
HXA	Heat exchanger	AR3	2	1.40E+05	n.a.[a]	n.a.[a]	Y	1	7.13E-06	n.a.[a]	3.66E-07	3.38E-05
HXA	Heat exchanger	AR6	2	3.50E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	1.98E-06	n.a.[a]	n.a.[a]	8.55E-06
HXA	Heat exchanger	HIFAR	3	3.47E+05	n.a.[a]	n.a.[a]	B	2	5.76E-06	n.a.[a]	1.02E-06	1.81E-05
HXA	Heat exchanger	B	8	2.38E+05	n.a.[a]	n.a.[a]	J	1	4.21E-06	n.a.[a]	2.16E-07	2.00E-05
HXA	Heat exchanger	S	7	9.05E+05	n.a.[a]	n.a.[a]	F	5	5.53E-06	n.a.[a]	2.18E-06	1.16E-05
HXA	Heat exchanger	DALAT	1	n.a.[a]	3.09E+04	n.a.[a]	n.a.[a]	0	2.24E-05	n.a.[a]	n.a.[a]	9.69E-05
HXB	Heat exchanger	BR01	1	n.a.[a]	6.69E+03	n.a.[a]	Y	1	1.49E-04	n.a.[a]	7.66E-06	7.09E-04
HXB	Heat exchanger	H	2	1.49E+05	n.a.[a]	n.a.[a]	F	23	1.54E-04	n.a.[a]	1.05E-04	2.18E-04

Text cont. on p. 153

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
HXB	Heat exchanger	M	2	1.45E+05	n.a.[a]	n.a.[a]	F	21	1.45E-04	n.a.[a]	9.69E-05	2.08E-04
HXB	Heat exchanger CS shell & Cu-Ni tubes	D	5	4.40E+05	n.a.[a]	n.a.[a]	Y	10	2.27E-05	n.a.[a]	1.23E-05	3.86E-05
HXC	Heat exchanger-evaporative condenser	HIFAR	3	3.47E+05	n.a.[a]	n.a.[a]	B	48	1.38E-04	n.a.[a]	1.07E-04	1.76E-04
HXC	Heat exchanger-evaporative condenser	HIFAR	3	3.47E+05	n.a.[a]	n.a.[a]	Y	7	2.02E-05	n.a.[a]	9.47E-06	3.79E-05
HXH 01	Heat exch. U tube horizontal shell and tube	Y	1	9.42E+04	n.a.[a]	n.a.[a]	B	1	1.06E-05	n.a.[a]	5.45E-07	5.04E-05
HXH 02	Heat exch. U tube horizontal shell and tube	Y	1	9.42E+04	n.a.[a]	n.a.[a]	B	1	1.06E-05	n.a.[a]	5.45E-07	5.04E-05
HXM	Heat exchanger, stainless steel, vertical, shell and tube	NRU	8	2.83E+06	n.a.[a]	n.a.[a]	Y	0	2.45E-07	n.a.[a]	n.a.[a]	1.06E-06
HXM	Heat exch. Straight tube vertical shell and tube	S	2	2.58E+05	n.a.[a]	n.a.[a]	Y	1	3.87E-06	n.a.[a]	1.98E-07	1.84E-05
HXM	Heat exchanger heavy water shell & tube type CS shell and SS tubes	D	3	5.20E+05	n.a.[a]	n.a.[a]	Y	0	1.33E-06	n.a.[a]	n.a.[a]	5.76E-06

Text cont. on p. 154

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
HXP	Heat exch. Plate type	B	2	5.94E+04	n.a.[a]	n.a.[a]	Y	2	3.37E-05	n.a.[a]	5.98E-06	1.06E-04
IAA	Instrumentation	TRIGA MARK-II	1	8.69E+03	n.a.[a]	n.a.[a]	B	1	1.15E-04	n.a.[a]	5.90E-06	5.46E-04
IAA	Instrumentation	TRIGA MARK-II	25	2.68E+06	n.a.[a]	n.a.[a]	F	3	1.12E-06	n.a.[a]	3.05E-07	2.90E-06
IAA	Instrumentation	TRIGA MARK-II	4	3.97E+05	n.a.[a]	n.a.[a]	F	3	7.56E-06	n.a.[a]	2.06E-06	1.95E-05
IAA	Instrumentation	H	60	3.73E+06	n.a.[a]	n.a.[a]	F	48	1.29E-05	n.a.[a]	9.99E-06	1.64E-05
IAA	Instrumentation	S	1	1.29E+05	n.a.[a]	n.a.[a]	F	1	7.74E-06	n.a.[a]	3.97E-07	3.67E-05
IAA	Instrumentation	Y	1	9.42E+04	n.a.[a]	n.a.[a]	n.a.[a]	0	7.36E-06	n.a.[a]	n.a.[a]	3.18E-05
IAA	Amplifier-rectifier unit	D	3	n.a.[a]	1.05E+05	n.a.[a]	A	1	9.52E-06	n.a.[a]	4.89E-07	4.52E-05
IAA01	Instrumentation	DALAT	3	n.a.[a]	8.59E+04	n.a.[a]	B	1	1.16E-05	n.a.[a]	5.97E-07	5.52E-05
IAA01	Instrumentation	DALAT	3	n.a.[a]	8.59E+04	n.a.[a]	F	6	6.99E-05	n.a.[a]	3.04E-05	1.38E-04
IAA02	Instrumentation	DALAT	2/1	n.a.[a]	2.86E+04	n.a.[a]	B	9	3.14E-04	n.a.[a]	1.64E-04	5.49E-04
IAA02	Instrumentation	DALAT	2/1	n.a.[a]	2.86E+04	n.a.[a]	F	4	1.40E-04	n.a.[a]	4.77E-05	3.20E-04
IAA03	Instrumentation	DALAT	1	n.a.[a]	2.86E+04	n.a.[a]	B	1	3.49E-05	n.a.[a]	1.79E-06	1.66E-04
IAA03	Instrumentation	DALAT	1	n.a.[a]	2.86E+04	n.a.[a]	F	1	3.49E-05	n.a.[a]	1.79E-06	1.66E-04
IAA04	Instrumentation	DALAT	1	n.a.[a]	2.86E+04	n.a.[a]	F	4	1.40E-04	n.a.[a]	4.77E-05	3.20E-04
IAA05	Instrumentation	DALAT	4	n.a.[a]	1.15E+05	n.a.[a]	B	9	7.86E-05	n.a.[a]	4.10E-05	1.37E-04

Text cont. on p. 155

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
IAA06	Instrumentation	DALAT	1	n.a.[a]	2.86E+04	n.a.[a]	B	14	4.89E-04	n.a.[a]	2.96E-04	7.65E-04
IAA06	Instrumentation	DALAT	1	n.a.[a]	2.86E+04	n.a.[a]	F	11	3.84E-04	n.a.[a]	2.16E-04	6.36E-04
IAA07	Instrumentation	DALAT	2	n.a.[a]	5.73E+04	n.a.[a]	F	5	8.73E-05	n.a.[a]	3.44E-05	1.84E-04
IAR	Control rod position. Indication	BR01	4	n.a.[a]	4.18E+04	n.a.[a]	F	3	7.18E-05	n.a.[a]	1.96E-05	1.86E-04
IAR	Control rod position indication	SI	1	n.a.[a]	2.00E+04	n.a.[a]	M	2	1.00E-04	n.a.[a]	1.78E-05	3.15E-04
IAR	Control rod position indication	DALAT	5	n.a.[a]	1.43E+05	n.a.[a]	B	8	5.59E-05	n.a.[a]	2.78E-05	1.01E-04
IAR01	Indicator-control rod absolute position	BR04	4	n.a.[a]	1.53E+04	n.a.[a]	F	1	6.55E-05	n.a.[a]	3.36E-06	3.11E-04
IAR02	Indicator – safety /control bar relative position channel	BR04	4	n.a.[a]	1.53E+04	n.a.[a]	F	1	6.55E-05	n.a.[a]	3.36E-06	3.11E-04
IAR02	Indicator – safety /control bar relative position	BR04	4	n.a.[a]	1.53E+04	n.a.[a]	B	1	6.55E-05	n.a.[a]	3.36E-06	3.11E-04
ICA	Reactor reg. Sys.	M	2	1.27E+05	n.a.[a]	n.a.[a]	F	23	1.81E-04	n.a.[a]	1.24E-04	2.56E-04
ICA01	Linear power amplifier (all modes)	NRU	5	6.57E+05	n.a.[a]	n.a.[a]	F	4	6.09E-06	n.a.[a]	2.08E-06	1.39E-05

Text cont. on p. 156

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
ICA01	linear power amplifier (unsafe modes)	NRU	5	6.57E+05	n.a.[a]	n.a.[a]	F	3	4.57E-06	n.a.[a]	1.24E-06	1.18E-05
ICA02	linear rate amplifier (all modes)	NRU	5	6.57E+05	n.a.[a]	n.a.[a]	F	1	1.52E-06	n.a.[a]	7.81E-08	7.22E-06
ICA02	linear rate amplifier (unsafe modes)	NRU	5	6.57E+05	n.a.[a]	n.a.[a]	F	1	1.52E-06	n.a.[a]	7.81E-08	7.22E-06
ICA03	log power amplifier (all modes)	NRU	5	6.57E+06	n.a.[a]	n.a.[a]	F	9	1.37E-06	n.a.[a]	7.15E-07	2.39E-06
ICA03	log power amplifier (unsafe modes)	NRU	5	6.57E+05	n.a.[a]	n.a.[a]	F	5	7.61E-06	n.a.[a]	3.00E-06	1.60E-05
ICA04	log rate amplifier (all modes)	NRU	4	6.57E+05	n.a.[a]	n.a.[a]	F	6	9.13E-06	n.a.[a]	3.98E-06	1.80E-05
ICA04	log rate amplifier (unsafe modes)	NRU	4	6.57E+05	n.a.[a]	n.a.[a]	F	1	1.52E-06	n.a.[a]	7.81E-08	7.22E-06
ICA05	ion chamber power supplies (all modes)	NRU	18	2.33E+06	n.a.[a]	n.a.[a]	F	8	3.43E-06	n.a.[a]	1.71E-06	6.19E-06
ICA05	ion chamber power supplies (unsafe modes)	NRU	18	2.33E+06	n.a.[a]	n.a.[a]	F	3	1.29E-06	n.a.[a]	3.51E-07	3.33E-06
ICA05	neutronic amplifier power supply (all modes)	NRU	18	4.41E+06	n.a.[a]	n.a.[a]	F	30	6.80E-06	n.a.[a]	4.90E-06	9.23E-06

Text cont. on p. 157

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
ICA05	Neutronic amplifier power supply (unsafe modes)	NRU	18	4.41E+06	n.a.[a]	n.a.[a]	F	8	1.81E-06	n.a.[a]	9.03E-07	3.27E-06
ICA05	Neutronic comparators (all modes)	NRU	16	3.29E+06	n.a.[a]	n.a.[a]	F	19	5.78E-06	n.a.[a]	3.78E-06	8.47E-06
ICA05	Neutronic comparators (unsafe modes)	NRU	16	3.29E+06	n.a.[a]	n.a.[a]	F	3	9.12E-07	n.a.[a]	2.49E-07	2.36E-06
ICA01	Log power amplifier	D	3	n.a.[a]	1.05E+05	n.a.[a]	A	5	4.76E-05	n.a.[a]	1.88E-05	1.00E-04
ICA02	Campbell unit	D	3	n.a.[a]	1.05E+05	n.a.[a]	A	1	9.52E-06	n.a.[a]	4.89E-07	4.52E-05
ICA03	Function generator	D	3	n.a.[a]	1.05E+05	n.a.[a]	n.a.[a]	0	6.60E-06	n.a.[a]	n.a.[a]	2.85E-05
ICA04	Linear power amplifier	D	3	n.a.[a]	1.05E+05	n.a.[a]	A	5	4.76E-05	n.a.[a]	1.88E-05	1.00E-04
ICA05	Pre-amplifier	D	3	n.a.[a]	1.05E+05	n.a.[a]	A	3	2.86E-05	n.a.[a]	7.79E-06	7.38E-05
ICA06	Mean power trip unit	D	3	n.a.[a]	1.05E+05	n.a.[a]	A	2	1.90E-05	n.a.[a]	3.38E-06	6.00E-05
ICA07	Set point unit	D	3	n.a.[a]	1.05E+05	n.a.[a]	A	1	9.52E-06	n.a.[a]	4.89E-07	4.52E-05
ICC	Flux ch. Analogue	TRIGA MARK-II	3	9.62E+04	n.a.[a]	n.a.[a]	B	2	2.08E-05	n.a.[a]	3.69E-06	6.54E-05
ICC	Flux ch. Analogue	TRIGA MARK-II	16	4.91E+05	n.a.[a]	n.a.[a]	F	14	2.85E-05	n.a.[a]	1.72E-05	4.46E-05
ICC	Flux ch. Analogue	TRIGA MARK-II	4	1.04E+05	n.a.[a]	n.a.[a]	I	3	2.89E-05	n.a.[a]	7.87E-06	7.47E-05
ICC	Flux ch. Analogue	BR01	1	n.a.[a]	1.09E+04	n.a.[a]	F	2	1.83E-04	n.a.[a]	3.26E-05	5.78E-04

Text cont. on p. 158

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
ICC	Instr. Ch. Analogue core flux-comparator module	BR04	4	n.a.[a]	1.53E+04	n.a.[a]	F	4	2.62E-04	n.a.[a]	8.96E-05	6.00E-04
ICC	Instr. Ch. Analogue core flux-comparator module	BR04	4	n.a.[a]	1.53E+04	n.a.[a]	K	1	6.55E-05	n.a.[a]	3.36E-06	3.11E-04
ICC	Instr. Ch. Analogue core flux	CZ	12	n.a.[a]	7.6E+04	n.a.[a]	F	1	1.32E-05	n.a.[a]	–[b]	–[b]
ICC	Instr. Ch. Analogue core flux	CZ	12	n.a.[a]	7.6E+04	n.a.[a]	B	8	1.058E-04	n.a.[a]	–[b]	–[b]
ICC	Instr. Ch. Analogue core flux	CH	7	9.73E+04	n.a.[a]	n.a.[a]	B	25	2.57E-04	n.a.[a]	1.79E-04	3.59E-04
ICC	Instr. Ch. Analogue core flux	CH	7	9.73E+04	n.a.[a]	n.a.[a]	F	12	1.23E-04	n.a.[a]	7.12E-05	2.00E-04
ICC	Instr. Ch. Analogue core flux	CH	7	9.73E+04	n.a.[a]	n.a.[a]	K	12	1.23E-04	n.a.[a]	7.12E-05	2.00E-04
ICC	Instr. Ch. Analogue core flux	CH	7	9.73E+04	n.a.[a]	n.a.[a]	I	2	2.06E-05	n.a.[a]	3.65E-06	6.47E-05
ICC	Instr. Ch. Analogue core flux	CH	7	9.73E+04	n.a.[a]	n.a.[a]	X	1	1.03E-05	n.a.[a]	5.27E-07	4.88E-05

Text cont. on p. 159

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
ICC	Instr. Ch. Analogue core flux	H	6	3.74E+05	n.a.[a]	n.a.[a]	F	4	1.07E-05	n.a.[a]	3.66E-06	2.45E-05
ICC	Instr. Ch. Analogue core flux	M	2	1.46E+05	n.a.[a]	n.a.[a]	F	13	8.89E-05	n.a.[a]	5.26E-05	1.41E-04
ICC	Signal comparator	D	3	n.a.[a]	1.05E+05	n.a.[a]		0	6.60E-06	n.a.[a]	n.a.[a]	2.85E-05
ICC	Instr. Ch. Analogue core flux	TRIGA	4	n.a.[a]	2.59E+05	n.a.[a]	B	89	3.44E-04	n.a.[a]	2.86E-04	4.10E-04
ICC	Instr. Ch. Analogue core flux	SI	3	n.a.[a]	6.00E+04	n.a.[a]	B	3	5.00E-05	n.a.[a]	1.36E-05	1.29E-04
ICC01	Instr. Ch. Analogue core flux	AR3	2	2.45E+05	n.a.[a]	n.a.[a]	F	18	7.34E-05	n.a.[a]	4.74E-05	1.09E-04
ICC01	Instr. Ch. Analogue core flux	AR6	3	n.a.[a]	5.00E+04	n.a.[a]		0	1.39E-05	n.a.[a]	n.a.[a]	5.99E-05
ICC01	Log power amplifier	A	1	7.80E+04	n.a.[a]	n.a.[a]		0	8.89E-06	n.a.[a]	n.a.[a]	3.84E-05
ICC01	Instr. Ch. Analogue core flux	DALAT	3	n.a.[a]	8.59E+04	n.a.[a]	B	3	3.49E-05	n.a.[a]	9.52E-06	9.03E-05
ICC01	Instr. Ch. Analogue core flux	DALAT	3	n.a.[a]	8.59E+04	n.a.[a]	F	3	3.49E-05	n.a.[a]	9.52E-06	9.03E-05
ICC02	Instr. Ch. Analogue core flux	AR3	3	3.68E+05	n.a.[a]	n.a.[a]	F	14	3.81E-05	n.a.[a]	2.30E-05	5.95E-05

Text cont. on p. 160

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
ICC02	Instr. Ch. Analogue core flux	AR6	3	n.a.[a]	5.00E+04	n.a.[a]	F	3	6.00E-05	n.a.[a]	1.63E-05	1.55E-04
ICC02	Safety channel	A	2	1.58E+05	n.a.[a]	n.a.[a]		0	4.40E-06	n.a.[a]	n.a.[a]	1.90E-05
ICC02	Instr. ch. Analogue core flux	DALAT	3	n.a.[a]	8.59E+04	n.a.[a]	B	6	6.99E-05	n.a.[a]	3.04E-05	1.38E-04
ICC02	Instr. ch. Analogue core flux	DALAT	3	n.a.[a]	8.59E+04	n.a.[a]	F	5	5.82E-05	n.a.[a]	2.29E-05	1.22E-04
ICC03	Instr. ch. Analogue core flux	AR3	1	1.23E+05	n.a.[a]	n.a.[a]	F	7	5.71E-05	n.a.[a]	2.68E-05	1.07E-04
ICC03	Servo power regulating channel	A	1	2.54E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	2.73E-06	n.a.[a]	n.a.[a]	1.18E-05
ICC03	Flux ch. Analogue	DALAT	3	n.a.[a]	8.59E+04	n.a.[a]	B	2	2.33E-05	n.a.[a]	4.14E-06	7.33E-05
ICC03	Flux ch. Analogue	DALAT	3	n.a.[a]	8.59E+04	n.a.[a]	F	6	6.99E-05	n.a.[a]	3.04E-05	1.38E-04
ICC04	Start-up/pulse channel	A	1	2.54E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	2.73E-06	n.a.[a]	n.a.[a]	1.18E-05
ICC05	Linear power channel	A	1	7.88E+04	n.a.[a]	n.a.[a]	n.a.[a]	0	8.79E-06	n.a.[a]	n.a.[a]	3.80E-05
ICD	Instrumentation channel-protection logic	D	3	4.46E+05	n.a.[a]	n.a.[a]	F	1	2.24E-06	n.a.[a]	1.15E-07	1.06E-05
ICF	Flux ch. Analogue	AR3	2	2.45E+05	n.a.[a]	n.a.[a]	F	4	1.63E-05	n.a.[a]	5.57E-06	3.73E-05

Text cont. on p. 161

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
ICF	Flow ch. Analogue	CH	2	2.78E+04	n.a.[a]	n.a.[a]	B	1	3.60E-05	n.a.[a]	1.85E-06	1.71E-04
ICF	Flow. ch. Analogue	H	1	7.22E+04	n.a.[a]	n.a.[a]	F	2	2.77E-05	n.a.[a]	4.92E-06	8.72E-05
ICF	Flow. ch. Analogue	M	6	3.90E+05	n.a.[a]	n.a.[a]	F	36	9.24E-05	n.a.[a]	6.86E-05	1.22E-04
ICF	Instr. ch. Analogue flow	S	20	2.58E+06	n.a.[a]	n.a.a	F	9	3.48E-06	n.a.a	1.82E-06	6.08E-06
ICF	Instr. ch. Analogue flow	Y	4	3.77E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	1.84E-06	n.a.[a]	n.a.[a]	7.95E-06
ICF	Flow monitoring fuel channels	C	190	n.a.[a]	7.49E+08	n.a.[a]	F	1	1.34E-09	n.a.[a]	6.85E-11	6.33E-09
ICF	Instrumentation-channel flow monitoring	D	390	n.a.[a]	3.90E+07	n.a.[a]	F	1	2.56E-08	n.a.[a]	1.32E-09	1.22E-07
ICF01	Flow ch. Analogue	TRIGA MARK-II	1	1.40E+05	n.a.[a]	n.a.[a]	F	1	7.13E-06	n.a.[a]	3.66E-07	3.38E-05
ICF01	Instr. ch. Analogue minimum flow–primary circuit	TRIGA	2	n.a.[a]	1.29E+05	n.a.[a]	B	8	6.20E-05	n.a.[a]	3.09E-05	1.12E-04
ICF02	Instr. ch. Analogue flow	TRIGA MARK-II	2	1.98E+05	n.a.[a]	n.a.[a]	F	1	5.05E-06	n.a.[a]	2.59E-07	2.40E-05
ICF02	Instr. ch. Analogue - differential flow–inlet-outlet pool	TRIGA	2	n.a.[a]	1.29E+05	n.a.[a]	B	21	1.63E-04	n.a.[a]	1.09E-04	2.34E-04

Text cont. on p. 162

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
ICF03	Instr. ch. Analogue minimum flow-emergency pump	TRIGA	2	n.a.[a]	1.29E+05	n.a.[a]	B	4	3.10E-05	n.a.[a]	1.06E-05	7.10E-05
ICL	Sensor level	HIFAR	3	3.47E+05	n.a.[a]	n.a.[a]	F	2	5.76E-06	n.a.[a]	1.02E-06	1.81E-05
ICL	Ievel ch. Analogue	H	1	6.21E+04	n.a.[a]	n.a.[a]	F	3	4.83E-05	n.a.[a]	1.32E-05	1.25E-04
ICL	Level ch. Analogue	S	17	2.20E+06	n.a.[a]	n.a.[a]	F	21	9.56E-06	n.a.[a]	6.40E-06	1.38E-05
ICL	Level ch. Analogue	S	17	2.20E+06	n.a.[a]	n.a.[a]	R	1	4.55E-07	n.a.[a]	2.33E-08	2.16E-06
ICL	Level ch. Analogue	Y	1	9.42E+04	n.a.[a]	n.a.[a]	n.a.[a]	0	7.36E-06	n.a.[a]	n.a.[a]	3.18E-05
ICL01	Level ch. Analogue	TRIGA	8	1.40E+06	n.a.[a]	n.a.[a]	F	16	1.14E-05	n.a.[a]	7.16E-06	1.73E-05
ICL01	Level ch. Analogue	TRIGA	8	1.40E+06	n.a.[a]	n.a.[a]	B	4	2.85E-06	n.a.[a]	9.75E-07	6.53E-06
ICL02	Instr. ch. Analogue level (min-pool water)	TRIGA	2	3.50E+05	n.a.[a]	n.a.[a]	B	8	2.29E-05	n.a.[a]	1.14E-05	4.12E-05
ICL03	Instr. ch. Analogue level (max-pool water)	TRIGA	2	3.50E+05	n.a.[a]	n.a.[a]	B	22	6.29E-05	n.a.[a]	4.26E-05	8.98E-05
ICP	Instr. ch. Analogue pressure	H	2	1.24E+05	n.a.[a]	n.a.[a]	F	7	5.64E-05	n.a.[a]	2.65E-05	1.06E-04
ICP	Instr. ch. Analogue pressure	S	24	3.10E+06	n.a.[a]	n.a.[a]	F	27	8.70E-06	n.a.[a]	6.14E-06	1.20E-05
ICP	Instr. ch. Analogue pressure	S	24	3.10E+06	n.a.[a]	n.a.[a]	Y	2	6.45E-07	n.a.[a]	1.15E-07	2.03E-06

Text cont. on p. 163

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
ICP	Instr. ch. Analogue pressure	Y	1	9.42E+04	n.a.[a]	n.a.[a]	n.a.[a]	0	7.36E-06	n.a.[a]	n.a.[a]	3.18E-05
ICT	instr. ch. analogue temperature	TRIGA MARK-II	6	6.31E+04	n.a.[a]	n.a.[a]	F	1	1.58E-05	n.a.[a]	8.12E-07	7.51E-05
ICT	instr. ch. analogue temperature	TRIGA MARK-II	3	2.97E+05	n.a.[a]	n.a.[a]	F	3	1.01E-05	n.a.[a]	2.75E-06	2.61E-05
ICT	Instr. ch. analogue temperature	H	5	3.10E+05	n.a.[a]	n.a.[a]	F	12	3.87E-05	n.a.[a]	2.23E-05	6.27E-05
ICT	Instr. ch. analogue temperature	M	1	4.05E+04	n.a.[a]	n.a.[a]	F	13	3.21E-04	n.a.[a]	1.90E-04	5.11E-04
ICT	Instr. ch. analogue temperature	S	12	1.55E+06	n.a.[a]	n.a.[a]	F	6	3.87E-06	n.a.[a]	1.68E-06	7.64E-06
ICT	Instr. ch. analogue temperature	S	12	1.55E+06	n.a.[a]	n.a.[a]	Y	1	6.45E-07	n.a.[a]	3.31E-08	3.06E-06
ICT	Instr. ch. analogue temperature	Y	6	5.65E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	1.23E-06	n.a.[a]	n.a.[a]	5.30E-06
ICT	Instrumentation temperature	A	1	7.88E+04	n.a.[a]	n.a.[a]	F	1	1.27E-05	n.a.[a]	6.51E-07	6.02E-05
ICT	Instrumentation temperature	A	1	7.88E+04	n.a.[a]	n.a.[a]	F	1	1.27E-05	n.a.[a]	6.51E-07	6.02E-05

Text cont. on p. 164

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
ICT	Instrumentation channel temperature	C	190	1.66E+07	n.a.[a]	n.a.[a]	F	1	6.01E-08	n.a.[a]	3.08E-09	2.85E-07
ICT01	Instr. ch. analogue fuel temperature	TRIGA	3	1.90E+05	n.a.[a]	n.a.[a]	B	40	2.11E-04	n.a.[a]	1.59E-04	2.74E-04
ICT02	Instr. ch. analogue difference inlet-outlet pool water temperature	TRIGA	2	1.20E+05	n.a.[a]	n.a.[a]	B	16	1.33E-04	n.a.[a]	8.36E-05	2.03E-04
ICT03	Instr. ch. analogue outlet pool temperature	TRIGA	2	1.20E+05	n.a.[a]	n.a.[a]	B	20	1.67E-04	n.a.[a]	1.10E-04	2.42E-04
ICT04	Instr. ch. analogue pool temperature	TRIGA	2	1.20E+05	n.a.[a]	n.a.[a]	B	13	1.08E-04	n.a.[a]	6.41E-05	1.72E-04
IDT	Instrumentation channel digital-temporizer counter	BR04	4	n.a.[a]	1.53E+04	n.a.[a]	F	3	1.97E-04	n.a.[a]	5.36E-05	5.08E-04
JBM	Brake drum-movable reactor bridge	BR04	8	n.a.[a]	2.37E+01	n.a.[a]	F	1	4.22E-02	n.a.[a]	2.17E-03	2.00E-01
JEE	Clutch-shut off rod electrical	D	9	n.a.[a]	1.42E+06	2780	F	1	7.04E-07	3.60E-04	3.61E-08	3.34E-06
JEM	Clutch mechanical	S	48	6.20E+06	n.a.[a]	n.a.[a]	F	3	4.84E-07	n.a.[a]	1.32E-07	1.25E-06
JFT	Pneumatic fitting	TRIGA	2	1.75E+05	n.a.[a]	n.a.[a]	Y	9	5.14E-05	n.a.[a]	2.68E-05	8.97E-05
JGF	Floating core tools	AR3	5	6.13E+05	n.a.[a]	n.a.[a]	F	1	1.63E-06	n.a.[a]	8.36E-08	7.74E-06

Text cont. on p. 165

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
JIA	Irradiation container	CH	15	2.08E+05	n.a.[a]	n.a.[a]	X	2	9.62E-06	n.a.[a]	1.71E-06	3.03E-05
JIP	Pneumatic transfer system	TRIGA MARK-II	3	2.97E+05	n.a.[a]	n.a.[a]	Y	1	3.37E-06	n.a.[a]	1.73E-07	1.60E-05
JIP	Pneumatic transfer system	NRU	1	3.00E+05	n.a.[a]	n.a.[a]		0	2.31E-06	n.a.[a]	n.a.[a]	9.99E-06
JIP	Pneumatic transfer system	CH	1	1.39E+04	n.a.[a]	n.a.[a]	X	1	7.20E-05	n.a.[a]	3.69E-06	3.41E-04
JIP	Pneumatic transfer system	Y	1	9.42E+04	n.a.[a]	n.a.[a]	F	1	1.06E-05	n.a.[a]	5.45E-07	5.04E-05
JIP01	Pneumatic transfer system	S	4	5.17E+05	n.a.[a]	n.a.[a]	F	4	7.74E-06	n.a.[a]	2.64E-06	1.77E-05
JIP02	Pneumatic transfer system	S	1	1.29E+05	n.a.[a]	n.a.[a]	X	1	7.74E-06	n.a.[a]	3.97E-07	3.67E-05
JLC	Lube oil cooler	Y	3	2.83E+05	n.a.[a]	n.a.[a]		0	2.45E-06	n.a.[a]	n.a.[a]	1.06E-05
JLC01	Lube oil cooler	S	21	2.71E+06	n.a.[a]	n.a.[a]	R	4	1.47E-06	n.a.[a]	5.03E-07	3.37E-06
JLC02	Lube oil cooler	S	3	3.88E+05	n.a.[a]	n.a.[a]	Y	24	6.19E-05	n.a.[a]	4.27E-05	8.71E-05
JPP	Penetration piping	S	15	1.94E+06	n.a.[a]	n.a.[a]	F	1	5.16E-07	n.a.[a]	2.65E-08	2.45E-06
JPP	Penetration piping	Y	2	1.88E+05	n.a.[a]	n.a.[a]		0	3.68E-06	n.a.[a]	n.a.[a]	1.59E-05
JPP	Penetration for piping <= 400 mm	D	9	1.60E+06	n.a.[a]	n.a.[a]	Y	1	6.25E-07	n.a.[a]	3.21E-08	2.96E-06

Text cont. on p. 166

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
JRB	Crane bridge	AR6	1	1.75E+05	n.a.[a]	n.a.[a]		0	3.96E-06	n.a.[a]	n.a.[a]	1.71E-05
JRB	Crane bridge	TRIGA	1	n.a.[a]	1.75E+05	n.a.[a]	F	18	1.03E-04	n.a.[a]	6.65E-05	1.53E-04
JRB01	Crane bridge main	AR3	1	1.23E+05	n.a.[a]	n.a.[a]	F	1	8.15E-06	n.a.[a]	4.18E-07	3.87E-05
JRB02	Crane bridge	AR3	1	1.23E+05	n.a.[a]	n.a.[a]	F	1	8.15E-06	n.a.[a]	4.18E-07	3.87E-05
JRB03	Crane bridge	AR3	1	1.23E+05	n.a.[a]	n.a.[a]	F	9	7.34E-05	n.a.[a]	3.83E-05	1.28E-04
JRB04	Crane bridge	AR3	1	1.23E+05	n.a.[a]	n.a.[a]	F	3	2.45E-05	n.a.[a]	6.67E-06	6.32E-05
JTR	Storage tank	BR04	1	n.a.[a]	5.68E+02	n.a.[a]	Y	1	1.76E-03	n.a.[a]	9.03E-05	8.35E-03
JTR	Tank storage liquid r.a. Waste	TRIGA	8	1.40E+06	n.a.[a]	n.a.[a]	F	5	3.57E-06	n.a.[a]	1.41E-06	7.50E-06
JTR	Tank storage liquid r.a. Waste	TRIGA	8	1.40E+06	n.a.[a]	n.a.[a]	Y	3	2.14E-06	n.a.[a]	5.83E-07	5.53E-06
JTR	Tank storage liquid r.a. Waste	TRIGA	8	1.40E+06	n.a.[a]	n.a.[a]	Q	1	7.13E-07	n.a.[a]	3.66E-08	3.38E-06
JXT	Tele manipulator	AR3	2	2.45E+05	n.a.[a]	n.a.[a]	X	1	4.08E-06	n.a.[a]	2.09E-07	1.93E-05
JXT	Tele manipulator	AR3	2	2.45E+05	n.a.[a]	n.a.[a]	B	5	2.04E-05	n.a.[a]	8.03E-06	4.29E-05
KAA	Circuit breaker	AT	10	9.92E+05	n.a.[a]	n.a.[a]	F	2	2.02E-06	n.a.[a]	3.58E-07	6.35E-06
KAA	Circuit breaker	S	300	3.88E+07	n.a.[a]	n.a.[a]	F	4	1.03E-07	n.a.[a]	3.52E-08	2.36E-07
KAA	Circuit breaker	Y	126	1.19E+07	n.a.[a]	n.a.[a]	F	4	3.37E-07	n.a.[a]	1.15E-07	7.71E-07

Text cont. on p. 167

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
KAA	Circuit breaker	DALAT	13	n.a.[a]	2.15E+06	n.a.[a]		0	3.22E-07	n.a.[a]	- n.a.[a]	1.39E-06
KAC	Circuit breaker-protection	BR04	1	n.a.[a]	1.28E+04	n.a.[a]	K	2	1.56E-04	n.a.a	2.78E-05	4.93E-04
KAC	Circuit breaker	S	3	3.88E+05	n.a.[a]	n.a.[a]	F	1	2.58E-06	n.a.[a]	1.32E-07	1.22E-05
KAC	Circuit breaker	Y	68	6.40E+06	n.a.[a]	n.a.[a]	n.a.[a]	0	1.08E-07	n.a.[a]	n.a.[a]	4.68E-07
KIA	Circuit breaker indoor AC application	S	3	3.88E+05	n.a.[a]	n.a.[a]	F	1	2.58E-06	n.a.[a]	1.32E-07	1.22E-05
KIA	Circuit breaker indoor AC application	Y	24	2.26E+06	n.a.[a]	n.a.[a]	n.a.[a]	0	3.07E-07	n.a.[a]	n.a.[a]	1.33E-06
KIA01	Circuit breaker 22 kv main oil CB	D	8	1.40E+06	n.a.[a]	n.a.[a]	F	15	1.07E-05	n.a.[a]	6.60E-06	1.65E-05
KIA02	Circuit breaker 3.3 kv main oil CB	D	11	1.93E+06	n.a.[a]	n.a.[a]	F	32	1.66E-05	n.a.[a]	1.21E-05	2.23E-05
KIA03	Circuit breaker 415 VAC air cooled	D	16	2.80E+06	n.a.[a]	n.a.[a]	F	7.5	2.68E-06	n.a.[a]	1.30E-06	4.93E-06
KIS	Circuit breaker isolation, ground fault	S	8	1.03E+06	n.a.[a]	n.a.[a]	G	1	9.67E-07	n.a.[a]	4.96E-08	4.59E-06
KIS	Circuit breaker isolation, ground fault	Y	2	1.88E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	3.68E-06	n.a.[a]	n.a.[a]	1.59E-05
KRP	Circuit breaker reactor protection	TRIGA MARK-II	15	1.49E+06	n.a.[a]	n.a.[a]	F	40	2.69E-05	n.a.[a]	2.03E-05	3.50E-05

Text cont. on p. 168

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
KSF	Feeder (junction box)	S	1	1.29E+05	n.a.[a]	n.a.[a]	F	5	3.87E-05	n.a.[a]	1.52E-05	8.13E-05
KTA	Fuse all voltage levels	TRIGA MARK-II	20	6.89E+04	n.a.[a]	n.a.[a]	F	1	1.45E-05	n.a.[a]	7.45E-07	6.89E-05
KTA	Fuse all voltage levels	B	63	1.87E+06	n.a.[a]	n.a.[a]	F	2	1.07E-06	n.a.[a]	1.90E-07	3.36E-06
KTA	Fuse all voltage levels	S	180	2.33E+07	n.a.[a]	n.a.[a]	F	30	1.29E-06	n.a.[a]	9.28E-07	1.75E-06
KTA	Fuse all voltage levels	S	180	2.33E+07	n.a.[a]	n.a.[a]	H	1	4.30E-08	n.a.[a]	2.20E-09	2.04E-07
KTA	Fuse all voltage levels	S	180	2.33E+07	n.a.[a]	n.a.[a]	R	4	1.72E-07	n.a.[a]	5.87E-08	3.93E-07
KTA	Fuse all voltage levels	S	180	2.33E+07	n.a.[a]	n.a.[a]	S	6	2.58E-07	n.a.[a]	1.12E-07	5.09E-07
KTA	Fuse all voltage levels	Y	43	4.05E+06	n.a.[a]	n.a.[a]	n.a.[a]	0	1.71E-07	n.a.[a]	n.a.[a]	7.40E-07
KTA	Fuse all voltage levels	DALAT	3	n.a.[a]	4.97E+05	n.a.[a]	F	1	2.01E-06	n.a.[a]	1.03E-07	9.55E-06
LAA	Transmitter general	S	425	5.49E+07	n.a.[a]	n.a.[a]	F	1	1.82E-08	n.a.[a]	9.34E-10	8.64E-08
LAA	Transmitter general	Y	15	1.41E+06	n.a.[a]	n.a.[a]	n.a.[a]	0	4.91E-07	n.a.[a]	n.a.[a]	2.12E-06
LAA	Transmitter, general	DALAT	1	n.a.[a]	2.86E+04	n.a.[a]	n.a.[a]	0	2.42E-05	n.a.[a]	n.a.[a]	1.05E-04
LCA	Transmitter core flux	DALAT	9	n.a.[a]	n.a.[a]	15939	B	2	n.a.[a]	1.25E-04	2.23E-05	3.95E-04
LCA	Transmitter core flux	DALAT	9	n.a.[a]	2.58E+05	n.a.[a]	B	1	3.88E-06	n.a.[a]	1.99E-07	1.84E-05
LCA	Transmitter core flux	DALAT	9	n.a.[a]	2.58E+05	n.a.[a]	F	2	7.76E-06	n.a.[a]	1.38E-06	2.44E-05

Text cont. on p. 169

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
LFF	Transmitter flow	SI	1	n.a.[a]	2.00E+04	n.a.[a]	n.a.[a]	0	3.47E-05	n.a.[a]	n.a.[a]	1.50E-04
LFF01	Transmitter flow	DALAT	1	n.a.[a]	4.40E+04	n.a.a	B	1	2.27E-05	n.a.[a]	1.17E-06	1.08E-04
LFF01	Transmitter flow	DALAT	1	n.a.[a]	4.40E+04	n.a.[a]	F	3	6.82E-05	n.a.[a]	1.86E-05	1.76E-04
LFF02	Transmitter flow	DALAT	1	n.a.[a]	4.33E+04	n.a.[a]	F	5	1.16E-04	n.a.[a]	4.55E-05	2.43E-04
LLL	Transmitter level	SI	1	4.35E+04	n.a.[a]	n.a.[a]	F	1	2.30E-05	n.a.[a]	1.18E-06	1.09E-04
LLL	Transmitter level	DALAT	1	n.a.[a]	5.41E+04	n.a.[a]	B	2	3.70E-05	n.a.[a]	6.57E-06	1.16E-04
LLL	Transmitter level	DALAT	1	n.a.[a]	5.41E+04	n.a.[a]	F	3	5.55E-05	n.a.[a]	1.51E-05	1.43E-04
LTT	Transmitter temperature	S	124	1.60E+07	n.a.[a]	n.a.[a]	C	1	6.24E-08	n.a.[a]	3.20E-09	2.96E-07
LTT	Transmitter temperature	S	124	1.60E+07	n.a.[a]	n.a.[a]	F	1	6.24E-08	n.a.[a]	3.20E-09	2.96E-07
LTT	Transmitter temperature	Y	4	3.77E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	1.84E-06	n.a.[a]	n.a.[a]	7.95E-06
LPD	Transmitter pressure difference	BR01	4	n.a.[a]	3.08E+04	n.a.[a]	F	3	9.73E-05	n.a.[a]	2.65E-05	2.51E-04
LPD	Transmitter pressure difference	BR01	4	n.a.[a]	3.08E+04	n.a.[a]	N	1	3.24E-05	n.a.[a]	1.66E-06	1.54E-04
MAA	Motor	Y	8	7.53E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	9.20E-07	n.a.[a]	n.a.[a]	3.98E-06
MAA01	Motor	B	2	5.94E+04	n.a.[a]	n.a.[a]	S	2	3.37E-05	n.a.[a]	5.98E-06	1.06E-04
MAA02	Motor	B	2	5.94E+04	n.a.[a]	n.a.[a]	S	2	3.37E-05	n.a.[a]	5.98E-06	1.06E-04

Text cont. on p. 170

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
MAA01	Motor	S	135	1.74E+07	n.a.[a]	n.a.[a]	F	86	4.93E-06	n.a.[a]	4.09E-06	5.90E-06
MAA01	Motor	S	135	1.74E+07	n.a.[a]	n.a.[a]	H	2	1.15E-07	n.a.[a]	2.04E-08	3.61E-07
MAA01	Motor	S	135	1.74E+07	n.a.[a]	n.a.[a]	R	1	5.73E-08	n.a.[a]	2.94E-09	2.72E-07
MAA01	Motor	S	135	1.74E+07	n.a.[a]	n.a.[a]	S	1	5.73E-08	n.a.[a]	2.94E-09	2.72E-07
MAA01	Motor	S	135	1.74E+07	n.a.[a]	n.a.[a]	Y	2	1.15E-07	n.a.[a]	2.04E-08	3.61E-07
MAA02	Motor	S	110	1.42E+07	n.a.[a]	n.a.[a]	F	14	9.85E-07	n.a.[a]	5.95E-07	1.54E-06
MAA02	Motor	S	110	1.42E+07	n.a.[a]	n.a.[a]	S	1	7.03E-08	n.a.[a]	3.61E-09	3.34E-07
MAC	Motor ac	S	140	1.81E+07	n.a.[a]	n.a.[a]	F	7	3.87E-07	n.a.[a]	1.82E-07	7.27E-07
MAC	Motor ac	S	140	1.81E+07	n.a.[a]	n.a.[a]	R	2	1.11E-07	n.a.[a]	1.96E-08	3.48E-07
MAC	Motor ac	S	140	1.81E+07	n.a.[a]	n.a.[a]	Y	1	5.53E-08	n.a.[a]	2.83E-09	2.62E-07
MAC	Motor ac	Y	8	7.53E+05	n.a.[a]	n.a.[a]		0	9.20E-07	n.a.[a]	-	3.98E-06
MAC01	Motor AC for shutdown cooling pump	D	3	n.a.[a]	9.84E+04	n.a.[a]	R	3	3.05E-05	n.a.[a]	8.31E-06	7.88E-05
MAC02	Motor AC 3.3 kv 540 kw for primary cooling pump	D	3	3.00E+05	n.a.[a]	n.a.[a]	R	15	5.00E-05	n.a.[a]	3.08E-05	7.70E-05

Text cont. on p. 171

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
MAC03	Motor AC 3.3 kv 450 kw for secondary cooling pump	D	5	3.00E+05	n.a.[a]	n.a.[a]	R	37	1.23E-04	n.a.[a]	9.20E-05	1.62E-04
MAD	Motor generator set	NRU	2	n.a.[a]	2.10E+05	n.a.[a]	R	6	2.85E-05	n.a.[a]	1.24E-05	5.63E-05
MAI	Motor AC induction	S	48	6.20E+06	n.a.[a]	n.a.[a]	F	6	9.67E-07	n.a.[a]	4.21E-07	1.91E-06
MAI	Motor AC induction	S	48	6.20E+06	n.a.[a]	n.a.[a]	R	3	4.84E-07	n.a.[a]	1.32E-07	1.25E-06
MAI	Motor AC induction	Y	9	8.48E+05	n.a.[a]	n.a.[a]		0	8.18E-07	n.a.[a]	-	3.53E-06
MSS	Motor servo	S	8	1.03E+06	n.a.[a]	n.a.[a]	F	3	2.90E-06	n.a.[a]	7.91E-07	7.50E-06
MSS	Motor servo	Y	3	2.83E+05	n.a.[a]	n.a.[a]		0	2.45E-06	n.a.[a]	n.a.[a]	1.06E-05
NCA	Signal comparator bistable	AR6	21	n.a.[a]	3.50E+05	n.a.[a]	F	9	2.57E-05	n.a.[a]	1.34E-05	4.48E-05
NCA	Signal comparator bistable	H	1	6.21E+04	n.a.[a]	n.a.[a]	F	4	6.44E-05	n.a.[a]	2.20E-05	1.47E-04
NCA	Signal comparator bistable	CZ	17	n.a.[a]	1.07E+05	n.a.[a]	F	4	3.73E-05	n.a.[a]	–[b]	–[b]
NCB	Personal computer	Y	2	1.88E+05	n.a.[a]	n.a.[a]	F	1	5.31E-06	n.a.[a]	2.72E-07	2.52E-05
NCB	Personal computer	Y	2	1.88E+05	n.a.[a]	n.a.[a]	R	2	1.06E-05	n.a.[a]	1.89E-06	3.34E-05
NCB01	Personal computer	TRIGA MARK-II	1	6.16E+04	n.a.[a]	n.a.[a]	F	1	1.62E-05	n.a.[a]	8.32E-07	7.70E-05

Text cont. On p. 172

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
NCB02	Personal computer	TRIGA MARK-II	2	1.98E+05	n.a.[a]	n.a.[a]	B	2	1.01E-05	n.a.[a]	1.79E-06	3.18E-05
NCD	Data acquisition system	BR01	1	n.a.[a]	1.09E+04	n.a.[a]	F	3	2.76E-04	n.a.[a]	7.53E-05	7.14E-04
NCD	Data acquisition module	BR04	1	n.a.[a]	3.81E+03	n.a.[a]	F	1	2.62E-04	n.a.[a]	1.34E-05	1.24E-03
NCD	Data acquisition system	TRIGA	1	1.75E+05	n.a.[a]	n.a.[a]	F	84	4.80E-04	n.a.[a]	3.97E-04	5.75E-04
NCD	Data acquisition system	TRIGA	1	1.75E+05	n.a.[a]	n.a.[a]	X	3	1.71E-05	n.a.[a]	4.67E-06	4.43E-05
NCH	Computer	CZ	1	n.a.[a]	6E+03	n.a.[a]	F	1	1.587E-04	n.a.[a]		
NKA	Computational module	AR6	27	4.73E+06	n.a.[a]	n.a.[a]	n.a.[a]	0	1.47E-07	n.a.[a]	n.a.[a]	6.33E-07
NKA	Computational module	BR01	2	8.76E+04	n.a.[a]	n.a.[a]	F	9	1.03E-04	n.a.[a]	5.36E-05	1.79E-04
NKA	Computational module	BR01	2	8.76E+04	n.a.[a]	n.a.[a]	N	1	1.14E-05	n.a.[a]	5.86E-07	5.42E-05
NKA	Computational module	BR01	2	8.76E+04	n.a.[a]	n.a.[a]	K	1	1.14E-05	n.a.[a]	5.86E-07	5.42E-05
NKA	Computational module	S	3	3.88E+05	n.a.[a]	n.a.[a]	X	1	2.58E-06	n.a.[a]	1.32E-07	1.22E-05
NKA	Computational module	Y	2	1.88E+05	n.a.[a]	n.a.[a]	F	1	5.31E-06	n.a.[a]	2.72E-07	2.52E-05
NKA	Computational module	Y	2	1.88E+05	n.a.[a]	n.a.[a]	R	1	5.31E-06	n.a.[a]	2.72E-07	2.52E-05
NKA01	Computational module	TRIGA MARK-II	33	1.65E+06	n.a.[a]	n.a.[a]	F	22	1.33E-05	n.a.[a]	9.01E-06	1.90E-05
NKA02	Computational module	TRIGA MARK-II	5	5.97E+04	n.a.[a]	n.a.[a]	K	5	8.37E-05	n.a.[a]	3.30E-05	1.76E-04
NMA	Signal modifier	TRIGA MARK-II	1	2.06E+04	n.a.[a]	n.a.[a]	F	1	4.85E-05	n.a.[a]	2.49E-06	2.30E-04

Text cont. on p. 173

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
NMA	Signal modifier	TRIGA MARK-II	1	9.41E+03	n.a.[a]	n.a.[a]	K	1	1.06E-04	n.a.[a]	5.45E-06	5.04E-04
NMA	Signal modifier voltage-pneumatic	S	3	3.88E+05	n.a.[a]	n.a.[a]	F	2	5.16E-06	n.a.[a]	9.17E-07	1.62E-05
NMA	Signal modifier	SI	1	n.a.[a]	2.00E+04	n.a.[a]	n.a.[a]	0	3.47E-05	n.a.[a]	n.a.[a]	1.50E-04
NMM	Median selector	AR6	3	5.26E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	1.32E-06	n.a.[a]	n.a.[a]	5.70E-06
NMR	Resistance-voltage transducer	AR6	6	1.05E+06	n.a.[a]	n.a.[a]	n.a.[a]	0	6.59E-07	n.a.[a]	n.a.[a]	2.85E-06
NMS	Square root extractor	AR6	4	7.01E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	9.89E-07	n.a.[a]	n.a.[a]	4.27E-06
NMV	Current-voltage transducer	AR6	7	1.23E+06	n.a.[a]	n.a.[a]	n.a.[a]	0	5.65E-07	n.a.[a]	n.a.[a]	2.44E-06
NMV	Transducer	B	17	5.05E+05	n.a.[a]	n.a.[a]	F	1	1.98E-06	n.a.[a]	1.02E-07	9.39E-06
NMX	Multiplier	AR6	1	1.75E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	3.96E-06	n.a.[a]	n.a.[a]	1.71E-05
NSA	Signal conditioning system for core flux, level	S	2	258480.00	n.a.[a]	n.a.[a]	F	2	7.74E-06	n.a.[a]	1.37E-06	2.44E-05
NSA01	Signal conditioning system for core flux, level, pressure, temperature general	TRIGA MARK-II	2	6.08E+04	n.a.[a]	n.a.[a]	B	2	3.29E-05	n.a.[a]	5.85E-06	1.04E-04

Text cont. on p. 174

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
NSA01	Signal conditioning system, flux, level, pressure, temp.	TRIGA MARK-II	2	2.54E+04	n.a.[a]	n.a.[a]	F	2	7.88E-05	n.a.[a]	1.40E-05	2.48E-04
NSA02	Signal conditioning system, flux, level, pressure, temp.	TRIGA MARK-II	3	3.16E+04	n.a.[a]	n.a.[a]	K	3	9.48E-05	n.a.[a]	2.59E-05	2.45E-04
NSC	Sign. cond.sys. Flux	B	2	5.94E+04	n.a.[a]	n.a.[a]	F	3	5.05E-05	n.a.[a]	1.38E-05	1.30E-04
NSC	Sign. cond. Sys. Flow	S	12	1.55E+06	n.a.[a]	n.a.[a]	F	1	6.45E-07	n.a.[a]	3.31E-08	3.06E-06
NSC	Sign. cond. Sys. Flux	S	12	1.55E+06	n.a.[a]	n.a.[a]	X	1	6.45E-07	n.a.[a]	3.31E-08	3.06E-06
NSC	Sign. cond. Sys. Flux	Y	2	1.88E+05	n.a.[a]	n.a.[a]	F	1	5.31E-06	n.a.[a]	2.72E-07	2.52E-05
NSC	Sign. cond. Sys. Flux	Y	2	1.88E+05	n.a.[a]	n.a.[a]	R	1	5.31E-06	n.a.[a]	2.72E-07	2.52E-05
NSC	Sign. cond. Sys. Flux	DALAT	1	n.a.[a]	2.86E+04	n.a.[a]	B	18	6.29E-04	n.a.[a]	4.06E-04	9.32E-04
NSC	Sign. cond. Sys. Flux	DALAT	1	n.a.[a]	2.86E+04	n.a.[a]	F	1	3.49E-05	n.a.[a]	1.79E-06	1.66E-04
NSF	Sign. cond. Sys. Flow	Y	2	1.88E+05	n.a.[a]	n.a.[a]	F	1	5.31E-06	n.a.[a]	2.72E-07	2.52E-05
NSF	Sign. cond. Sys. Flow	Y	2	1.88E+05	n.a.[a]	n.a.[a]	L	1	5.31E-06	n.a.[a]	2.72E-07	2.52E-05
OCC	Control rod cruciform, boron	S	8	1.03E+06	n.a.[a]	n.a.[a]	M	1	9.67E-07	n.a.[a]	4.96E-08	4.59E-06
OCR	Control rod single control rod assembly	TRIGA MARK-II	3	2.97E+05	n.a.[a]	n.a.[a]	M	2	6.73E-06	n.a.[a]	1.20E-06	2.12E-05

Text cont. on p. 175

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	**Component Population**	**Cumulative calendar time**	**Cumulative operating time**	**Demands**	**Failure mode**	**Failures**	**Failure rate**	**Failure probability**	**90% Confidence bounds**	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
OCR	Control rod single control rod assembly	M	11	7.37E+05	n.a.[a]	n.a.[a]	M	14	1.90E-05	n.a.[a]	1.15E-05	2.97E-05
OCR	Control rod single, control rod assembly	TRIGA	8/6	n.a.[a]	4.86E+05	n.a.[a]	M	47	9.67E-05	n.a.[a]	7.47E-05	1.23E-04
OCR	Control rod	A	4	–[b]	–[b]	380	M	0	n.a.[a]	1.82E-03	n.a.[a]	7.85E-03
OCR	Shut off rod-boron	C	6	–[b]	–[b]	2485	F	0	n.a.[a]	2.79E-04	n.a.[a]	1.20E-03
OCR01	Snubber-shutoff rod	D	9	–[b]	–[b]	2780	C	3	n.a.[a]	1.08E-03	2.94E-04	2.79E-03
OCR02	Clutch-shut off rod electrical-slippage	D	9	1.34E+06	n.a.[a]	n.a.[a]	K	1	7.46E-07	n.a.[a]	3.83E-08	3.54E-06
OCR01	Safety rod-single rod assembly	BR01	3	n.a.[a]	3.13E+04	n.a.[a]	M	3	9.57E-05	n.a.[a]	2.61E-05	2.47E-04
OCR01	Control rod single, control rod assembly	DALAT	1	n.a.[a]	2.86E+04	n.a.[a]	M	0	2.42E-05	n.a.[a]	-	1.05E-04
OCR02	Control rod-single rod assembly	BR01	1	n.a.[a]	1.04E+04	n.a.[a]	M	2	1.91E-04	n.a.[a]	3.40E-05	6.03E-04
OCR02	Control rod single, control rod assembly	DALAT	6	n.a.[a]	1.72E+05	n.a.[a]	M	0	4.04E-06	n.a.[a]	-	1.74E-05

Text cont. on p. 176

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
OCS	Shut off rod mechanical failure to drop	NRU	18	–[b]	–[b]	2.10E+05	F	1	n.a.[a]	4.76E-06	2.44E-07	2.26E-05
OCS	Control rod clustered silver, indium, cadmium control rod	M	1	n.a.[a]	6.70E+04	n.a.[a]	F	1	1.49E-05	n.a.[a]	7.66E-07	7.08E-05
OCS	Control rod clustered silver, indium, cadmium control rod	CZ	12	n.a.[a]	7.6E+04	n.a.[a]	C	10	1.323E-04	n.a.[a]		
ORA	Control rod drive	AR3	4	n.a.[a]	1.84E+05	n.a.[a]	M	6	3.26E-05	n.a.[a]	1.42E-05	6.42E-05
ORA	Control rod drive	AR3	4	n.a.[a]	1.84E+05	n.a.[a]	K	6	3.26E-05	n.a.[a]	1.42E-05	6.42E-05
ORA	Control rod drive	AR6	5	n.a.[a]	8.34E+04	n.a.[a]		0	8.31E-06	n.a.[a]	n.a.[a]	3.59E-05
ORA	Control rod drive	TRIGA MARK-II	2	3.40E+04	n.a.[a]	n.a.[a]	M	2	5.89E-05	n.a.[a]	1.05E-05	1.85E-04
ORA	Control rod drive	TRIGA MARK-II	3	2.97E+05	n.a.[a]	n.a.[a]	M	2	6.73E-06	n.a.[a]	1.20E-06	2.12E-05
ORA	Control rod drive	NRU	18	3.10E+05	n.a.[a]	n.a.[a]	F	7	2.26E-05	n.a.[a]	1.06E-05	4.24E-05
ORA	Control rod drive	H	12	n.a.[a]	7.54E+05	n.a.[a]	F	11	1.46E-05	n.a.[a]	8.18E-06	2.41E-05
ORA	Control rod drive	M	11	n.a.[a]	3.38E+05	n.a.[a]	S	2	5.92E-06	n.a.[a]	1.05E-06	1.86E-05
ORA	Control rod drive	M	11	n.a.[a]	3.38E+05	n.a.[a]	F	8	2.37E-05	n.a.[a]	1.18E-05	4.27E-05
ORA	Control rod drive	B	4	1.19E+05	n.a.[a]	n.a.[a]	F	4	3.37E-05	n.a.[a]	1.15E-05	7.70E-05
ORA	Control rod drive	S	9	1.16E+06	n.a.[a]	n.a.[a]	F	17	1.46E-05	n.a.[a]	9.31E-06	2.19E-05

Text cont. on p. 177

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
ORA	Control rod drive	S	9	1.16E+06	n.a.[a]	n.a.[a]	X	1	8.60E-07	n.a.[a]	4.41E-08	4.08E-06
ORA	Control rod drive	Y	3	2.83E+05	n.a.[a]	n.a.[a]	F	9	3.19E-05	n.a.[a]	1.66E-05	5.56E-05
ORA	Control rod drive	Y	3	2.83E+05	n.a.[a]	n.a.[a]	S	1	3.54E-06	n.a.[a]	1.82E-07	1.68E-05
ORA	Control rod drive	TRIGA	8/6	n.a.[a]	4.86E+05	n.a.[a]	C	3	6.17E-06	n.a.[a]	1.68E-06	1.60E-05
ORA	Control rod drive	TRIGA	8/6	–[b]	–[b]	7442	B	96	n.a.[a]	1.29E-02	1.08E-02	1.53E-02
ORA	Control rod drive	TRIGA	8/6	–[b]	–[b]	13493	F	60	n.a.[a]	4.45E-03	3.55E-03	5.51E-03
ORA	Control rod drive	TRIGA	8/6	n.a.[a]	4.86E+05	n.a.[a]	M	22	4.53E-05	n.a.[a]	3.06E-05	6.46E-05
ORA01	Control rod drive	DALAT	1	n.a.[a]	2.86E+04	n.a.[a]	C	5	1.75E-04	n.a.[a]	6.88E-05	3.67E-04
ORA02	Control rod drive	DALAT	4	n.a.[a]	1.15E+05	n.a.[a]	C	4	3.49E-05	n.a.[a]	1.19E-05	7.99E-05
ORA02	Control rod drive	DALAT	4	n.a.[a]	1.15E+05	n.a.[a]	F	1	8.73E-06	n.a.[a]	4.48E-07	4.14E-05
ORA03	Control rod drive	DALAT	2	n.a.[a]	5.73E+04	n.a.[a]	C	4	6.99E-05	n.a.[a]	2.39E-05	1.60E-04
PDA	Pump diesel driven	S	3	3.88E+05	n.a.[a]	n.a.[a]	S	1	2.58E-06	n.a.[a]	1.32E-07	1.22E-05
PMA	Pump motor driven	M	2	2.84E+04	n.a.[a]	n.a.[a]	R	2	7.05E-05	n.a.[a]	1.25E-05	2.22E-04
PMA	Pump motor driven	M	2	2.84E+04	n.a.[a]	n.a.[a]	n.a.[a]	0	2.44E-05	n.a.[a]	n.a.[a]	1.06E-04
PMA	Pump motor driven	B	4	1.19E+05	n.a.[a]	n.a.[a]	F	20	1.68E-04	n.a.[a]	1.12E-04	2.45E-04
PMA	Pump motor driven	Y	5	4.71E+05	n.a.[a]	n.a.[a]	R	3	6.37E-06	n.a.[a]	1.74E-06	1.65E-05

Text cont. on p. 178

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
PMA	Pump motor driven	Y	5	4.71E+05	n.a.[a]	n.a.[a]	F	2	4.25E-06	n.a.[a]	7.55E-07	1.34E-05
PMA	Pump motor driven	SI	1	n.a.[a]	2.00E+04	n.a.[a]	R	1	5.00E-05	n.a.[a]	2.56E-06	2.37E-04
PMA01	Pump motor driven	AR3	2	n.a.[a]	7.49E+04	n.a.[a]	X	13	1.74E-04	n.a.[a]	1.03E-04	2.76E-04
PMA01	Pump motor driven	AR3	2	n.a.[a]	7.49E+04	n.a.[a]	Y	1	1.34E-05	n.a.[a]	6.85E-07	6.34E-05
PMA01	Pump motor driven	AR3	2	n.a.[a]	7.49E+04	n.a.[a]	R	2	2.67E-05	n.a.[a]	4.75E-06	8.41E-05
PMA01	Pump motor driven	AR3	2	–[b]	–[b]	364	S	3	n.a.[a]	8.24E-03	2.25E-03	2.12E-02
PMA01	Pump motor driven	TRIGA MARK-II	1	1.26E+05	n.a.[a]	n.a.[a]	F	1	7.94E-06	n.a.[a]	4.07E-07	3.77E-05
PMA01	Pump motor driven	TRIGA MARK-II	1	7.21E+04	n.a.[a]	n.a.[a]	R	1	1.39E-05	n.a.[a]	7.11E-07	6.58E-05
PMA01	D_2O main pump-motor operated	HIFAR	3	n.a.[a]	1.82E+05	n.a.[a]	B	8	4.40E-05	n.a.[a]	2.19E-05	7.93E-05
PMA01	D_2O main pump-motor operated	HIFAR	3	n.a.[a]	1.82E+05	n.a.[a]	R	2	1.10E-05	n.a.[a]	1.95E-06	3.46E-05
PMA01	D_2O main pump-motor operated	HIFAR	3	n.a.[a]	1.82E+05	n.a.[a]	Y	2	1.10E-05	n.a.[a]	1.95E-06	3.46E-05
PMA01	D_2O main pump-motor operated	HIFAR	3	–[b]	–[b]	629	S	3	n.a.[a]	4.77E-03	1.30E-03	1.23E-02
PMA01	Pump motor driven-primary cooling	BR01	2	n.a.[a]	1.03E+04	n.a.[a]	Y	7	6.81E-04	n.a.[a]	3.20E-04	1.28E-03

Text cont. on p. 179

[a] n.a.: not applicable

[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
PMA01	Pump motor driven-primary cooling	BR01	2	n.a.[a]	1.03E+04	n.a.[a]	B	9	8.75E-04	n.a.[a]	4.57E-04	1.53E-03
PMA01	Pump motor driven-primary cooling	BR01	2	n.a.[a]	1.03E+04	n.a.[a]	R	1	9.73E-05	n.a.[a]	4.99E-06	4.61E-04
PMA01	Chilled water pump-motor operated	BR04	2	n.a.[a]	3.81E+03	n.a.[a]	Y	15	3.93E-03	n.a.[a]	2.42E-03	6.06E-03
PMA01	Main coolant pump DC motors (start)	NRU	4	–[b]	–[b]	1.48E+03	S	7	n.a.[a]	4.72E-03	2.22E-03	8.84E-03
PMA01	Main coolant pump DC motors (run)	NRU	4	n.a.[a]	9.41E+02	n.a.[a]	R	3	3.19E-03	n.a.[a]	8.69E-04	8.24E-03
PMA01	Pump motor driven	CZ	9	n.a.[a]	5.7E+04	n.a.[a]	R	5	8.82E-05	n.a.[a]	–[b]	–[b]
PMA01	Pump motor driven	CZ	9	n.a.[a]	5.7E+04	n.a.[a]	H	1	1.76E-05	n.a.[a]	–[b]	–[b]
PMA01	Pump motor driven	CZ	9	n.a.[a]	5.7E+04	n.a.[a]	I	1	1.76E-05	n.a.[a]	–[b]	–[b]
PMA01	Pump motor driven	S	7	9.05E+05	n.a.[a]	n.a.[a]	F	0	7.66E-07	n.a.[a]	n.a.[a]	3.31E-06
PMA01	Pump primary coolant	A	3	2.37E+05	n.a.[a]	n.a.[a]	F	2	8.46E-06	n.a.[a]	1.50E-06	2.66E-05
PMA01	Pump motor driven, emergency pump	TRIGA	1	n.a.[a]	5.00E+04	n.a.[a]	F	17	3.40E-04	n.a.[a]	2.17E-04	5.10E-04
PMA01	Pump motor driven, emergency pump	TRIGA	1	n.a.[a]	5.00E+04	n.a.[a]	R	8	1.60E-04	n.a.[a]	7.96E-05	2.89E-04

Text cont. on p. 180

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
PMA01	Pump motor driven, emergency pump	TRIGA	1	n.a.[a]	5.00E+04	n.a.[a]	S	6	1.20E-04	n.a.[a]	5.23E-05	2.37E-04
PMA01	Pump motor driven, emergency pump	TRIGA	1	n.a.[a]	5.00E+04	n.a.[a]	B	2	4.00E-05	n.a.[a]	7.11E-06	1.26E-04
PMA01	Pump motor driven	DALAT	2/1	–[b]	–[b]	2449	H	1	n.a.[a]	4.08E-04	2.09E-05	1.94E-03
PMA01	Pump motor driven	DALAT	2/1	n.a.[a]	3.17E+04	n.a.[a]	R	1	3.15E-05	n.a.[a]	1.62E-06	1.50E-04
PMA02	Pump motor driven	TRIGA MARK-II	1	9.90E+04	n.a.[a]	n.a.[a]	F	1	1.01E-05	n.a.[a]	5.18E-07	4.79E-05
PMA02	D_2O shutdown pump-motor operated	HIFAR	2	n.a.[a]	5.40E+04	n.a.[a]	B	1	1.85E-05	n.a.[a]	9.50E-07	8.78E-05
PMA02	D_2O shutdown pump-motor operated	HIFAR	2	n.a.[a]	5.40E+04	n.a.[a]	R	2	3.70E-05	n.a.[a]	6.58E-06	1.17E-04
PMA02	Pump motor driven-secondary cooling	BR01	2	n.a.[a]	1.03E+04	n.a.[a]	Y	5	4.86E-04	n.a.[a]	1.92E-04	1.02E-03
PMA02	Pump motor driven-secondary cooling	BR01	2	n.a.[a]	1.03E+04	n.a.[a]	B	3	2.92E-04	n.a.[a]	7.95E-05	7.54E-04
PMA02	Chilled water pump-motor operated	BR04	2	n.a.[a]	3.81E+03	n.a.[a]	Y	12	3.15E-03	n.a.[a]	1.82E-03	5.10E-03
PMA02	Main coolant pump AC motors (start)	NRU	8	–[b]	–[b]	5.46E+03	S	53	n.a.[a]	9.71E-03	7.63E-03	1.22E-02

Text cont. on p. 181

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
PMA02	Pump motor driven	S	10	1.29E+06	n.a.[a]	n.a.[a]	F	4	3.10E-06	n.a.[a]	1.06E-06	7.08E-06
PMA02	Pump motor driven	S	10	1.29E+06	n.a.[a]	n.a.[a]	R	4	3.10E-06	n.a.[a]	1.06E-06	7.08E-06
PMA02	Pump secondary coolant	A	2	1.58E+05	n.a.[a]	n.a.[a]	F	6	3.81E-05	n.a.[a]	1.66E-05	7.51E-05
PMA02	Pump motor driven, centrifugal, main circulating pump	TRIGA	4	n.a.[a]	1.12E+05	n.a.[a]	F	26	2.32E-04	n.a.[a]	1.63E-04	3.22E-04
PMA02	Pump motor driven, centrifugal, main circulating pump	TRIGA	4	n.a.[a]	1.12E+05	n.a.[a]	S	22	1.96E-04	n.a.[a]	1.33E-04	2.80E-04
PMA02	Pump motor driven, centrifugal, main circulating pump	TRIGA	4	n.a.[a]	1.12E+05	n.a.[a]	R	29	2.59E-04	n.a.[a]	1.85E-04	3.53E-04
PMA02	Pump motor driven, centrifugal, main circulating pump	TRIGA	4	n.a.[a]	1.12E+05	n.a.[a]	E	6	5.36E-05	n.a.[a]	2.33E-05	1.06E-04
PMA02	Pump motor driven, centrifugal, main circulating pump	TRIGA	4	n.a.[a]	1.12E+05	n.a.[a]	Y	20	1.79E-04	n.a.[a]	1.18E-04	2.59E-04
PMA02	Pump motor driven	DALAT	2/1	n.a.[a]	3.17E+04	n.a.[a]	F	2	6.31E-05	n.a.[a]	1.12E-05	1.98E-04
PMA02	Pump motor driven	DALAT	2/1	n.a.[a]	3.17E+04	n.a.[a]	R	7	2.21E-04	n.a.[a]	1.04E-04	4.15E-04

Text cont. on p. 182

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
PMA02	Pump motor driven	DALAT	2/1	–[a]	–[b]	2449	S	4	n.a.[a]	1.63E-03	5.58E-04	3.73E-03
PMA03	D_2O scavenge pumps-motor operated	HIFAR	2	2.32E+05	n.a.[a]	n.a.[a]	B	1	4.31E-06	n.a.[a]	2.21E-07	2.04E-05
PMA03	D_2O scavenge pumps-motor operated	HIFAR	2	2.32E+05	n.a.[b]	n.a.[a]	Y	2	8.62E-06	n.a.[a]	1.53E-06	2.71E-05
PMA03	Pump motor driven	BR01	2	n.a.[a]	2.19E+04	n.a.[a]	R	2	9.13E-05	n.a.[a]	1.62E-05	2.87E-04
PMA03	Pump motor driven	BR01	2	n.a.[a]	2.19E+04	n.a.[a]	B	2	9.13E-05	n.a.[a]	1.62E-05	2.87E-04
PMA03	Chilled water pump-motor operated	BR04	2	n.a.[a]	3.81E+03	n.a.[a]	Y	2	5.24E-04	n.a.[a]	9.32E-05	1.65E-03
PMA03	Purification system pump motors	NRU	2	n.a.[a]	1.40E+05	n.a.[a]	R	5	3.57E-05	n.a.[a]	1.41E-05	7.51E-05
PMA03	Pump motor driven	S	4	5.17E+05		n.a.[a]	F	4	7.74E-06	n.a.[a]	2.64E-06	1.77E-05
PMA03	Secondary circuit pump	TRIGA	3	n.a.[a]	1.12E+05	n.a.[a]	F	16	1.43E-04	n.a.[a]	8.96E-05	2.17E-04
PMA03	Secondary circuit pump	TRIGA	3	n.a.[a]	1.12E+05	n.a.[a]	R	2	1.79E-05	n.a.[a]	3.17E-06	5.62E-05
PMA03	Secondary circuit pump	TRIGA	3	n.a.[a]	1.12E+05	n.a.[a]	S	8	7.14E-05	n.a.[a]	3.55E-05	1.29E-04
PMA03	Secondary circuit pump	TRIGA	3	n.a.[a]	1.12E+05	n.a.[a]	Y	3	2.68E-05	n.a.[a]	7.30E-06	6.92E-05
PMA03	Pump motor driven	DALAT	2/1	n.a.[a]	3.09E+04	n.a.[a]	F	1	3.23E-05	n.a.[a]	1.66E-06	1.53E-04

Text cont. on p. 183

[a] –: data not available

[b] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
PMA04	H_2O main pumps-motor operated	HIFAR	4	n.a.[a]	2.72E+05	n.a.[a]	B	40	1.47E-04	n.a.[a]	1.11E-04	1.91E-04
PMA04	H_2O main pumps-motor operated	HIFAR	4	n.a.[a]	2.72E+05	n.a.[a]	R	14	5.15E-05	n.a.[a]	3.11E-05	8.05E-05
PMA04	H_2O main pumps-motor operated	HIFAR	4	n.a.[a]	2.72E+05	n.a.[a]	Y	13	4.78E-05	n.a.[a]	2.83E-05	7.60E-05
PMA04	H_2O main pumps-motor operated	HIFAR	4	–[b]	–[b]	944	S	16	n.a.[a]	1.69E-02	1.07E-02	2.56E-02
PMA04	Feed water pump-motor operated	BR04	1	n.a.[a]	5.68E+02	n.a.[a]	Y	3	5.28E-03	n.a.[a]	1.44E-03	1.37E-02
PMA04	Pump motor driven	S	2	2.58E+05	n.a.[a]	n.a.[a]	X	3	1.16E-05	n.a.[a]	3.16E-06	3.00E-05
PMA04	Pump motor driven	S	2	2.58E+05	n.a.[a]	n.a.[a]	Y	6	2.32E-05	n.a.[a]	1.01E-05	4.58E-05
PMA04	Pump motor driven	S	2	2.58E+05	n.a.[a]	n.a.[a]	F	3	1.16E-05	n.a.[a]	3.16E-06	3.00E-05
PMA04	Pump motor driven	S	2	2.58E+05	n.a.[a]	n.a.[a]	E	1	3.87E-06	n.a.[a]	1.98E-07	1.84E-05
PMA04	Centrifugal purification system pump	TRIGA	3	1.75E+05	n.a.[a]	n.a.[a]	F	23	1.31E-04	n.a.[a]	8.98E-05	1.86E-04
PMA04	Centrifugal purification system pump	TRIGA	3	1.75E+05	n.a.[a]	n.a.[a]	Y	3	1.71E-05	n.a.[a]	4.67E-06	4.43E-05

Text cont. on p. 184

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
PMA04	Centrifugal purification system pump	TRIGA	3	1.75E+05	n.a.[a]	n.a.[a]	R	2	1.14E-05	n.a.[a]	2.03E-06	3.60E-05
PMA04	Centrifugal purification system pump	TRIGA	3	1.75E+05	n.a.[a]	n.a.[a]	S	1	5.71E-06	n.a.[a]	2.93E-07	2.71E-05
PMA04	Centrifugal purification system pump	TRIGA	3	1.75E+05	n.a.[a]	n.a.[a]	B	16	9.14E-05	n.a.[a]	5.73E-05	1.39E-04
PMA04	Pump motor driven	DALAT	2	n.a.[a]	3.09E+04	n.a.[a]	R	1	3.23E-05	n.a.[a]	1.66E-06	1.53E-04
PMA05	H_2O shutdown pumps	HIFAR	2	n.a.[a]	3.10E+04	n.a.[a]	B	20	6.45E-04	n.a.[a]	4.28E-04	9.37E-04
PMA05	H_2O shutdown pumps	HIFAR	2	n.a.[a]	3.10E+04	n.a.[a]	Y	2	6.45E-05	n.a.[a]	1.15E-05	2.03E-04
PMA05	Critical cell drain pump-motor operated	BR04	1	n.a.[a]	1.00E+02	n.a.[a]	R	1	1.00E-02	n.a.[a]	5.13E-04	4.74E-02
PMA05	Pump motor driven	S	2	2.58E+05	n.a.[a]	n.a.[a]	Y	11	4.26E-05	n.a.[a]	2.39E-05	7.04E-05
PMA05	Pump motor driven	S	2	2.58E+05	n.a.[a]	n.a.[a]	F	5	1.93E-05	n.a.[a]	7.62E-06	4.07E-05
PMA05	Centrifugal radioactive waste system pump	TRIGA	4	1.75E+05	n.a.[a]	n.a.[a]	F	37	2.11E-04	n.a.[a]	1.58E-04	2.78E-04
PMA05	Centrifugal radioactive waste system pump	TRIGA	4	1.75E+05	n.a.[a]	n.a.[a]	Y	1	5.71E-06	n.a.[a]	2.93E-07	2.71E-05
PMA05	Centrifugal radioactive waste system pump	TRIGA	4	1.75E+05	n.a.[a]	n.a.[a]	R	4	2.29E-05	n.a.[a]	7.81E-06	5.23E-05

Text cont. on p. 185

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
PMA05	Centrifugal radioactive waste system pump	TRIGA	4	1.75E+05	n.a.[a]	n.a.[a]	S	4	2.29E-05	n.a.[a]	7.81E-06	5.23E-05
PMA05	Centrifugal radioactive waste system pump	TRIGA	4	1.75E+05	n.a.[a]	n.a.[a]	B	18	1.03E-04	n.a.[a]	6.65E-05	1.53E-04
PMA06	Pump motor driven	DALAT	1	n.a.[a]	8.45E+03	n.a.[a]	n.a.[a]	0	8.20E-05	n.a.[a]	n.a.[a]	3.54E-04
PMA07	Pump motor driven	S	3	3.88E+05	n.a.[a]	n.a.[a]	F	10	2.58E-05	n.a.[a]	1.40E-05	4.37E-05
PMT	Pump motor & turbine driven 10 kw	D	3	n.a.[a]	1.47E+05	3840	S	1	6.81E-06	2.60E-04	3.50E-07	3.23E-05
PMT	Pump motor & turbine driven	D	3	n.a.[a]	1.47E+05	n.a.[a]	R	4	2.73E-05	n.a.[a]	9.31E-06	6.24E-05
PTA	Hydraulic turbine shutdown cooling pump	D	3	n.a.[a]	4.89E+04	n.a.[a]	R	1	2.04E-05	n.a.[a]	1.05E-06	9.70E-05
PWB	Pump horizontal.	TRIGA MARK-II	1	9.90E+04	n.a.[a]	n.a.[a]	R	1	1.01E-05	n.a.[a]	5.18E-07	4.79E-05
PWB	Pump horizontal.	CH	2	2.78E+04	n.a.[a]	n.a.[a]	R	1	3.60E-05	n.a.[a]	1.85E-06	1.71E-04
PWB	Pump horizontal.	M	1	1.00E+03	n.a.[a]	n.a.[a]	R	1	1.00E-03	n.a.[a]	5.13E-05	4.74E-03
PWB	Pump horizontal.	S	3	3.88E+05	n.a.[a]	n.a.[a]	F	2	5.16E-06	n.a.[a]	9.17E-07	1.62E-05
PWB	Pump horizontal.	S	3	3.88E+05	n.a.[a]	n.a.[a]	R	6	1.55E-05	n.a.[a]	6.74E-06	3.05E-05
PWB	Pump horizontal.	S	3	3.88E+05	n.a.[a]	n.a.[a]	S	2	5.16E-06	n.a.[a]	9.17E-07	1.62E-05

Text cont. on p. 186

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
PWB	Pump horizontal.	S	3	3.88E+05	n.a.[a]	n.a.[a]	Y	3	7.74E-06	n.a.[a]	2.11E-06	2.00E-05
PWC	Main coolant pumps	NRU	8	n.a.[a]	1.25E+06	n.a.[a]	Y	11	8.82E-06	n.a.[a]	4.95E-06	1.46E-05
PWC	Main coolant pump	NRU	8	n.a.[a]	1.25E+06	n.a.[a]	R	79	6.34E-05	n.a.[a]	5.21E-05	7.64E-05
PWC	Pump centrifugal	CH	1	1.39E+04	n.a.[a]	n.a.[a]	F	1	7.20E-05	n.a.[a]	3.69E-06	3.41E-04
PWC	Pump centrifugal	CH	1	1.39E+04	n.a.[a]	n.a.[a]	R	1	7.20E-05	n.a.[a]	3.69E-06	3.41E-04
PWC	Pump centrifugal	M	4	n.a.[a]	2.91E+05	n.a.[a]	R	39	1.34E-04	n.a.[a]	1.01E-04	1.75E-04
PWC	Pump centrifugal	M	4	n.a.[a]	2.91E+05	n.a.[a]	S	8	2.75E-05	n.a.[a]	1.37E-05	4.97E-05
PWC	Pump centrifugal	B	2	5.94E+04	n.a.[a]	n.a.[a]	F	1	1.68E-05	n.a.[a]	8.63E-07	7.98E-05
PWC	Pump centrifugal	B	2	5.94E+04	n.a.[a]	n.a.[a]	R	2	3.37E-05	n.a.[a]	5.98E-06	1.06E-04
PWC	Pump centrifugal	B	2	5.94E+04	n.a.[a]	n.a.[a]	S	1	1.68E-05	n.a.[a]	8.63E-07	7.98E-05
PWC	Pump centrifugal	B	2	5.94E+04	n.a.[a]	n.a.[a]	Y	1	1.68E-05	n.a.[a]	8.63E-07	7.98E-05
PWC	Pump centrifugal	S	6	7.75E+05	n.a.[a]	n.a.[a]	F	5	6.45E-06	n.a.[a]	2.54E-06	1.36E-05
PWC	Pump centrifugal	S	6	7.75E+05	n.a.[a]	n.a.[a]	Y	6	7.74E-06	n.a.[a]	3.37E-06	1.53E-05
PWC	Pump centrifugal	Y	5	4.71E+05	n.a.[a]	n.a.[a]	D	1	2.12E-06	n.a.[a]	1.09E-07	1.01E-05
PWC	Pump centrifugal	Y	5	4.71E+05	n.a.[a]	n.a.[a]	Y	4	8.49E-06	n.a.[a]	2.90E-06	1.94E-05
PWC	Pump centrifugal	Y	5	4.71E+05	n.a.[a]	n.a.[a]	S	2	4.25E-06	n.a.[a]	7.55E-07	1.34E-05

Text cont. on p. 187

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
PWC	Pump centrifugal	Y	5	4.71E+05	n.a.[a]	n.a.[a]	R	7	1.49E-05	n.a.[a]	6.98E-06	2.79E-05
PWC	Pump centrifugal	Y	5	4.71E+05	n.a.[a]	n.a.[a]	F	1	2.12E-06	n.a.[a]	1.09E-07	1.01E-05
PWC01	Pump centrifugal	AR6	2	n.a.[a]	3.34E+04	n.a.[a]	B	1	3.00E-05	n.a.[a]	1.54E-06	1.42E-04
PWC01	Pump centrifugal	AR6	2	–[b]	–[b]	2000	S	1	n.a.[a]	5.00E-04	2.56E-05	2.37E-03
PWC02	Pump centrifugal	AR6	2	n.a.[a]	1.67E+04	n.a.[a]	Y	2	1.20E-04	n.a.[a]	2.13E-05	3.77E-04
PWC02	Pump centrifugal	AR6	2	n.a.[a]	1.67E+04	n.a.[a]	F	1	6.00E-05	n.a.[a]	3.08E-06	2.84E-04
PWC03	Pump centrifugal	AR6	2	n.a.[a]	3.20E+04	n.a.[a]	Y	1	3.13E-05	n.a.[a]	1.60E-06	1.48E-04
PWC03	Pump centrifugal	AR6	2	n.a.[a]	3.20E+04	n.a.[a]	R	1	3.13E-05	n.a.[a]	1.60E-06	1.48E-04
PWC04	Pump centrifugal	AR6	1	n.a.[a]	1.67E+02	n.a.[a]	F	0	4.16E-03	n.a.[a]	n.a.[a]	1.80E-02
PWC05	Pump centrifugal	AR6	1	n.a.[a]	1.67E+02	n.a.[a]	F	0	4.16E-03	n.a.[a]	n.a.[a]	1.80E-02
PWC06	Pump centrifugal	AR6	2	n.a.[a]	3.34E+03	n.a.[a]	F	0	2.08E-04	n.a.[a]	n.a.[a]	8.98E-04
PWE	Pump vert.	CH	2	2.78E+04	n.a.[a]	n.a.[a]	R	2	7.20E-05	n.a.[a]	1.28E-05	2.27E-04
PWE	Pump vert.	CH	2	2.78E+04	n.a.[a]	n.a.[a]	S	1	3.60E-05	n.a.[a]	1.85E-06	1.71E-04
PWE	Pump vert.	H	3	n.a.[a]	2.24E+05	n.a.[a]	R	30	1.34E-04	n.a.[a]	9.65E-05	1.82E-04
PWE	Pump vert.	H	3	n.a.[a]	2.24E+05	n.a.[a]	S	6	2.68E-05	n.a.[a]	1.17E-05	5.29E-05
PWE	Pump vert.	M	2	n.a.[a]	7.68E+03	n.a.[a]	S	1	1.30E-04	n.a.[a]	6.68E-06	6.18E-04

Text cont. on p. 188

[a] n.a.: not applicable

[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
PWS	Purification pumps	NRU	2	n.a.[a]	n.a.[a]	1.20E+02	S	1	n.a.[a]	8.33E-03	4.27E-04	3.89E-02
PWS	Purification pumps	NRU	2	n.a.[a]	1.40E+05	n.a.[a]	R	6	4.29E-05	n.a.[a]	1.87E-05	8.46E-05
QAA	Air cooler	S	3	3.88E+05	n.a.[a]	n.a.[a]	F	32	8.25E-05	n.a.[a]	6.01E-05	1.11E-04
QAA	Air cooler	S	3	3.88E+05	n.a.[a]	n.a.[a]	R	4	1.03E-05	n.a.[a]	3.52E-06	2.36E-05
QAA	Air cooler	S	3	3.88E+05	n.a.[a]	n.a.[a]	S	3	7.74E-06	n.a.[a]	2.11E-06	2.00E-05
QAA	Air cooler	S	3	3.88E+05	n.a.[a]	n.a.[a]	Y	2	5.16E-06	n.a.[a]	9.17E-07	1.62E-05
QBF	Blower fan-cooling tower	HIFAR	6	n.a.[a]	3.02E+05	n.a.[a]	B	39	1.29E-04	n.a.[a]	9.71E-05	1.69E-04
QBF	Blower fan-cooling tower	HIFAR	6	n.a.[a]	3.02E+05	n.a.[a]	R	11	3.64E-05	n.a.[a]	2.04E-05	6.03E-05
QBF	Blower fan-cooling tower	HIFAR	6	6.95E+05	n.a.[a]	n.a.[a]	S	1	1.44E-06	n.a.[a]	7.38E-08	6.83E-06
QBF	Blower fan	B	2	5.94E+04	n.a.[a]	n.a.[a]	S	1	1.68E-05	n.a.[a]	8.63E-07	7.98E-05
QBF	Blower fan	S	33	4.26E+06	n.a.[a]	n.a.[a]	B	3	7.03E-07	n.a.[a]	1.92E-07	1.82E-06
QBF	Blower fan	S	33	4.26E+06	n.a.[a]	n.a.[a]	F	164	3.85E-05	n.a.[a]	3.37E-05	4.38E-05
QBF	Blower fan	S	33	4.26E+06	n.a.[a]	n.a.[a]	n.a.[a]	0	1.63E-07	n.a.[a]	n.a.[a]	7.02E-07
QBF	Blower fan	S	33	4.26E+06	n.a.[a]	n.a.[a]	R	16	3.75E-06	n.a.[a]	2.35E-06	5.70E-06
QBF	Blower fan	S	33	4.26E+06	n.a.[a]	n.a.[a]	S	3	7.03E-07	n.a.[a]	1.92E-07	1.82E-06
QBF	Blower fan	S	33	4.26E+06	n.a.[a]	n.a.[a]	T	1	2.34E-07	n.a.[a]	1.20E-08	1.11E-06

Text cont. on p. 189

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
QBF	Blower fan	S	33	4.26E+06	n.a.[a]	n.a.[a]	X	2	4.69E-07	n.a.[a]	8.33E-08	1.48E-06
QBF	Blower fan	S	33	4.26E+06	n.a.[a]	n.a.[a]	Y	4	9.38E-07	n.a.[a]	3.20E-07	2.15E-06
QBF	Blower fan	Y	12	1.13E+06	n.a.[a]	n.a.[a]	R	11	9.73E-06	n.a.[a]	5.46E-06	1.61E-05
QBF	Blower fan	Y	12	1.13E+06	n.a.[a]	n.a.[a]	Y	1	8.85E-07	n.a.[a]	4.54E-08	4.20E-06
QBF01	Blower fan	DALAT	2	n.a.[a]	5.00E+04	n.a.[a]	R	1	2.00E-05	n.a.[a]	1.02E-06	9.48E-05
QBF02	Blower fan	DALAT	2	n.a.[a]	5.00E+04	n.a.[a]	R	7	1.40E-04	n.a.[a]	6.56E-05	2.63E-04
QBF02	Blower fan	DALAT	2	–[b]	–[b]	1134	S	8	n.a.[a]	7.05E-03	3.52E-03	1.27E-02
QCH	Compressor diaphragm-helium circulation	D	3	9.00E+04	n.a.[a]	n.a.[a]	R	7	7.78E-05	n.a.[a]	3.65E-05	1.46E-04
QCI	Compressor-instrument air	BR04	2	n.a.[a]	1.28E+04	n.a.[a]	B	1	7.82E-05	n.a.[a]	4.01E-06	3.71E-04
QCI	Compressor-instrument air	BR04	2	n.a.[a]	1.28E+04	n.a.[a]	R	1	7.82E-05	n.a.[a]	4.01E-06	3.71E-04
QCI	Instrument air compressor	TRIGA	2	6.50E+04	n.a.[a]	n.a.[a]	F	35	5.38E-04	n.a.[a]	3.98E-04	7.14E-04
QCI	Instrument air compressor	TRIGA	2	6.50E+04	n.a.[a]	n.a.[a]	R	2	3.08E-05	n.a.[a]	5.47E-06	9.69E-05

Text cont. on p. 190

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
QCI	Instrument air compressor	TRIGA	2	6.50E+04	n.a.[a]	n.a.[a]	S	3	4.62E-05	n.a.[a]	1.26E-05	1.19E-04
QCI	Instrument air compressor	TRIGA	2	6.50E+04	n.a.[a]	n.a.[a]	B	10	1.54E-04	n.a.[a]	8.35E-05	2.61E-04
QCI	Instrument air compressor	TRIGA	2	6.50E+04	n.a.[a]	n.a.[a]	Y	1	1.54E-05	n.a.[a]	7.89E-07	7.30E-05
QCI01	Compressor-instrument air	BR01	1	–[b]	–[b]	25	S	1	n.a.[a]	4.00E-02	2.05E-03	1.76E-01
QCI01	Air compressor Worthington	NRU	3	n.a.[a]	1.50E+04	n.a.[a]	R	2	1.33E-04	n.a.[a]	2.37E-05	4.20E-04
QCI02	Compressor-instrument air	BR01	1	n.a.[a]	4.26E+02	n.a.[a]	R	5	1.17E-02	n.a.[a]	4.62E-03	2.47E-02
QCI02	Compressor-instrument air	BR01	1	n.a.[a]	4.26E+02	n.a.[a]	B	2	4.69E-03	n.a.[a]	8.34E-04	1.48E-02
QCI02	Air compressor Joy	NRU	1	n.a.[a]	3.50E+04	n.a.[a]	R	16	4.57E-04	n.a.[a]	2.87E-04	6.94E-04
QCX	Freon compressor	HIFAR	3	3.47E+05	n.a.[a]	n.a.[a]	B	56	1.61E-04	n.a.[a]	1.28E-04	2.02E-04
QCX	Freon compressor	HIFAR	3	3.47E+05	n.a.[a]	n.a.[a]	R	26	7.49E-05	n.a.[a]	5.25E-05	1.04E-04
QCX	Freon compressor	HIFAR	3	3.47E+05	n.a.[a]	n.a.[a]	T	1	2.88E-06	n.a.[a]	1.48E-07	1.37E-05
QCX	Freon compressor	HIFAR	3	3.47E+05	n.a.[a]	n.a.[a]	Y	1	2.88E-06	n.a.[a]	1.48E-07	1.37E-05

Text cont. on p. 191

[a] n.a.: not applicable

[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
QCX	Freon compressor	HIFAR	3	3.47E+05	n.a.[a]	n.a.[a]	S	10	2.88E-05	n.a.[a]	1.56E-05	4.89E-05
QCX01	Compressor-freon gas	BR01	2	n.a.[a]	4.38E+04	n.a.[a]	B	2	4.57E-05	n.a.[a]	8.11E-06	1.44E-04
QCX01	Compressor-freon gas	BR01	2	n.a.[a]	4.38E+04	n.a.[a]	R	1	2.28E-05	n.a.[a]	1.17E-06	1.08E-04
QCX01	Chiller freon compressor-air conditioning	BR04	4	n.a.[a]	2.56E+04	n.a.[a]	R	10	3.91E-04	n.a.[a]	2.12E-04	6.64E-04
QCX01	Chiller freon compressor-air conditioning	BR04	4	n.a.[a]	2.56E+04	n.a.[a]	Y	1	3.91E-05	n.a.[a]	2.01E-06	1.86E-04
QCX02	Self-container compressor-air conditioning	BR04	3	n.a.[a]	3.83E+04	n.a.[a]	R	2	5.22E-05	n.a.[a]	9.27E-06	1.64E-04
QCY	Freon compressor-air dryer	BR04	2	n.a.[a]	1.28E+04	n.a.[a]	R	4	3.13E-04	n.a.[a]	1.07E-04	7.16E-04
QCY	Freon compressor-air dryer	BR04	2	n.a.[a]	1.28E+04	n.a.[a]	Y	3	2.35E-04	n.a.[a]	6.40E-05	6.07E-04
QDA	Damper-automatic control-air exhausting	BR04	5	n.a.[a]	5.11E+04	n.a.[a]	B	1	1.96E-05	n.a.[a]	1.00E-06	9.28E-05
QDA	Damper	B	2	5.94E+04	n.a.[a]	n.a.[a]	F	1	1.68E-05	n.a.[a]	8.63E-07	7.98E-05
QDA	Damper	S	86	1.11E+07	n.a.[a]	n.a.[a]	F	3	2.70E-07	n.a.[a]	7.36E-08	6.98E-07
QDA	Damper	Y	2	1.88E+05	n.a.[a]	n.a.[a]	F	1	5.31E-06	n.a.[a]	2.72E-07	2.52E-05

Text cont. on p. 192

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
QDA	Damper	Y	2	1.88E+05	n.a.[a]	n.a.[a]	R	1	5.31E-06	n.a.[a]	2.72E-07	2.52E-05
QDA01	Ventilation damper	NRU	6	–[b]	–[b]	1.26E+03	E/O	3	n.a.[a]	2.38E-03	6.49E-04	6.14E-03
QDA02	Ventilation damper	NRU	4	–[b]	–[b]	1.44E+03	E/O	1	n.a.[a]	6.96E-04	3.57E-05	3.30E-03
QDM01	Damper-local manual control-air exhausting-critical cell VAC	BR04	6	n.a.[a]	3.83E+04	n.a.[a]	R	1	2.61E-05	n.a.[a]	1.34E-06	1.24E-04
QDM02	Damper-remote manual control-air recirculating-critical cell VAC	BR04	8	–[b]	–[b]	2988	O	1	n.a.[a]	3.35E-04	1.72E-05	1.59E-03
QFB	Blower fan-critical cell VAC	BR04	2	n.a.[a]	1.28E+04	n.a.[a]	B	1	7.82E-05	n.a.[a]	4.01E-06	3.71E-04
QFB	Blower fan-Critical Cell VAC	BR04	2	n.a.[a]	1.28E+04	n.a.[a]	R	1	7.82E-05	n.a.[a]	4.01E-06	3.71E-04
QFV	Containment ventilation fan-air recirculation-critical cell	BR04	2	n.a.[a]	1.28E+04	n.a.[a]	B	1	7.82E-05	n.a.[a]	4.01E-06	3.71E-04
QFV01	Containment ventilation fan	BR01	1	4.38E+04	n.a.[a]	n.a.[a]	R	1	2.28E-05	n.a.[a]	1.17E-06	1.08E-04

Text cont. on p. 193

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
QFV01	Containment ventilation fan	BR01	1	4.38E+04	n.a.[a]	n.a.[a]	B	3	6.85E-05	n.a.[a]	1.87E-05	1.77E-04
QFV01	Containment ventilation fan	NRU	5	n.a.[a]	6.88E+05	n.a.[a]	R	1	1.45E-06	n.a.[a]	7.46E-08	6.90E-06
QFV02	Containment ventilation fan I&C controls	NRU	5	n.a.[a]	8.10E+04	n.a.[a]	R	18	2.22E-04	n.a.[a]	1.44E-04	3.30E-04
QFV03	Containment ventilation fan	BR01	1	5.27E+00	n.a.[a]	n.a.[a]	R	2	3.80E-01	n.a.[a]	6.74E-02	1.19E+00
QFV04	Containment ventilation fan	BR01	1	4.38E+04	n.a.[a]	n.a.[a]	R	1	2.28E-05	n.a.[a]	1.17E-06	1.08E-04
QFV05	Containment-ventilation fan	BR01	1	4.38E+04	n.a.[a]	n.a.[a]	R	1	2.28E-05	n.a.[a]	1.17E-06	1.08E-04
QNA01	Cooling fan	TRIGA	8	n.a.[a]	5.26E+05	n.a.[a]	F	61	1.16E-04	n.a.[a]	9.27E-05	1.44E-04
QNA01	Cooling fan	TRIGA	8	n.a.[a]	5.26E+05	n.a.[a]	B	12	2.28E-05	n.a.[a]	1.32E-05	3.70E-05
QNA02	Cooling fan secondary circuit	TRIGA	6	n.a.[a]	1.94E+05	n.a.[a]	F	65	3.35E-04	n.a.[a]	2.70E-04	4.12E-04
QNA02	Cooling fan secondary circuit	TRIGA	6	n.a.[a]	1.94E+05	n.a.[a]	S	9	4.64E-05	n.a.[a]	2.42E-05	8.10E-05
QNA02	Cooling fan secondary circuit	TRIGA	6	n.a.[a]	1.94E+05	n.a.[a]	R	7	3.61E-05	n.a.[a]	1.69E-05	6.78E-05

Text cont. on p. 194

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
QNA02	cooling fan secondary circuit	TRIGA	6	n.a.[a]	1.94E+05	n.a.[a]	B	14	7.22E-05	n.a.[a]	4.36E-05	1.13E-04
QVA	HVAC unit-auxiliary building	BR01	3	1.31E+05	n.a.[a]	n.a.[a]	Y	2	1.52E-05	n.a.[a]	2.70E-06	4.79E-05
QVG	HVAC unit air ventilation, general	TRIGA	6	n.a.[a]	5.26E+05	n.a.[a]	F	16	3.04E-05	n.a.[a]	1.91E-05	4.62E-05
QVG	HVAC unit air ventilation, general	TRIGA	6	n.a.[a]	5.26E+05	n.a.[a]	S	3	5.70E-06	n.a.[a]	1.55E-06	1.47E-05
QVG	HVAC unit air ventilation, general	TRIGA	6	n.a.[a]	5.26E+05	n.a.[a]	B	1	1.90E-06	n.a.[a]	9.75E-08	9.02E-06
QVR	HVAC unit control room ventilation	S	3	3.88E+05	n.a.[a]	n.a.[a]	F	1	2.58E-06	n.a.[a]	1.32E-07	1.22E-05
QVR	HVAC unit control room ventilation	S	3	3.88E+05	n.a.[a]	n.a.[a]	I	1	2.58E-06	n.a.[a]	1.32E-07	1.22E-05
QVS	HVAC unit-space conditioner	HIFAR	6	6.95E+05	n.a.[a]	n.a.[a]	B	32	4.60E-05	n.a.[a]	3.35E-05	6.18E-05
QVS	HVAC unit-space conditioner	HIFAR	6	6.95E+05	n.a.[a]	n.a.[a]	F	5	7.19E-06	n.a.[a]	2.83E-06	1.51E-05
QVS	HVAC unit-space conditioner	HIFAR	6	6.95E+05	n.a.[a]	n.a.[a]	Y	5	7.19E-06	n.a.[a]	2.83E-06	1.51E-05

Text cont. on p. 195

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
QVA	HVAC unit auxiliary building	S	3	3.88E+05	n.a.[a]	n.a.[a]	Y	1	2.58E-06	n.a.[a]	1.32E-07	1.22E-05
QVE	HVAC unit electric equipment area ventilation	S	2	2.58E+05	n.a.[a]	n.a.[a]	Y	1	3.87E-06	n.a.[a]	1.98E-07	1.84E-05
QVE	HVAC unit electric equipment area ventilation	S	2	2.58E+05	n.a.[a]	n.a.[a]	F	2	7.74E-06	n.a.[a]	1.37E-06	2.44E-05
QVE	HVAC unit electric equipment area ventilation	S	2	2.58E+05	n.a.[a]	n.a.[a]	Y	2	7.74E-06	n.a.[a]	1.37E-06	2.44E-05
QVG	HVAC unit air ventilation, general	TRIGA	6	n.a.[a]	5.26E+05	n.a.[a]	F	16	3.04E-05	n.a.[a]	1.91E-05	4.62E-05
QVG	HVAC unit air ventilation, general	TRIGA	6	n.a.[a]	5.26E+05	n.a.[a]	S	3	5.70E-06	n.a.[a]	1.55E-06	1.47E-05
QVG	HVAC unit air ventilation, general	TRIGA	6	n.a.[a]	5.26E+05	n.a.[a]	B	1	1.90E-06	n.a.[a]	9.75E-08	9.02E-06
RAA	Relay auxiliary	S	1500	1.94E+08	n.a.[a]	n.a.[a]	O	1	5.16E-09	n.a.[a]	2.65E-10	2.45E-08
RCA	Relay control AC	S	568	7.34E+07	n.a.[a]	n.a.[a]	E	2	2.72E-08	n.a.[a]	4.84E-09	8.58E-08
RCA	Relay control AC	S	568	7.34E+07	n.a.[a]	n.a.[a]	F	66	8.99E-07	n.a.[a]	7.25E-07	1.10E-06

Text cont. on p. 196

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
RCA	Relay control AC	S	568	7.34E+07	n.a.[a]	n.a.[a]	G	24	3.27E-07	n.a.a	2.25E-07	4.60E-07
RCA	Relay control AC	S	568	7.34E+07	n.a.a	n.a.[a]	H	1	1.36E-08	n.a.a	6.99E-10	6.46E-08
RCA	Relay control AC	S	568	7.34E+07	n.a.[a]	n.a.[a]	O	1	1.36E-08	n.a.[a]	6.99E-10	6.46E-08
RCA	Relay control AC	S	568	7.34E+07	n.a.[a]	n.a.[a]	R	10	1.36E-07	n.a.[a]	7.39E-08	2.31E-07
RCA	Relay control AC	S	568	7.34E+07	n.a.[a]	n.a.[a]	S	8	1.09E-07	n.a.[a]	5.42E-08	1.97E-07
RCA	Relay control AC	DALAT	6	n.a.[a]	1.72E+05	n.a.[a]	F	1	5.82E-06	n.a.[a]	2.99E-07	2.76E-05
RCD	Relay control DC	S	96	1.24E+07	n.a.[a]	n.a.[a]	F	28	2.26E-06	n.a.[a]	1.60E-06	3.09E-06
RCD	Relay control DC	S	96	1.24E+07	n.a.[a]	n.a.[a]	R	11	8.87E-07	n.a.[a]	4.97E-07	1.47E-06
RCL	Relay control	S	200	2.58E+07	n.a.[a]	n.a.[a]	F	8	3.10E-07	n.a.[a]	1.54E-07	5.58E-07
RPH	Relay power 300-460 A	S	45	5.82E+06	n.a.[a]	n.a.[a]	F	3	5.16E-07	n.a.[a]	1.41E-07	1.33E-06
RPH	Relay power 300-460 A	S	45	5.82E+06	n.a.[a]	n.a.[a]	S	2	3.44E-07	n.a.[a]	6.11E-08	1.08E-06
RPH	Relay power 300-460 A	S	45	5.82E+06	n.a.[a]	n.a.[a]	X	1	1.72E-07	n.a.[a]	8.82E-09	8.16E-07
RPL	Relay power 40-60 A	S	180	2.33E+07	n.a.[a]	n.a.[a]	F	8	3.44E-07	n.a.[a]	1.71E-07	6.20E-07
RRA	Relay protective-I&C sys.	BR04	210	n.a.[a]	8.01E+05	n.a.[a]	B	3	3.75E-06	n.a.[a]	1.02E-06	9.68E-06
RRA	Relay protective-I&C sys.	BR04	210	n.a.[a]	8.01E+05	n.a.[a]	I	4	4.99E-06	n.a.[a]	1.71E-06	1.14E-05

Text cont. on p. 197

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
RRA	Relay protective-I&C sys.	BR04	210	n.a.[a]	8.01E+05	n.a.[a]	K	1	1.25E-06	n.a.[a]	6.40E-08	5.92E-06
RRA	Protection relay 48 VDC	D	9	–[b]	–[b]	2708	O	3	n.a.[a]	1.11E-03	3.02E-04	2.86E-03
RRS	Switch relay 15 VDC	D	24	n.a.[a]	8.40E+05	n.a.[a]	F	1	1.19E-06	n.a.[a]	6.11E-08	5.65E-06
RRV	Relay, voltage protection	S	88	1.14E+07	n.a.[a]	n.a.[a]	F	7	6.15E-07	n.a.[a]	2.89E-07	1.16E-06
RTA	Relay time delay	DALAT	6	–[b]	–[b]	10626	C	1	n.a.[a]	9.41E-05	4.83E-06	4.46E-04
RWA	Relay, general	B	24	7.13E+05	n.a.[a]	n.a.[a]	F	2	2.80E-06	n.a.[a]	4.98E-07	8.83E-06
RWA	Relay, general	S	939	1.21E+08	n.a.[a]	n.a.[a]	F	9	7.42E-08	n.a.[a]	3.87E-08	1.29E-07
RWA	Relay, general I&C system	BR04	726	n.a.[a]	2.77E+06	n.a.[a]	F	4	1.44E-06	n.a.[a]	4.93E-07	3.31E-06
RWA	Relay, general I&C system	BR04	726	n.a.[a]	2.77E+06	n.a.[a]	H	1	3.61E-07	n.a.[a]	1.85E-08	1.71E-06
RWA	Relay, general I&C system	BR04	726	n.a.[a]	2.77E+06	n.a.[a]	I	4	1.44E-06	n.a.[a]	4.93E-07	3.31E-06
RXA	Relay contacts	B	12	3.57E+05	n.a.[a]	n.a.[a]	F	1	2.80E-06	n.a.[a]	1.44E-07	1.33E-05
SAA	Switch-nuclear channels-test and calibration	BR04	10	n.a.[a]	1.42E+03	n.a.[a]	F	1	7.04E-04	n.a.[a]	3.61E-05	3.34E-03

Text cont. on p. 198

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
SCC	Switch contacts	B	26	7.73E+05	n.a.[a]	n.a.[a]	F	7	9.06E-06	n.a.[a]	4.25E-06	1.70E-05
RTA	Relay time delay	DALAT	6	–[b]	–[b]	10626	C	1	n.a.[a]	9.41E-05	4.83E-06	4.46E-04
RWA	Relay, general	B	24	7.13E+05	n.a.[a]	n.a.[a]	F	2	2.80E-06	n.a.[a]	4.98E-07	8.83E-06
RWA	Relay, general	S	939	1.21E+08	n.a.[a]	n.a.[a]	F	9	7.42E-08	n.a.[a]	3.87E-08	1.29E-07
RWA	Relay, general I&C system	BR04	726	n.a.[a]	2.77E+06	n.a.[a]	F	4	1.44E-06	n.a.[a]	4.93E-07	3.31E-06
RWA	Relay, general I&C system	BR04	726	n.a.[a]	2.77E+06	n.a.[a]	H	1	3.61E-07	n.a.[a]	1.85E-08	1.71E-06
RWA	Relay, general I&C System	BR04	726	n.a.[a]	2.77E+06	n.a.[a]	I	4	1.44E-06	n.a.[a]	4.93E-07	3.31E-06
RXA	Relay contacts	B	12	3.57E+05		n.a.[a]	F	1	2.80E-06	n.a.[a]	1.44E-07	1.33E-05
SAA	Switch-nuclear channels-test and calibration	BR04	10	n.a.[a]	1.42E+03	n.a.[a]	F	1	7.04E-04	n.a.[a]	3.61E-05	3.34E-03
SCC	Switch contacts	B	26	7.73E+05	n.a.[a]	n.a.[a]	F	7	9.06E-06	n.a.[a]	4.25E-06	1.70E-05
SCC	Switch contacts	S	35	4.52E+06	n.a.[a]	n.a.[a]	F	25	5.53E-06	n.a.[a]	3.84E-06	7.72E-06
SCC	Switch contacts	Y	9	8.48E+05	n.a.[a]	n.a.[a]	F	5	5.90E-06	n.a.[a]	2.32E-06	1.24E-05
SCC	Switch contacts	Y	9	8.48E+05	n.a.[a]	n.a.[a]	S	1	1.18E-06	n.a.[a]	6.05E-08	5.60E-06

Text cont. on p. 199

[a] n.a.: not applicable

[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
SCC	Switch contacts	Y	9	8.48E+05	n.a.[a]	n.a.[a]	R	1	1.18E-06	n.a.[a]	6.05E-08	5.60E-06
SCC	Switch contacts	Y	9	8.48E+05	n.a.[a]	n.a.[a]	E	1	1.18E-06	n.a.[a]	6.05E-08	5.60E-06
SDA	Switch digital channel pressure/vacuum, pressure, level	CH	2	2.78E+04	n.a.[a]	n.a.[a]	K	1	3.60E-05	n.a.[a]	1.85E-06	1.71E-04
SFA01	Switch flow	DALAT	2	n.a.[a]	8.80E+04	n.a.[a]	n.a.[a]	0	7.88E-06	n.a.[a]	n.a.[a]	3.40E-05
SFA02	Switch flow	DALAT	2	n.a.[a]		6168	F	1	-	1.62E-04	8.32E-06	7.69E-04
SLA	Switch level	DALAT	2	n.a.[a]	1.08E+05	n.a.[a]	n.a.[a]	0	6.41E-06	n.a.[a]	n.a.[a]	2.77E-05
SMA	Switch manual	DALAT	8	n.a.[a]	2.29E+05	n.a.[a]	K	2	8.73E-06	n.a.[a]	1.55E-06	2.75E-05
SMA01	Switch-manual-instrument air supply	BR04	1	–[b]	–[b]	1420	C	1	n.a.[a]	7.04E-04	3.61E-05	3.34E-03
SMA02	Switch-manual-nuclear instrumentation	BR04	1	n.a.[a]	3.81E+03	n.a.[a]	F	1	2.62E-04	n.a.[a]	1.34E-05	1.24E-03
STA	Switch temperature	DALAT	2	n.a.[a]	8.56E+04	n.a.[a]	n.a.[a]	0	8.09E-06	n.a.[a]	n.a.[a]	3.50E-05
TA2	Transformer 22/415 V	C	7	2.45E+06		n.a.[a]	F	1	4.08E-07	n.a.[a]	2.09E-08	1.93E-06
TA6	Transformer 6kv/380V	M	2	n.a.[a]	4.36E+05	n.a.[a]	F	6	1.38E-05	n.a.[a]	5.99E-06	2.72E-05
TA6	Transformer 6kv/380V	DALAT	1	n.a.[a]	1.66E+05	n.a.[a]	n.a.[a]	0	4.19E-06	n.a.[a]	n.a.[a]	1.81E-05

Text cont. on p. 200

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
TAA	Transformer	TRIGA MARK-II	7	4.33E+05	n.a.[a]	n.a.[a]	F	2	4.61E-06	n.a.[a]	8.20E-07	1.45E-05
TAA01	Transformer	S	2	2.58E+05	n.a.[a]	n.a.[a]	F	3	1.16E-05	n.a.[a]	3.16E-06	3.00E-05
TAA02	Transformer	S	1	1.29E+05	n.a.[a]	n.a.[a]	F	3	2.32E-05	n.a.[a]	6.33E-06	6.00E-05
TIC	Transformer (instrument)	S	431	1.29E+05	n.a.[a]	n.a.[a]	F	2	1.55E-05	n.a.[a]	2.75E-06	4.88E-05
TUA01	Transformer 500 kva	NRU	2	6.00E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	1.16E-06	n.a.[a]	n.a.[a]	4.99E-06
TUA02	Transformer 1000 kva	NRU	1	3.00E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	2.31E-06	n.a.[a]	n.a.[a]	9.99E-06
TUB01	Transformer sub-station 22/3.3 kv three phase liquid filled 10 MVA	D	2	3.00E+05	n.a.[a]	n.a.[a]	F	1	3.33E-06	n.a.[a]	1.71E-07	1.58E-05
TUB02	Transformer sub-station 22/415 kv three phase liquid filled 2 MVA	D	4	7.00E+05	n.a.[a]	n.a.[a]	F	1	1.43E-06	n.a.[a]	7.33E-08	6.78E-06
UCA	Controller	S	30	3.88E+06	n.a.[a]	n.a.[a]	C	1	2.58E-07	n.a.[a]	1.32E-08	1.22E-06
UCA	Controller	S	30	3.88E+06	n.a.[a]	n.a.[a]	F	1	2.58E-07	n.a.[a]	1.32E-08	1.22E-06
UCE	Controller electronic	S	11	1.42E+06	n.a.[a]	n.a.[a]	F	14	9.85E-06	n.a.[a]	5.95E-06	1.54E-05
UCE	Controller electronic	S	11	1.42E+06	n.a.[a]	n.a.[a]	Y	1	7.03E-07	n.a.[a]	3.61E-08	3.34E-06
UCE01	Controller electronic	BR01	2	4.38E+04	n.a.[a]	n.a.[a]	F	3	6.85E-05	n.a.[a]	1.87E-05	1.77E-04

Text cont. on p. 201

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
UCE01	Controller electronic-nuclear instrumentation	BR04	1	n.a.[a]	3.81E+03	n.a.[a]	F	2	5.24E-04	n.a.[a]	9.32E-05	1.65E-03
UCE02	Controller electronic	BR01	1		1.09E+04	n.a.[a]	F	1	9.21E-05	n.a.[a]	4.72E-06	4.37E-04
UCF	Flow controller	S	20	2.58E+06	n.a.[a]	n.a.[a]	F	2	7.74E-07	n.a.[a]	1.37E-07	2.44E-06
UCF	Flow controller	S	20	2.58E+06	n.a.[a]	n.a.[a]	R	0	2.68E-07	n.a.[a]	-	1.16E-06
UCF	Flow controller	S	20	2.58E+06	n.a.[a]	n.a.[a]	Y	1	3.87E-07	n.a.[a]	1.98E-08	1.84E-06
UIA	Analogue display	Y	4	3.77E+05	n.a.[a]	n.a.[a]	F	4	1.06E-05	n.a.[a]	3.63E-06	2.43E-05
UIA	Indicating instrument	TRIGA	4	1.30E+04	n.a.[a]	n.a.[a]	F	6	4.62E-04	n.a.[a]	2.01E-04	9.11E-04
UIA	Indicating instrument	TRIGA	4	1.30E+04	n.a.[a]	n.a.[a]	B	1	7.69E-05	n.a.[a]	3.95E-06	3.65E-04
UIA01	Indicating instrument-analogue display-nuclear instrumentation	BR04	2	n.a.[a]	7.63E+03	n.a.[a]	F	2	2.62E-04	n.a.[a]	4.66E-05	8.25E-04
UIA02	Indicating instrument-analogue display-nuclear instrumentation	BR04	4	n.a.[a]	1.53E+04	n.a.[a]	F	3	1.97E-04	n.a.[a]	5.36E-05	5.08E-04
UIA03	Indicating instrument-analogue display-water level	BR04	1	n.a.[a]	3.81E+03	n.a.[a]	I	1	2.62E-04	n.a.[a]	1.34E-05	1.24E-03
UID01	Digital instrument	DALAT	1	n.a.[a]	4.28E+04	n.a.[a]	B	1	2.34E-05	n.a.[a]	1.20E-06	1.11E-04

Text cont. on p. 202

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
UID01	Digital instrument	DALAT	1	n.a.[a]	4.28E+04	n.a.[a]	F	2	4.67E-05	n.a.[a]	8.30E-06	1.47E-04
UID02	Digital instrument	DALAT	1	n.a.[a]	5.41E+04	n.a.[a]	F	2	3.70E-05	n.a.[a]	6.57E-06	1.16E-04
UIE	Indicating instrument-digital and analogue display-nuclear instrumentation	BR04	2	n.a.[a]	7.63E+03	n.a.[a]	F	2	2.62E-04	n.a.[a]	4.66E-05	8.25E-04
UIE	Indication instrument electronic	B	37	1.10E+06	n.a.[a]	n.a.[a]	F	20	1.82E-05	n.a.[a]	1.21E-05	2.64E-05
UIE	Indication instrument electronic	Y	4	3.77E+05	n.a.[a]	n.a.[a]	F	1	2.65E-06	n.a.[a]	1.36E-07	1.26E-05
UIE	Indication instrument electronic	Y	4	3.77E+05	n.a.[a]	n.a.[a]	R	3	7.96E-06	n.a.[a]	2.17E-06	2.06E-05
UIL	Indication lamp	S	1200	1.55E+08	n.a.[a]	n.a.[a]	F	3	1.93E-08	n.a.[a]	5.27E-09	5.00E-08
UIL	Indication lamp	BR01	78	n.a.[a]	8.47E+05	n.a.[a]	F	4	4.72E-06	n.a.[a]	1.61E-06	1.08E-05
UIR	Recorder	B	1	2.97E+04	n.a.[a]	n.a.[a]	F	1	3.37E-05	n.a.[a]	1.73E-06	1.60E-04
UIR	Recorder	S	21	2.71E+06	n.a.[a]	n.a.[a]	F	1	3.68E-07	n.a.[a]	1.89E-08	1.75E-06
UIR	Power recorder	TRIGA	1	n.a.[a]	6.40E+04	n.a.[a]	K	5	7.81E-05	n.a.[a]	3.08E-05	1.64E-04
UIR	Power recorder	TRIGA	1	n.a.[a]	6.40E+04	n.a.[a]	F	24	3.75E-04	n.a.[a]	2.59E-04	5.27E-04
UIR	Power recorder	TRIGA	1	n.a.[a]	6.40E+04	n.a.[a]	C	10	1.56E-04	n.a.[a]	8.48E-05	2.65E-04

Text cont. on p. 203

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
UIR01	Recorder	DALAT	1	n.a.[a]	4.40E+04	n.a.[a]	F	2	4.55E-05	n.a.[a]	8.08E-06	1.43E-04
UIR02	Recorder	DALAT	1	n.a.[a]	4.33E+04	n.a.[a]	F	4	9.25E-05	n.a.[a]	3.16E-05	2.12E-04
UIR03	Recorder	DALAT	3	n.a.[a]	1.28E+05	n.a.[a]	B	1	7.78E-06	n.a.[a]	3.99E-07	3.69E-05
UIR03	Recorder	DALAT	3	n.a.[a]	1.28E+05	n.a.[a]	F	15	1.17E-04	n.a.[a]	7.20E-05	1.80E-04
UIX	Other indicating instrument	TRIGA MARK-II	1	6.36E+04	n.a.[a]	n.a.[a]	F	1	1.57E-05	n.a.[a]	8.07E-07	7.46E-05
UIX	Other indicating instrument	S	2	258 480	n.a.[a]	n.a.[a]	F	14	5.42E-05	n.a.[a]	3.27E-05	8.47E-05
UIX01	Other indicating instrument	DALAT	1	n.a.[a]	2.86E+04	n.a.[a]	B	26	9.08E-04	n.a.[a]	6.36E-04	1.26E-03
UIX02	Other indicating instrument	DALAT	1	n.a.[a]	2.86E+04	n.a.[a]	B	5	1.75E-04	n.a.[a]	6.88E-05	3.67E-04
UMC	Manual control device pushbutton	BR01	3	n.a.[a]	3.26E+04	n.a.[a]	K	2	6.14E-05	n.a.[a]	1.09E-05	1.93E-04
UMC	Manual control device pushbutton	DALAT	13	n.a.[a]	3.72E+05	n.a.[a]	K	1	2.69E-06	n.a.[a]	1.38E-07	1.27E-05

Text cont. on p. 204

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
UMC01	Manual control device pushbutton-nuclear instrumentation	BR04	21	n.a.[a]	8.01E+04	n.a.[a]	F	6	7.49E-05	n.a.[a]	3.26E-05	1.48E-04
UMC02	Manual control device pushbutton-movable reactor bridge	BR04	8	–[b]	–[b]	426	B	2	n.a.[a]	4.69E-03	8.35E-04	1.47E-02
UNA	Annunciator, alarm	AR6	19	3.33E+06	n.a.[a]	n.a.[a]		0	2.08E-07	n.a.[a]	-	9.00E-07
UNA	Annunciator, general	DALAT	1	n.a.[a]	2.86E+04	n.a.[a]	F	3	1.05E-04	n.a.[a]	2.86E-05	2.71E-04
URS	Reactor scram system	CH	1	1.39E+04	n.a.[a]	n.a.[a]	K	1	7.20E-05	n.a.[a]	3.69E-06	3.41E-04
URS	Reactor scram system	CH	1	1.39E+04	n.a.[a]	n.a.[a]	X	1	7.20E-05	n.a.[a]	3.69E-06	3.41E-04
URS	Reactor scram channel	A	1	–[b]	–[b]	380	F	1	n.a.[a]	2.63E-03	1.35E-04	1.24E-02
VA1	Air operated check valve	NRU	2	–[b]	–[b]	1.12E+03	E/O	4	n.a.[a]	3.57E-03	1.22E-03	8.15E-03
VA1	Valve air operated	TRIGA	4	n.a.[a]	1.12E+05	n.a.[a]	O	12	1.07E-04	n.a.[a]	6.18E-05	1.74E-04
VA1	Valve air operated	TRIGA	4	n.a.[a]	1.12E+05	n.a.[a]	E	4	3.57E-05	n.a.[a]	1.22E-05	8.17E-05
VA1	Valve air operated	TRIGA	4	n.a.[a]	1.12E+05	n.a.[a]	F	2	1.79E-05	n.a.[a]	3.17E-06	5.62E-05
VA101	Valve air operated-water temperature control and fast filling water system	BR04	2	n.a.[a]	n.a.[a]	1494	E	2	n.a.[a]	1.34E-03	2.38E-04	4.21E-03

Text cont. on p. 205

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
VA101	Valve air operated-water temperature control and fast filling water system	BR04	2	n.a.[a]	7.63E+03	n.a.[a]	Y	1	1.31E-04	n.a.a	6.72E-06	6.22E-04
VA102	Valve air operated-chilled water system	BR04	3	–[b]	–[b]	2241	O	1	n.a.[a]	4.46E-04	2.29E-05	2.12E-03
VAR01	Control valve-moderator	C	3	–[b]	–[b]	2982	O	3	n.a.[a]	1.01E-03	2.74E-04	2.60E-03
VAR02	Dump valve-moderator	C	3	–[b]	–[b]	2982	O	5	n.a.[a]	1.68E-03	6.61E-04	3.52E-03
VAR01	Control valve-moderator	D	3	–[b]	–[b]	1357	O	1	n.a.[a]	7.37E-04	3.78E-05	3.49E-03
VAR02	Dump valve-moderator	D	3	–[b]	–[b]	1357	O	4	n.a.[a]	2.95E-03	1.01E-03	6.73E-03
VAT	Valve air operated butterfly 150 mm	D	4	–[b]	–[b]	1000	O	1	n.a.[a]	1.00E-03	5.13E-05	4.73E-03
VAT	Valve air operated butterfly 150 mm	D	4	5.96E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	1.16E-06	n.a.[a]	n.a.[a]	5.03E-06
VCA	Valve self-operated check, demin. Cont.	AR3	2	2.45E+05	n.a.[a]	n.a.[a]	X	1	4.08E-06	n.a.[a]	2.09E-07	1.93E-05
VCA	Valve self-operated check	AR6	2	3.50E+05	n.a.[a]	n.a.[a]	F	0	1.98E-06	n.a.[a]	-	8.55E-06
VCA	Valve self-operated check	BR04	4	–[b]	–[b]	1494	E	2	- n.a.[a]	1.34E-03	2.38E-04	4.21E-03

Text cont. on p. 206

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
VCA	Tilting disc check valve	NRU	8	1.68E+06	n.a.[a]	n.a.[a]	n.a.[a]	0	4.13E-07	n.a.[a]	n.a.[a]	1.78E-06
VCA	Tilting disc check valve	NRU	8	–[b]	–[b]	3.84E+02	n.a.[a]	0	n.a.[a]	1.81E-03	n.a.[a]	7.77E-03
VCA	Check valve 150 mm	C	2	–[b]	–[b]	1728	n.a.[a]	0	n.a.[a]	4.01E-04	n.a.[a]	1.73E-03
VCA01	Check valve 150-300 mm	D	9	–[b]	–[b]	1280	O	1	n.a.[a]	7.81E-04	4.01E-05	3.70E-03
VCA01	Valve self-operated check	DALAT	3		6.34E+04		n.a.[a]	0	1.09E-05	n.a.[a]	n.a.[a]	4.72E-05
VCA02	Check valve 400 mm	D	2	–[b]	–[b]	1728	O	1	n.a.[a]	5.79E-04	2.97E-05	2.74E-03
VCA02	Check valve 400 mm	D	2	–[b]	–[b]	1728	E	1	n.a.[a]	5.79E-04	2.97E-05	2.74E-03
VCA02	Valve self-operated check	DALAT	2	n.a.[a]	3.09E+04	n.a.[a]	n.a.[a]	0	2.24E-05	n.a.[a]	n.a.[a]	9.69E-05
VCF	Valve op. By floating device	AR3	1	1.23E+05	n.a.[a]	n.a.[a]	C	4	3.26E-05	n.a.[a]	1.11E-05	7.46E-05
VCF	Valve op. By floating device	AR6	4	7.01E+05	n.a.[a]	n.a.[a]	F	20	2.85E-05	n.a.[a]	1.89E-05	4.15E-05
VDA	Valve solenoid operated	BR04	2	n.a.[a]	3.81E+03	n.a.[a]	F	1	2.62E-04	n.a.[a]	1.34E-05	1.24E-03
VDA	Valve solenoid operated	S	36	4.65E+06	n.a.[a]	n.a.[a]	F	5	1.07E-06	n.a.[a]	4.23E-07	2.26E-06
VDA	Valve solenoid operated	S	36	4.65E+06	n.a.[a]	n.a.[a]	O	1	2.15E-07	n.a.[a]	1.10E-08	1.02E-06
VDA	valve solenoid operated	S	36	4.65E+06	n.a.[a]	n.a.[a]	Y	1	2.15E-07	n.a.[a]	1.10E-08	1.02E-06

Text cont. on p. 207

[a] n.a.: not applicable

[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
VDA01	Valve solenoid operated	HIFAR	12	1.39E+06	n.a.[a]	n.a.[a]	B	51	3.68E-05	n.a.[a]	2.88E-05	4.65E-05
VDA01	Valve solenoid operated	HIFAR	12	1.39E+06	n.a.[a]	n.a.[a]	E	1	7.22E-07	n.a.[a]	3.70E-08	3.42E-06
VDA01	Valve solenoid operated	HIFAR	12	1.39E+06	n.a.[a]	n.a.[a]	F	5	3.61E-06	n.a.[a]	1.42E-06	7.59E-06
VDA01	Valve solenoid operated	HIFAR	12	1.39E+06	n.a.[a]	n.a.[a]	K	2	1.44E-06	n.a.[a]	2.56E-07	4.54E-06
VDA01	Valve solenoid operated	HIFAR	12	1.39E+06	n.a.[a]	n.a.[a]	O	7	5.05E-06	n.a.[a]	2.37E-06	9.49E-06
VDA01	Valve solenoid operated	HIFAR	12	1.39E+06	n.a.[a]	n.a.[a]	Y	6	4.33E-06	n.a.[a]	1.89E-06	8.54E-06
VDA02	Valve solenoid operated	HIFAR	3	3.47E+05	n.a.[a]	n.a.[a]	B	20	5.76E-05	n.a.[a]	3.82E-05	8.38E-05
VDA02	Valve solenoid operated	HIFAR	3	3.47E+05	n.a.[a]	n.a.[a]	C	1	2.88E-06	n.a.[a]	1.48E-07	1.37E-05
VDA02	Valve solenoid operated	HIFAR	3	3.47E+05	n.a.[a]	n.a.[a]	E	4	1.15E-05	n.a.[a]	3.94E-06	2.64E-05
VDA02	Valve solenoid operated	HIFAR	3	3.47E+05	n.a.[a]	n.a.[a]	O	1	2.88E-06	n.a.[a]	1.48E-07	1.37E-05
VDA02	Valve solenoid operated	HIFAR	3	3.47E+05	n.a.[a]	n.a.[a]	Q	4	1.15E-05	n.a.[a]	3.94E-06	2.64E-05
VDA02	Valve solenoid operated	HIFAR	3	3.47E+05	n.a.[a]	n.a.[a]	Y	3	8.65E-06	n.a.[a]	2.36E-06	2.23E-05
VMA	Valve motor operated	AR6	1	1.75E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	3.96E-06	n.a.[a]	n.a.[a]	1.71E-05
VMA	Valve motor operated	TRIGA MARK-II	1	9.90E+04	n.a.[a]	n.a.[a]	E	2	2.02E-05	n.a.[a]	3.59E-06	6.36E-05
VMA	Valve motor operated	HIFAR	8	9.24E+05	n.a.[a]	n.a.[a]	B	7	7.58E-06	n.a.[a]	3.56E-06	1.42E-05

Text cont. on p. 208

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
VMA	Valve motor operated-inlet header	HIFAR	8	9.26E+05	n.a.[a]	n.a.[a]	C	3	3.24E-06	n.a.[a]	8.83E-07	8.37E-06
VMA	Valve motor operated-inlet header	HIFAR	8	9.26E+05	n.a.[a]	n.a.[a]	E	1	1.08E-06	n.a.[a]	5.54E-08	5.12E-06
VMA	Valve motor operated-inlet header	HIFAR	8	9.26E+05	n.a.[a]	n.a.[a]	F	5	5.40E-06	n.a.[a]	2.13E-06	1.14E-05
VMA	Valve motor operated-inlet header	HIFAR	8	9.26E+05	n.a.[a]	n.a.[a]	O	7	7.56E-06	n.a.[a]	3.55E-06	1.42E-05
VMA	Valve motor operated-inlet header	HIFAR	8	9.26E+05	n.a.[a]	n.a.[a]	Q	1	1.08E-06	n.a.[a]	5.54E-08	5.12E-06
VMA	Valve motor operated-inlet header	HIFAR	8	9.26E+05	n.a.[a]	n.a.[a]	Y	17	1.84E-05	n.a.[a]	1.17E-05	2.75E-05
VMA	Valve motor operated	BR01	4	n.a.[a]	4.11E+04	n.a.[a]	D	3	7.29E-05	n.a.[a]	1.99E-05	1.89E-04
VMA	Valve motor operated	BR01	4	n.a.[a]	4.11E+04	n.a.[a]	Y	1	2.43E-05	n.a.[a]	1.25E-06	1.15E-04
VMA	Valve motor operated	H	3	n.a.[a]	2.24E+05	n.a.[a]	n.a.[a]	0	3.09E-06	n.a.[a]	n.a.[a]	1.34E-05
VMA	Valve motor operated	M	7	n.a.[a]	5.09E+05	n.a.[a]	O	4	7.86E-06	n.a.[a]	2.68E-06	1.80E-05
VMA	Valve motor operated	M	7	n.a.[a]	5.09E+05	n.a.[a]	I	2	3.93E-06	n.a.[a]	6.98E-07	1.24E-05
VMA	Valve motor operated	M	7	n.a.[a]	5.09E+05	n.a.[a]	n.a.[a]	0	1.36E-06	n.a.[a]	n.a.[a]	5.89E-06
VMA	Valve motor operated	S	136	1.76E+07	n.a.[a]	n.a.[a]	C	1	5.69E-08	n.a.[a]	2.92E-09	2.70E-07

Text cont. on p. 209

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
VMA	Valve motor operated	S	136	1.76E+07	n.a.[a]	n.a.[a]	E	8	4.55E-07	n.a.[a]	2.26E-07	8.21E-07
VMA	Valve motor operated	S	136	1.76E+07	n.a.[a]	n.a.[a]	F	38	2.16E-06	n.a.[a]	1.62E-06	2.83E-06
VMA	Valve motor operated	S	136	1.76E+07	n.a.[a]	n.a.[a]	O	12	6.83E-07	n.a.[a]	3.94E-07	1.11E-06
VMA	Valve motor operated	S	136	1.76E+07	n.a.[a]	n.a.[a]	R	6	3.41E-07	n.a.[a]	1.49E-07	6.74E-07
VMA	Valve motor operated	S	136	1.76E+07	n.a.[a]	n.a.[a]	S	5	2.84E-07	n.a.[a]	1.12E-07	5.98E-07
VMA	Valve motor operated	S	136	1.76E+07	n.a.[a]	n.a.[a]	Y	7	3.98E-07	n.a.[a]	1.87E-07	7.48E-07
VMA	Valve motor operated	TRIGA	4	n.a.[a]	1.12E+05	n.a.[a]	O	12	1.07E-04	n.a.[a]	6.18E-05	1.74E-04
VMA	Valve motor operated	TRIGA	4	n.a.[a]	1.12E+05	n.a.[a]	E	1	8.93E-06	n.a.[a]	4.58E-07	4.24E-05
VMA	Valve motor operated	TRIGA	4	n.a.[a]	1.12E+05	n.a.[a]	F	4	3.57E-05	n.a.[a]	1.22E-05	8.17E-05
VMA	Valve motor operated	TRIGA	4	n.a.[a]	1.12E+05	n.a.[a]	K	1	8.93E-06	n.a.[a]	4.58E-07	4.24E-05
VMA01	Blockage valve main circulating pump	AR3	4	4.91E+05	n.a.[a]	n.a.[a]	Y	6	1.22E-05	n.a.[a]	5.33E-06	2.41E-05
VMA01	Blockage valve main circulating pump	AR3	4	4.91E+05	n.a.[a]	n.a.[a]	C	1	2.04E-06	n.a.[a]	1.05E-07	9.67E-06
VMA01	Electrically operated valve (30 cm diameter)	NRU	16	2.10E+06	n.a.[a]	n.a.[a]	F	1	4.76E-07	n.a.[a]	2.44E-08	2.26E-06
VMA01	valve motor operated	DALAT	2	n.a.[a]	4.48E+04	n.a.[a]	n.a.[a]	0	1.55E-05	n.a.[a]	n.a.[a]	6.68E-05

Text cont. on p. 210

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
VMA02	Electrically operated valve (15 cm diameter)	NRU	6	n.a.[a]	8.40E+05	n.a.[a]	C	5	5.95E-06	n.a.[a]	2.35E-06	1.25E-05
VMA02	Electrically operated valve (15 cm diameter)	NRU	6	–[b]	–[b]	1.14E+03	C	5	n.a.[a]	4.39E-03	1.73E-03	9.20E-03
VMA03	Motorized emergency gate valve (9 cm diameter)	NRU	6	–[b]	–[b]	236	O	4	n.a.[a]	1.69E-02	5.81E-03	3.84E-02
VMA03	Motorized emergency gate valve (9 cm diameter)	NRU	6	–[b]	–[b]	236	E	8	n.a.[a]	3.39E-02	1.70E-02	6.03E-02
VMA01	Valve motor operated safety injection 100 mm	D	4	–[b]	–[b]	128	O	1	n.a.[a]	7.81E-03	4.01E-04	3.65E-02
VMA01	Valve motor operated safety injection 100 mm	D	4	5.95E+05	n.a.[a]	n.a.[a]	B	2	3.36E-06	n.a.[a]	5.97E-07	1.06E-05
VMA02	Valve motor operated gate > 150 mm	D	10	1.48E+06	n.a.[a]	n.a.[a]	n.a.[a]	0	4.68E-07	n.a.[a]	n.a.[a]	2.02E-06
VMT01	Valve motor operated butterfly 15 cm	D	2	–[b]	–[b]	1280	O	2	n.a.[a]	1.56E-03	2.78E-04	4.91E-03
VMT01	Valve motor operated butterfly 15 cm	D	2	2.98E+05	n.a.[a]	n.a.[a]	n.a.[a]	0	2.33E-06	n.a.[a]	n.a.[a]	1.01E-05
VMT02	Valve motor operated butterfly 15- 40 cm	D	8	1.19E+06	n.a.[a]	n.a.[a]	n.a.[a]	0	5.82E-07	n.a.[a]	n.a.[a]	2.52E-06

Text cont. on p. 211

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
VRA	Air operated PRV (failure to reseat or reseal after actuation)	NRU	2	1.75E+05	n.a.[a]	n.a.[a]	Y	4	2.28E-05	n.a.[a]	7.80E-06	5.22E-05
VRA	Valve relief	S	96	1.24E+07	n.a.[a]	n.a.[a]	Y	0	5.59E-08	n.a.[a]	n.a.[a]	2.41E-07
VSA	Valve safety	S	42	5.43E+06	n.a.[a]	n.a.[a]	E	1	1.84E-07	n.a.[a]	9.45E-09	8.74E-07
VSA	Valve safety	S	42	5.43E+06	n.a.[a]	n.a.[a]	F	1	1.84E-07	n.a.[a]	9.45E-09	8.74E-07
VSA	Valve safety	S	42	5.43E+06	n.a.[a]	n.a.[a]	Y	1	1.84E-07	n.a.[a]	9.45E-09	8.74E-07
VWB	Valve-ball valve	HIFAR	6	6.95E+05	n.a.[a]	n.a.[a]	B	18	2.59E-05	n.a.[a]	1.67E-05	3.84E-05
VWB	Valve-ball valve	HIFAR	6	6.95E+05	n.a.[a]	n.a.[a]	E	5	7.19E-06	n.a.[a]	2.83E-06	1.51E-05
VWB	Valve-ball valve	HIFAR	6	6.95E+05	n.a.[a]	n.a.[a]	Y	2	2.88E-06	n.a.[a]	5.11E-07	9.06E-06
VWG	Gate valve > 15 cm	D	6	9.50E+05	n.a.[a]	n.a.[a]	D	1	1.05E-06	n.a.[a]	5.40E-08	4.99E-06
VWG01	Valve gate	AR6	2	3.50E+05	n.a.[a]	n.a.[a]	Y	4	1.14E-05	n.a.[a]	3.90E-06	2.61E-05
VWG02	Valve gate	AR6	2	3.50E+05	n.a.[a]	n.a.[a]	Y	10	2.85E-05	n.a.[a]	1.55E-05	4.84E-05
VWG	Valve gate	CZ	20	n.a.[a]	1.26E+05	n.a.[a]	F	7	5.56E-05	n.a.[a]	–[b]	–[b]
VWG	Valve gate	CZ	20	n.a.[a]	1.26E+05	n.a.[a]	F	1	7.9E-06	n.a.[a]	–[b]	–[b]
VWJ	Valve plug valve	S	72	9.31E+06	n.a.[a]	n.a.[a]	Y	1	1.07E-07	n.a.[a]	5.51E-09	5.10E-07
VWN	Valve needle valve	S	36	4.65E+06	n.a.[a]	n.a.[a]	F	2	4.30E-07	n.a.[a]	7.64E-08	1.35E-06

Text cont. on p. 212

[a] n.a.: not applicable
[b] –: data not available

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
VWN	valve needle valve	S	36	4.65E+06	n.a.[a]	n.a.[a]	R	3	6.45E-07	n.a.[a]	1.76E-07	1.67E-06
VWP	Valve diaphragm	Y	3	2.83E+05	n.a.[a]	n.a.[a]	Y	3	1.06E-05	n.a.[a]	2.89E-06	2.74E-05
VWP01	Diaphragm valve 3"	AR3	1	1.23E+05	n.a.[a]	n.a.[a]	C	2	1.63E-05	n.a.[a]	2.90E-06	5.13E-05
VWP01	Diaphragm valve 3"	AR3	1	1.23E+05	n.a.[a]	n.a.[a]	B	1	8.15E-06	n.a.[a]	4.18E-07	3.87E-05
VWP02	Diaphragm valve 2"	AR3	1	1.23E+05	n.a.[a]	n.a.[a]	C	3	2.45E-05	n.a.[a]	6.67E-06	6.32E-05
VWT	Valve-butterfly valve	HIFAR	3	3.47E+05	n.a.[a]	n.a.[a]	B	42	1.21E-04	n.a.[a]	9.20E-05	1.57E-04
VWT	Valve-butterfly valve	HIFAR	3	3.47E+05	n.a.[a]	n.a.[a]	C	1	2.88E-06	n.a.[a]	1.48E-07	1.37E-05
VWT	Valve-butterfly valve	HIFAR	3	3.47E+05	n.a.[a]	n.a.[a]	E	14	4.03E-05	n.a.[a]	2.44E-05	6.31E-05
VWT	Valve-butterfly valve	HIFAR	3	3.47E+05	n.a.[a]	n.a.[a]	K	1	2.88E-06	n.a.[a]	1.48E-07	1.37E-05
VWT	Valve-butterfly valve	HIFAR	3	3.47E+05	n.a.[a]	n.a.[a]	Y	4	1.15E-05	n.a.[a]	3.94E-06	2.64E-05
VWT	Valve-butterfly valve	BR01	8	n.a.[a]	8.76E+04	n.a.[a]	Y	1	1.14E-05	n.a.[a]	5.86E-07	5.42E-05
VWT	Valve butterfly valve	S	150	1.94E+07	n.a.[a]	n.a.[a]	F	2	1.03E-07	n.a.[a]	1.83E-08	3.25E-07
VXA	Valve manual	TRIGA MARK-II	30	2.98E+06	n.a.[a]	n.a.[a]	F	1	3.36E-07	n.a.[a]	1.72E-08	1.59E-06
VXA	Valve manual	H	76	n.a.[a]	5.67E+06	n.a.[a]	B	26	4.59E-06	n.a.[a]	3.21E-06	6.36E-06
VXA	Valve manual	M	5	n.a.[a]	3.63E+05	n.a.[a]	B	2	5.51E-06	n.a.[a]	9.79E-07	1.73E-05

Text cont. on p. 213

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
VXA01	Manual valve-secondary cooling water	HIFAR	20	2.32E+06	n.a.[a]	n.a.[a]	Q	2	8.62E-07	n.a.[a]	1.53E-07	2.71E-06
VXA01	Manual valve-secondary cooling water	HIFAR	20	2.32E+06	n.a.[a]	n.a.[a]	B	5	2.16E-06	n.a.[a]	8.49E-07	4.53E-06
VXA01	Manual valve-secondary cooling water	HIFAR	20	2.32E+06	n.a.[a]	n.a.[a]	Y	5	2.16E-06	n.a.[a]	8.49E-07	4.53E-06
VXA01	Manual valve-secondary cooling water	HIFAR	20	2.32E+06	n.a.[a]	n.a.[a]	E	2	8.62E-07	n.a.[a]	1.53E-07	2.71E-06
VXA01	Manual valve-secondary cooling water	HIFAR	20	2.32E+06	n.a.[a]	n.a.[a]	C	1	4.31E-07	n.a.[a]	2.21E-08	2.04E-06
VXA01	Valve manual	DALAT	5	n.a.[a]	9.52E+04	n.a.[a]	F/D	0	7.28E-06	n.a.[a]	n.a.[a]	3.15E-05
VXA02	Cont. Demin. Pump blockage valve	AR3	4	4.91E+05	n.a.[a]	n.a.[a]	Y	1	2.04E-06	n.a.[a]	1.05E-07	9.67E-06
VXA02	Manually op. Globe valves	HIFAR	2	2.32E+05	n.a.[a]	n.a.[a]	B	3	1.29E-05	n.a.[a]	3.52E-06	3.34E-05
VXA02	Manually op. Globe valves	HIFAR	2	2.32E+05	n.a.[a]	n.a.[a]	C	1	4.31E-06	n.a.[a]	2.21E-07	2.04E-05
VXA02	Manually op. Globe valves	HIFAR	2	2.32E+05	n.a.[a]	n.a.[a]	E	1	4.31E-06	n.a.[a]	2.21E-07	2.04E-05
VXA02	Valve manual	DALAT	8	n.a.[a]	1.86E+05	n.a.[a]	F/D	0	3.74E-06	n.a.[a]	n.a.[a]	1.61E-05
VXA03	Valve manual	DALAT	6	n.a.[a]	1.27E+05	n.a.[a]	F/D	0	5.46E-06	n.a.[a]	n.a.[a]	2.36E-05

Text cont. on p. 214

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
VXA04	Cooling tower blockage valve	AR3	3	3.68E+05	n.a.[a]	n.a.[a]	Y	3	8.15E-06	n.a.[a]	2.22E-06	2.11E-05
VXA04	Cooling tower blockage valve	AR3	3	3.68E+05	n.a.[a]	n.a.[a]	C	3	8.15E-06	n.a.[a]	2.22E-06	2.11E-05
VXA04	Valve manual	DALAT	2	n.a.[a]	1.69E+04	n.a.[a]	F/D	0	4.10E-05	n.a.[a]	n.a.[a]	1.77E-04
WSD	Shielded door	AR3	1	1.23E+05	n.a.[a]	n.a.[a]	X	1	8.15E-06	n.a.[a]	4.18E-07	3.87E-05
XAA	Fuel element-natural uranium	C	190	n.a.[a]	2.50E+07	n.a.[a]	Y	5	2.00E-07	n.a.[a]	7.89E-08	4.21E-07
XAC	Calandria tube	C	190	n.a.[a]	6.66E+07	n.a.[a]	Y	2	3.00E-08	n.a.[a]	5.34E-09	9.46E-08
XAM	MTR fuel element, general	CH	60	8.34E+05	n.a.[a]	n.a.[a]	B	11	1.32E-05	n.a.[a]	7.40E-06	2.18E-05
XCM	Fuel element handling tool, manual	TRIGA MARK-II	1	9.90E+04	n.a.[a]	n.a.[a]	X	2	2.02E-05	n.a.[a]	3.59E-06	6.36E-05
XCM	Fuel element handling tool, manual	B	2	5.94E+04	n.a.[a]	n.a.[a]	F	1	1.68E-05	n.a.[a]	8.63E-07	7.98E-05
XHA	Fuel element HEU general	DALAT	100	n.a.[a]	2.72E+06	n.a.[a]	n.a.[a]	0	2.55E-07	n.a.[a]	n.a.[a]	1.10E-06
XHO	Fuel element	A	34	4.47E+06	n.a.[a]	n.a.[a]	n.a.[a]	0	1.55E-07	n.a.[a]	n.a.[a]	6.70E-07
XHT01	Fuel element TRIGA, standard Flip	TRIGA MARK-II	9	8.92E+05	n.a.[a]	n.a.[a]	Y	1	1.12E-06	n.a.[a]	5.75E-08	5.32E-06

Text cont. on p. 215

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	**Component Population**	**Cumulative calendar time**	**Cumulative operating time**	**Demands**	**Failure mode**	**Failures**	**Failure rate**	**Failure probability**	**90% Confidence bounds**	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
XHT02	Fuel element TRIGA, standard LEU	TRIGA MARK-II	85	8.43E+06	n.a.[a]	n.a.[a]	Y	4	4.75E-07	n.a.[a]	1.62E-07	1.09E-06
XLT	Fuel element TRIGA, standard LEU	Y	147	1.38E+07	n.a.[a]	n.a.[a]	Y	1	7.22E-08	n.a.[a]	3.71E-09	3.43E-07
XMR	Fuel element rod type MEU	M	195	n.a.[a]	3.57E+06	n.a.[a]	n.a.[a]	0	1.94E-07	n.a.[a]	n.a.[a]	8.40E-07
XPA	Fuel element process tube, gen.	H	82	n.a.[a]	6.09E+06	n.a.[a]	J	9	1.48E-06	n.a.[a]	7.70E-07	2.58E-06
XRT	Refl. Element graphite, triga	DALAT	1	n.a.[a]	2.86E+04	n.a.[a]	Y	0	2.42E-05	n.a.[a]	n.a.[a]	1.05E-04
YAA	Emergency filter-ventilation	D	2	3.15E+05	n.a.[a]	n.a.[a]	Y	0	2.20E-06	n.a.[a]	n.a.[a]	9.51E-06
YDA	Demineralizer	Y	1	9.42E+04	n.a.[a]	n.a.[a]	F	4	4.25E-05	n.a.[a]	1.45E-05	9.72E-05
YDA	Demineralizer	Y	1	9.42E+04	n.a.[a]	n.a.[a]	0	1	1.06E-05	n.a.[a]	5.45E-07	5.04E-05
YDA	Demineralizer	Y	1	9.42E+04	n.a.[a]	n.a.[a]	R	1	1.06E-05	n.a.[a]	5.45E-07	5.04E-05
YEN	Ejector H_2SO_4, NaOh	TRIGA	4	n.a.[a]	1.30E+04	n.a.[a]	F	13	1.00E-03	n.a.[a]	5.92E-04	1.59E-03
YEN	Ejector H_2SO_4, NaOh	TRIGA	4	n.a.[a]	1.30E+04	n.a.[a]	J	8	6.15E-04	n.a.[a]	3.06E-04	1.11E-03
YFM	Filter liquid, mechanical restriction	AR3	1	1.23E+05	n.a.[a]	n.a.[a]	Q	1	8.15E-06	n.a.[a]	4.18E-07	3.87E-05

Text cont. on p. 216

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
YFM	Filter liquid, mechanical restriction	AR6	1	1.75E+05	n.a.[a]	n.a.[a]	F	0	3.96E-06	n.a.[a]	n.a.[a]	1.71E-05
YFM	Filter liquid, mechanical restriction	TRIGA MARK-II	1	8.66E+04	n.a.[a]	n.a.[a]	Y	1	1.16E-05	n.a.[a]	5.93E-07	5.48E-05
YFM	Filter liquid, mechanical restriction	B	2	5.94E+04	n.a.[a]	n.a.[a]	Q	4	6.73E-05	n.a.[a]	2.30E-05	1.54E-04
YFM	Filter liquid, mechanical restriction	S	12	1.55E+06	n.a.[a]	n.a.[a]	F	14	9.03E-06	n.a.[a]	5.46E-06	1.41E-05
YFM	Filter liquid, mechanical restriction	S	12	1.55E+06	n.a.[a]	n.a.[a]	R	18	1.16E-05	n.a.[a]	7.50E-06	1.72E-05
YFM	Filter liquid, mechanical restriction	S	12	1.55E+06	n.a.[a]	n.a.[a]	Y	6	3.87E-06	n.a.[a]	1.68E-06	7.64E-06
YFM	Filter liquid, mechanical restriction	Y	1	9.42E+04	n.a.[a]	n.a.[a]	Q	3	3.19E-05	n.a.[a]	8.68E-06	8.23E-05
YFM	Filter liquid, mechanical restriction	Y	1	9.42E+04	n.a.[a]	n.a.[a]	R	1	1.06E-05	n.a.[a]	5.45E-07	5.04E-05
YFM	Filter liquid, mechanical restriction	Y	1	9.42E+04	n.a.[a]	n.a.[a]	0	2	2.12E-05	n.a.[a]	3.77E-06	6.69E-05
YFX	Ion exchange filter	BR04	1	n.a.[a]	3.81E+03	n.a.[a]	B	1	2.62E-04	n.a.[a]	1.34E-05	1.24E-03
YFX	Ion exchange filter	CH	4	5.56E+04	n.a.[a]	n.a.[a]	Y	1	1.80E-05	n.a.[a]	9.23E-07	8.53E-05

Text cont. on p. 217

[a] n.a.: not applicable

TABLE VI–2. GENERIC COMPONENT RELIABILITY DATA FOR RESEARCH REACTOR PSA (cont.)

		Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
Code	**Component type description**	**Code**	**#**	**h**	**h**	**#**		**#**	**1/h**	**1/demand**	**5%**	**95%**
YFX	Ion exchange filter	B	2	5.94E+04	n.a.a	n.a.a	F	5	8.41E-05	n.a.a	3.32E-05	1.77E-04
YFX	Ion exchanger filter	S	10	1.29E+06	n.a.[a]	n.a.[a]	Q	1	7.74E-07	n.a.[a]	3.97E-08	3.67E-06
YFX	Ion exchange filter	DALAT	1	n.a.[a]	8.45E+03	n.a.[a]	n.a.[a]	0	8.20E-05	n.a.[a]	n.a.[a]	3.54E-04

[a] n.a.: not applicable

Annex VII
EXAMPLES OF FAILURE DATA ALGORITHMS USED IN DATABASE TABLE VI–1

Table VII–1 provides information for users wishing to develop their own facility reliability database. To enable this, details of the original EXCEL algorithms used in Table VI–1 are provided. Three examples are given, two for failure rates and one for a demand failure, with the appropriate confidence bound calculations. Component codes for Table VI–1, AAR, ACA and DGA are used as examples. The columns are labelled from A to M across the top and in rows labelled 5, 6 and 162, to provide a simple alphanumeric grid reference. The row numbers correspond to the original EXCEL database row numbers for AAR, ACA and DGA components. Nine specific grid calculations (e.g. E5, J6 …. up to M162) are described below.

TABLE VII–1. FAILURE RATE DATA ALGORITHM EXAMPLES

Original excel grid row number	A	B	C	D	E	F	G	H	I	J	K	L	M
			Reactor	Component Population	Cumulative calendar time	Cumulative operating time	Demands	Failure mode	Failures	Failure rate	Failure probability	90% Confidence bounds	
	Code	Component type description	Code	#	h	h	#		#	1/h	1/demand	5%	95%
5	AAR	Sensor air (moving air)	AR3	3	2.89E+05	n.a.[1]	n.a.[1]	F	2	6.92E-06	n.a.[1]	1.23E-06	2.18E-05
6	ACA	Sensor core flux	A	3	2.90E+05	n.a.[1]	n.a.[1]	B	0	2.39E-06	n.a.[1]	n.a.[1]	1.03E-05
162	DGA	Diesel generator	HIFAR	2	n.a.[1]	n.a.[1]	1.45E+03	S	11	n.a.[1]	7.60E-03	4.27E-03	1.25E-02

[1] n.a.: not applicable

E5 Cumulative Calendar Time of Component (facility recorded value)

D5*11*365*24 = 3 components x 11 years x 365 day/year x 24 h/day = 2.89 x 10^5 component-h

J5 Failure Rate with failures >0

=IF(ISNUMBER(F5),(IF(I5=0,(CHIINV(0.5,2))/(2*F5),I5/F5)),(IF(ISNUMBER(E5),(IF(I5=0,(CHIINV(0.5,2))/(2*E5),I5/E5)),"-")))

If the number of failures I5 is 0 (which it is not in this case) then Equation (IV–23) is used for the failure rate, otherwise the failure rate is

I5/E5 =2/289000 = 6.92 x10^{-6} /h

J6 Failure Rate with 0 Failures

With the number of failures in I6 as 0, Equation (IV–23) is used for the failure rate = 0.693/E2 = 2.39 x10^{-6}/h

L5 Failure Rate 5% Confidence Bound

=IF(I5="-","-",IF(I5=0,"-",(IF(ISNUMBER(J5),((CHIINV(0.95,2*I5))/(IF(ISNUMBER(F5),2*F5,2*E5))),

(IF(ISNUMBER(K5),1/(1+((G5-I5+1)/I5)*FINV(0.05,2*(G5-I5+1),2*I5)),"-"))))))

If the number of failures is 0 (which it is not in this case) then the failure rate 5% confidence limit is not provided (e.g. L6), otherwise Equation (IV–18) (5% limit) is used for the 5% limit and is 1.23 x10^{-6}/h.

M5 Failure Rate 95% Confidence Bound

=IF(I5="-","-",IF(ISNUMBER(F5),(CHIINV(0.05,2*(I5+1)))/(2*F5),(IF(ISNUMBER(E5),(CHIINV(0.05,2*(I5+1)))/(2*E5),1/(1+(((G5-I5)/(I5+1))*(1/FINV(0.05,2*(I5+1),2*(G5-I5)))))))))

Equation (IV–18), (95% limit), is used for the failure rate 95% confidence limit and is 2.18 x10^{-5}/h.

G162 Number of Demands = facility recorded value = 1450

K162 Failure probability per demand

=IF(ISNUMBER(G162),(IF(I162=0,CHIINV(0.5,2)/(2*G162),I162/G162)),"-")

If there is a number in the demand failure data in column G162, then the average failure per demand is calculated from I162/K162 =11/1450 = 7.6 x10^{-3}. If there is a number in the demand column G162 then the failure probability on demand algorithm is used, otherwise the failure rate algorithm is used (e.g. see J1 and J2 examples above) to calculate failure rates.

L162 Demand Failure 5% Confidence Bound

=IF(I162="-","-",IF(I162=0,"-",(IF(ISNUMBER(J162),((CHIINV(0.95,2*I162))/(IF(ISNUMBER(F162),2*F162,2*E162))),(IF(ISNUMBER(K162),1/(1+((G162-I162+1)/I162)*FINV(0.05,2*(G162-I162+1),2*I162)),"-"))))))

If there is a number in the demand failure data in column G162, then Equation (IV–21) is used for the demand failure 5% confidence limit which is 4.27 x10-3/demand.

M162 Demand Failure 95% Confidence Bound

=IF(I162="-","-",IF(ISNUMBER(F162),(CHIINV(0.05,2*(I162+1)))/(2*F162),

(IF(ISNUMBER(E162),(CHIINV(0.05,2*(I162+1)))/(2*E162),1/(1+(((G162-I162)/(I162+1))*(1/FINV(0.05,2*(I162+1),2*(G162-I162)))))))))

If there is a number in the demand failure data in column G162 then Equation (IV–22) is used for the demand failure 95% confidence limit, which is 1.25x10^{-2}/demand.

ABBREVIATIONS

A	Ampere
ASEP	Accident Sequence Evaluation Programme
ATHEANA	A Technique for Human Event Analysis
BFM	Beta Factor Model
BFR	Binomial Failure Rate
CCF	Common Cause Failure
CREAM	Cognitive Reliability and Error Analysis Method
CRP	Coordinated Research Project
CS	Carbon Steel
Ch.	Channel
Cond.	Conditioning
DC	Direct Current
ECCS	Emergency Core Cooling System
EF	Error Factor
EFC	Error Forcing Context
FMEA	Failure Mode and Effects Analysis
FMECA	Failure Mode, Effects and Criticality Analysis
Gen.	General
HAZOP	Hazard and Operability Analysis
HEP	Human Error Probability
HEART	Human Error Assessment and Reduction Technique
HFRCA	Hidden Human Failure Root Cause Analysis
HRA	Human reliability Analysis
HVAC	Heating Ventilation Air Conditioning
I & C	Instrumentation & Control
IE	Initiating Event
Inst.	Instrument
kW	Kilo Watt
MEU	Medium Enriched Uranium
MGL	Multiple Greek Letter
MTTF	Mean Time To Failure

MTTR	Mean Time To Repair
NAA	Neutron Activation Analysis
NPP	Nuclear power Plant
Op.	Operated
PBF	Partial Beta Factor
PRV	Pressure Relief Valve
PSA	Probabilistic Safety Assessment
PSF	Performance Shaping Factors
RCM	Reliability Centred Maintenance
RCS	Reactor Control System
RSS	Reactor Shutdown System
Sec.	Secondary
SHARP	Systematic Human Acting Reliability Procedure
Sign.	Signal
SS	Stainless Steel
Sys.	System
THERP	Technique for Human Error-Rate Prediction
UPM	Unified Partial Method
VAC	Volt Alternating Current
VDC	Volt Diect Current

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