KOZLODUY NPP

THE EXPIRIENS AT KOZLODUY NPP ON AGEING MANAGEMENT AND LONG TERM OPERATION

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Kozloduy NPP

1. Introduction

Kozloduy NPP p.l.c. is a single-owner joint-stock company with 100% of its shares held by the state. The Company was granted a license the State Energy Regulatory Committee for generation of electric power and heat.

There are in nowadays two power generation units on the plant site, with total installed capacity 2000 MW, equipped with pressurized-water reactors and a spent fuel storage facility. Maintain high level of safety is an indispensable condition for the existence of nuclear power production.

The legal requirements with regard to the Ageing management are included in the following national laws and regulations:

- Safe Use of Nuclear Energy Act, 2002,
- Regulation on the Procedure for Issuing Licences and Permits for Safe Use of Nuclear Energy, 2004
- Regulation for Providing the Safety of Nuclear Power Plants, 2004

2. Strategic approach in ageing and plant life management in Kozloduy NPP

- Possible life extension on the basis of safety related and economical considerations;
- Implementation of necessary modernization within the program for safety upgrading;
- Focused investment for monitoring of ageing parameters and for system / components upgrading in the frame of a comprehensive AMP;
- Development of new Surveillance Programs for main components, further evaluations with pre-irradiated specimens, ets.

To be sure, that process requires serious investments. However, we believe that it is the only alternative in the long term that can assure our success in the energy context of Bulgaria and Europe.

2.1. What does Kozloduy NPP invest into?

In most general terms:

- extension of the service life of the facilities and
- cutting down of production costs and optimization of electricity cost price.

The largest-scale investment project at Kozloduy NPP is the Modernization Program that is being performed on Units 5 and 6. It was a response to established discrepancies between the characteristics of our 1000 MW units and the new international safety and reliability requirements that were developed during the nineties towards the equipment safety, scope, number and quality of accident analyses.

Developed on the basis of the full scope of IAEA recommendations for VVER-1000 Units (Model B-320), the Modernization Program for Units 5&6 was organized as a set of 212 specific measures, distributed in groups according to their main purpose. The expected effect of their implementation is to achieve:

- Improvement of the safety of Units 5&6 through implementation of new design solutions;
- Validation of an adequate safety level by means of various analyses and additional studies in conformity with internationally adopted regulations;
- Safety upgrading through replacement of the equipment with expiring design life and of critical equipment.
- Improvement of work efficiency and operating conditions.

While we eliminate the non-conformances with international safety practice, we strive to increase the availability of the power units. The analyses planned under that program and replacement of the outdated components and systems by new, more reliable equipment, will permit a switchover to the concept of risk-based maintenance and shorter unit outages leading to increased output of the 1000-MW units.

2.2. Performance of the Modernization Program was organized in two Phases:

- **Phase 1 – "Engineering**" encompassing generation and delivery of input data, development of Terms of Reference specifying the requirements of Kozloduy NPP towards the new systems, conceptual designs and equipment specifications under the Program measures.
- **Phase 2 – "Implementation**" including the development of detailed design documentation, production and delivery of the equipment, installation and tests, licensing and commissioning.

The contractors for implementation of priority measures were selected by international bidding in 1996. It was won by two bidders – Westinghouse of USA, and the European Consortium Kozloduy constituted by three leaders in the nuclear industry of the Old Continent – Framatome, Siemens and Atomenergoexport.

Main areas of changes /improvement/ implementation are:

- Technological equipment upgrade.
- Control systems upgrade.
- Analyses.
- Documentation.
- Decommissioning.

2.3. Electrical and I&C ageing management

Electrical and I&C ageing management is a developing field, as yet there is no accepted and definitive solution. An ageing management strategy is therefore required to control and minimize the risk. The International Working group on Nuclear Power Plant I&C of the IAEA has developed a TECDOC "Management of ageing of I&C equipment in nuclear power plants" in 1999 on that subject .This IAEA- TECDOC provide a review of the ageing characteristics and describes some of the technologies and procedures that are currently available for management of ageing. It comprises the experience from various nuclear utilities across the world, examining ageing of specific components and also ageing management techniques, similar to KNPP used one.

Most existing instrumentation and control (I&C) systems in nuclear power plants (NPPs) throughout the world were designed with analog equipment and relays. These were the only available technologies when NPPs were designed 25-45 years ago A majority of them are still operating with much of their original I&C equipment or with obsolete digital equipment both of which are becoming, or already are, obsolete, costly to operate, or degrading in performance. Utilities are faced with increasing operating and maintenance (O&M) costs to maintain acceptable performance of this equipment in their plants. There is also a need in many plants for safety or performance improvements The use of analog equipment and relays limited the ability of the original designers to implement features that could improve the overall operation of NPPs. With modem technology, especially digital technology, the issues of the obsolescence of analog and aged digital equipment can be addressed. These issues include the lack of availability of spare parts and the deterioration of the infrastructure of suppliers to support this ageing equipment. Moreover, many performance improvements that were not feasible or practical with analog equipment can now be effectively implemented with modem technology. Potential improvements such as integrated controls; new functionality; reduced duplication of equipment, functionality, and information; reduced O&M costs, enhanced safety, increased performance; and integrated information for the user can now be realized with modern technology. This is especially feasible with digital systems. In addition, modern technology offers improved reliability and cost-effective operation which has been demonstrated in other process industries. Operational time of I&C systems of Bulgarian NPP is about 30 years, though the lifetime of individual parts of I&C systems is limited by 10-15 years. I&C systems were designed in 60-70-th in accordance with the existing regulations and available technical solutions. Obsolesce of those I&C systems require the reconstruction of existing systems

There are some reasons for I&C modernization at NPP. One of them is the equipment obsolesce. In most cases it is not possible to perform equipment replacement to a similar one The reasons are as follows - evolutionary changes took place in the field of I&C systems. Analogue equipment have being replaced by digital equipment based of computer technology, - in many cases the existing operational I&C equipment has not been produced any more The next reason to make modernization of I&C systems are the changes in regulations, which now include more stringent requirements related to quality, safety and reliability Codes OPB-88 and PBY RU AS-89 contain the new requirements for NPP I&C systems such as: -requirement for diagnostics applied not only to technological equipment but also to I&C s hardware and software; -requirement for information support of the operator; -requirement for independence and redundancy of protection system channels, etc .

Modernization of I&C systems at operating NPP is under way in Kozloduy now.

Some examples (measures) from Modernization Program are presented below:

Installation of completely new systems, unforeseen in the original design of the unit:

- H2 monitoring and recombination system preventing the probability of explosions in containment in case of design-base accidents;
- System of protective measures for upgrading main steam and feed water lines against break;
- System for RPV (reactor pressure vessel) level measurement and control ensuring reliable data in case of accidents with loss of coolant, primary to secondary leak, cooldown without a main circulation pump in operation etc.
- Reactor pressure vessel cold overpressurization protection automatic system;
- Filtered ventilation system for beyond design-basis accidents protecting the containment from loss of tightness and minimizing radioactive releases in environment
- System for continuous monitoring of 6 κV motor insulation status;

Those systems meet the recommendations for units 5, 6 in IAEA guiding document "Safety Issues and their Ranking for NPP with WWER-1000, Model 320".

- **Replacement of equipment of expiring lifetime and high failure rate:**
- Uninterruptible power supply system with greatly improved working parameters:

100 000-hour-mean time between failures to new equipment failure against 8000 hours for the old system;

- Improved readiness and reliability of relay protection main electrical circuit automation by installing two redundant sets of protection and new microprocessor equipment of increased lifetime
- Replacement of Safety System 6 kV switchgear thus eliminating the issues related to unreliable function of the former breakers:
- New generator breaker for short circuit current switching off.

- **New system for radiation monitoring of greater preciseness, allowing continuous and precise monitoring of NPP releases of aerosol waste.**

- **New "Ovation" computer information system (CIS):**

-performing all functions of the former system;

-with additionally booted nuclear application programs for monitoring of important parameters of the main equipment;

-having practically unlimited possibilities of storing and archiving information of unit processes.

- **New digital unit process control system (UKTS) improving the operator interface and functional reliability and availability of the system through**:

– implementation of modern digital technology;

– implementation of a design with divided functions;

– redundant configurations;

– technically-friendly maintenance due to self-diagnosis functions and module-based project;

– flexibility for future modernizations and expansions without having to shutdown the unit.

- **New automated turbine control system (ASYT) with larger access to unit data and capability of technological processes and event analyses through a common platform and communication network with the other information control systems (CIS and UKTS).**

- **New technologies and equipment for facility status monitoring and preventive detection and elimination of defects are implemented:**

– Diagnostic system for detection, localization and analysis of primary leaks of high resolution (< 1 kg/h) that limits failure consequences and decreases possible idle time;

– Metal fatigue monitoring system limits the impact of thermal cycles on piping and equipment;

2.4. Activities with focus on degradation mechanisms of RPV of Kozloduy Unit 5&6:

Beside installation of completely new systems and modernization of old one, 50 safety analysis were completed.

One of them was implemented under Measure 23212 “Develop a program for studying reactor metal samples and determine the critical brittleness temperature”. New designed assemblies No. 5.1, 5.2 and 5.3 have been installed in the RPV of Kozloduy Unit 5 and also new designed assemblies No. 6.1, 6.2 and 6.3 have been installed in the RPV of Kozloduy Unit 6. A new standard irradiation surveillance assembly is being inserted in NPP Kozloduy Unit 6 and irradiated for one fuel cycle (cycle 9). With aid of the STINT2 code a heat transfer model has been developed to calculate the heating up of the channel flow inside the heavy reflector, where the surveillance specimens are positioned. With sufficiently conservative assumptions with respect to maximum heating it was shown that the specimen’s temperature will remain well below the irradiation temperature of 305 (290±15) °C required according to PNAE-G-7-002-86. Under nominal conditions less than 299 °C are achieved at the container. New designed assemblies has incorporated a Fluence Detectors and Temperature Monitors as follows:

- Fe -, Nb -, Cu - and AlCo (0.1 % Co) - detectors in the form of wires are incorporated in each new surveillance assemblies within tubes in capsules made

from aluminum. The relevant material certificates as were included in the supply documentation

- The temperature monitors (wires of low melting eutectic alloys) were installed in holes drilled in the top end of model Charpy specimens.

In addition an ex-vessel detectors are being installed in the air cavity behind the vessels on units 5&6 of KNPP from 1993. Ex-vessel measurements together with detailed plant-specific neutron transport calculation is the most accurate approach currently available for vessel fluence monitoring.

For monitoring and prediction of the RPV material behaviour in irradiation conditions a special long term surveillance program is under way with the participation Institute of metallography of Bulgarian Academy of Science. Within the program a comprehensive investigation of representative samples manufactured with the same technology as the one used for RPV manufacturing started some reliable and accurate techniques to predict doses incurred by various reactor components were developed and applied.

The data obtained will be used for forehead prediction of the material behaviour in irradiation conditions, re-irradiation after annealing as well for neutron flax measurement and validation of calculation models.

2.5. Experience with Periodic Safety Review (PSR) at NPP Kozloduy

- In frame of the **Modernization Program measure 26122** the NPP Kozloduy SAR revision after 20 years of operation was finished in 2006 (based on requirements of ПНАЭ Г-01-036-95)**.**
- Regular revisions of SAR correspond to a current applicable licensing practice in Republic of Bulgaria.
- Following a number of discussions on common aspects and differences between the SAR revision and PSR, and with regard to preferred trends in EU and IAEA, a decision has been made to perform also PSR for NPP Kozloduy as an additional independent action after 20 years of operation.

The NPP Kozloduy PSR implementation after 20 years of operation according to the IAEA Guideline was motivated namely by the intention to harmonize the form of PSR implementation with a practice which is standard in EU countries, and to start a process of the future licence renewal. It was a necessary precondition for the reactor units' operation licence renewal in year 2009.

Approach – at two stages:

- Stage 1 "PSR" - implementation was realized by NPP employees (working team), according to IAEA NS-G-2.10 Guideline –deadline June 30 this year-assessment of the current safety status of the plant
- Stage 2 "In-depth safety review " – NPP Kozloduy sign a Contract with Main constructor OKB Gidropres, Russia ". Participation of external organizations will be limited to review of the results of the 1-st stage, a provision of the PSR

methodological assistance and further to carry out a consultancies activity- deadline Oct 30, year 2009.

A Periodic Safety Review (PSR) at NPP Kozloduy after 20 years of operation is underway now.

3. Conclusion:

The Modernization Program as a part of a comprehensive AMP of Units 5, 6:

– ensures long-term effective operation (35 and 39 fuel companies residual life time) due to their enhanced safety and reliability;

– catalyzes the erection of Belene NPP with the transfer of competence and experience;

Programme for life time management is prepared and were presented as a licensing document in license renewal process for Units 5&6 since 2008.

Utilizing the potential of the best in the European and American nuclear energy, and proceeding from the latest requirements of the regulatory documents of the Chief Design Engineer and IAEA, we are sure that, after already completed Modernization Program, our power units will be definitely among the safest, most reliable ones in the world and that their service life can be extended by 15-20 years beyond the design time limits.

References:

[1] Technical Reports Series No. 338 “Methodology for the Management of Ageing of NPP Components Important to Safety”, Vienna (1992)

[2] IAEA “Safety Issues and their Ranking for NPP with WWER-1000, Model 320”, Vienna (1995).

[3] IAEA Services Series No.4 “AMAT guidelines”. IAEA, Vienna (1999)

[4] IAEA Tecdoc No. 1016 “Modernization of I&C in nuclear power plants”, Vienna (1998)