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DATA PROCESSING CENTER FOR INFORMATION ON PERFORMANCE OF NUCLEAR POWER PLANT EQUIPMENT AND SYSTEMS AND ANALYSIS OF OPERATING EXPERIENCE OF "ENERGIYA" NUCLEAR POWER PLANT

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11. ABSTRACT (200 words or less)

The source document for this translation is a collection of figures and presentation-type charts outlining the relationships of the various agencies involved with the reliability and safety of nuclear plants operating in the USSR. The extensive use of computer technology is reflected in the descriptions of the kinds of data that can be found in the various data bases concerned. The specific types of equipment and systems associated with the data bases are shown. Major components of the nuclear power industry are outlined and related to the specific type of information that is necessary for the operation of these components. It is important to note that personal computers are used in many of these applications, thus reducing the need for large-scale computers.

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DATA PROCESSING CENTER FOR INFORMATION ON THE PERFORMANCE OF NUCLEAR POWER PLANT EQUIPMENT AND SYSTEMS AND ANALYSIS OF OPERATING EXPERIENCE

NPO "ENERGIYA"

Translation of "Tsentr po sboru i obrabotke
Informatsiya o rabote oborudovaniya i sistem AS
Analiza opyta
Ekspluatatsii
Atomnykh
Stantsii

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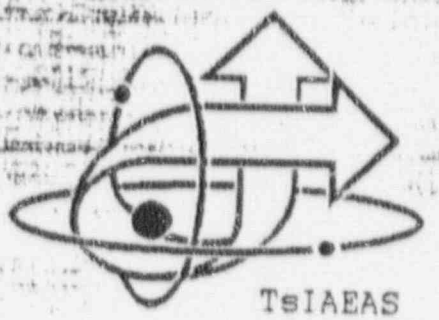
AES (NUCLEAR POWER PLANT) OPERATION (VNIIAES)



Center for the collection and processing

of information on the performance of nuclear power plant equipment and systems

Analysis of experience

of operation

of nuclear

plants

DATA PROCESSING CENTER FOR INFORMATION ON THE PERFORMANCE OF NPP EQUIPMENT + SYSTEMS + ANALYSIS OF OPERATIONAL EXPERIENCE

TARATUNIN

It is absurd for a dying man to hide his illness from the doctor.

Three Mile Island, Chernobyl are two carastrophes showing that the "Peaceful atom" is not so peaceful and does not forgive conceit and indifference. These two events plunged peaceful atomic energy into the deepest crisis of faith, the exit from which is expensive, difficult and requires the participation of absolutely all interested parties, including the population of the region. The effectiveness of working with the population, the Timeliness and Adequacy of the scientific-technical programs and measures for the reliability and safety of nuclear plants are for the most part determined by the development of an industrial information system covering operational violations and the technical status of the power units, the life history of each unit of equipment. Such vital actions as the following are extremely difficult or even unrealizable without this system:

- probabilistic safety analysis;
- equipment quality control;
- shift to preventive maintenance by status;
- proper notification of population;

Those are the necessary conditions for the organization of such a system. As far back as 1987 an Information Center

(TsIAEAS) was created in the structure of VNIIAES by Resolution of the Government of the USSR. The chief engineers of the AS's (February 1990 Badakovo) arrived at a unanimous opinion about the joint development of an industrial system covering incidents and violations in nuclear plant operation, the maintenance of a data bank on AS equipment and system reliability, the need to incorporate into AS's computerized reliability analysis (KTAN AS) and the creation of adequate data bases at the plant level, as well as the readiness of the AS for the organization of an operational (intercomputer and facsimile) link among AS's, the regulating organs and the industrial information Center. I.e. "perestroika" took place from the top. Now it's a question of immediate action. The labor collectives of the AS's are shifting to a market-planned economy. The dictates of the supplier and the planner are a thing of the past. Atomic power engineering is now being legislated in the USSR while at the same time there is a growing responsibility on the part of the labor collectives to society and the users of energy for reliable and safe operation of the power units. In these conditions it is necessary for the labor collectives of the AS, irrespective of the enormity of the internal problems, to devote special attention to the development of plant information systems and the consolidation of the industry information center and to the questions of systems analysis of power unit reliability and

safety. It is necessary to realize that one More such incident in the century of the present and next generations, regardless of where it occurs, will close the "atomic century" of our century and stop, if not the development, then in any case the use of nuclear power plants for many decades. TsIAEAS is the only industrial information, coordinated and scientific Center which is ready and capable of protecting the interests of active AS's both within the country and at the international level, attracting for this the strengths of VNIIAES, industrial and union enterprises, NII [scientific-research institutes], schools of higher learning, academic institutes, as well as the scientific centers of the countries with developed atomic energy. TsIAEAS is open to interested and sincere cooperation.

Director of TsIAEAS  V.V. Taratunin

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- YaPPU [NUCLEAR STEAM PRODUCING UNIT] LABORATORY
- LABORATORY FOR PUMP EQUIPMENT AND WATER SUPPLY SYSTEMS
- THERMOMECHANICAL EQUIPMENT LABORATORY

DIVISION OF AS OPERATIONAL EXPERIENCE ANALYSIS

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- LABORATORY FOR THE SYSTEMS ANALYSIS OF AS RELIABILITY
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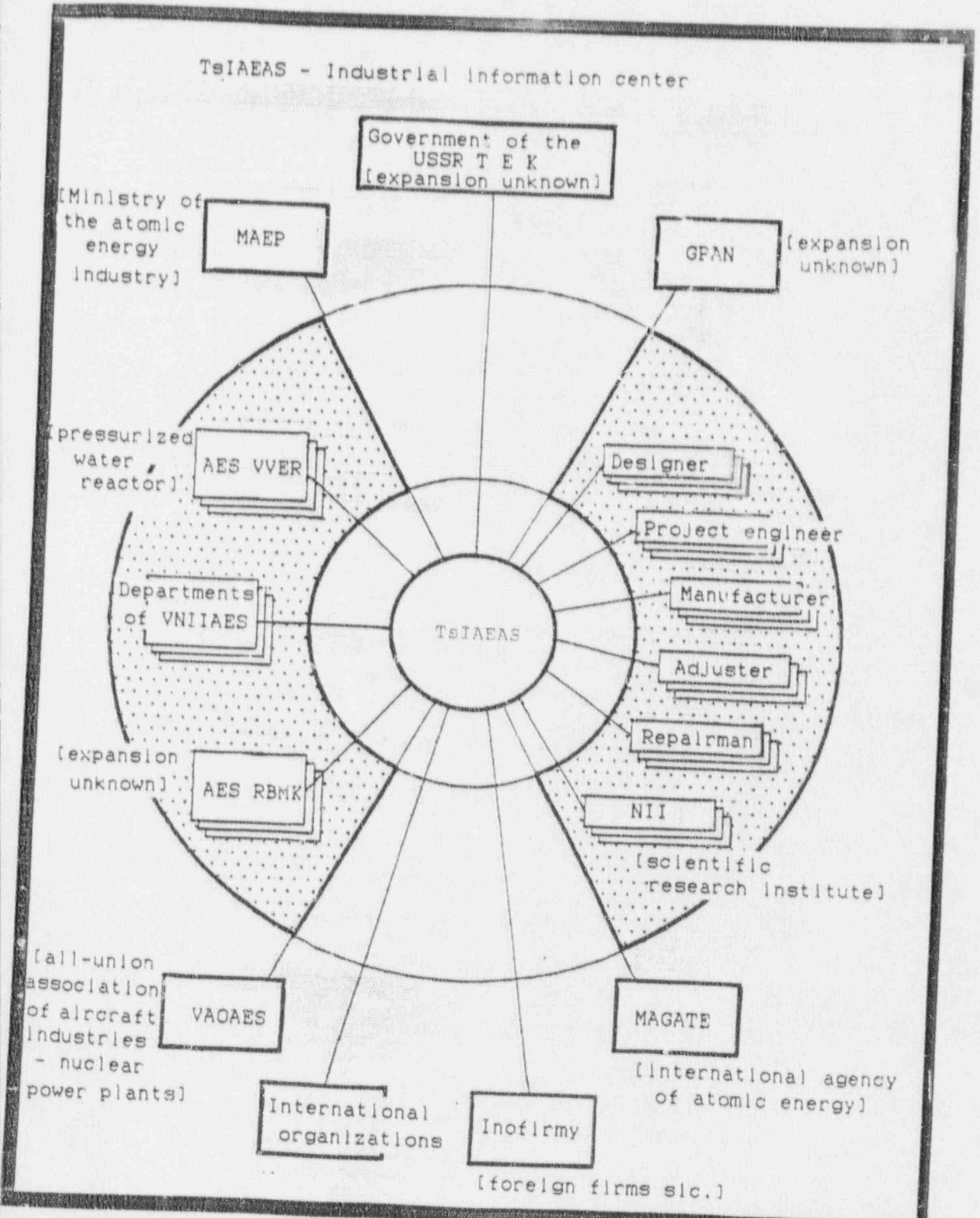

TsIAEAS - Industrial information center
Government of the USSR T E K [expansion unknown]
[Ministry of the atomic energy industry]
MAEP
GPAN
[expansion unknown]
[pressurized water reactor]
AES VVER
Designer
Project engineer
Manufacturer
Adjuster
Repairman
NII
[scientific research institute]
Departments of VNIIAES
TsIAEAS
[expansion unknown]
AES RBMK
[all-union association of aircraft industries - nuclear power plants]
VAOAES
MAGATE
[international agency of atomic energy]
International organizations
Inofirmy
[foreign firms sic.]

1. TsIAEAS - INDUSTRIAL INFORMATION CENTER 1

IN 1987 TsIAEAS was created in VNIIAES by a Resolution of the SM [council of ministers] of the USSR for organizing the collection, processing and analysis of the reliability, safety and economic information of active AS's.

TsIAEAS is a scientific-research center, a group of scientists, engineers and technicians associated for one task - to guarantee both the economic and social viability of atomic energy. The works of the leading specialists of TsIAEAS are well-known in the USSR and abroad.

The object of the research is the efficiency, safety and reliability of AS's in the operational phase.

The methods of research are the statistical, quantitative-probabilistic and structural-engineering analysis of information about incidents and violations in AS operation, defects, damages and AS equipment and system failures.

TsIAEAS is the principal production subdivision of the institute and industry, EQUIPPED WITH STATE-OF-THE-ART COMPUTING TECHNOLOGY AND COMMUNICATION FACILITIES.

TsIAEAS organizes and performs the functions of:

- collection and analysis of information on violations in AS operation (ISI [incident information system] AS USSR);

- collection and processing of equipment reliability information (SSOIN [expansion unknown] "ATOMENERGO");

- national coordinator of the system for the collection, analysis and exchange of information on the quality of the equipment furnished to the AS's of the member countries of the SEV (ISKO AS) [expansion unknown];

- national coordinator of the MAGATE and SEV incident information system (ISI MAGATE, ISI SEV);

- the principal subdivision of VNIIAES as the interface organization of the Moscow regional center VAO AS.

As of today TsIAEAS has available the data bases:

- incidents and violations in AS operation since 1984;

- equipment falures and damages since 1977;

- technical-economic indices of AS operation since 1984;

- AS operation indices.

The specialists of TsIAEAS have developed and adopted for 2 AS's appropriate positions on the collection and investigation of the causes of failures, the processing and transmission of information on equipment reliability. A standard position on the AS reliability laboratories has been developed.

For solving the main problems TsIAEAS attracts the leading specialists of VNIIAES, the Kurchatov IAE [atomic energy institute], the OKB [bureau of experimental design] "Gidropress", the OKBM [bureau of experimental design - machine construction], NIKIET [design and scientific research institute of energy technology], the VNIIAM [expansion unknown], the AEP [expansion unknown] and its departments, factory NII [scientific-research institutes], Higher institute of learning science (MIFI [expansion unknown], MEI [Moscow energy institute], IATE [expansion unknown], MGU [Moscow state university], KGU [Kiev state university], MIET [Moscow institute of energy technology]),

Academic institutes.

The final product:

- generalized and systematized information on accidents, incidents and deviations in AS operation;
- lists of original incidents and chains of succesive events causing incidents;
- information on typical defects, damages and failures, including analysis of their causes;
- quantitative indices of the attained safety level, including the Human factor;
- quantitative indices of the attained efficiency level;
- quantitative indices of OSVB [equipment and systems important for safety] reliability;
- specification and monitoring of the reliability requirements for OSVB;
- methods and engineering program systems for computerized

collection and analysis of reliability, safety and efficiency information of AS's (KTAN AS), including information networks, data bases and application program packages;

- expert findings for the TOB's of new projects and redesign projects;

- technological regulations to assure OSVB reliability.

The main trends in the use of TSIAEAS products:

- safety control of nuclear power units;

- increase in AS economic effectiveness;

- increase in the quality of new AS projects;

- increase in the quality of AS equipment;

- social shielding of atomic energy.

The main users and customers of our product are AS's, domestic and foreign organizations and firms developing and monitoring atomic energy.

TsIAEAS performs a complex of operations with respect to the development and maintenance of software and provides the technical services for the adoption of information technology at nuclear plants and in other interested organizations.

2.1.1. The design and adoption of problem data bases:

- AS equipment and system reliability,
- indices of power unit operation,
- incidents and violations in AS operation,
- operational reports from AS's,
- special tasks.

2.1.2. SUBD [data base control system] installation

SUBD's installed on personal computers:

- ☐ Clipper
- ☐ FoxBase
- ☐ dBase

SUBD's installed on ES-series computers:

- ☐ SPEKTR
- ☐ ADABAS

2.1.3. The development of on-line interfaces for data base maintenance

The service developed supports:

- ☐ the use of reference information;
- ☐ on-line information retrieval;
- ☐ standard accounting forms;
- ☐ formation of the RANDOM INQUIRY with possible storage in a library of standard inquiries;
- ☐ CORRECTION of data base information;
- ☐ GRAPHIC REPRESENTATION of processed information.

2.2.1. Information networks

Presently there is being developed an INFORMATION NETWORK of nuclear plants based on an automated system of remote data transmission with the use of general purpose telephone channels.

- TsIAEAS proposes that interested organizations participate in joint developments.

2.2.2. Local computer networks

At the present time TsIAEAS is conducting operations with respect to the adoption of the existing software of local computer netwtorks.

- TsIAEAS proposes that interested organizations participate in the modeling of the information technologies of nuclear plants in an ETHERNET type of LOCAL NETWORK of personal computers.

2.2.3. Intercomputer exchange SM-2 computers and IBM PC's

TsIAEAS is handling the development of software and has for the interested organizations proposals on the technical facilities for organizing INFORMATIONAL INTERCOMPUTER EXCHANGE of technological data between SM-2 computers and personal computers of the IBM PC type.

The "Expert systems" group, forming part of TsIAEAS, is occupied with the creation of expert systems (ES) for the most varied fields of atomic energy.

- ES's are program systems, simulating the work of people - experts in a specified field.
- ES's are the technology of creating programs based on the methods of artificial intelligence.
- ES's can be developed in any field, in which there is a need and the possibility of formalizing expert knowledge.
- The creation of ES's means that knowledge built into this system becomes the property of non-specialists.

3. COLLECTION AND ANALYSIS OF INFORMATION ON AS EQUIPMENT AND SYSTEM RELIABILITY

The specialists of the division for the collection and analysis of information on AS equipment reliability perform work directed toward an increase in reliability and other indices of quality for the equipment and systems important for the safety of nuclear plants. The procedure for processing the information received from the AS provides for a careful analysis of it by expert-specialists, a refinement by additional data, checking and input to the computer. The statistical processing of operational data and the evaluation of equipment reliability indices are carried out, making it possible to create a bank of source data for a systems analysis of AS reliability and for working out the requirements for newly developed equipment. Informational materials are regularly output (lists of failures, combined generalized data, statistical informational bulletins). Twice a year reports on the analysis of the reliability of reactor, thermomechanical and electrotechnical equipment are compiled with recommendations for improvement.

3.1 AS equipment reliability information system

The reliability information system is:

- a data base for defects, damages abd failures of equipment;

- reports with an analysis of equipment reliability, the causes and consequences of damages, with recommendations and proposals directed toward the increase in reliability and other constituents of the concept of "equipment quality";

- informational bulletins with an analysis of the statistical data on defects, damages and failures in the operation of AS equipment;

- the transmission of equipment reliability information to the users;

- feedback with industry;

- an equipment catalog on PEVM [personal computers].

THE BASIS OF THE RELIABILITY INFORMATION SYSTEM - data bases on defects, damages and failures of AS equipment, including:

- entry monitoring of equipment supplied to an AS; 8

- failures of reactor and thermomechanical equipment and of the pipelines of the operating systems for the reactor installations;

- failures of thermomechanical equipment and the mains of the industrial pipeline systems;

- failures of the pump equipment of the AS operating systems;

- failures of the AS electrical equipment;

- failures and defects of the fittings of the AS operating systems;

- failures of AS circulating water supply systems.

The AS equipment failure data bases were created on the basis of state-of-the-art personal computers of the IBM PC/XT type. The software of the data bases - the FoxBase SUBD - permits the specialists of the division to:

- process the information arriving from the AS;
- handle the on-line input of information into the data bases and the reliable storage of it;
- perform the correction of data bases;

calculate equipment and system reliability indices;

- handle information retrieval and distribute information according to user request.

Informational data bases are:

- several tens of thousands of reports of AS equipment malfunctions which appeared in the in the period 1977-1989,
- operational history of each AS's equipment,
- a basis for:
  - determining the reliability indices of operable equipment,
  - developing the requirements for reliability indices of p anned equipment,
  - conducting systems analysis of power unit reliability, including:
    - evaluation of the stream parameter of initial events in the AS,
    - evaluation of TO and R [expansions unknown] optimality,
    - performance of probabilistic analysis of power unit safety;
  - making technical decisions with respect to:
    - the selection of equipment for an AS,
    - a change in TO and R regulations,
    - ZIP [expansion unknown] planning,
    - equipment modernization,

AS redesign,

increasing equipment quality for manufacturing,

the creation of new models of equipment,

licensing of equipment,

optimization of configuration decisions of planned AS's,

removal of an AS from operation,

- making managerial decisions with respect to guaranteeing AS operational safety.

TsIAEAS is equipped with a complex of technical facilities for the collection, analysis, storage and transmission of information to users with the use of different types of computers, which, starting in 1990 are joined in a Unified computer network (based on personal computers). TsIAEAS CAN MAKE AVAILABLE TO THE USERS SYSTEMS FOR ACCESSING ANY NECESSARY INFORMATION FROM BOTH THE PERSONAL COMPUTERS OF THE CENTER, AND FROM A USER PERSONAL COMPUTER GIVEN A MACHINE LINK.

3.2. Conducting inspection of the operational status of equipment and systems important for AS safety

The objective of inspection:

- detection of operational "bottlenecks",

- generalization of operational experience.

The results of inspection:

- evaluation of the effect of operational events caused by equipment malfunctions on power unit reliability and safety,
- development of TO and R regulations,
- development of measures for increasing the reliability and safety of power unit operation.

Inspection may be conducted according to the "Program for checking AS operational safety", created by TsIAEAS based on MAGATE requirements, or by other system programs developed by TsIAEAS depending on the inspection objectives specified by the client.

3.3. AS equipment quality control 10

THE NPO ''ENERGIYA'' VNIIAES TsIAEAS IS PROPOSING MEASURES FOR A THOROUGH IMPROVEMENT IN THE SERVICING OF AS EQUIPMENT, ACCOUNTING FOR AND ANALYZING EMERGING DEFECTS, PERFECTING INFORMATION SUPPORT ACCORDING TO THESE QUESTIONS OF THE EQUIPMENT DEVELOPERS AND THE MANUFACTURERS, PROVIDING FEEDBACK VIA INFORMATION ON THE ADOPTED MEASURES AND THE DEVELOPMENTS UNDERTAKEN FOR RAISING THE QUALITY OF AS EQUIPMENT.

TsIAEAS is the developer of the concept of AS equipment quality control at the stage of operation which includes the solution of the following problems:

- accounting for and analyzing defects, damages and failures,
- organizing feedback,
- information support.

The concept distinguishes two levels of control.

- The first - external level of control is connected with the furnishing of high-quality equipment, its quality assembly, adjustment and start-up, i.e. action is taken for design, manufacture, transportation, storage and assembly.
- The second - internal level of control is

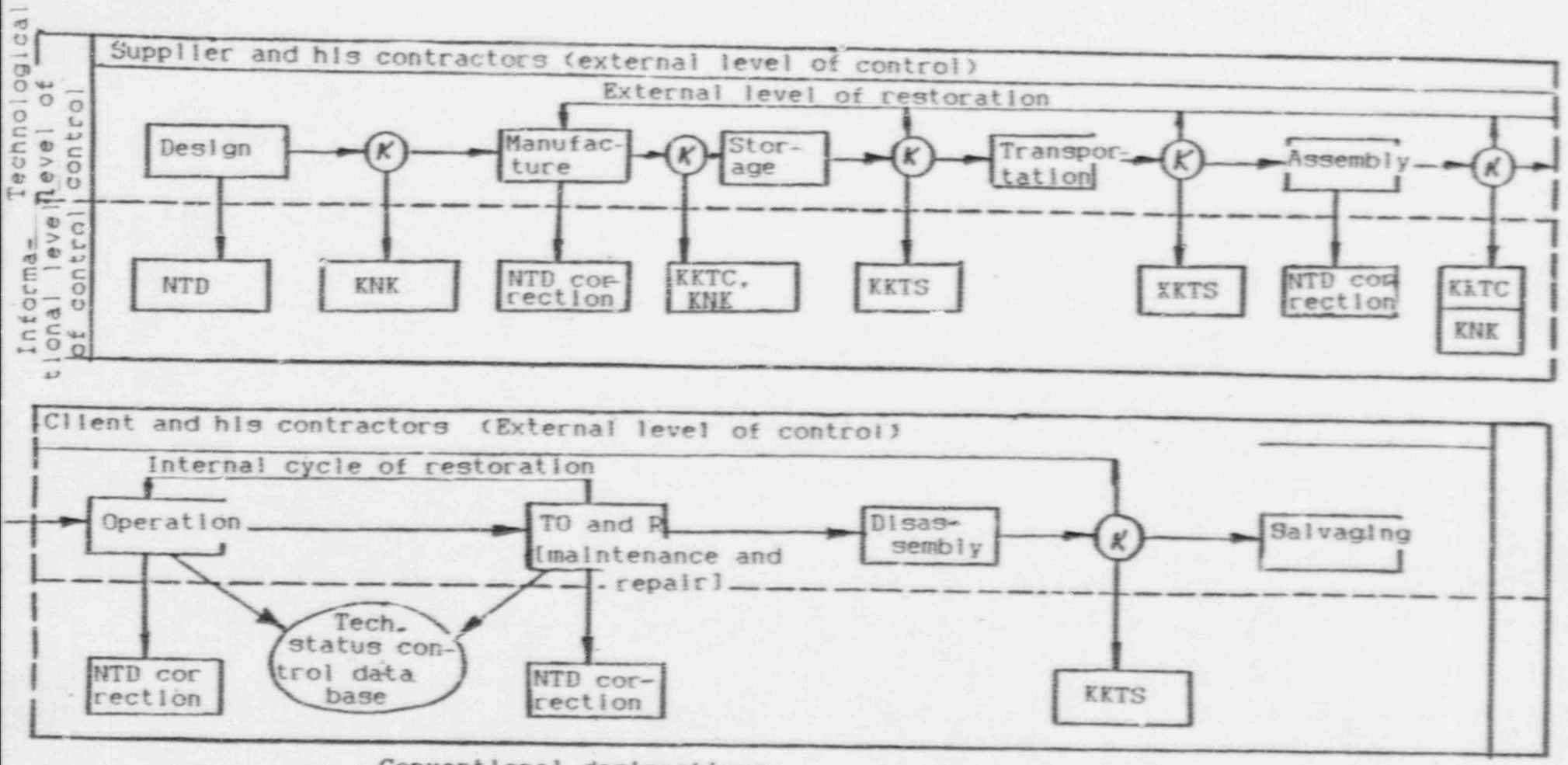
implemented by influencing the quality of operation so as to exclude equipment damage because of violations of its modes of operation, and improving maintenance and repair (TOIR).

The basic principle of control must be the systems approach, i.e. the rational distribution of control actions both between levels and within each level of control. The systems approach requires the existence of dual links between levels: the development of new kinds of equipment, changes in manufacturing technology and assembly must be based, on the one hand, on the attained level of reliability, and on the other - account for the status and possibilities of the technology base. Quality control is possible only by taking into account the quantitative indices of the achieved and required levels of reliability, i.e. the quantitative analysis of reliability is an instrument for the formation of any control decisions. The proposed technological diagram for equipment quality control and the diagram of information streams of control corresponding to it are depicted in figs. 1 and 2.

Via the information support of the concept of quality control it is proposed to create for each AS an

automated equipment defect and failure data base with integration of information into the central data base (TsBD) of VNIIAES TsIAEAS, from which the needed data will be transmitted to both levels of control (fig. 1).

In fig. 2 are indicated two cycles of AS equipment recovery: the internal, dealing only with its modes of operation, and the external, providing for changes in its manufacture, storage,transportation and assembly. The solution of the problems of AS quality support within the framework of the systems approach requires the availability of quality support programs at all stages of AS creation and operation, including site selection, design, development and manufacture of equipment, construction, entry into operation and removal of an AS from operation.



Conventional designations

NTD - scientific-technical documentation
- working drawings
- technical conditions
- operational instructions
- regulations and TO and R technology
- assembly and disassembly technology
- salvage technology

KNK - norm-monitoring card

KKTS - technical status monitoring card

TO & R - maintenance and repair

K - monitoring

Fig. 1 Technological diagram of equipment quality control

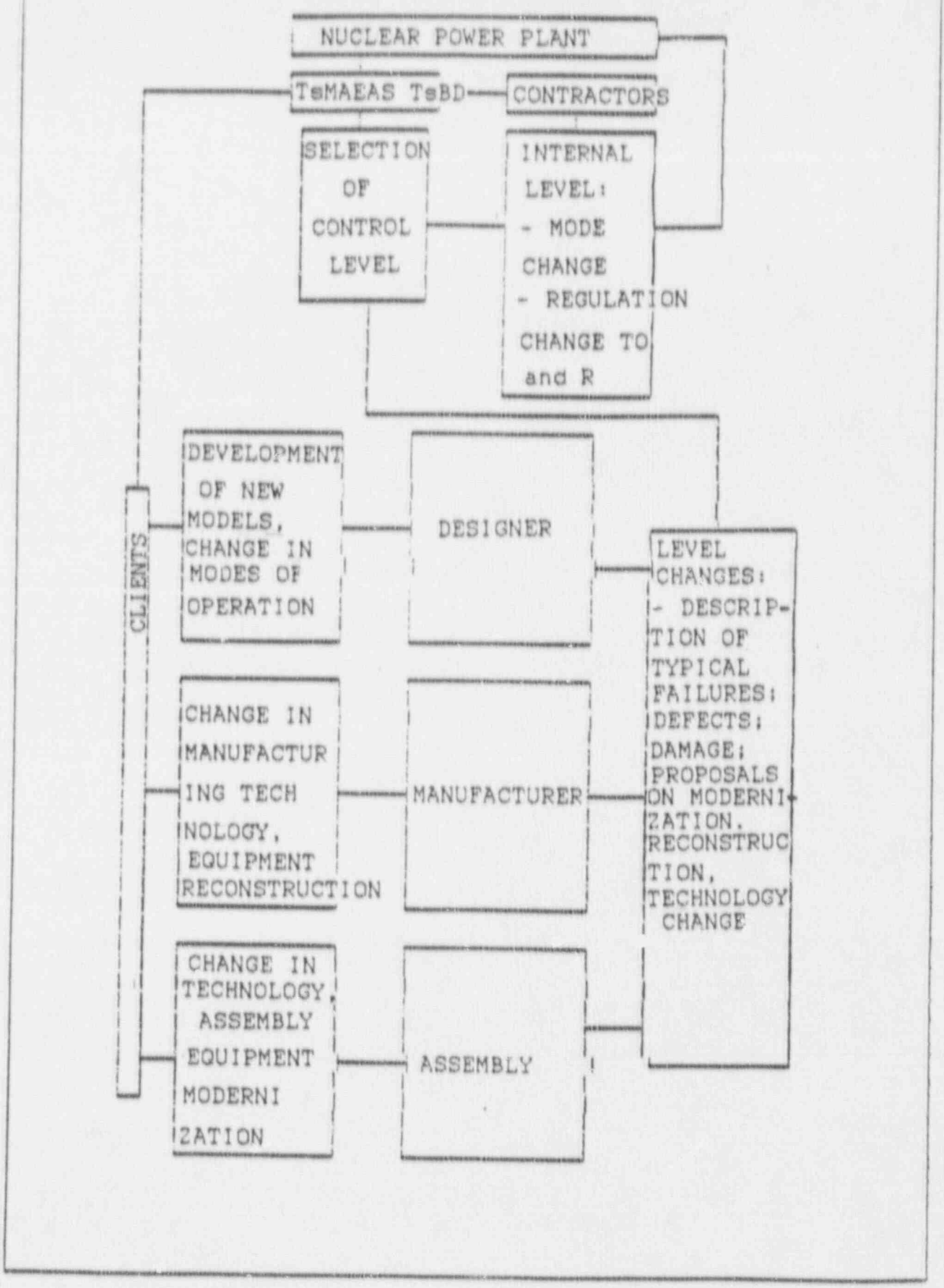

NUCLEAR POWER PLANT
TsMAEAS TsBD
CONTRACTORS
SELECTION OF CONTROL LEVEL
INTERNAL LEVEL: - MODE CHANGE - REGULATION CHANGE TO and R
CLIENTS
DEVELOPMENT OF NEW MODELS, CHANGE IN MODES OF OPERATION
DESIGNER
LEVEL CHANGES: - DESCRIPTION OF TYPICAL FAILURES; DEFECTS; DAMAGE; PROPOSALS ON MODERNIZATION, RECONSTRUCTION, TECHNOLOGY CHANGE
CHANGE IN MANUFACTURING TECHNOLOGY, EQUIPMENT RECONSTRUCTION
MANUFACTURER
CHANGE IN TECHNOLOGY, ASSEMBLY EQUIPMENT MODERNIZATION
ASSEMBLY

Fig. 2

Efforts are being conducted in this direction on the 13
creation of the NTD "Requirements for the program to guarantee quality for AS's" and of programs to guarantee quality in AS operation.

The indicated documents are being worked up with regard for the recommendations of MAGATE and domestic and foreign AS operational experience.

TsIAEAS proposes:

- to develop a quality control system, primarily for reliability, of AS equipment, reflecting the interrelationship of firms and organizations of the Ministry of the atomic energy industry of the USSR with the organizations - developers and firms of ministry-suppliers of AS equipment (external level).

- to organize an information system on the quality of design, manufacture, assembly and operation of AS equipment, in which is provided rational information support, compatibility of technical facilities for presenting information, development of the necessary NTD and financial support of this system by all the organizations participating in it.

to present the systematized information (lists) about

defects, damages and failures of AS equipment which appeared at the stages of input monitoring and during its operation; the results of the analysis of equipment malfunctions, their causes and consequences, the measures directed toward the elimination of these causes; the quantitative indices of AS equipment reliability; catalogs of AS equipment on personal computers;

to develop programs and carry out inspections of the status of AS operation;

to develop for an AS programs for guaranteeing quality at a stage of its operation.

4. ANALYSIS OF AS OPERATING EXPERIENCE

The specialists of the Division for analyzing AS operating experience are well-versed in working in atomic energy. They perform a complex of operations directed toward increasing the reliability and safety of AS power units. Among them the most important and corresponding to current level, in the estimation of the MAGATE experts, the specialists of the Nuclear Regulatory Commission of the USA, is the creation and support of the functioning of the information system on violations in AS operation and their technico-economic indices.

THE INFORMATION SYSTEM ON VIOLATIONS IN AS OPERATION

The information system today is:

- data bases on all violations in AS operation starting with 1984;
- bulletins on all the important events for AS's, of both the USSR and other countries;
- a data base on technico-economic indices of AS operation;
- reviews of violations in AS operation;
- reports with an analysis of power unit operation and recommendations as to measures directed toward

increasing the safety and stability of operations;

- exchange of information within the framework of MAGATE programs and intergovernmental agreements on operating experience and incidents in AS's;
- exchange of detailed incident information with the member-countries of the Council for Economic Aid.

The functioning of the information system is supported by state-of-the-art computer technology and most important - by the highly-qualified specialists of the main laboratories of VNIIAES (more than 20), who perform functions in the following directions:

- the evaluation of the indices characterizing the operation of the power units;
- the technological analysis of events affecting safety, and the analysis of transfer processes in
- the dynamic modes of operation of the power unit;
- the analysis of hydro-chemical modes;
- the analysis of damages of metallic and welded joints;
- the analysis of the operation of heat-liberating 15 elements and

production channels,

reactor equipment,

control and protection systems,

thermo-mechanical equipment,

electrical equipment,

fittings,

turbine plants,

safety systems,

AS personnel;

- analysis of AS equipment and systems maintenance and repair.

I.e. The information system is specific and generalized information on AS operation, incidents in AS's, measures directed toward increasing safety. With its help you get additional knowledge for the operation of AS's with maximum safety and reliability.

It is an information system when knowledge on the operation of an entire industry and of world atomic energy becomes your knowledge. The information system, if it is effectively used, makes it possible to eliminate those dangerous violations in AS operation which have already occurred in other AS's and in different conditions.

At the present time efforts are being conducted in the modernization and improvement of system operation. The completion of these efforts will permit:

- nuclear plants and other users to have access to data bases on violations in AS operation,

technico-economic indices and other data on AS

operation directly with their own PC's;

- to use in the automated mode data about incidents for numerical probabilistic analysees of safety, to determine quickly which corrective measures should be used in a given case taking into account the accumulated experience;
- to make effective decisions for increasing efficiency, reliability and safety of AS's;
- to be linked with the data bases of international organizations and other countries.

The high level of the efforts of TsIAEAS in the analysis of operating experience is provided also by:

- extensive participation in international cooperation with specialists of other countries, primarily the USA, Great Britain, France, Sweden, FRG, Finland, the member countries of the CMEA, and the international organizations: MAGATE, VAO AS, MKhO "Interatomenergo";
- cooperation within the framework of the joint coordination committee on the safety of civilian nuclear reactors of the USA-USSR, headed by Academician Ponomarev-Stepny N.N.;
- work in the technical and consultative committees of MAGATE in practically all of the branches of their activity, as well as in other international programs.

All this makes it possible to accumulate and use the 16
knowledge obtained in developments in all branches of activity.

The effectiveness of these efforts will steadily grow with the constructive criticism and effective support by the nuclear plants of the unique organization providing scientific tracking of AS operation - VNIIAES.

ANALYSIS OF RELIABILITY OF SAFETY SYSTEMS ON OPERABLE AS'S.

The basis of this work is information on the operational experience of safety systems.

The well-versed specialists, having experience in start-debugging operations and tests of AS safety systems, with the use of special calculation program packages perform the following kinds of work to your order:

- develop instructions and manuals for operating safety systems;
- perform optimization of periodic sampling and testing of safety systems;
- substantiate technical decisions by changing modes of operation of safety system equipment in cases connected with one channel of the safety system going down , i.e. for a change in the degree of system back-up;

- carry out developments for increasing reliability and optimizing the operating modes of the safety system equipment;
- formulate and substantiate the requirements for the equipment used in safety systems, for delivery to new AS's and modernization of power units.

TECHNICAL EXPERTISE OF AS DOCUMENTATION

For the possibility of considering design data and the standard-technical AS documentation for the NTS [science and technical council] of the MAEP [ministry of the atomic energy industry] and the affirmation of it by the Minatomenergoprom of the USSR it is necessary to have the findings of VNIIAES.

Technical expertise is the only possibility to take into account the generalized experience of AS operation in newly developed projects and reconstruction projects.

TsIAEAS is the organizer of these efforts in VNIIAES. The leading specialists of VNIIAES in all branches of operation take part in the technical expertise.

5. COMPUTERIZED QUANTITATIVE-PROBABILISTIC RELIABILITY ANALYSIS 17

5.1 TRENDS OF SCIENTIFIC RESEARCH

CATALOGING AND TECHNOLOGICAL ANALYSIS OF AS EQUIPMENT AND SYSTEMS:

THE DEVELOPMENT OF CRITERIA FOR SELECTING EQUIPMENT AND SYSTEMS IMPORTANT FOR SAFETY (OSVB);
THE DEVELOPMENT OF THE COMPOSITION AND STRUCTURE OF THE DATA FOR THE OSVB LIST.

STRUCTURAL ANALYSIS OF AS RELIABILITY.

THE ALLOCATION OF REQUIREMENTS FOR AS EQUIPMENT AND SYSTEM RELIABILITY.

COMPUTATION WITH REGARD FOR THE OPERATIONAL DATA OF THE RELIABILITY INDICES OF AS EQUIPMENT AND SYSTEMS:

OPERATING IN THE BASE MODE;
BEING IN THE MODE OF OPERATIONAL DUTY;
WITH FULL RECOVERY.

SPECIAL PROCESSING OF STATISTICAL DATA:

THE COMBINATION OF SMALL SAMPLES;
THE COMBINATION OF SAMPLES OBTAINED FROM DIFFERENT

SOURCES;

SPECTRAL ANALYSIS OF CHARACTERISICS;

THE COMPUTATION OF CONFIDENCE INTERVALS.

THE COMPUTATION OF RELIABILITY INDICES FOR PIPELINES AND PRESSURE VESSELS. THE BUILDING OF MODELS OF DEFECT DEVELOPMENT.

THE TESTING OF PROGRAMS BY COMPUTATION OF RELIABILITY INDICES.

THE COMPUTATION OF EQUIPMENT RELIABILITY INDICES. THE ISSUING OF ANNUAL BULLETINS ON THE ATTAINED LEVEL OF AS RELIABILITY.

5.2. TsIAEAS handles extensive cooperation with industrial 18
18 institutes and higher level scientific schools, with foreign research centers

USSR

. I.V. Kurchatov Institute of atomic energy, Moscow,

. All-union scientific-research and planning and design institute of atomic energy machine construction, Moscow

. Atomenergoproekt and its departments

. Scientific-research and design institute of energy technology, Moscow

. Experimental design bureau "Gidropress", Podolsk

. Experimental design bureau of machine construction, Gorkii

. Moscow state university

. Kiev state university

. Moscow energy institute

. Institute of atomic energy, Obninsk

USA

. INPO

. NRC

FRG

. GRS

NRB (Peoples Republic of Bulgaria)

. NITI "Energoproekt"

VNR (Hungarian Peoples Republic)

. AES "Paksh"

. Budapest technical university

. VEIKI (expansion unknown) 19

. ERETERV (expansion unknown)

GDR

. KKV (expansion unknown) "Bruno Leuschner"

PNR (Polish Peoples Republic)

. IAE

ChSFR (Czechoslovak Socialist Federated Republic sic)

. IYaI (expansion unknown)

. VUIE (expansion unknown)

. "Shkoda"

6. THE TECHNOLOGY OF THE SYSTEMS SOLUTION OF THE RELIABILITY PROBLEMS OF A POWER PLANT AND OF SYSTEMS IMPORTANT FOR SAFETY

20

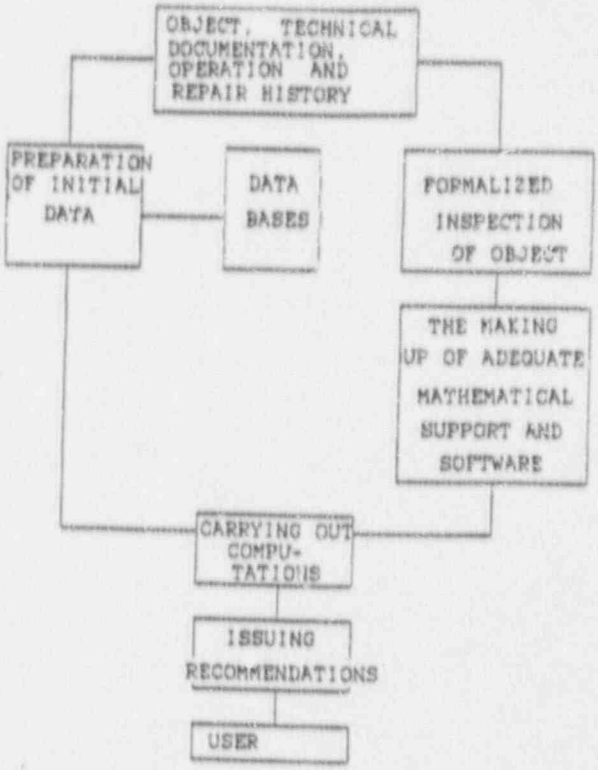


Fig. 3

VNIIAES is the proprietor of the unique technology of the systems solution of power unit reliability problems and of systems important for safety.

21

The generalization of the developments of quantitative-probabilistic analysis of reliability completed in VNIIAES made it possible to work out the unique formalized language for describing the processes of operation and repair.

This language permits the production engineer to describe

formally all the existing, from his point of view, interrelationships typical for the indicated processes. As a result a closed system of concepts is formed which is adequate for the solution of reliability problems. For the description of an object, depending on the problem being solved, all or a part of the stages proposed below are used.

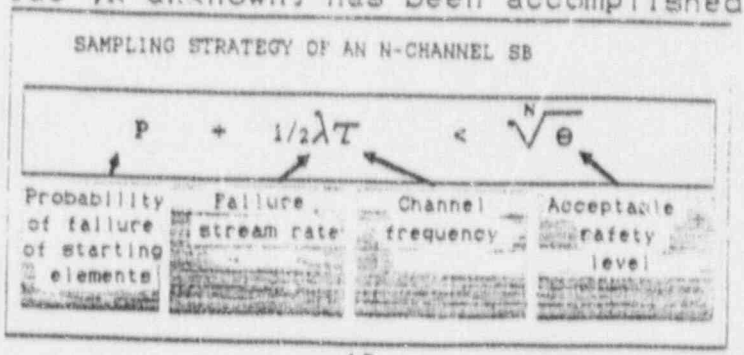
- The selection of an adequate level of object detailing, which is accomplished by the production engineer based on an analysis of emergency and preventive repair and is reduced, essentially, to a determination of a set of non-intersecting elements, considered later as subjects of repair and the actions of production processes.
  The building of a structure-assembly diagram of the equipment.
- The identification of a set of operating modes of equipment operation and systems (working, hot standby etc).
- The building of structure-functional diagrams of systems and power units. (At this stage there is determined the totality of the restrictions on the modes of operation of power units and systems, related to the modes of operation and the efficiency of the subordinate and allied stuctures).
- The structuring of equipment nodes, present in the functional standby. (The procedure is intended for the

identification of the non-intersecting sets which are the elementary subjects of the solution of the problem of inspection optimization).

- The structural-technological analysis and the build of structural-logic diagrams. (The procedure makes possible to describe formally the effect of failures on the mode of operation and efficiency of allied equipment).
- The formalized description of the various aspects of repair, for example, the degree of restoration, rules of conduct and so on.

Developments with respect to the qualitative-probabilistic analysis of reliability are actively being introduced into the operation of AS units. As of today:

- a new TO and R regulation for diesel generators has been introduced;
- the PPR [scheduled maintenance] regulation of the KoAES turbine plant has bben optimized;
- the on-line correction of the sampled channels 22 of the SB [safety system] (ZAES, YuUAES, RAES) [Z, YuU ,R unknown] has been accomplished.



APPENDIX

109507 Moscow Ferganskaya 25 BNIIAES 1

NPO "ENERGIYA"

KDV - THE SYSTEM FOR EVERYONE

IF YOU WANT:

- to work in SETL (expansion unknown),
- TO START WORK RIGHT AWA [illegible]lth the data base ANY STRUCTURE, not worrying at all about the availability of the programmer staff for system maintenance.

IF YOU NEED TO HAVE:

- an information area of up to 32 KILOBYTES, exceptionally FAST ACCESS to data bases,
- GOOD SERVICE,
- A USER-FRIENDLY interface,

You need the KDV system!

- ☐ VERSATILITY of the system,
- ☐ color adjustment for a specific user,
- ☐ ability to change configuration,
- ☐ capability of operating with QUASI- and MINIdisks,
- ☐ GRAPHIC possibilities,

- ☐ operation in RUSSIAN without studying documentation thanks to STEPWISE INSTRUCTIONS,
- ☐ an extensive set of services for INPUT of information to the data base with formalized MONITORING, for MODIFICATION and selection of information in TABLES OF ARBITRARY FORM without the restrictions typical for most data base control systems,
- ☐ NO NEED TO STUDY the languages of these systems,
- ☐ PROMPTING according to hierarchical vocabularies,

- ALL THIS SAVES YOUR TIME AND MONEY!

The KDV system operates on PC-AT/XT and IBM - compatible computers ("Robotron" etc).

SO, THE VERSATILE SYSTEM KDV IS FOR ANY DATA BASES.

With the acquisition and adaptation of this system THE SERVICE CAPABILITIES can be supplemented or changed based on YOUR SUGGESTIONS.

Division of Information Systems Software
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NPO "Energiya"

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INFORMATION SYSTEM FS-3 3

The program complex FS-3 is directed toward operation with the data base "AS EQUIPMENT MALFUNCTIONS".

- The program complex was developed on the basis of the Clipper SUBD and supports work with data base files in the dBASE III FORMAT in the ON-LINE MODE.
- The program complex is designed for the input, processing and output of information according to an ARBITRARY retrieval criterion. Information can be output to a printer and to a magnetic medium.
- The program complex is quickly adjustable to operation with ANY other data bases, including those containing textual information.
- The program complex allows the connection of different computation programs for carrying out the necessary STATISTICAL PROCESSING of the information stored in the data base and supports the ouput of results in TABULAR or GRAPHIC FORM.
- The program complex makes available to the user extensive SERVICE for operation with data bases. In addition to the general necessary capabilities for data

base management, additional services are included which make the processes of input and output of information significantly easier:

- the use of REFERENCE INFORMATION from dictionary -references for the input, editing and output of information,
- the ability to supplement the dictionary-references with new data directly with information input,
- the formation of an arbitrary retrieval criterion including the capability of masked retrieval, retrieval by context in textual information,
- on-line preparation of retrieval criteria and output tabular forms with the storage of them in the form of standard requests.

With acquisition and adaptation of this system THE SERVICE CAPABILITIES can be supplemented or changed based on YOUR SUGGESTIONS.

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Data base

"TECHNICO-ECONOMIC AS INDICES" 5

The program system "TER" was created in TsIAEAS of VNIIAES NPO "Energiya" for the maintenance of the data base of the AS technico-economic indices.

- The program system "TER" for the maintenance of the data bases of the AS technico-economic indices implements the methods of determining the actual use and non-use of the installed electrical power of an energy unit and of the nuclear power plant as a whole.
- The program system, on the basis of technical reports on the thermal efficiency of AS operation via form No. 3 - TEK [thermal efficiency factor], calculates the mean square values of the technical indices of the operation of:
  - the power unit,
  - the nuclear steam producing unit,
  - the turbine plants,
  - the nuclear power plant.
- The TER program has been implemented on personal computers of the IBM PC type with the use

of the Clipper SUBD and supports work with data base files in the format of dBase III in the on-line mode.

- There is a version of the program for ES series computers.

The TER program system is operated in VNIIAES and can be recommended to design, construction and operating AS organizations for the analysis of the thermal efficiency of plant operation.

With acquisition and adaptation of this system THE SERVICE CAPABILITIES can be suplemented or changed based on YOUR SUGGESTIONS.

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The program system for operating with the data base "AS SYSTEMS OF CIRCULATING WATER SUPPLY"

The data base "AS systems of circulating water supply" is designed for the accumalation and analysis of information on the chemical and temperature characteristics of the water in the water coolers and sources of water supply of the AS, on the measures directed toward the improvement of the operational characteristics of the equipment and the working environment.

- The on-line interface of the data base offers the user an operating mode in the form of a "menu" with the use of reference information.
- The program system carries out information retrieval in the data base at the request of the user and constructs graphs using the data found. The graphic information is presented for both the analysis of individual characteristics and the comparative analysis of groups of characteristics.

The program system is operated on personal computers of the

IBM PC type. The state-of-the-art software of the data bases, the Clipper SUBD for personal computers, is the foundation for the development.

- The proposed program system can be recommended for data base maintenance at the plant level. The use of this program system is possible for the accumulation and analysis of information on the operational characteristics of the production water supply systems of the reactor building.

With acquisition and adaptation of this system THE SERVICE CAPABILITIES can be supplemented or changed based on YOUR SUGGESTIONS.

Division of Information Systems Software
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Program system for operation with the data base "AS SYSTEMS OF THE CIRCULATING WATER SUPPLY" 8

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Program for generating the 9

STATISTICAL REPORT ON VIOLATIONS IN AS OPERATION (SON)

- The SON program generates the statistical report in the form of matrix tables. The tables depict the frequency distribution of violations, unloadings of power units and underproduction of electric power with respect to the various informative signs of violations.
- For convenience in the work of the user the possibility of building groups of tables by reactor type for an arbitrary report period has been provided.
- The SON program uses the Clipper SUBD and supports operation with data base files in the dBase III format in the on-line mode. There is a version of the program for ES series computers with the use of the "SPEKTR" SUBD.

The service capabilities and the forms of statistical reporting can be supplemented or changed based on the suggestions of the client.

Division of Information Systems Software

TsIAE AS telephone 172-93-37, 376-12-75

Program for generating the STATISTICAL REPORT ON VIOLATIONS IN AS OPERATION (SON)

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The program system 11

directed toward operation with the data base

"VIOLATIONS IN AS OPERATION"

- The program system supports operation with the data base containing reports on violations in AS operation which are generated on the basis of the investigations of violations.
- The program system offers the user extensive capabilities for working with the data base, significantly facilitating the processes of input, output and editing of information:
  - the use of reference information from the reference dictionaries for the input, editing and output of information,
  - supplementing dictionary-references with new data directly during information input,
  - the formation of an arbitrary retrieval criterion, including masked retrieval and retrieval by context in textual information, with the automatic generation of multipage single-level tables of output information,

- on-line preparation of the retrieval criterion of the output tabular forms with storage of them as standard requests.

- The program system is implemented on the basis of the Clipper SUBD on personal computers and on ES series computers using the "SPEKTR" (ADABAS) SUBD.

With the acquisition and adaptation of this system the service capabilities can be supplemented or changed based on YOUR SUGGESTIONS.

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The program system directed toward operation with the data base "VIOLATIONS IN AC OPERATION" 12

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EXPERT SYSTEMS 13

The "expert systems" group has developed and installed:

- PEKS - the shell-system (shell) of the classical type, capable of operating with illegible expert evaluations. The system, in particular, is used as the shell of an expert system-adviser for diagnosing the malfunctions of the GTsN (main circulating pump) and certain uses of a similar kind. The system was developed for the SM-4 computer and the Pascal programming language. An expanded version of the system is now being developed for IBM PC's.

- EDES - an on-line real time expert-diagnostic system for diagnosing the transient regimes of a unit. EDES is supposed to be used as a part of a system of unit monitoring and operating conditions diagnosis. The system has been developed for the SM-4 computer and the C programming language.

- EKSPLAN - a system designed for the automatic

generation of Fortran codes for three-dimensional neutron-physics reactor computations. The generated codes are programs with a complex structure, including source module calls, alternative and parallel (for single-processor computers) branches of calculations and so on.

- MATREKS - a system designed for the selection of a reactor, a chamber and the methods for investigating reactor materials and objects with regard for the large number of reactors, chambers and methods, the variety of materials and the strict limitations for selecting methods. It is proposed for the user of a chain or (chains) of methods optimal for a criterion selected by the user. The system was developed for IBM PC's and the PROLOG programming language.

At the present time there are being developed:

- An expert system for analyzing the propagation processes of dependent failures in the production systems of AS power units for the analysis of their reliability. Applications: analysis of design decisions in the SAPR [automated design system] with the use of the computed probabilities

(frequencies) of failures; instruction of the

operators in the training mode and testing of design decisions; support of the operator controlling the power unit.

- SAFEKS - an experimental expert system for evaluation of the current safety level of an AS. It is being developed for IBM PC's and the Prolog programming language.

Several other projects are in the development stage.

In the development of an ES well-known specialists from the field for which the ES is being made up are brought in on a temporary basis.

The costs for the development of the above-listed systems come to 35 to 200,000 rubles. The time for developing an ES from problem statement to completion is 6-12 months.

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D I A S 15

program system for the analysis of
AS equipment reliability indices

DIAS is a necessary facility for conducting quantitative analysis of equipment reliability via the statistical information obtained during AS operation.

The newest methods of non-parametric estimation of reliability indices have been implemented in the DIAS program system. A non-parametric estimate is adequate for the operating conditions of AS equipment since it does not distort the statistical information by the assumptions about any distribution law and makes it possible to take into account repair quality, as well as the effect of censoring by the selection of one of the possible types of restoration:

FULL RESTORATION

An assumption of full restoration corresponds to the case of replacement of the failing equipment by new, since the sampling of running time before and after failure is

homogeneous.

PARTIAL RESTORATION

In most cases the restoration of equipment after repair is not full, i.e. the quality of the equipment is not raised to the initial state. In this case DIAS allows computation in the mode of "partial restoration" and calculates a mean estimate and a confidence interval of the degree of restoration.

MINIMAL RESTORATION

In the case where, as a result of repair, only the restoration of efficiency occurs without a change in the characteristics of equipment reliability, it is possible to speak of a minimal restoration of an element in repair. In practice this corresponds to the case where element means a large mechanical system, and restoration concerns only a small part of it. DIAS makes it possible to estimate reliability indices for given conditions in the "minimal restoration" regime.

FULL RESTORATION WITH CENSORING

In practice part of the elements of restoration occurs not as a result of an equipment failure, but in the conducting of planned repair, as well as for the failure of other elements in one production chain. The consideration of this effect in the assumption of full restoration is possible in

the "full restoration with censoring" regime.

MINIMAL RESTORATION WITH CENSORING

The actual practice of repairs can be most adequately reflected in the regime "minimal restoration with censoring", which assumes the minimal restoration of equipment in the case of failure and full for planned repairs.

In addition DIAS permits computations for a small quantity of statistical data. This is very important for highly reliable AS equipment.

DIAS provides the capability of computing the following basic indices of equipment reliability:

- mean sevice time to failure,
- mean restoration time,
- mean down time,
- mean failure stream parameter,
- industrial utilization factor,
- availability.

The program system provides the capability of constructing graphs of the following functions:

- the distribution of time to failure,
- the density of the distribution of time to failure,

- restoration function,
- failure rate function,
- failure stream parameter,
- probability of fault-free operation.

The results of the computations can be used for raising equipment reliability in design, as well as for optimization in carying out planned-preventive repairs of AS equipment.

DIAS functions in the on-line mode, which makes available to the user great capabilities for input, output and storage of initial information and computation results, as well as the selection of the operating mode of the system. The input of data can be handled from a terminal screen and from a file created by the DIAS facilities and by any text editor. There is the possibility of a system change for the use of data bases by the creation of a retrieval module. During operation a check is made of the correctness of all the input information, as well as a check of the allowability of operator commands.

A convenient system of prompting and informational messages allows a rapid mastering of the system capabilities and helps in its operation.

DIAS can be a desk-top instrument of a specialist of the AS reliability subsection, since it combines simplicity of use with a great total of internal knowledge and is freed from routine computations.

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The documentation, supplied with DIAS, contains an exhaustive description of the capabilities and the operating rules of the system.

DIAS is designed for use on personal computers of the IBM PC XT/AT type (and compatible models) with the graphic monitor of the type EGA or CGA. There is also a version of DIAS for the ES-1055.

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DIAS 18

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"FLOWER" ver 2.0

The "FLOWER" package is designed for the computation of the basic reliability indices of a power unit (EB) or of any of the components of its subsystems by the methods of random Markov processes with continuous time and a discrete set of states. The package may be used for the modeling of:

:: the growth dynamics of an object (reliability problem),

:: the growth dynamics of an anomalous process (safety problem).

For the reliability problem the package makes it possible to compute the following basic indices:

> the readiness factor,

> the failure stream parameter,

> the time to failure (mean time to failure),

> the mean restoration time etc.

For the problem of the probabilistic analysis of safety (VAB) the package provides the capability of calculating the quantitative index -

> the frequency of realization of emergency states

(for the "fault-tree" method the computation of these indices is a fortiori approximate). In addition the package permits modeling of failures according to general cause.

All the interesting investigations of characteristics can be obtained as time functions, which allows in most cases the tracking of the dynamics of change of these characteristics.

Provided in the package are:

:: the problem of both constant equipment failure and restoration rates, and as functions of time (the latter makes it possible, in particular, to account for equipment aging);

:: the autommated construction of the EB state curve and the determination of the transfer rates among EB states;

:: the accomplishment of packing and storing the transfer rate matrices in accordance with specially developed methods;

:: the solution of the Kolmogorov-Chapman system of differential equations for determining the probabilities of graph states;

:: the computation of the basic reliability indices and the frequencies of realization of emergency states;

:: the illustration of the results obtained by graphs, tables etc.

The basic restrictions of the package.

They are primarily determined by computer capabilities (the actual size of the OZU [random access memory] and memory on magnetic media).

Presently there is provided the capability of determining the state graph with the number of vertices N_v = 1000 and the number of transfers N_p = 4000 (for fixed rates) and N_v = 500 and N_p = 800 (for variable rates).

The computation time essentially depends on computer capabilities and the size of the state graph (from several minutes to several hours).

In the package is provided the capability of full computation for a specified time interval in several stages (a reset of the intermediate results into a file and the start of computation from them is used for the next session of work with the package).

This package was used for a probabilistic analysis of the attained safety level of a research reactor of the pool type. A consolidated graph with 33 states and 56 transfers

(time dependent) was constructed. The following were calculated for a 5-year interval:

:: the readiness factor,

:: the frequency of realization of the following emergency situations:

- rupture of 1st loop pipeline,
- full disconnection,
- release of radioactivity to atmosphere,
- full disruption of active zone.

Computation time is the following:

> for the ES-1834 computer (Robotron) - 40 minutes,

> for the PC AT computer (16 MHz) - 4 minutes.

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NPO "ENERGIYA"

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ESO - THE PROGRAMMING SYSTEM FOR COMPUTING THE OPTIMUM STRATEGY FOR MAINTENANCE AND REPAIR OF AS EQUIPMENT

Te ESO programming system is designed for the planning of strategies for preventive repairs and maintenance (sampling, inspection) of separate equipment and systems. Preventive repair and maintenance are practically the only effective means of influencing the reliability of the equipment and systems available to the AS personnel.

In the final analysis safety, reliability and efficiency of power unit operation depends on a rational use of this expensive facility under conditions of limited human and material resources, of actual limitations on repair capacity.

What equipment, and in what time periods should it be subjected to preventive repair, so as not to lower power unit efficiency, but to guarantee its safe and reliable operation?

What frequency is sufficient for conducting sampling

and inspection so as to guarantee the required safety level?

The ESO system is a reliable instrument for solving these problems.

The ESO system has no analog in universal practice.

The specific statistical data on the operational history of each unit of equipment, each TU [production unit sic] in repair and maintenance is the initial information for the ESO programming system.

ESO - THE PROGRAMMING SYSTEM FOR COMPUTING THE OPTIMUM STRATEGY FOR MAINTENANCE AND REPAIR OF AS EQUIPMENT 22

The ESO system is built on the basis of probabilistic and statistical models of the change in the technical state of equipment, with the use of the latest advances in the theory.

:: The system makes it possible to select the optimum times of repair of equipment by one of the four service strategies:

. A - Full planned repair, full emergency repair, replacement of equipment, minimum emergency repair (repair of a failing node, detail, assembly unit or parts of them).

. B - Full emergency repair and full planned repair.

. C - Full planned repair and minimum emergency repair.

. D - Minimum and full emergency repairs.

The service strategy is selected by the user based on the characteristics of the specific equipment.

:: The ESO programming system provides the capability of constructing a graph of the superposition of AS equipment repair times. The optimum repair cycles for specified equipment, as well as the mean specific losses, the production use factor and the operational readiness factor (for SB) which are obtained in this way are the results of the system's operation.

:: The ESO system functions in the on-line mode which makes it convenient for the user to operate and provides great capabilities for the input, output and storage of information, as well as the selection of the system operating mode. There is the possibility of operating with data bases upon connecting the appropriate additional module.

:: Data input can be accomplished either from the keyboard of a personal computer or from a file which can be created by the facilities of the ESO programming system and by any other means (text editor and so on).

Monitoring of the correctness of all the input

information is carried on during operation.

The ESO programming system is designed for use on personal computers of the IBM-PC/XT/AT type (and those compatible with them) with on-line memory size of not less than 256 kilobytes. The availability of a graphics monitor and adapter CGA/EGA/VGA is desirable.

The mathematical methods and the computational algorithms built into the ESO programming system underwent practical checking in the selection of the optimum repair cycles of certain kinds of equipment of the Kolsk AS.

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1. INPUT SCREEN FOR TECHNICO-ECOMOMIC INDICES

MODEL == B == PLANNED-PREVENTIVE REPAIR

TECHNICO-ECONOMIC INDICES					
REPAIR DURATION /HOURS/	REPAIR LABOR /MAN-HOURS/	CREW SIZE /MEN/	LABOR PRICE /RUBLES PER MAN-HOUR/	MATERIAL COSTS /1000'S OF RUBLES/	POWER REQUIRED /MEGA-WATTS/
208	-	3	2.92	628.2	0.0

NAME	VALUE
COMBINATION FACTOR	1
BASE RATE	1.0
VARIABLE COMPOSITION NET COST	1.2

2. OUTPUT SCREEN FOR RESULTS OF SYSTEM OPERATION

KEY:

```
                STRATEGY B
OPTIMUM K t.l.              :   0.9951
CONDUCT MINOR REPAIR FOR ACCRUED RUN TIME  1 YEAR
CONDUCT OVERHAUL FOR ACCRUED RUN TIME  5 YEARS
RECOVERY PERIOD    30 YEARS
OPTIMUM LOSSES              RUBLES PER YEAR
```

Division of Computer Technology for Quantitative Reliability Analysis TsIAE AS telephone 172-90-93, 37701-41

ESO - THE PROGRAMMING SYSTEM FOR COMPUTING THE OPTIMUM STRATEGY FOR MAINTENANCE AND REPAIR OF AS EQUIPMENT 24

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INFORMATION SUPPORT OF OPERATIONS DIRECTED TO THE INCREASE OF AS RELIABILITY AND SAFETY

By this time several tens of thousands of reports on defects, failures and damages of equipment detected in operating AS units during 1977-1990 have been accumulated in the TsIAEAS data bases.

TsIAEAS can make available on a stipulated basis the following systematized and generalized informational materials:

- a list of departmental equipment with an indication of: the nature, assumed causes and consequences of failures and damages detected in the AS's of the Minatomenergoproma of the USSR; the statistical estimation of the operational indices of reliability and recommended quantitative requirements for the reliability of similar models;
- data on failures, damages and accidents with the equipment of active AS units for coming up with the necessary measures to eliminate the causes of their occurrences;

- the analysis of operational experience and technico-economic indices of the operation for making recommendations with respect to the improvement of the characteristics of AS equipment and systems;
- a detailed analysis of operational events: unplanned stops, deviations from standard conditions, failures in the operation of equipment and systems, accidents in AS's;
- an estimate of the effect on AS unit reliability of the quality of assembly, start-set up and repair-recovery operations based on the statistical information obtained from the AS;
- a comparative analysis of reliability and other quality indices of the equipment of domestic and foreign AS's.

Information interesting to users may be presented as a function of the form of transmission:

- upon completion of a contract for a one-time collection of data for the period of observation needed by the user (the price is established as a function of the volume of information);

INFORMATION SUPPORT OF OPERATIONS DIRECTED TO THE INCREASE OF AS RELIABILITY AND SAFETY 26

- connection to the TsIAEAS network via MODEM or by coordinated regulation (quarterly, annually) with the conclusion of the agreement about subscriber payment (about 10-15,000 rubles per year).
- by one-time requests with registered letters to the address of TsIAEAS VNIIAES with a subsequent payment for the submitted data according to the actual expenses (with presentation of a statement to the information user).

Laboratory of AS Equipment Quality,
TsIAEAS, telephone : 376-15-65.

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NPO "ENERGIYA"

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INFORMATIONAL DATA BASE ON INPUT MONITORING OF AS THERMO-MECHANICAL EQUIPMENT WWITH VVER-1000 REACTORS

TsIAEAS VNIIAES NPO "ENERGIYA" has created a data base on defects, detected in the pre-operational monitoring of the thermo-mechanical equipment of the reactor and turbine departments. It is based on personal computers of the IBM PC/XT type.

:: Reactor equipment:

- housing and upper block, within-housing unit;
- steam generator;
- water tank of the SAOZ [emergency core cooling system];
- pressure equalizer;
- GTsN-195M [primary coolant pump];
- main circulation pipelines;
- SAOZ pipelines;
- pressure equalizer system;
- pipelines for purge-replenishment and water purification bypass, fresh steam, emergency feed water and others.

:: Machine shop equipment:

- main and drive turbine;
- deaerator;
- high- and low-pressure preheaters;

INFORMATIONAL DATA BASE ON INPUT MONITORING OF AS THERMO-MECHANICAL EQUIPMENT WITH VVER-1000 REACTORS 28

- moisture separator-reheater (SPP);
- condensate collectors I and II stage;
- heat exchanger and condensate pumps;
- main boiler;
- steam pipes of the BRU-K [high speed pressure regulator for steam release to condenser], BRU-A [high speed pressure regulator for steam release to atmosphere], BRU-SN [booster regulator for steam release to internal station systems], heating I and II stage steam of the SPP;
- pressure oil pipelines and pipelines for regulating the TG [turbine generator] and the TPN [turbine feed pumps].

Software based on the FoxBase+ SUBD makes it possible to process the initial information on the defects of the above-mentioned equipment, its input into the data base, correction and organization, as well as to issue information

generalized by AS on equipment defects, the possible causes of their appearance and measures for their elimination.

The output of the indicated information to the display screen and to the printer by user request is provided for.

TsIAEAS can make available:

:: Organized and generalized materials on defects of thermo-mechanical equipment by different request criteria (AS, manufacturing firm, type of damaged equipment, kind of defects etc)

AS Equipment Quality Laboratory,
TsIAEAS, telephone : 376-15-65.

109507 Moscow Ferganskaya 25 VNIIAES 29

NPO "ENERGIYA"

Telex: 411026 UKLON Telephone 3770104

PRE-OPERATIONAL QUALITY CONTROL OF EQUIPMENT ARRIVING AT AN AS

TsIAEAS VNIIAES NPO "ENERGIYA" proposes to develop and introduce the EQUIPMENT QUALITY CONTROL SYSTEM:

for supplying equipment to an AS from a manufacturing plant-

INPUT CONTROL;

for storage and transportation-

SAFETY CONTROL;

for assembly, start and adjustment-

PRE-OPERATIONAL CONTROL;

for repair and test-

QUALITY CONTROL.

The concept of quality monitoring and control, development and introduction of NTD [expansion unknown] is proposed for the stage-wise conducting of operations:

:: the development of the system for the collection, processing and use of information for input control with the organization of a data base for defects and damages discovered by input quality control of equipment arriving at a newly installed AS unit;

:: the compilation of standardized documents for performing corrective measures for the elimination of the causes of defects and damages;

:: the set up of the introduction to an AS of developed engineering decisions, of modernized and newly developed nodes, changes in the active equipment and other developments directed to raising the operational quality of AS equipment and systems.

AS Equipment Quality Laboratory
TsIAEAS, telephone : 376-15-75

PRE-OPERATIONAL QUALITY CONTROL OF EQUIPMENT ARRIVING AT AN AS

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NPO "ENERGIYA"

Telex : 411026 UKLON Telephone 3770104

INFORMATION SYSTEM FOR FAILURES OF AS ELECTRO-ENGINEERING EQUIPMENT

TsIAEAS VNIIAES NPO "ENERGIYA" has created a relational data base set up on personal computers of the IBM PC/XT type for electro-engineering equipment.

The information obtained is processed, systematized and based on it, failures and damages of electro-engineering equipment for AS's are analyzed.

The data base operates under the control of the FoxBase+ SUBD which enables the creation of all possible reports and the display and printing of output.

TsIAEAS VNIIAES can make available the systematized and generalized informational materials for the electro-engineering equipment of an AS.

:: data on failures and damages of electro-engineering equipment to develop the necessary measures to eliminate their causes;

:: the evaluation of the effect of such equipment on the

operational reliability of AS units;

:: the quantitative indices of equipment reliability.

AS Equipment Quality Laboratory,

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INFORMATION SYSTEM FOR FAILURES OF AS ELECTRO-ENGINEERING EQUIPMENT

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INFORMATIONAL DATA BASE FOR THE AS CIRCULATING WATER SUPPLY SYSTEM

:: The data base is intended for the accumulation and analysis of information:

- on the hydrochemical composition of the water sources of the industrial water supply and the coolers of the circulating water supply of an AS;
- on the temperature conditions of the coolers for the circulating water supply system;
- on the turbo-unit operation indices: the actual temperature stresses in the condensers of the main turbine, the down time in repair, the underproduction of electrical power caused by the deterioration of the vacuum in the condensers;
- on the measures directed to the improvement of the operational characteristics of the circulation system equipment;
- on measures for water quality improvement.

:: The data base also has available the certificate data

of the elements of the AS circulation systems: water coolers, the equipment of the circulating pump stations, the discharge and drain pipelines, THE CONSUMERS OF CIRCULATING WATER.

:: The programming syste.i handles information retrieval in the data base in accordance with user requests.

:: The plotting of graphs with the data of the hydrochemical composition of water is handled. The graphic information is presented as individual and comparative characteristics.

The Laboratory for Pump Equipment and Industrial Water Supply Systems, TsIAEAS, telephone`: 172-96-52.

INFORMATIONAL DATA BASE FOR THE AS CIRCULATING WATER SUPPLY SYSTEM 34

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INFORMATIONAL DATA BASE FOR FAILURES OF PUMP EQUIPMENT

:: The data base for defects and failures of pump equipment contains about 6500 events and covers the period of its functioning from the introduction of AS's into operation to the present.

:: The collected information is mainly concerned with the pump equipment of the principal production systems of GTsN's [primary coolant pumps], safety system pumps, feed and condensate pumps, those of the principal consumers of industrial water and of the circulating water supply.

:: The existing information of the data base can be used in the analysis and evaluation of the operational reliability of the pumps, the determination of the degree of their correspondence to the conditions of operation in an AS and to industrial conditions, the identification of the shortest-lived nodes and

parts, and in developing measures to increase the operational reliability and safety in an AS.

Laboratory for Pump Equipment and Industrial Water Supply Systems, TsIAEAS, telephone: 172-96-52

INFORMATIONAL DATA BASE FOR FAILURES OF PUMP EQUIPMENT 36

109507 Moscow erganskaya 25 VNIIA. /37
NPO "ENERGIYA"
Telex: 411026 UKLON Telephone: 3770104

FILTER-TRAP FOR THE AS SYSTEMS OF INDUSTRIAL WATER SUPPLY

:: The filter-trap is designed for the collection and removal of suspended particles (dying Dreissensia and others) in AS industrial water supply systems.

:: The filter-trap is a hydraulic settling tank and a latticed filter, associated in one unit, installed on the horizontal and vertical sections of the pipelines.

With the flow of water with suspended matter into the filter-trap the large Dreissensia and other particles subside in the settling tank, and the smaller particles are retained in the latticed filters (cell sizes 3-4 mm), periodically being cleansed without breaking them up. The particles passing through the filter will circulate around the industrial water system without lowering the reliability of system operation as a whole.

:: The filter-traps may be successfully used in industrial water supply systems with pipeline diameters of 100-600 mm.

VNIIAES will be able to transmit the working drawings for

manufacturing the filter-traps to users on a contract basis starting from January 1991.

Laboratory for Pump Equipment and Industrial Water Supply Systems, TsIAEAS, telephone : 172-95-52.

FILTER-TRAP FOR THE AS SYSTEMS OF INDUSTRIAL WATER SUPPLY 38

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INFORMATIONAL DATA BASE FOR FAILURES OF FITTINGS IN THE SYSTEMS OF AS UNITS WITH VVER-440, VVER-1000, RBMK-1000, RBMK-1500

TsIAEAS VNIIAES NPO "ENERGIYA" has created a data base on failures, defects and damages of fittings in the systems of the reactor and turbine plants based on personal computers of the IBM PC/XT type.

The software which is based on the FoxBase+ SUBD enables:

- input of data to the data base,
- processing of initial information,
- correction,
- systemization and information retrieval,
- issuing of information on malfunctions, their causes and consequences for the nodes and elements of the fittings,
- output to display screens and printers in a form satisfactory to the user.

TsIAEAS can make available generalized FITTINGS DATA of the safety systems and the PRODUCTION SYSTEMS of the AS

units:

:: failure classifier;

:: statistical data on failures, defects and damages;

:: calcualted values of reliability indicators.

Thermo-mechanical Equipment Laboratory,

TsIAEAS, telephone : 172-95-09.

INFORMATIONAL DATA BASE FOR FAILURES OF FITTINGS IN THE SYSTEMS OF AS UNITS WITH VVER-440, VVER-1000, RBMK-1000, RBMK-1500

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NPO "ENERGIYA"

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INDICES OF AS OPERATIONAL SAFETY

THE SYSTEM OF INDICES OF AS OPERATIONAL SAFETY PROVIDES THE ABILITY TO:

:: monitor the changes in safety level of AS operation;

:: conduct a qualitative evaluation of AS operational safety;

:: evaluate the effectiveness of measures undertaken to raise the level of safe AS operation;

:: compare the levels of operational safety of individual power units, and of the AS as a whole;

:: compare the levels of operational safety of domestic AS's and similar AS's operated in other countries;

:: discover the areas requiring special attention for guaranteeing safe AS operation;

:: distribute more rationally the resources directed toward raising the quality of AS operation and safety;

:: formulate scientific-technical progams.

THE SYSTEM OF INDICES OF AS OPERATIONAL SAFETY SUMMARIZES:

:: domestic operational experience,

:: experience in the use of quantitative operational

indices of AS's in countries with developed atomic power engineering,

:: experience in using international systems of operational indices (MAGATE, VAO AS).

REQUIREMENTS FOR THE USE OF THE INDICES:

:: availability

:: objectivity

:: uniqueness,

:: simplicity.

INDICES OF AS OPERATIONAL SAFETY 42

LIST OF OPERATIONAL INDICES INTENDED FOR USE:

:: the number of out-of-plan stops reported in 7000 hours of powered operation;

:: the number of actions for emergency protection of the reactor reported in 7000 hours of powered operation;

:: the number of out-of-plan actions of the safety systems during powered operation of the reactor;

:: the unreadiness factor of the safety systems;

:: the unreadiness of operating personnel;

:: the collective dose of radioactive radiation of personnel;

:: the usage factor of established power;

:: industrial safety of personnel (index being

developed);

:: the reliability of fuel elements (index being developed);

:: maintenance and repair of equipment (index being developed);

: efficiency of control circuits and automation (index being developed);

:: environmental protection (index being developed);

:: recovery of radioactive wastes (index being developed).

AREA 3, SUPPORTING AS SAFETY, ESTIMATED BY THE INDICES:

:: stability of power unit operation;

:: reliability of safety system;

:: qualification of personnel;

:: protection of personnel from radiation;

:: efficiency of power unit usage.

Division of AS Operational Experience Analysis,
TsIAEAS, telephone : 377-02-27, 172-93-41.

109507 Moscow Ferganskaya 25 TsIAEAS

NPO "ENERGIYA"

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THE HUMAN FACTOR

Based on the studies of the experience of ISI MAGATE, VAO AS, INPO in solving the problem of violatins in AS operation connected with the human factor and their minimization TsIAEAS provides:

- a classification of the causes of the violations in AS operation connected with human activity;
- information on violations according to a given classification.

Based on this data an analysis of violations in AS operation related to the human factor has been carried out.

Corrective measures, derived from the results of the analysis of violations, have been proposed to reduce the number of violations related to the "man-machine" interface.

1. CLASSIFICATION OF CAUSES

(Errors of AS personnel)

1.1. A violation of instructions or other documents (violation of technical conditions or any other regulations).

1.2. Error in analysis, incorrect reaction, diagnosis of action, incorrect understanding.

1.3. Inattention, carelessness, confusion, thoughtlessness.

1.4. Error by oversight (omission, neglect).

1.5. Error in inspection, (verification), maintenance, testing or adjustment (calibration).

1.6. Error in repair and subsequent testing (quality-less repair).

1.7. Deficiencies in administrative control, organization or operations planning (incorrect instructions, recommendations).

1.8. Deviation from program of operations or switching forms.

THE HUMAN FACTOR 44

2. INFORMATION ON VIOLATIONS BY CLASSIFICATION OF CA[illegible]ES

(Tables and diagrams)

2.1. The distribution of the number of violations due to the fault of AS personnel, by plants.

2.2. The distribution of the number of violations due to the fault of personnel, by groups of AS equipment.

2.3. The distribution of the number of violations due to the

fault of personnel, by hours of the day.

2.4. The distribution of errors by shift.

2.5. The distribution of errors of personnel by categories.

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EXPRESS - A PROGRAMMING SYSTEM FOR THE EVALUATION OF RELIABILITY INDICES

TsIAEAS VNIIAES has developed the EXPRESS program package which makes it possible to evaluate the main reliability indices:

- failure stream rate;
- restoration parameter;
- probability of non-response to requirements.

The evaluation is carried out on the basis of statistical information on equipment failures and repairs. The methods applied have a strict mathematical foundation.

The use of the EXPRESS package makes it possible to:

:: carry out fast-analysis of failure and repair information;

:: construct optimum (irreducible) confidence intervals for evaluation of parameters;

:: conduct initial investigations of the equipment aging process;

:: conduct computations on data bases (in the batch mode).

EXPRESS is an irreplaceable instrument for solving various problems of Probabilistic Analysis of Safety, using statistical data, for example, PSA PACK.

EXPRESS - A PROGRAMMING SYSTEM FOR THE EVALUATION OF RELIABILITY INDICES

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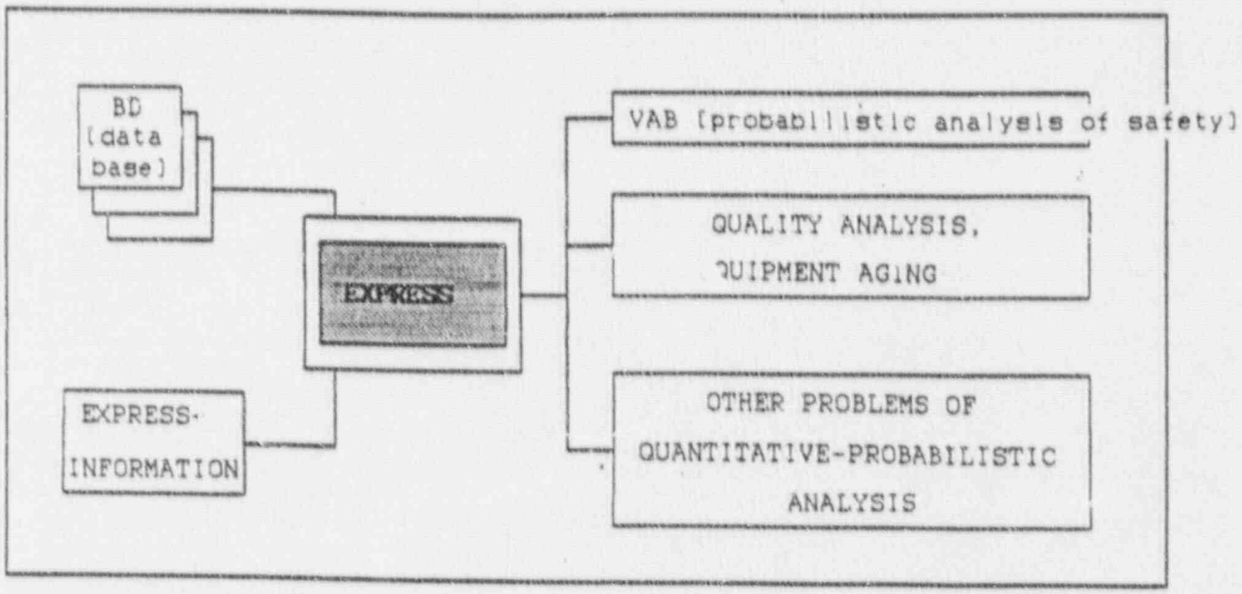
Block diagram:



The EXPRESS package has been implemented in the on-line mode which makes it possible to enter data from the keyboard and to load it from text files, store all data and calculated results on disk, edit and supplement it. The package is supplied with Help and is "foolproof" for the input and correction of data, as well as with disk operations (write/read), thus protecting the results of the user's work from random errors.

The EXPRESS package is designed for use on the IBM PC XT/AT personal computer, Robotron.

Division of Computer Technology for the Quantitative Analysis of Reliability, TsIAEAS, telephone : 377-01-41.

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INFORMATIONAL DATA BASE FOR FAILURES OF REACTOR INSTALLATION EQUIPMENT

TsIAEAS VNIIAES GPO "ENERGIYA" has built a data base on personal computers of the IBM PC/XT type to cover defects, damages and failures of reactor and thermal engineering equipment, and of the pipelines of the production systems of AS reactor installations.

The software based on the FoxBase+ SUBD permits the processing of initial information, its entry into the data base, correction and systematization of the data, information retrieval and the supplying of information on malfunctions, their causes and consequences for nodes and elements of:

- reactors (housing, upper block, VKU [in-vessel devices]),
- equipment of SUZ [heat exchangers],
- steam generators,
- pressure equalizers,
- water tanks,
- heat exchange equipment,

. pipelines of the circulation loops and pipelines of the production systems of AS reactor installations.

to display screens and printers in any form in accordance with a user's request.

TsIAEAS can make available systematized and generalized data on the equipment and systems of AS reactor installations:

:: initial information on defects, damages and failures (list of malfunctions, their causes and consequences);

:: analysis of statistical data on defects, damages and failures, measures to eliminate the causes of malfunctions;

:: analysis of initial events;

INFORMATIONAL DATA BASE FOR FAILURES OF REACTOR INSTALLATION EQUIPMENT

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:: quantitative reliability indices;

:: catalog of equipment on PEVM (personal computers).

Reactor Equipment Laboratory,
TsIAEAS, telephone : 172-93-94.

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NPO "ENERGIYA"

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INFORMATIONAL DATA BASE FOR FAILURES OF TURBINE INSTALLATION EQUIPMENT

TSIAEAS VNIIAES NPO "ENERGIYA" has created, based on personal computers of the IBM PC/XT type, a data base on the defects, damages and failures of thermal engineering equipment and the pipelines of the production systems of the AS turbine installations.

The software which is based on the FoxBase+ SUBD permits the processing of initial information, its input into the data base, correction and systemization of the data, information retrieval and the supplying of information on malfunctions, their causes and consequences for the nodes and elements of:

- main and drive turbines,
- condensers,
- high and low pressure preheaters,
- separators-steam regenerators,
- other heat exchange equipment,
- pipelines of the production systems of AS turbine installations

to the display screen and the printer in any form in accordance with a user's request.

TsIAEAS can provide systemized and generalized data on the equipment and systems of AS turbine installations:

:: initial information on defects, damages and failures (list of malfunctions, their causes and consequences);

:: analysis of statistical data on defects, damages and failures, measures to eliminate the causes of malfunctions;

:: analysis of initial events;

:: quantitative reliability indices;

INFOR TIONAL DATA BASE FOR FAILURES OF TURBINE INSTALLATION EQUI IT

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:: catalog of equipment on PEVM's

Laboratory of AS Thermomechanical Equipment,
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NPO "ENERGIYA"

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INSPECTION OF THE OPERATIONAL STATUS OF THE AS

TsIAEAS VNIIAES NPO "ENERGIYA"

:: conducts inspection of AS operational status by the program "Checking AS operational safety", developed by TsIAEAS,

:: develops systems programs and conducts AS inspection by contract with a client.

The results of an inspection are made available in the form of textual, graphic and other materials by agreement with a client.

The results of an inspection are information for decision making with respect to raising the reliability and the safety of an AS.

Reactor Equipment Laboratory,

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INSPECTION OF THE OPERATIONAL STATUS OF THE AS 52

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NPO "ENERGIYA"

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QUALITY ASSURANCE IN AS OPERATION

TsIAEAS VNIIAES NPO "ENERGIYA" proposes to develop the "Quality assurance program for AS operation" - POKAS (E)

AS QUALITY = > AS SAFETY

The objective of the "Program" is the planning and accomplishment, at the operational stage of an AS, of the activity necessary to attain and preserve the required quality of equipment, systems and buildings important for AS safety, and a verification that with the carrying out of this activity the required quality is attained.

POKAS (E) is a batch of documents directed to both the administrative and the technical aspects of assuring safe operation of an AS for the following kinds of activity:

:: organization of AS operational and administrative control;

:: equipment maintenance and repair;

:: equipment modernization;

:: guarantee of radiation protection;

:: fuel handling;

:: radioactive waste handling;

:: chemical support,

:: supervision of equipment, systems and buildings important for safety;

:: training of AS personnel;

:: guidance of documentation.

A standardized basis for POKAS (E) - the requirements of the corresponding domestic NTD's [scientific-research divisions sic] in the field of nuclear power engineering.

POKAS (E) - the generalized experience in the operation of domestic AS's taking into account the recommendations of MAGATE, the ISO standards, the experience of AS quality control of the countries leading in nuclear power engineering.

QUALITY ASSURANCE IN AS OPERATION 54

POKAS (E) - a vital argument in work with the community!

Reactor Equipment Laboratory,

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