Task 12: RELIABILITY DATA COLLECTION AND ANALYSIS TO SUPPORT PROBABILISTIC SAFETY ANALYSIS (PSA)

An Evaluation of Questionnaire Results

Prepared by a Task Force of Principal Working Group N° 5

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TABLE OF CONTENTS

Introduction

1. Organizations involved in PSA and plant-specific data collection

2. Types of probabilistic data to be evaluated
   a) Component-related and conditioning events
   b) Initiating events
   c) Human interactions

3. Scope of data evaluation

4. Elements of data collection
   a) Incident event data and sources
   b) Plant engineering data
   c) Component operation data
   d) Component boundaries
   e) Component population
   f) Reliability data analyses

5. Data collection and analysis management
   a) Data treatment and quality assurance
   b) Computer-aided databases
   c) Manpower requirements for data collection and analysis

6. Summary

Appendix 1: Examples of Reliability Data Systems

Appendix 2: List of organizations involved in the questionnaire and additional respondents to this report.
INTRODUCTION

In 1990, the OECD-Principal Working Group 5: "Risk Assessment" established a subgroup, Task 12, to focus on the subject of data collection and analysis to support Probabilistic Safety Assessments (PSA). It was considered that exchange of information on the respective experience of the different organizations in the member countries as well as in other countries would be useful. A questionnaire was set up and distributed to organizations in the member countries and, through the International Atomic Energy Agency, to the non-OECD countries. The results of the responses of 44 organizations representing 26 countries were evaluated under the leadership of F.K. King, Canada and compiled in an OECD-report /1/ under the title of:

"Task 12: Data Collection and Analysis to Support Probabilistic Safety Analysis (PSA) Questionnaire Results, May 1992".

Due to the many insights and practical examples resulting from the responses by the organizations, a review and summary of the specific issues on data collection, derived from these responses, were performed by the current task leader, H.-P. Balfanz, Germany and presented in this follow-up report.

The draft report of this paper was again distributed to all participants for comment. The participants were asked to evaluate the applicability of the approaches of the reliability data collection and analysis which are described in this report.

From the answers it was found that the report reflects the state-of-the-art in this field.

One answer to this subject from Krsko NPP, Slovenia is given here: The report, which I have gone through is the valuable example of the international professional exchange of the information. The report itself, is from my viewpoint reflecting the real "state-of-the-art" in the field of data collection and analysis activities, between the different states and organizations.

The participants involved in the questionnaire agreed on taking further steps with respect to an exchange of experience. In this respect, OECD Principal Working Group 5 plans an International Workshop, entitled "Reliability Data Collection in Support of PSA, Maintenance and Life-Assurance Programmes" in Toronto, Canada, 15th-17th May, 1995.
1. **Organizations involved in PSA and plant-specific data collection**

44 organizations, representing 26 countries, responded to the questionnaire \(1\) and indicated their engagement in data collection for PSA of NPP (Appendix 2).

The majority of responding organizations are the utilities running a NPP. The minority are national institutes or institutes of utilities. Their main task is that of centralizing the data collections from multiple NPPs.

All utilities involved either have already completed a plant-specific PSA, have it in progress or are in planning it. In accordance with this application, all utilities but one have or intend to have a reliability data system to support PSA. About half of the respondents have completed one or more PSAs, varying from Level 1 to Level 3. More than half of the respondents plan to maintain a living PSA, which is usually to be updated in the range of 1 up to 5 years. Some indications mention PSA data updateings every three months or when changes occur.

**Comment:**

To get a better picture of common and adequate time intervals of PSA updating, the following points should be distinguished:

1. Complete PSA update according to the state-of-the-art;
2. Update of models according to relevant changes of hardware and software (procedures);
3. Update of input data according to current plant experiences.

National reliability data banks are mentioned as follows:

- **TUD** - Swedish reliability database. Data published in the Reliability Data Handbook (T-Book) (older name is ATV) and in the Initiating Event Book (I-Book)
- **DACNE** - Spanish data bank
- **SRDF** - French reliability data collection system.

**Comment:**

The generic aspects on centralized databases should be treated further in respect of generic data improvements (e.g. of passive component failure frequencies and CCF) and the necessity, due to data comparison, of standardizing reliability data parameters and assessments.

Apart from the main objective of reliability data analysis for obtaining basic input data for PSA, a number of organizations use the data to also support activities such as operation, test interval and maintenance optimization, spare parts management, material procurement, management of ageing components, identification of common cause failures (CCF), human reliability studies, licensing activities and basic material for plant staff training.

Studsvik, Sweden mentioned:

Beside using reliability data analysis for obtaining basic input data to PSA, it has been
used to support decision making at authorities, for example in handling application of exemption from the technical specifications.

AIB - Vincotte Nuclear, Belgium, indicates the use of performance indicators: the main purpose of the SIRIU5 system is to obtain information about unavailabilities of safety-related systems. The objective of this system is to try and find some maintenance-related performance indicators, which could be used to improve the maintenance program and to evaluate these improvements in addition to the other safety performance indicators.

2. **Types of probabilistic data to be evaluated**

The main types of probabilistic data to be used for PSA are:

- **Comp.** component-related events (e.g., failure rates, repair times)
- **Syst.** common cause failure frequencies (CCF)
- **CE** system train unavailabilities due to maintenance
- **IE** conditioning events (e.g., operating in abnormal modes)
- **HI** initiating events
- **HI** human interactions (errors)

a) Component-related and conditioning events:

Most organizations collect data on the time of component failure, repair time, surveillance test frequency and duration. Some collect data on failure cause and effects. Very few collect data on component operating history, and then only for selected components, on operating environment, means of detection and on common cause failures. Operating history data are mostly approximated, based on system and unit operating history.

A component is mostly defined as an item procured, and based on replaceability and functionality (so-called component boundary).

AIB-Vincotte Nuclear, Belgium, indicates a potential underestimation of test and maintenance unavailabilities, as compared with other data used in current PSAs.

Nuclear Power Co., India, indicates that importance of failure assessment is not given to passive components like pipes and vessels. Considering the repeated failures of welded joints at the heat affected zones in BWRs and some general problems seen in reactor pressure vessel components in plants etc., it is worthwhile to compile and provide database to establish generic nature of problems and review corrective actions needed.

CCF-data are generally collected through root cause analyses of failure events. If real or potential CCF events are identified, the dependency of multiple failures or degradations can easily be codified for further statistical evaluation.

EDF, France, characterizes common cause failures at, for example, two components by the beta factor approach, to be estimated in the following way:

\[
= \text{rate of common cause failure} / \text{rate of independent faults} + \text{rate of CCF.}
\]
These beta factors are determined by a detailed analysis of the PWR plant unit operating feed-back files and by using the shock model (binomial distribution method).

The study of about 5,000 failure records was completed to identify common cause failures. Beta factors between $3 \times 10^2$ and $10^{-1}$ for several types of equipment were estimated:

- instrumentation (sensors, transmitters, analog measuring equipment)
- pumps
- valves in primary and secondary systems (pneumatic, electrical valves, check valves, hand-operated valves)
- circuit breakers and contactors (especially 6.6 kV equipment, trip breakers).

Rochester Gas & Electric (RG&E), USA, also attempted to collect plant specific common cause failure data. Approximately 20,000 maintenance and operational records were reviewed for 20 plant systems and 1900 parent components over a 9 year data window. The following results were obtained:

- of common cause failures - 10
- of components affected by common cause failures - 5
- of independent failures - 446
- of independent failures in component population affected by CCFs - 84.

As can be seen, only an extremely small population was affected by CCFs (i.e., 5 components out of 1900 or 0.3 %). In addition the components which were affected by CCFs had a disproportional number of independent failures (i.e., 84 of the 446 independent failures or 18 %). Therefore, the data suggests that CCFs are relatively rare occurrences, affecting only a small population of components which have a large number of observed independent failures.

b) Initiating events:

Data on initiating events are mostly obtained through an analysis of plant event reports like the LERs.

The Arizona Public Service (APS), USA, approach to initiating event characterization was to utilize U. S. Industry data for anticipated transient initiating events (from NUREG/CR-3862 and NSAC-111) to establish an apriori distribution describing the frequency of each transient initiating event. In order to incorporate plant specific experience, APS has utilized bayesian methods to combine the apriori distribution with the plant specific experience in recent to the Palo Verde PRA. As part of the initiating event quantification process, all plant trips are periodically reviewed and classified into the appropriate PRA initiating event classification (or a new classification created if necessary) based upon the initiators effect on plant systems and the mitigating systems required to operate.

Lovisa NPP, Finland, and Kanupp, Pakistan, mentioned the same practice to this issue. Kanupp recommends a worldwide reactor type-specific IE-date evaluation.

c) Human interactions (errors):
Only a few organizations collect plant-specific data on human interactions. Human interactions and error rate evaluation are indicated in different ways:

Arizona Public Service, USA:

The contribution of human error to all plant trips and some lesser incidents are reviewed for focussing on those actions, that may be risk-significant. At this time, estimates of human error probabilities (HEPs) based on plant-specific data have been made in only a few cases - the most important ones being inadvertent actuation of all fire dampers during testing of the fire protection system.

PAKS NPP, Hungary:

Human interactions are examined during regular and specific simulator-based training exercises and are recorded by the Operator Action Monitoring System (only for the cases contained in the Emergency Procedures).

For regular training the information is recorded by the on-line COPAS (Computerized Operator Assistance System), while for specific exercises additional information is manually recorded by observers on detailed data sheets.

COFRENTES NPP, Spain:

Following the SHARP methodology, human actions were analyzed and classified accordingly. Specific models have been used to assess human errors. Data for individual human errors came from generic data sources, HGR for the cognitive part of the dynamic human actions and from NUREG/CR-1278 (THERP) for the procedural manual parts.

Loviisa NPP, Finland:

Quantitative human error data are collected at plant side, but mostly generic and modified generic data are used (ASEP-HRA guide is used in PSA).

3. Scope of data evaluation

The scopes of the various plant-specific component-reliability data collection systems are mostly focused on components in safety and safety-related systems and in all systems, which are within the scope of PSA models.

By this approach, 1100 components for each pair of units are included (EDF, France). About one third of the utilities collect reliability data on all plant components.

These failure data collection systems are generally based on the plant-side event reporting system for maintenance and work orders.

By this approach, only those component events are transferred to the PSA component database, which are contained in the PSA models (TVO Finland and similar to others).

The advantage of this application is the flexibility of component data evaluation. Components originally not included in the PSA can easily be added to the database, if
required so (applied at specific German plants).

In the KAERI-NPP, South Korea, maintenance data are collected for all systems and components. The number of components in a typical plant amounts to 35,000. The collection system named PUMAS-N (Power Unit Management System for Nuclear) is a multi-purpose system. Several systems/components are included in the system unnecessary in the scope of PSA, like, for instance, fuel buildings, water treatment systems, etc.

Lovisa NPP, Finland, indicates that they have in use a system with rather similar extent of component data collection as mentioned above.

Others indicate systems and components, which are outside the scope of PSA models, such as:

- Fuel handling and transport systems
- Safety valves and overpressure protection systems of conventional pressure vessels in NPP.

Systems and components that are contained in the scope of PSA models, but for which no plant-specific data are collected - as indicated for some applications - are:

- instrumentation and electronic components, like relays, transmitters and electronic devices
- pipes, vessels and heat exchanger tube ruptures.

Rochester Gas-Electric Corp., USA, indicates:

Small electrical devices are typically subcomponents; therefore, obtaining data on this level without a detailed and computerized maintenance work order system is very difficult indeed, if not impossible.

Likewise, no data were collected for transmitters (pressure, level and temperature). Once again, many times failures are 'hidden' among other equipment failures on a work order. Moreover, the data analysis effort was started before the system analysis task and it was not known, which transmitters would be modelled.

Kanuppp, Pakistan, collects plant-specific data of instrumentation and electronic components, like relays, transmitters, switches, controllers, etc for ECCS, containment spray system, protective system and regulating computers.

Others indicated that small electronic devices have only little influence on PSA results, except CCF.

Passive components are generally excluded, because failure frequencies of pipes and vessels are very low and a good plant specific statistical basis cannot be achieved. Generic data for these components are expected to be adequate. (To this subject, see statement from NPC, India, chap. 2.a).
4. Elements of data collection

a) Incident event data and sources.

Plant-specific data are based on field reports describing plant events, component deficiencies and maintenance work carried out.

The original sources of failure events are contained in all operational plant documents, such as: operation logs, maintenance logs, in-service reports, work authorizations, order-to-operate forms, jumper and degradation control sheets, preventive maintenance records, periodically monitored equipment parameters and process parameters, surveillance records, various test results, calibration sheets.

In some applications, field staffs use specially designed forms for failure event records and codifications, from which the staff people in a central department compile reliability data. Data compilation is mainly a manual process, except in the few organizations that have a computerized plant work management system. Data compilation varies from on-going to periodic proceedings. The compiled data are mostly stored in an electronic database. The approach varies from one common database containing data on all components, to separate databases for different categories of components. These are both mainframe-based and PC-based. Comparing the scope and the extent of details of technical information to be stored in different databases, we notice rather great differences.

An example given by the Finnish utilities shows one of the most extensive PSA data bases, which includes the following items:

Attributes for each failure event are collected, such as: failure event identification code, component identification code, type of the failing component, failure detection time, beginning time of repair action, ready-time repair action (component operable), room identification code, failure report identification code, number of men working, man-hours used for repair, reason code of waiting time, PSA-type code of the component, status of the repaired object, component inoperable due to specific item.

Failure codes are collected, such as: how the failure was detected, consequence of the failure, failure type (physical, e.g. jammed, stopped), repair action done (e.g. replaced by new unit), direct observed cause of failure, root cause of failure.

A description in clear text of the failure event and of the repair actions is carried out.

Added in the reclassification for each failure event:

1. Repair time
2. Estimated failure duration before failure detection
3. Total failed time
4. Criticality of the failure: component inoperable as from failure occurrence, component inoperable during repair only, component operable also during repair
5. Failure mode used in the PSA mode (according to a component type specific list)
6. Possible CCF
7. Notes
8. Initials of classifier.
Additional elements to be reported from other applications are:

- Operational environment at the time of failure event occurrence;
- Inspection frequency;
- Total cost of event restoring and costs incurred due to the loss of production.

b) Plant engineering data

Plant engineering data are collected and stored in the dB for those components to be considered. These data are used to support the reliability data processing in respect of event investigation and of compiling component sample sizes (component population).

The application by Ontario Hydro, Canada, is stated here as a representative example:

For the mature data system, the following data will be collected: component identification number (including station unit, component type, component number), component subtype, design attributes (e.g., size, flow rate), manufacturer, stock code number, model number, serial number, location, normal application (e.g., standby), process condition (e.g., fluid, pressure, temperature, flow rate), operating environment, operation flow sheet, in-service data, removed-from-service data.

Of course, comparison of the different applications shows some considerable differences in the details of the types of engineering data to be collected.

The CEC reliability database mentioned 20 engineering attributes (e.g., design-related) and up to 20 operating attributes (e.g., application-related).

NPP Muhleberg, Switzerland, indicates a typical trend of data treatment: the probability data are part of standard maintenance, replacement and/or repair procedures. No specific collection mechanism has existed up till now. In the near future, all these data will be integrated into a computerized maintenance system.

c) Component operating data:

Component operating data are generally collected for safety significant components, like pumps and other rotating equipment items.

Cofrentes NPP, Ibredola, Spain: DACNE database supplies the following information:

- Date of operation
- Operation mode
- Type of maintenance
- Operating hours
- Operating cycles (demands)
- Operating parameters
- Operating hours and cycles accumulated.

Council of Nuclear Safety and Eskom, South Africa, stresses the correlation of incident events and operational data:
Total running hours and the running hour, on which each event has taken place (i.e. time to failure, time to repair, etc.).

What should be collected has not yet been fully implemented:

- The number of successful starts and the number of unsuccessful starts (failure on demand)
- The number of failures whilst running (running failures)
- The number of times a component/system was left in a state of not ready to perform its design function, i.e., (1) restoration after maintenance, (2) incorrect line-up (operations).

Arizona Public Service, USA, indicates a very specific approach of collecting operational data:

Demands have been estimated based on test and operating procedures. A program was initiated several years ago to acquire much more accurate demand rates by placing small electromagnetic detectors on the power cables to key components. The detector is 'non-intrusive' (it simply wraps around the cable) and can be read at any time to determine the number of component actuations. The detectors were actually designed and built, but, due to programmatic problems, they have not been installed. This program may be reestablished in the future.

d) Component boundaries

Necessary for obtaining consistent data is a definition of component boundaries in reliability data collection and for using these data in the fault tree models.

In this matter, the responses from the applicants have resulted quite differently, and they are characterized by:

ISEG-NPP Krsko (Yugoslavia):

The component boundaries are defined in several ways. Basic criteria are:

- Line-replacable unit, vendor-supplied unit, vendor drawing boundaries, CDA/CAE drawing boundaries.

For the purpose of PSA data collection, the predefined boundaries will be compared with the boundaries defined in the process of plant system modelling, and defined in the sense of data retrieval possibilities and plant system models.

EdF, France:

Component boundaries are defined in a User Guide as per 3 levels:

- functional aspect of components (diesel generator, turbine-driven pump)
- type of equipment (motor, pump, turbine, transformer)
- internal considerations (stator, rotor, bearing).
OKG Vattenfall, Sydkraft, Sweden:

In the Reliability Data Book (T-Book), based on the TUD data collection system and on LER reports, a component generally consists of the main component and its equipment, component-related switchyard equipment, control equipment and manoeuvring and indication equipment (see Fig. 1).

e) Component population

The component populations are compiled from similar components to increase the sample size of components and their operational service time, thus obtaining better statistics, e.g. of the failure rates of a specific component type.

This implies that the component must be similar not only in respect of design, but also as to its environmental, operational and maintenance conditions, so as to be sure, that the failure attributes of each component are comparable, as otherwise the estimated failure data would be very uncertain.

Ontario Hydro, Canada:

The data system will allow the user to define a population of components to suit the user's needs. However, for the purpose of estimating failure rates, repair times, etc., it is defined as those having the same engineering attributes (this is referred to as the 'unique' group). This serves for minimizing the variability of factors that could affect the reliability and maintainability of the components of interest.

GRS, Germany:

Experience has shown, that populations must include at least three characteristics: type, type of activation and type of plant systems. This has been evaluated through detailed analyses of recent years.

Northeast Utilities, USA:

Insufficient populations for categorizing by valve type (gate, globe) are typically: borated vs. non-borated, inside containment vs. outside, seawater vs. non-seawater.

f) Reliability data analyses

A majority of the organizations perform basic statistical analyses, such as failure rate and mean repair time estimations. Some perform failure trend analyses, fit distributions and analyses for common cause failures. Others perform Bayesian analyses to account for incremental experience. The component population is mostly defined on a basis of component type, subtype and size and the system of which they form a part, but not on any statistical considerations.

Different operational conditions of similar components should be taken into consideration by the statistical approach in any case (see point e).
The main objectives of reliability data analyses are:

- Improvement of PSA data, e.g. to determine differences between failure rates used in PSA and estimates from plant experience
- Trend analyses (wear-out patterns) for engineering purposes
- Identification of components with high failure rates and related failure causes observed from plant experiences.

A comprehensive data analysis is given by Imatran (IVO) Finland:

**OFF-LINE (PSA):**

- Statistical tests for trends in failure intervals.

For specified failure modes:

- Failure rates for individual components/failure intervals
- Failure rates for groups of components (identical or similar)
- Unavailabilities of components (fractional dead times)
- Fitting of learning models (trend models) for obtaining current values for failure rates/unavailabilities.
- Comparisons to generic data
- Uncertainty distributions or error factors.

The approach of combining generic and plant-specific failure data is described by Power Reactor/Nuclear Fuel Dev. Corp of Japan:

Generic failure rates are basically produced on a basis of the geometric average between CREDO and other applicable reliability data sources. Plant-specific data are updated, using the Bayesian technique. The generic failure rate is used as prior distribution. Plant-operational experience is applied for likelihood functions. If a plant-specific data population is too small and plant-specific failure rates are higher than the upper boundary of the generic failure rate, plant-specific data will be discarded and generic failure rates will be used.

5. **Data collection and analysis management**

   a) Data treatment and quality assurance

   Data collection and processing management is typically handled by different expert groups, such as:

   - Surveillance testing group
   - Experience feedback group
   - Plant inspectors, data retrieval from utilities log book
   - PSA group.

   Typical examples of data processing are given by the following institutions:
Kozloduy, Bulgaria:

Data collection is done by filling-in of forms by experts at NPP departments. These experts are assisted and controlled by data collection teamleaders, who supervise all these forms.

New failure sheets are in use, where the data are entered in a database.

The database is passed on to the NPP supervision and safety analyses subdepartment, where all engineering, operational and failure data are analyzed.

After the data having been organized, structured and analyzed, the resulting information is distributed to various users (on site or off-site) in an appropriate form.

Many contributors stress the importance of quality assurance of failure event investigation, so as to receive consistent failure data.

Paks NPP, Hungary:

The QA is provided for by a 2-step review of the data collection sheets, and by discussions if these are needed. The first review is performed by the engineer responsible for data collection, the second one is made automatically by the software (it checks whether all required data are present, but it does not prove the consistency of the data).

At Ontario Hydro, Canada, a specific guidance of the data analyst’s work has been established:

Based on the information contained in work reports (25,000 up till now) and in system operational flow sheets, and on their knowledge of CANDU stations and components, the data analysts determine the identity of the component(s) having failed, the corresponding failure mode and the failure mechanism. So as to enable consistent data compilation, the data analysts must follow procedural guidelines, which include a standard list of component boundary definitions, failure modes and failure mechanisms. The other data elements that constitute the failure event record are obtained directly from or are calculated from the data in the work package information.

The failure event records are then verified and audited by senior data analysts before being entered into the Component Failure Event database. The purpose of this verification and auditing process is to confirm the accuracy of the failed component identification, failure mode and mechanism, and to check on any duplication or omission.

Kema, Netherlands, indicates the necessity of classifying failure events into 4 categories:

1. Catastrophic failure
2. Degraded failure
3. Incipient failure
4. Not applicable
The records included in the first three categories are retrieved and the information of interest is extracted. Only the catastrophic failures are taken into account for reliability estimates.

EdF, France:

With a view to obtaining large amounts of data, EdF France has established national databanks. S.R.D.F. (Reliability Data Collection System) and F.E. (Event File) are analyzed, along with the file of statistical data on the operation of the French nuclear power plants. By this approach, local, national and international data assessments are handled. In the time period from 1978 till 1988, the national experience obtained 20,000 event reports. Among these reports, 5,000 failure events were evaluated to identify common cause failures.

EdF, France stated that updating is a continuous process through the computerized database.

This reliability database will be kept up to date within periods of 2 or 3 years.

Rochester Gas - Electric Corp., USA, indicates a general trend to reliability data treatment:

We are currently trying to implement a program within RG & E to use the combined resources of the PRA, Reliability-Centered Maintenance and NPRDS organizations to streamline this process, as part of preparation for the US-Maintenance Rule.

The U.S. Maintenance Rule which becomes effective in July 1996 will probably create a noticeable improvement in the ability of US utilities to obtain failure and reliability data to support PSA applications. It is anticipated that the Maintenance Rule will impact the scope of data collected, the elements contained in any data base, and data analysis management.

Ginna PRA will be maintained as 'living' as possible, the data collection activities probably won't be done more frequently than annually. This is due to the fact that the close out of plant records is relatively slow and the addition of one or two failure events will not affect the PRA results to a great degree. It is realized that the new failures are an important trending consideration, but this is not within the charter of the PRA task. This is really a maintenance task.

There were 288 failures modes (organized by component type and system) included within the Ginna integrated PRA model. Plant specific data was utilized in calculating the failure rate or probability for more than 200 of these failure modes. The collected plant specific data were evaluated against generic data obtained from available sources (e.g., NUREGs, previously published PSAs) and the following insights were obtained:

a) Approximately 25% of the calculated plant specific values were within a factor of 3 of the generic value.

b) Approximately 8% of the calculated plant specific values were greater than a factor of 3 higher than the generic value.

c) Approximately 8% of the calculated plant specific values were greater than a factor of 3 lower than the generic value.

d) The remaining 60% of the plant specific data contained no observed failures over the 9 year data window.
b) Computer-aided databases

Processing of the huge number of data to be used for plant-specific data evaluation requires a computerized database. A great number of databases are already in use for reliability data analysis (RDA). Most databases are PC-based, some are on workstations or on mainframe computers.

The general structure of databases results from an example by Ontario Hydro, Canada:

To meet its requirements of RDA, the component reliability data system must have the capability to capture the necessary event, engineering and operating history data, to retrieve the required data, and to perform the necessary data analyses. To enable this, the data system is made up of a number of modules as shown in Fig.2.

The capacity of data storage is specified as follows:

- Failure event data: 2.7 Mbytes/4-unit station/year
- Engineering data: 250 Mbytes/4-unit station/year
- Reliability data: 8 Mbytes/4-unit station/year.

For each component, 17 attributes of engineering data are stored for data analysis.

c) Manpower requirements for data collection and analysis

Most of the organizations employ qualified personnel and clear procedures and guidelines, so as to enable consistent data compilation. The resources required for managing data systems varies 0.5 to 3.0 persons-year/unit-year.

Special efforts are necessary for handling centralized national and plant-specific data collection, as indicated by the Swedish approach:

The organization responsible for the system (TUD-system) is within the Vattenfall main office in Vallingby, Stockholm. This department has 20 people employed. Six of them work directly in activities related to TUD. These people also serve the other two nuclear power utilities in Sweden with 'processed' data. Data from the TUD-system are the basis for the Reliability Data Book (T-book) for all Swedish units and for TVO 1&2 in Finland. On the sites, approx. 2-3 people at each site work in maintenance and fault reporting application.

6. Summary

The OECD-Principal Working Group 5: "Risk Assessment" established a subgroup, Task 12, in 1990 on the subject of data collection and analysis to support Probabilistic Safety Assessments (PSA). Information on the related experience of various organizations in the OECD countries, as well as non-OECD countries was collected by setting up and circulating a questionnaire.

The responses to the Questionnaire /1/ by 44 organizations representing 26 countries, involved in PSA and data collection, describe the main aspects of reliability data collection and analysis applied worldwide in the nuclear field. So far, fruitful information on the state-of-the-
art of this subject, has been collected indeed and is summarized in this report.

A vast majority of the organizations have either already implemented, or plan to implement a reliability data system to support PSA. Some examples of reliability data systems are presented in the appendix.

A number of organizations also use the data to support activities such as operation and maintenance optimization, spare parts management, material procurement, management of ageing components, identification of common cause failures and licensing activities.

Most of the organizations employ qualified personnel and procedures and guidelines, to enable consistent data compilation. The resources required to manage the data systems vary from 0.5 to 3.0 person-year/unit-year.

The participants of the questionnaire agreed on taking further steps with respect to an exchange of experience. The majority of the participating utilities welcome the question of having an international workshop on data collection and analysis to support PSA. The main interests are stated here:

1. Exchange of experience with people involved in data collection; state-of-the-art of data systems in other countries
2. Data analysis tools for living PSA
3. Exchange of reliability data, opportunity of pooling data, standardized data approach
4. Methodological assistance on data analysis, handling of uncertainties
5. Time-dependent failure frequencies, CCF, human factor failure rates
6. Trend analysis, ageing, preventive maintenance optimization.

An international OECD-Workshop, named "Reliability Data Collection in Support of PSA, Maintenance and Life-Assurance Programmes", is planned in Toronto, Canada, 15th - 17th May 1995.
Reference

Appendix 1: Examples of Reliability Data Systems

1.1 Loviisa Power Plant Information System
1.2 HEW, Germany, Data Base Structure
1.3 The Scandinavian Nuclear Power Reliability Data System
1.4 NPP Leibstadt, Switzerland, Data Banks for Nuclear Power Plant Operation
1.5 Status Report on Databases in the Branch Information on NPP Operating Experience, Russia
Appendix 2:

List of Organizations Involved in the Questionnaire and Additional Respondents to this Report.
Figure 1. Physical boundary of centrifugal pumps *)

*) This figure, taken from the Swedish Reliability Data Book (T-Book), is given here as an example in the process of reliability data collection.
Figure 2. Component Reliability Data System *)

*) This figure, taken from the Ontario Hydro data base system, is given as an example.
Appendix 1: Examples of Reliability Data Systems

1.1 Loviisa Power Plant Information System

1.2 HEW, Germany, Data Base Structure

1.3 The Scandinavian Nuclear Power Reliability Data System

1.4 NPP Leibstadt, Switzerland, Data Banks for Nuclear Power Plant Operation

1.5 Status Report on Databases in the Branch Information on NPP Operating Experience, Russia
LOVIISA POWER PLANT INFORMATION SYSTEM

Basic data
- Operation Equipment data
- Room data
- Site data

Materials management
- Helsinki

Preventive maintenance
- Work area data
- Route data
- Realization follow-up

Work planning
- Work order instructions
- Special persons

Distributed materials management
- Storage operation
- Purchase operation
- Invoice processing

Process computer

Outages planning and management
- Scheduling of outages
- Graphic display
- Report

Scheduled tests
- Component
- Test
- Follow-up

Probabilistic safety analysis
- Analysis programs
- Helsinki

Maintenance history
- Fault history
- Repair history
- Operation site history

Personnel register
- Resources
- Radiation protection
- Employer information

29.10.1990
DATABASE LOGIC MODEL

Work Instruction specific data
Scheduled tests
Equipment data
Object specific data
KZ-summary data
Equipment exchange data
Performed repair data
History output page data
Fault data
- human errors
Numbers of history search summary page
DESCRIPTION OF THE MAINTENANCE HISTORY SYSTEM

The purpose of the partial system is to collect information about maintenance and operations and record it in a separate data base. When making a work order, the orderer also gives information required by the maintenance history, in addition to the work order information. On the work order display there are own fields for the information. A printed work instruction creates a history outline in the history data base. The outline can be completed and changed, if necessary, by the system updated displays (receipt of the work instruction). The worker, the foreman and the shift supervisor give required information as the work proceeds and when the work is completed.

The work planner of the area in question checks the given updated information and, if necessary, completes it when the work instruction has been returned to work planning. If equipment has been changed during the work, this information is updated in the basic data system, from where it automatically is transferred directly to the history data base.

Work instructions with technical specifications are directed immediately to the history supervisor who checks the given information, adds necessary further information to the history and initials the given history information.

From the ADP-terminal the history supervisor also checks all the given history information that requires history. The supervisor adds necessary information to the history and initials the given history information.

The history supervisor also checks the special reports and the disturbance reports made at the plant and adds information acquired from these to the history. He also adds human errors occurred at the plant to the history system. This information is based on special reports, disturbance reports and survey/interview forms.

The maintenance history system also functions as a PSA (probabilistic safety assessment) information data base from which information required for analyses can be copied into separate files.

The test results from the scheduled test system are also transferred to the history system and the test information is shown in the Kennz-history.

Every user of the system can see the information on the display and/or print it. The history supervisor and some other persons involved can see the special information on the display and/or print it.
APPENDIX - Germany HEW Data Base Structure

Component Disturbance

Registration in Databank

Replacement  Repair

External Repair

Failure Mode Classification Based on Repair Report

Scram Report

Event Classification

Data Base: KKB Generic Reliability Data

Evaluation Software

KKB-Specific Reliability Data
THE ATV-SYSTEM AND ITS USE

Kent Ekberg, Morgan Andersson
The Swedish State Power Board

Jean-Pierre Bento
Nuclear Safety Board of the Swedish Utilities

INTRODUCTION

The ATV-system, the Scandinavian Nuclear Power Reliability Data System, was developed during the late seventies and in the summer at 1980 the first reliability parameters were presented from the complete system.

The main goal of the ATV-system is to produce reliability data and the appendant failure statistics for components of technical systems of importance for either the power production or the safety of the units. In order to achieve this, modern information system theory and advanced data processing techniques are used. Another important feature is the close cooperation with the local maintenance management systems. Activities of importance for efficiency of power production which the system is to support with relevant data are

- reliability analyses
- availability analyses
- life cycle cost analyses
- probabilistic risk assessments (PRA)
- planning and performance of maintenance
- spare parts optimization
- trend analyses
BACKGROUND

The ATV-system was initiated in 1974 by three Swedish Nuclear Power Utilities (Oskarshamns Power Company, Southern Sweden Power Supply Company and Swedish State Power Board). In 1978 a systematic failure reporting from the nuclear units in Sweden started on a regular basis. In 1981, when the complete system was designed and implemented, the Finnish Nuclear Power Company -TVO - joined the system.

The ATV-system is to be a common concern of the member power companies but with administration committed to one body under the guidance of a joint steering committee. The administration is committed to the Swedish State Power Board. Besides the member companies, who own the system, authorities and the main manufacturers are represented in the steering committee.

THE ATV SYSTEM - A DESCRIPTION

The ATV-system contains failure event information, engineering reports (background data describing the observed components), unit operating data and operating time readings (of certain components) from twelve Swedish and two Finnish nuclear units. Figure 1 shows an overview over the ATV-system.

![ATV System Diagram]

Figure 1 : The ATV-system.
The failure reporting

The failure reporting from the nuclear units was started in the autumn of 1976 for an introductory test year. After revision the regular reporting is running from January 1978. At the same time the construction of the complete system was started. The evident reason for starting the failure reporting before the completion of the system was the desire not to lose valuable information from units already in operation. Information is at present retrieved from:

<table>
<thead>
<tr>
<th>Unit</th>
<th>Main contractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barsebäck 1 and 2</td>
<td>BWR  ASEA-ATOM</td>
</tr>
<tr>
<td>Forsmark 1,2 and 3</td>
<td>BWR  ASEA-ATOM</td>
</tr>
<tr>
<td>Olkiluoto 1 and 2</td>
<td>BWR  ASEA-ATOM</td>
</tr>
<tr>
<td>Oskarshamn 1,2 and 3</td>
<td>BWR  ASEA-ATOM</td>
</tr>
<tr>
<td>Ringhals 1</td>
<td>BWR  ASEA-ATOM</td>
</tr>
<tr>
<td>Ringhals 2, 3 and 4</td>
<td>PWR  Westinghouse</td>
</tr>
</tbody>
</table>

The way of collecting the information and the reporting from the power stations are decided by each reporting station. The collection of data has been integrated into the existing administrative routines in order to minimize the effort and promote good quality of the data. Before transmission to the ATV handling system the failure reports are revised by a responsible ATV-rapporteur at each station.

For every failure event a failure report is produced, where the failed item is identified with the unique unit identification code. Several time periods and time points are registered together with failure codes and on which component category the action is taken. Good descriptions of the failure event in plain language is very important. This information is collected and submitted to the ATV-system.

Engineering reports

The largest input of information to the system is the so called "engineering reports", which consists of background data on all components followed up. This information is necessary for a reliability data system, as the components have to be clearly identified as well as their characteristics of importance for the reliability.
The engineering reports contain:

- identifying data
- manufacturer data
- engineering data
- operating data
- preventive maintenance data (only some components of importance)

The identifying data is used to enable a correct connection to the failure reports and consists of functional item number (system and component code) and component category for all components.

The information in the engineering reports is transmitted to the ATV-system as it is available in the local maintenance management systems. This is possible as the ATV-requirements were taken into consideration when creating the item inventory files.

In November 1984 the ATV-system contained

- 66 000 failure reports
- 225 000 engineering reports

**Unit operating data**

In order to obtain the basic quantitative values needed (operating times to failure, repair times, successful and unsuccessful activations etc) to assess reliability characteristics, the failure and engineering reports are completed by an operating data recording. The purpose is to assess e.g. the time a component has been in operation between two failures. This information is collected from the existing unit availability information system (the TGV-system), which gives the operating history of the unit. The history is transformed into points of time for transactions between defined operating states. The identified states are

- cold shutdown
- start-up
- hot stand by
- power operation
Aside from these, turbine trips and reactor scrams are also notified. The systems and their components are expected to have a well-defined function in those operating states. Consequently, their operating history can be deduced from the so constructed operating profile.

**OUTPUT FROM ATV**

All the information in the ATV-system is stored in a database. The database handling system used is Univac's DMS-1100. The structure of the database is created to satisfy the needs for fast response, flexibility and data secrecy. A special query language processor (QLP) is used for retrieval and presentation of data stored in the base, which allows spontaneous questions for failure information, component information etc to be asked and answered through the telecommunication facilities.

In order to be able to present reliability characteristics a number of evaluation programmes have been developed. These programmes calculate failure rate with optional confidence limits, mean time to failure (MTTF), mean time to repair (MTTR), mean down time, success rate etc.

In today's performance only the exponential distribution is considered. The evaluation programmes mainly present:

- reliability characteristics for functional items
- reliability characteristics for component categories divided into - types - manufacturers
- reliability characteristics for a group of components (e.g. all gate valves with inlet size 10-15 mm)
- success rate for a group of components
- reliability characteristics presented yearly for a component category, type and manufacturer

When calculating the reliability characteristics on a chosen population the belonging failure reports can also be presented in a standardized layout. Figure 2 shows a page from the ATV-DATABOOK where reliability data are presented for all types of components which are stored in the system. The ATV-databook is published every year.
Figure 2. A page from the ATV-databook

The system is prepared for the possibility of presenting other distributions than the exponential by only developing new evaluating programmes. This belongs to the future plans for development of the system.

THE USE OF ATV

Reliability data from the ATV-system can be used in analyses for different purposes. Sometimes direct selections from the system can be enough for the user, sometimes some work must be done to the information. Of special interest in this respect is life cycle cost analyses and probabilistic risk assessments.

Trend analyses

With help of the evaluation programmes in the ATV-system reliability characteristics can be achieved on single components or groups of components, specified e.g. through unit and system code or via type, manufacturer, size, flow, pressure, environment, material etc. Through suitable sorting the information can give answers on interesting questions as - how is the trend of the failures? -which type of valve has most failures per year? - etc. The user can by himself define his selection criteria limited only to the information which is stored in the system.
Spare parts optimization

An important area is to optimize spare parts for the nuclear units. Swedish State Power Board, SSPB, has a special computer programme in order to optimize spare parts. A lot of parameters are used in the programme and one of the critical is the exchange rate for failures. This parameter is provided from the ATV-system through a special evaluation programme.

Life cycle cost analyses

For many technical plants and systems the reliability and maintainability are of great economical importance. In order to quantify the costs in a life cycle cost (LCC)-model reliability data is a necessity. The ATV-system gives good data for LCC-analyses for the nuclear power industry and also for other process industries.

Within the SSPB the LCC-analysis nowadays are widely used to support the decision-making. A great number of system modifications, maintainability improvements and spare part purchases have been based on recommendation from analyses. References (1) and (2) describes the basic LCC-methodology and give some examples of its use. In analyses like these the ATV-system is a perquisite for a good result.

Probabilistic Risk Assessment

In accordance with a government decision, probabilistic risk assessment (PRA) studies are to be performed, and updated on a recurring basis, for each of the Swedish nuclear power plants. Four such studies have already been performed.

Long before the initiation of the first of these PRA studies, and in order to strengthen credibility, the Swedish nuclear utilities realized the important necessity of possessing an accurate and reliable Swedish database for failure probabilities for all major safety related components.

Coordinated by the Nuclear Safety Board of the Swedish Utilities (RES) and with the participation of all Swedish nuclear power utilities, the Swedish Nuclear Power Inspectorate, Asea-Atom and Studsvik, a project started in 1981 for developing such a database. In 1982 the first version of the so called "T-Book" was published constituting a comprehensive, user-oriented data handbook for use in current and future Swedish PRA studies.
QUALITY

The most important factor for a reliability data system is to keep good quality of the input data. When creating the ATV-system the following factors promoting good quality of the data were considered:

- Voluntary cooperation by the utilities for defining the requirements and development of the system.
- Failure and engineering reports based on and integrated with the local maintenance routines and information systems.
- Fast and easy feedback of data to the reporting stations.
- Designated persons responsible for the different activities according to the instructions. A central secretariat responsible for the running administration and follow-up.
- A user's manual defining the characteristics and the treatment of the system
- Education of and information to all involved.

After completion of the system some activities have been added for improving the quality of the input information.

- Publishing an ATV-pamphlet
- Quantitative and qualitative analyses of the input information

Nowadays the quantitative analyses of the failure reporting are updated every year. These analyses have shown an upward trend in the coverage of the reported failures to the ATV-system. The coverage has increased from about 50% in year 1976 to about 80-90% in year 1980-83. Small fluctuations can be seen among different units.

In order to improve the quality of the input information all failure reports from each unit have been studied during a certain time period. This work has shown the weaknesses both in the reporting at each unit and in the ATV-system. Looking at the details the most important failure data code (failure mode) proved to be very reliable. Only six percent was judged to be faulty. The main result of this study shows the need of more information to plant personnel about the use and the necessity of the ATV-system.
The "T-Book" has been developed on the basis of appropriate statistics from the ATV-system, the information of which was complemented, when pertinent, with statistics originating from a review of the Swedish LERs ( Licensing Event Reports). Whenever statistically feasible the "T-Book" contains plant specific failures data (failure to start/open on demand, failure to run, repair times etc) for pumps, valves, diesel engines, instrumentation etc which mainly belong to safety systems. Confidence intervals are provided, based on the use of the Gamma-distribution for failure rates and a Beta-distribution for failures per demand. Figure 3 shows an example from the "T-book".

The updated second version of the "T-Book", in English version, is expected to be released at the beginning of year 1985. After finding the methods and the extent of the T-book by the work of the first two versions, the future updating will be an integrated part of the ATV-system.

| Component type: Centrifugal pump, horizontal |
| Operating mode: Operation |
| Flow rate: 40-60 kg/s |
| Pump head: 0.5-0.7 MPa |

<table>
<thead>
<tr>
<th>Plant</th>
<th>Failure mode</th>
<th>fails to run 10 E-6 /h</th>
<th>active repair time (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barsebäck 1 (BWR)</td>
<td>34. (*)</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Barsebäck 2 (BWR)</td>
<td>21. (*)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forsmark 1 (BWR)</td>
<td>34. (*)</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Forsmark 2 (BWR)</td>
<td>24. (*)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oskarshamn 1 (BWR)</td>
<td>15. (*)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oskarshamn 2 (BWR)</td>
<td>30. (*)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ringhals 1 (BWR)</td>
<td>40. (*)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Ringhals 2 (PWR)</td>
<td>69. (*)</td>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>

All BWR plants

5 %-percentile 5
Mean 28
95 %-percentile 66

(*) No critical failure have been reported

Figure 3. A page from the T-book.
1. ABSTRACT

The Leibstadt Plant KKL, situated at the river Rhein in Switzerland, is a BHR-6, Mark III, GE-Plant with a BBC turbogenerator set with a net electrical output of 990 MW. In December 1973, the work contract was signed and in December 1984 KKL started the commercial operation.

The construction period was influenced by the TMI-incident in 1979. The incident prompted a very tedious review by the authorities, vender, and KKL. Together with a new construction permit procedure, the original start up date was seriously delayed.

In 1975 the first employees for the operation phase were hired. The main work for those was for the preparation of the plant operation- and maintenance-management. This paper deals with this task and the build-up of data banks on the computer for SOFT- and HARDWARE, plant operation and the collection of plant experience and maintenance activities.

2. INTRODUCTION

The experience with first generation nuclear power plants in Switzerland (Beznau I and II in 1969 and 1971, Muehleberg 1972) revealed that the absence of a quick retrieval method of SOFTWARE and HARDWARE data makes a successful plant operation very difficult. Another handicap was that the utility was not provided with all the necessary information on system- component design data, fabrication data, and maintenance instruction manuals.

This situation made it difficult and time consuming to perform the diagnosis of failures due to nonavailabilities of systems and components. It was not seldom that extra tests had to be performed for the diagnosis due to lack of decent plant data.

In many cases the utilities had to contact the suppliers years after the plants were already in operation to obtain the missing instructions for purchasing the right spare parts. This situation was not at all satisfactory. In short, it is an absolute necessity that the plant documentation is complete independent if it is used for safety or non-safety systems. For the plant availability everything is essential.

Considering that the KKL-Plant is larger and more complex than older plants and with more stringent requirements, data management is best done with computers.

3. PLANT MANAGEMENT

Out of the above mentioned situation KKL could tackle the problem right from the beginning and learn from the experience gained by other utilities.

After a very thorough analysis of the requirements for a good organisation-structure all the relevant element required for a successful operation could
be identified. In Figure 1 the most important ones are schematically listed.

An important decision was made already early in the project to introduce the computer for the tremendous amount of data handling. After that decision it became obvious that a clearcut identification numbering system must be applied for identifying the SOFT- and HARDWARE and be used very systematically in the project. Eventhough this seems logical it was not always easy to implement. KKL used the AK-No. System a "Plant Component Identification System".

Each component was provided with a unique individual number, from which valuable information can be derived. The same number is used for the identification of the SOFTWARE (see Figure 1) and placed on the components in the plant.

The development of all the computerised organisation structures with associated data banks was formulated around the main strategy:

\[ \text{Availability} = \text{function of (Reliability, Maintainability)} \]

a) Plant availability = Production of electricity
b) Safety system availability = Safety
c) SOFT- and HARDWARE availability = Plant Management (efficient maintenance)

From this definition the importance of the availability becomes obvious. In this paper only item c) will be more closely described. For the preperation of a scheduled or unscheduled shutdown it is of prime importance that a quick and good intervention will bring back the plant on the grid quickly or to the demanded power level. This, of course, makes a reliable access to the required SOFT- and HARDWARE a must.

At KKL we perform non periodic planned, routine nonperiodic preventive maintenance and inpection work during normal operation. During that period it is especially important that the safety of the plant is always guaranteed. To achieve this goal KKL works with flowchart checklists. Checklist activities are sometimes very complex and the controlling thereof is supported with a computer.

At this time I might mention that the use of the computer can in no way replace the well trained personal. During introduction phase of the computers a large number of detail management procedures were developed together with all the people involved in the work process. This paid off because the users of the programs could identify the parameters which had to be collected in the data banks for ease of access and manipulation.

Remember the slogan "Time and Quality is Money". It shall be remembered only for completeness in pointing out, how complicated the procedures can be for a change or purchase of qualified equipment or even a welding procedure. Just for these occasions a reliable and fast retrieval of data from data banks is necessary to keep the non available operation time to an absolute minimum.

In KKL specific work management procedures, the use of the data banks is described.

In Figure 2 a list of computer programs for data bank application is presented.

As can be seen from Figure 2 some data banks were built up during the plant erection period, namely "DOKU", "TISYS", "PWP" and "SABBAT". "DATA BASE" was purchased from the plant vender. "ABA" and "ABS" will be built up constantly to collect the plant maintenance data, plant modifications and some operating activities.

In Figure 3 a short display is given on how the computer function and its data banks are connected in our computer center and made available on local terminals and printers.
Records and plant parameters on line-printers and on the process computer are not discussed in this paper because they cannot be retrieved electronically from data banks as described here. Furthermore, the purpose of the latter mentioned data is of different use.

4. CONCLUSION

KXL is convinced that it was a good investment to start very early in the project phase to implement the electronic data handling system. The investment was twofold:

First: A thorough analysis of the future operation/maintenance management and the definition of plant documentation requirements to our vendors.

Second: Computer-program development and hardware purchase to implement the applications.

Return of the investment:

A contribution to the high capacity factors since commercial operation which started Dec. 1984. The overall capacity factor at the end of the second cycle was 87.76 %, which includes a 9 week outage for refuelling and condenser retubing to titanium. During the second cycle from September 11, 1985 to August 1, 1986 a capacity factor of 97.83 % was achieved.

We have learned how valuable good, precise, fast retrievable information is for good plant management. We are not yet where we want to be, since not all the single island solutions are coupled in an optimised manner. More intensive use of the system will enable us, however, to point to possible shortcomings which may be eliminated.

5. RECOMMENDATIONS

If a utility which already operates nuclear power plants intends to fully use computers and data banks for plant management, an analysis of the present situation must be a prerequisite. A thorough plant identification numbering system is necessary. Utilities which are in the phase of purchasing nuclear power stations should buy data banks as much as possible from the supplier, and fit them to the utilities use. Transfer of accurate data from computer to computer is more reliable than feeding the company data bank from paper information.
Figure 1: Base Plant Management Structure

SOFTWARE:

Under this item the plant documentation is understood:
- Regulations
- System design specifications
- Component design specifications
- QC-Documentation for the erection phase
- Purchase specifications
- Maintenance manuals/procedures
- Operation manuals/procedures
- Emergency procedures
- Plant records
- Equipment data listings
  etc.

HARDWARE:

- Spare parts
- General and special tools
- Consumable items (ion resins, gases (H2, N2, CO2, AR, HE), diesel fuel, paper for printers etc.)
- Plant inventory items

PERSONAL:

The personal was trained to work with the computer for in- and output treatment of soft- and hardware items.

Note: Beside the technical training some time was devoted to the technical administration training.

Figure 2: Data Banks / Computer Programs

<table>
<thead>
<tr>
<th>Name of the program</th>
<th>Function-description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 DOKU</td>
<td>Recording of codified parameters for the plant documentation. Generating specific document-listings out of data bank. (See SOFTWARE items on Fig. 1). Up to February 1986 110'000 record sets were stored on data bank.</td>
</tr>
<tr>
<td>2 TISYS</td>
<td>Recording of codified parameters for HARDWARE items. see Fig. 1. Generating specific listings, controlling of parts in- and outflow from the stock. Up to February 1986 25'000 record sets were stored on the data bank.</td>
</tr>
<tr>
<td>3 PWP</td>
<td>Recording of codified parameters for periodic maintenance activity. Generating listings for periodic or operating time-dependent work orders. (Lubrication, change of bearings, change of rubber items etc.). Up to February 1986 40'000 record sets for 10'000 components were stored.</td>
</tr>
</tbody>
</table>
4 ABA  Recording of codified parameters for work-request handling with the objective to build up an equipment-failure, inspection, overhaul data bank including resources and manrems used to complete work.

5 ABS  Recording and controlling of safety tagging system together with 4 (ABA) for work on the plant. Data bank is kept only temporarily.

6 SABBAT  Controlling of periodic system- and instrument testing according to technical specification. Generates periodic test work sheets. Up to February 1986 300 test specifications were stored.

7 DATA BASE  Data Bank for specific KKL component data. This information was taken over from the plant vender. The data banks include data sets for valves, electrical actuators and motors, instruments and a set of MISC. electro-mechanical equipment.

          Data base data will be used later in preparing preventive maintenance actions.

8 ARTEMIS  Is a network program which controls on a time and personal basis critical paths during plant outages. Produces graphical displays for different applications.
Figure 3

- Collecting of DATA
- Build up of DATA BANKS
- Preparing of Lists
  - on Terminals
  - on Paper (Printers)
- Producing graphs

--- INPUT from Terminals from Tapes

---- OUTPUT to Terminals to Printers to Tapes
The Centre for Nuclear Power Plant Information and Operational Analysis (TsIAEhAS), set up within the All-Union Research Institute for Nuclear Power Plant Operation (VNIIAEhAS) by Decree of the Central Committee of the Communist Party of the Soviet Union and Council of Ministers of the USSR in 1987, is carrying out intensive development work on a branch information system on nuclear power plant operating experience ("OPENS") focused on the technological and quantitative (probabilistic) analysis of the reliability and safety of nuclear generating units.

At the current stage of development, the TsIAEhAS branch information system consists of a dispersed database system linked up in a local network and comprising:

- A database on technical and economic performance;
- A database on power losses during plant operation;
- A database on daily loads;
- A database on technical solutions;
- A database on plant malfunctions;
- A specialized database on safety system failures;
- A dispersed database on defects, damage and failures in the main mechanical equipment of nuclear power plants;
- A database on defects discovered during acceptance inspection of thermomechanical equipment;
- Databases on reliability indices for the equipment and "data-desk" type systems.

These activities are financed centrally through Main Administration 29 of the USSR Ministry of Nuclear Power and Industry.

The database on technical and economic performance contains information on the thermal cost-effectiveness of plant operation and is intended for use in assessing and analysing the economic performance of power equipment and the technical level of its operation by utility staff. The technical and economic performance data are given for the period from 1989 to the present.

The database on technical and economic performance comprises:
- Performance data for the plant as a whole;
- General operational performance data for individual generating units;
- Performance data for nuclear steam supply systems;
- Performance data for turbogenerators;
- Data on the thermal cost-effectiveness of the units.

Information volume: 1.5 MB (7014 entries).

The database on power losses during plant operation contains information on reductions in electricity production by units resulting from planned and unplanned outages, together with the reasons for these outages, and from power limitations. The database was established on 1 October 1990. Information volume: 170 KB (542 entries).

The database on daily loads contains information on daily electrical loads for the generating units. Information volume: 3.3 MB (19 000 entries).

The database on technical solutions (in the development stage) contains the following information:
- Description of the technical solution;
- Number and date of approval;
- Coding of equipment and systems reflected in the solution;
- Outline of solutions adopted;
- Originator of the solution with whom it was agreed and approved.

The database on plant malfunctions contains information on malfunctions subject to investigation under the current regulations governing the procedure for investigating malfunctions, PNAEv G-12-00587. It covers the period 1 January 1986-31 March 1990. The information volume is 13 MB (1589 entries). The information is structured in 52 fields.

The specialized database on safety system failures contains information on failures and defects of the electromechanical, electrical, heat exchange and thermal equipment of the safety systems and of the process instrumentation and control equipment for the period 1 January 1981-31 December 1990. The information volume is 5.574 MB (3386 entries).

The dispersed database on defects, damage and failures in the main mechanical equipment of nuclear power plants contains information on equipment problems discovered at plants with WWER and RBMK-type reactors between 1977 and September 1990.
This dispersed database is installed in the local network of PCs at the TsIAEhAS.

It includes databases on:
- Failures of the reactor and thermal equipment and of the piping of reactor systems;
- Failures of the thermal equipment and piping of turbine systems;
- Pump failures;
- Electrical equipment failures;
- Valve failures;
- Process instrumentation and control equipment failures.

Information volume: 50.3 MB (26 004 entries).

The databases on WWER and RBMK reactor equipment failures contain information on problems in the reactor and thermal equipment and the reactor system piping, including:
- Reactor (pressure vessel, upper block, internals);
- Reactor control and protection system equipment (servo-motor, electrical equipment);
- Steam generator;
- Pressure compensator;
- Hydraulic accumulators;
- Auxiliary system heat exchange equipment (of component cooling circuit, feed and purge systems, gas loop, and others);
- Piping of main circulation system, multiple forced circulation circuit, reactor auxiliary systems;
- Emergency cooling and protection system piping;
- Main equipment connection pipes.

Information volume: 9.5 MB (3700 entries).

The database on turbine system failures contains information on problems in:
- Main and auxiliary turbines;
Main and auxiliary turbine condensers;
- High and low pressure feedwater heaters;
- Moisture separators/reheater units;
- Turbine room de-aerators;
- Condensate feed pipes;
- Steam lines;
- Pressure oil circuits and control system oil circuits.

Information volume: 7 MB (2870 entries).

The database on pump failures contains information on problems in:
- Reactor coolant pumps;
- Safety system pumps;
- Pumps of the primary circuit feed/purge system and controlled leakage system;
- Feed and condensate pumps;
- Service water system pumps;
- Circulation pumps.

Information volume: 14 MB (8154 entries).

The database on electrical equipment failures contains information on problems in:
- Turbogenerators;
- Transformers;
- Accumulator batteries;
- 6 kW and 0.4 kW motors;
- Cable distributors and wires;
- Power cables and control cables.

Information volume: 3.2 MB (1900 entries).
The database on valve failures contains information on problems with the reactor and turbine system valves, including isolating and regulating valves, non-return valves and relief valves (in all, more than 20 categories according to their functions).

Information volume: 9.6 MB (5000 entries).

The database on process instrumentation and control equipment failures contains information on problems in:

- Sensors;
- Amplifiers;
- Power supply units;
- Starters;
- Transducers;
- Indicating and recording instruments and others.

Information volume: 6.4 MB (3780 entries).

The database on defects discovered during acceptance inspection of the thermomechanical equipment contains information regarding damage to the main reactor and turbine equipment of plants with WWER-1000 reactors, including information on: reactor pressure vessel and upper block, pressure vessel internals, steam generators, hydraulic accumulator of the emergency coding and protection system, pressure compensator, reactor coolant pump, reactor coolant piping, main and auxiliary turbine, de-aerator, high and low pressure feedwater heater, moisture separator/reheater, heat exchangers, turbine condenser, condensate pumps, and piping of various kinds.

Total information volume: 0.6 MB (600 entries).

The "data-desk" (DD) type databases on plant equipment and systems reliability contain operating and repair times for the "SVB"[*] equipment and periodic and one-off assessments of the reliability indices for this equipment (failure rates in standby mode; failure rates in operating mode; probability of failures to respond on demand; repair frequencies) intended for use in quantitative analyses of reliability and safety. As at 31 March 1991, the following databases had been established:

- DD on operating times and failures of the "SVB" equipment at the Kalinin plant (information volume: 300 KB, 597 entries);

[*] Translator's Note: Abbreviation untraceable, possibly "safety-related systems".
- DD on reliability indices for "SVB" equipment at the Kalinin plant, the Zaporozhe plant and the South Ukrainian plant (information volume: 620 KB, 189 entries);

- DD on reliability indices for the safety system at the Zaporozhe plant (primary circuit emergency cooling system and standby diesel generating plant) (information volume: 8.0 KB, 30 entries);

- DD on frequencies of initiating events at nuclear power plants (information volume: 33.360 KB, 206 entries);

- DD on reliability indices for the equipment of the Rovno plant (information volume: 8.038 KB, 42 entries);

- DD on reliability indices for nuclear power plant valves, including Units 1 and 2 of the Zaporozhe plant, Unit 1 of the Balakovo plant, Unit 1 of the South Ukrainian plant, and Unit 5 of the Novo Vornezh plant (information volume: 12.316 KB, 597 entries).

**Database structure**

Each of the databases mentioned consists of a quasi-permanent part including a dictionary-catalogue (nuclear power plant glossary, list of equipment suppliers, equipment catalogues, equipment classifier) and a variable part including information on equipment problems and plant performance, and descriptions of malfunctions, their causes and effects on safety, and personnel errors.

**Software**

For work with the database on technical and economic performance, a software package based on the Clipper database management system (DBMS) has been developed which allows computation and readout of technical and economic performance data for any time period for a given type of reactor unit.

For the database on daily loads, a software package has been produced, based on the Clipper DBMS, which allows graphs of the electrical loads for the reactor units to be plotted and displayed or pointed out.

For the dispersed database, the FS-3 software package has been developed, based on the Clipper DBMS ("Reactor equipment", "Turbine system equipment" management systems) and Fox Pro ("Pump equipment", "Electrical equipment", "Process instrumentation and control equipment" management systems).

The software packages permit interactive work with the database files and are intended for the input, correction and readout or printout of information using any desired search criteria; they can be linked up to various computation applications for any required statistical processing of information stored in the database.
Information acquisition and processing

The acquisition and processing of information on technical and economic performance, causes of power losses and daily loads is carried out on the basis of monthly reports from nuclear power plants on form 3-TEnK (AS) and of daily operating bulletins on plant operation.

The TsIAEhAS obtains information on plant equipment malfunctions from three main sources:

- The "SSOIN" system (in accordance with USSR Ministry of Nuclear Power Decree No. 38 of 27 January 1987) – up to 10%;

- Malfunction investigation files (in accordance with the provisions of PNAEh-C-12-005-87) – up to 15%; and

- Individual specialized acquisition by teams from the TsIAEhAS – over 75%.

(signed) V.V. Taratunin
Director
TsIAEhAS, VNIIAEhS
Appendix 2:

List of Organizations Involved in the Questionnaire and Additional Respondents to this Report.
D.2 Survey Respondent Information

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Phone : 
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NOTE: Respondents who complete this questionnaire will receive a copy of the Task 12 report summarizing all the responses received, sent to the above address.

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