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HOUSEKEEPING PROGRAM FOR THE KOZLODUY NUCLEAR POWER PLANT

E. SOLLET

The Housekeeping aid program for the Kozloduy Nuclear Power Plant in Bulgaria was set up by WANO in 1991, within the framework of the support that this organization decided to provide for the nuclear power plants of Eastern Europe, more specifically in relation to the Soviet design VVER pressurized-water reactor plants.
The general WANO assistance program for the nuclear power plants of Eastern Europe, which apart from the Housekeeping program also included the Twinning Program and the program for Improvement to Safety Conditions, backed by INSAG, was submitted to the IAEA and the EEC in July 1991. The Commission of the European Communities set aside 11.5 million ECUs for aid to Bulgaria, within the PHARE program.
These 11.5 million ECUs were for five different programs, three proposed by WANO: 5 million for the six-month improvement program (see the article on this subject published in this journal in March of this year), 3 million for the Housekeeping program and 1.5 million for the Twinning program. In addition, 0.5 million ECUs were assigned to creating the PIU (Program Implementation Unit), made up of five international experts acting as coordinators of the six-month improvement program, 1 million to support by the European Regulatory Bodies for the Bulgarian Regulatory Authority, and 0.5 million to a study of possible alternative electricity supplies if the Bulgarian reactors were shut down, this study being awarded to Eurelectric. The successful bidders as regards the regulatory activities were ISPN (France), GRS (Germany), Vinçotte (Belgium), the British Nuclear Inspectorate and the Spanish Consejo de Seguridad Nuclear (Nuclear Safety Council).

NEED FOR THE HOUSEKEEPING PROGRAM

The reasons justifying the Housekeeping support program for the Kozloduy Nuclear Power Plant are many and highly important. In this respect, the following may be underlined, in chronological order:

- The accident at the Chernobyl plant and the political changes occurring in the former Soviet Union and in the countries previously included in its sphere of influence paved the way for the International Agencies, mainly the IAEA, to inspect the safety conditions in the Soviet designed nuclear power plants.
- There was concern among the Kozloduy operating personnel with respect to the state of the plant.
- The OSART inspection carried out by the IAEA in Kozloduy Units 1-4 in June 1991, in response to a request from the Bulgarian Government, underlined the existence of numerous deficiencies, apart from those already known to and identified by the IAEA through a conceptual review of VVER-440/230 reactor design and other studies.
- The OSART report recommended closure of Units 1-4 of the Kozloduy Nuclear Power Plant. The following is an extract from the main conclusions of this report:

«The design deficiencies of the VVER-440/230 reactors are well known, and include the absence of a containment building, the insufficient diversity and redundancy of safety injection systems and the lack of any segregation between safety systems. In view of these design faults, it is essential that high levels of excellence be maintained in both equipment conditions and operating and maintenance standards. With regard to operational aspects, greater emphasis might have been given to issues such as operator training under normal and emergency conditions, the safety equipment might have received better maintenance and the compartments housing such safety systems might have been in suitable condition.
This was not the case at Kozloduy. The

eneral state of conservation of the plant nd its equipment was unacceptable. oor conditions were observed in all are- s, including safety and safety-related quipment, conditions such that correct peration of the equipment under acci- ent conditions is not guaranteed. Until uch time as these safety deficiencies re corrected, it would be unwise to ope- te any of Units 1-4.

he current condition of the Kozloduy ant, including the poor state of conser- ation, is essentially the result of a lack of onsciousness regarding safety, a situa- on which has arisen due to the electricity roduction systems receiving higher prio- y than non-productive systems such as e safety and emergency equipment. uch an approach is the very antithesis of e "culture" required to safeguard nucle- r safety.

n Bulgaria there is a need for a new cul- re swinging the balance from produc- on to a situation in which safety consi- erations might also play a part. This afety culture must make it possible for a ositive influence to be brought to bear n the way in which all those directly or ndirectly involved in nuclear safety take ecisions and act.»

- The Bulgarian Government accepted the OSART report but did not agree to shut down the 4 VVER-440/230 units of the Kozloduy plant, since 40% of the country's electricity requirements are covered by the installation.
  It did, however, agree to shut down Units 3 and 4 (the most modern of the four) for upgrading and improvements, these to be followed by Units 1 and 2 (the oldest) for an extensive program along these same lines.
  Units 3 and 4 were shut down in the Summer of 1991, and were started up again in the Autumn of that year. Units 1 and 2 were then shut down, and remain so at this time (Autumn, 1992).
- The Bulgarian Government then requested international assistance and advice, with a view to achieving the participation of western experts and the financial support required to address the problems at Kozloduy; i.e., improvements to put right the design deficiencies and assistance for specific problems.
- WANO, with Community financing, is initially offering western experts to provide the assistance required in two areas: the six-month improvement program and the Housekeeping program, the latter centered exclusively on activities relating to the improvements to be made to the state of conservation of the plant and to revision of the tests performed on the safety equipment of Units 3 and 4 prior to restart.

DESCRIPTION OF KOZLODUY NUCLEAR POWER PLANT

The Kozloduy Nuclear Power Plant is located on the Danube River in the northeast of Bulgaria, on the frontier with Romania.

The site, which is some 200 kilometer from the capital of Sofia, has 6 press-urized-water reactors: 4 of the VVER-440/230 type and 2 of the VVER-1000 type. The total installed capacity amounts to 3,600 MWe.

Unit 1 went into operation in 1974, Unit 2 in 1975, Unit 3 in 1981, Unit 4 in 1982 and Unit 5 in 1987; Unit 6 is currently in the phase of nuclear testing at power.

Each 440/230 unit feeds two turbine-generator sets, cooled with water from the Danube. The nuclear steam supply system has 6 loops with horizontal steam generators, one reactor coolant pump per loop, connecting pipes measuring 500 mm in diameter and a pressurizer fitted with relief and safety valves. The reactor vessel is clad internally with stainless steel.

Each of the coolant loops may be isolated from the reactor by means of valves located in its two legs (hot and cold). Each unit feeds two 220 MWe turbine-generator sets with saturated steam at 4.3 MPa.

Emergency reactor cooling is accomplished by way of a high-pressure safety system with two independent groups of safety pumps, each containing three pumps. The pumps take suction from a common tank containing 800 m^3 of boric acid solution. This tank is also used to feed the spray system for the reactor confinement zone.

The reactors, grouped in banks of two, are housed in a building that does not have a containment. Instead, there is a sealed reactor compartment with vent valves discharging overpressures directly to the atmosphere.

OBJECTIVES OF THE KOZLODUY NUCLEAR POWER PLANT HOUSEKEEPING PROGRAM

The main objectives of the WANO Housekeeping program for the Kozloduy Nuclear Power Plant are as follows:

- Improvement to the conditions of conservation and maintenance of the plant equipment.
- Returning the safety systems to the level of reliability that existed at the beginning of the plant operating phase.
- Help the Kozloduy personnel to prepare the programs for shutdown of Units 1 and 2, using similar programs for western plants as a reference, and including support in defining the tasks to be performed during the outage.
- Improvements to general states of plant cleanliness, conservation and maintenance.
- Assistance for Kozloduy in organizing stores and in defining necessary spares, which are to be provided by Greifswald NPP, a plant of the same model now shut down by the German Government.
- Support in other areas, such as: Radiological Protection, Fire-fighting and Planning.

As may be appreciated, the program has been organized in order to provide strong support in a certain number of areas. Its activities were designed to help the Kozloduy Organization in defining the standards and the scope and schedule of the work to be performed, and to assist them in the surveillance and coordination of tasks.

DEVELOPMENT OF THE HOUSEKEEPING PROGRAM

The WANO Housekeeping program centered on the four VVER-440/230 reactors of Kozloduy NPP and had an initial duration of 6 months, starting in August 1991. On arrival of the group of international experts, the state of the units was as follows:

- Unit 1. Shut down for an intensive, 6-month upgrading program.
- Unit 2. In operation, but to be shut down immediately after start-up of Unit 3.
- Unit 3. Shut down for a general overhaul aimed at improving the operating conditions of the systems and the general state of conservation and maintenance.
- Unit 4. In operation following a shutdown similar to that of Unit 3.

Consequently, the work of the group was distributed as follows:

UNIT 4

Support for the Kozloduy organization in order to at least maintain the same level of equipment and system quality as then existed, implementing a system of periodic checks to detect any deterioration and initiate repairs as soon as possible.

UNIT 3

Following start-up, the activities to be carried out within the framework of the Housekeeping program would be the same as in Unit 4; in addition, the validity of the safety system tests performed at the plant would be verified. This verification would consist of the following:

- Comparison of the tests performed at Kozloduy with those carried out at Greifswald, with a view to detecting possible deficiencies.
- Comparison of the results of the tests with the required reference values.
- If any faults, deficiencies or inconsistencies were detected, the group would specify the necessary repairs.

UNITS 1 AND 2

During shutdown of the two groups, the efforts of the Housekeeping program would center fundamentally on these two units, the following work activities being defined:

Maintenance

- Scheduling and planning of outage tasks.
- Repair of leaks from spent fuel pool in Unit 1.
- General decontamination and cleaning.
- Lighting and protection of surfaces.
- Inspection of systems, developing inspection guidelines aimed at systematically identifying and evaluating existing deficiencies, and subsequently drawing up a plan for repair of the most important, such as: leaks, loss of insulating materials, inappropriate electrical connections, removal of inflammable materials, etc.

Requalification Test

- Planning, performance and evaluation of system and component functional tests.

In-Service Inspection

- Introduction of improved techniques for the analysis of deficiencies in welds and base metal of important safety-related plant equipment.

Emergency Confinement Volume

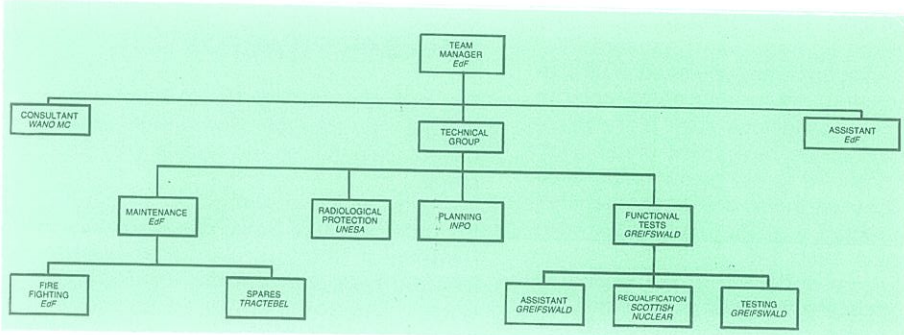
- Improvements to integrity by repairing door seals, penetrations, performance of valve leak tests, etc.

Spares

- Identification of maintenance needs.
- Improvements to storages system.
- Improvements to inventory control.
- Establishment of a long-term spares program.

Radiological Protection

- Implementation of a short and long-term program of improvements.



F I *Housekeeping Functional Organization Chart.*

Fire-Fighting

- Implementation of an urgent program of improvements: Removal of inflammable materials, cleaning and repair of oil leaks, replacement of insulating materials, construction of fire barriers, installation of fire doors, installation of means of detection, and replacement of fire extinguishing systems.
- Formulation of a general analysis of fire-fighting resources and definition of a program of improvements.

Quality Control and Assurance

- Definition of methods for surveillance and checking of the correct performance of modifications.

All the above activities would be carried out by the members of the international group of experts in direct collaboration with their counterparts at the Kozloduy plant. The group would also provide technical support if required.
Initially, the group of experts was as indicated in Figure I, their nationalities and companies being as follows:

- 5 experts from France, EdF (4 initial members for the Housekeeping Group and 1 subsequent member for the OAT).
- 3 experts from Germany, from Greifswald NPP.
- 1 from the United Kingdom, representing SCOTTISH NUCLEAR.
- 1 from Belgium, representing TRACTIBEL.
- 1 from Spain, representing UNESA.
- 1 from Russia, representing WANO MC.
- 1 from the United States, representing INPO.

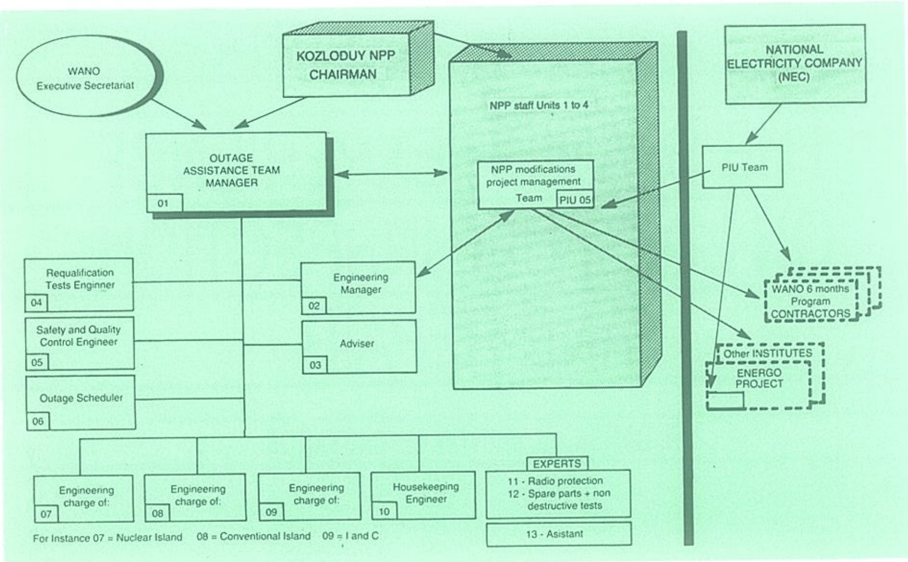
In parallel with the above activities, the group collaborated with the plant in preparing a shutdown program for Units 1 and 2. The objective of this program was to restore the functional availability of the equipment and systems and improve the safety and reliability of Kozloduy Units 1 and 2. The scope of the program was based on the conclusions of the OSART inspection and of the safety evaluations performed on the VVER-440/230 reactors by the IAEA, along with the requirements of the Bulgarian regulatory authority.
The Agency's report classified safety-related aspects in four categories.

- Category 4.
  Maximum priority in terms of safety. The principle of defense-in-depth has been violated to an unacceptable degree. Urgent measures are required to solve pending problems. Meanwhile, temporary measures (known as Special Measures) must be immediately applied.
- Category 3.
  Also high priority, albeit somewhat less so than category 4 issues. The principle of defense-in-depth has been met but not to a satisfactory degree. Corrective actions and temporary measures are required.
- Category 2.
  The principle of defense-in-depth has been violated, but not beyond a minimum acceptable level. Measures are required to increase the level of safety.
- Category 1.
  Of lower priority and impact on safety.

Given the complexity and extent of the outage program, which is expected to last three years, the group of experts was restructured, and even the name of the support organization was changed. The new organization, which is shown in Figure II, became known as the OAT: Outage Assistance Team, and its functions were widened to include not only the previous Housekeeping but also engineering, documentation, operational support, setting up of a safety committee and training.

OUTAGE SCHEDULE

The outage schedule for Kozloduy Units 1 and 2 (improvements to safety conditions and equipment requalification) took into account all the safety issues included in the IAEA report within categories



F II *Outage Assistance Team Organization Chart.*

4 and 3, many of those included in category 2 and several from category 1, as well as all the requirements of the Bulgarian regulatory authority (BSA). The schedule was discussed and commented on by this organization and by the consortium of regulatory bodies supporting BSA.

For each activity, three different phases of development were considered: research, design and performance. The research phase would include detailed definition of the overall scope of the improvements to be made, the requirements to be met and the detailed solutions proposed.

With regard to completion, all the phases of each activity were scheduled in four stages.

- I. During the 1992 outage
- II. For the next outage.
- III. For the third outage.
- IV. For a possible future unit reconstruction program.

The scope of the outage program was as indicated in Table I.

CONCLUSIONS

The evaluations of the IAEA and other western agencies, and the initial impressions of the members of the WANO Housekeeping group underlined the general state of disorder existing at the plant, the almost total lack of normal operating and emergency procedures, the lack of quality assurance in plant operation, systematic non-compliance with the few technical specifications in place and a lack of attention to plant procedures.

Nevertheless, it is hoped that with the help being provided by WANO (improvements are, indeed, already visible), the safety culture that is being implemented, the support provided by the IAEA to the Bulgarian regulatory authority, the ongoing outage program, and a new operating organization not impregnated with the errors of the past, it will be possible - if so decided - for the Kozloduy Nuclear Power Plant, which is vitally necessary for the economic development and well-being of the Bulgarian people, to continue operating under acceptable safety conditions.

1. *REACTOR CORE*

1.1 Nuclear instrumentation
1.2 Evaluation of core safety margins
1.3 Fuel surveillance
1.4 Refuelling procedures and test schedule

2. *ENGINEERED SYSTEMS*

2.1 Confinement integrity
2.2 Confinement: Severe accident conditions
2.3 Removal of core residual heat
2.4 Service water supply system
2.5 ECCS. Complete LOCA spectrum and long-term cooling capacity
2.6 ECCS. Redundancy, physical separation and independence
2.7 ECCS. Isolation of primary leaks
2.8 Isolation of main steam lines
2.9 Primary pressure relief
2.10 Secondary pressure relief
2.11 System isolation capacity
2.12 Ventilation/cooldown capacity
2.13 Dynamic stresses in case of pipe break

3. *MECHANICAL INTEGRITY OF EQUIPMENT*

3.1 Radiation embrittlement. Ana-lysis and technical information
3.2 Radiation embrittlement. Verification of efficiency of annealing
3.3 Vessel embrittlement. Reduction of vessel neutron flux
3.4 Protection of vessel against overpressures at low temperatures
3.5 Vessel inspection. Acceptance criteria
3.6 Inspection of vessel and support structures
3.7 Vessel stress analysis
3.8 Application of leak-before-break (LBB) concept
3.9 In-service inspection of primary circuit
3.10 Stress analysis of primary circuit
3.11 In-service inspection of secondary circuit

4. *INSTRUMENTATION AND CONTROL*

4.1 Surveillance systems for accidents beyond the DBA
4.2 Quality and conditions of I&C equipment
4.3 Interaction between protection and control functions
4.4 Redundancy, physical separation and independence of I&C channels
4.5 Operational support
4.6 Interlocks. Protection against human error
4.7 Qualification of electrical and I&C equipment
4.8 Classification of electrical and I&C equipment
4.9 Priority of safety equipment emergency signals
4.10 Test capacity of I&C equipment
4.11 Inhabitability of control room. Remote shutdown panel
4.12 Setpoints. Evaluation of protections and interlocks

5. *ELECTRICAL SYSTEMS*

5.1 Redundancy, separation and independence
5.2 Quality and conditions of equipment
5.3 DC batteries and systems
5.4 Diesel generator loads and improved capacity

6. *ACCIDENTS*

6.1 Analysis of confinement
6.2 Additional reactor protection system signals
6.3 Analysis of accidents beyond the DBA
6.4 Analysis of accidents during fuel handling and under cold shutdown conditions
6.5 Extension of accident and transient analysis scope
6.6 LOCA
6.7 Radiological consequences
6.8 Probabilistic safety analysis

7. *FIRE-FIGHTING*

8. *MANAGEMENT*

8.1 Documentation control program
8.2 Documentation control facilities
8.3 The role of management
8.4 Leadership
8.5 Safety culture
8.6 Cleanliness, maintenance and conservation
8.7 Organization
8.8 Control of modifications
8.9 Operating experiences
8.10 Quality assurance and control
8.11 Radiological protection
8.12 Health and safety
8.13 Industrial safety
8.14 Computer systems

9. *OPERATING PROCEDURES*

9.1 Procedural programs
9.2 Emergency operating procedures
9.3 Operating limits and conditions
9.4 Normal operating procedures

10. *PLANT OPERATION*

10.1 Surveillance program
10.2 Surveillance procedures
10.3 Work control system
10.4 Shift organization
10.5 Auxiliary tagging material

11. *MAINTENANCE*

11.1 Maintenance program
11.2 Procedures
11.3 State of equipment conservation
11.4 Stores

12. *TRAINING AND QUALIFICATION*

12.1 Training program
12.2 Simulator
12.3 Training facilities
12.4 Training materials

13. *EMERGENCY PLAN*

13.1 Emergency plan
13.2 Emergency procedures
13.3 Emergency facilities
13.4 Training and drills
13.5 Post-accident sampling