

Strengthening the Capabilities of State Nuclear Regulatory Inspectorate of Ukraine through Interaction of Ukrainian and International Technical Safety Organizations in the Framework of Licensing of Long Term Operation of South-Ukrainian NPP Unit 1

The Energy Strategy of Ukraine for the period until 2030 foresees that about half of the Ukrainian NPP units will constitute those with extended lifetime (long term operation) over the next 10 years. The first "pilot" plants for long term operation were Rivne units 1 and 2 (VVER-440/213) in 2010. South-Ukrainian NPP unit 1 (VVER-1000/V-302) is the next step in gaining long term operation experience in Ukraine (appropriate decision was taken in 2012). In both cases, the decision was preceded by many-year comprehensive activities performed by the Utility, Regulator and national and international scientific and technical support organizations, which were involved in safety substantiation from the Utility and Regulator sides.

Keywords: State Nuclear Regulatory Inspectorate of Ukraine; Ukrainian NPP units; Framework of Licensing of Long Term Operation.

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Посилення можливостей Держатомрегулювання через взаємодію українських та міжнародних організацій технічної підтримки в рамках ліцензування робіт з продовження строку експлуатації енергоблока № 1 Южно-Української АЕС

Енергетичною стратегією України на період до 2030 року передбачено, що строк експлуатації більше половини діючих енергоблоків АЕС буде продовжено на період, що перевищує проектний на 10 років. Першими «пілотними» енергоблоками, для яких продовжено строк експлуатації, стали енергоблоки №№ 1 та 2 Рівненської АЕС (ВВЕР-440/В-213). Наступним є енергоблок № 1 Южно-Української АЕС (ВВЕР-1000/В-302). В обох випадках прийняттю рішення про продовження строку експлуатації передувала багаторічна сумлінна діяльність Експлуатуючої організації, Держатомрегулювання та організацій науково-технічної підтримки — як національних, так і міжнародних, залучених до підготовки відповідних обґрунтувань безпеки та проведення їх експертизи (технічної оцінки).

Ключові слова: Держатомрегулювання, ліцензування робіт з продовження строку експлуатації енергоблока, енергоблоки атомних електростанцій.

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The Energy Strategy of Ukraine for the period until 2030 foresees that about half of the power units in Ukraine will constitute those with extended lifetime (long term operation) over the next 10 years.

The first "pilot" long term operation (LTO) plants were Rivne units 1 and 2 (VVER-440/213). Based on the periodic safety review, the Regulatory Authority of Ukraine made a decision to extend their lifetime for 20 years beyond the design-basis period under condition that the next safety review would be conducted in 10 years.

South-Ukrainian NPP unit 1 (VVER-1000/V-302) is the next step in gaining long term operation experience in Ukraine. The decision on long term operation of South-Ukrainian NPP unit 1 was taken by the Regulatory Authority of Ukraine (SNRIU) in November 2013 with its subsequent safety review in 10 years.

This decision was preceded by many-year comprehensive activities performed by the Utility, Regulator and national and international scientific and technical support organizations, which were involved from the Utility and Regulator sides.

Development of Regulatory Documents (Rules and Standards) for Long Term Operation. The first and most important step before starting the long term operation activity was the development of respective rules and standards. These standards are based on the best international experience, IAEA recommendations and cooperation of national TSOs with international technical and scientific organizations to develop new regulatory documents.

The development of rules and standards for long term operation of Ukrainian NPPs started in 2004 with approval of Resolution No. 263-r "Comprehensive Program for Extending Lifetime of Operating Nuclear Power Units" (dated 29 April 2004) by the Cabinet of Ministers of Ukraine.

A hierarchic approach in developing and revising regulatory documents is one of the basic principles of regulatory and legislative control in Ukraine. This principle is implemented in a hierarchic pyramid representing regulatory documents on nuclear and radiation safety (NRS) at several levels (see Fig. 1).

The current Ukrainian regulations that establish requirements for LTO and ageing management of NPPs include, in particular, the Comprehensive Program for Extending Lifetime of Operating Nuclear Power Units [1], General Safety Provisions for Nuclear Power Plants (regarding the requirements

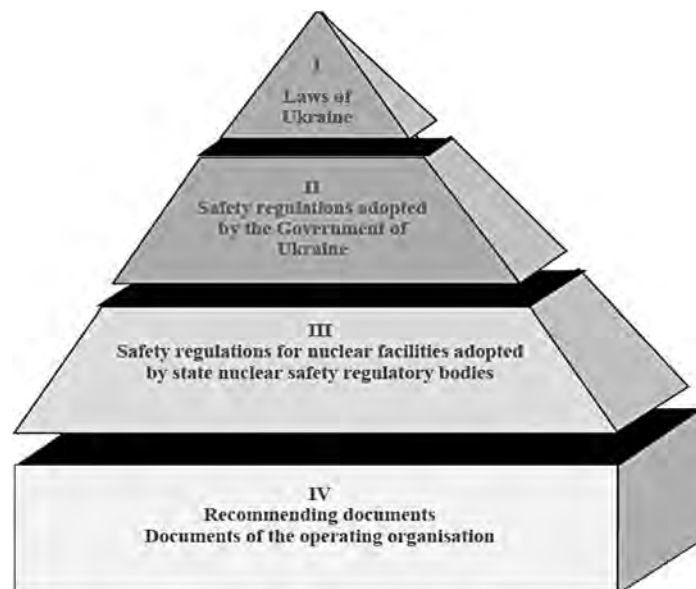


Fig. 1 Hierarchic pyramid of NRS legislative and regulatory framework

for ageing management and LTO) [2], General Requirements for NPP Lifetime Extension Based on Periodic Safety Review [3], Rules for Design and Safe Operation of Equipment and Piping of Nuclear Power Facilities (regarding the requirements for lifetime extension (para. 2.1.11)) [4], Requirements for the Structure and Contents of Periodic Safety Review Report for Operating NPP Units [5], and Standard Program for Ageing Management of NPP Unit Components [6].

All these documents have been analyzed very carefully by the team of International Technical and Scientific Support Organizations (i.e. GRS, IRSN, ITER) to evaluate their compliance with international experience, practices and IAEA recommendations. The main conclusion made by EU experts is as follows: *Existing Ukrainian laws and regulations specifying issues and conditions for NPP lifetime extension constitute a first solid basis for the purposes of lifetime extension. These regulations are developed considering IAEA recommendations, current international experience and practice. Nevertheless, they should be improved and completed taking into account corresponding recommendations.* Therefore, the improvement of Ukrainian regulations continues in the framework of co-operation between the Ukrainian Regulatory Authority and its TSO with International Technical and Scientific Support Organizations.

Requirements for Periodic Safety Review. In accordance with nuclear and radiation safety regulations [2] and [3], the main document submitted by the Utility to the Regulatory Authority along with the application for license extension is a periodic safety review report (PSRR). It includes 14 safety factors (see Fig. 2) and describes results of all activities performed in the framework of long term operation arrangements.



Fig. 2. Safety factors

Technical Evaluation and Review of Periodic Safety Review Report. The PSRR is subjected to mandatory state review (technical evaluation and review) on nuclear and radiation safety. The National and International Technical and Scientific Support Organizations were involved into the state review for evaluation of safety factors and associated documents.

These activities were primarily aimed at assessing the current technical state of structures, systems and components, implementation of an effective ageing management program, equipment qualification and upgrade package.

One of the most important components that determine the possibility of long term operation as a whole is the reactor pressure vessel (RPV) (see Fig. 3).

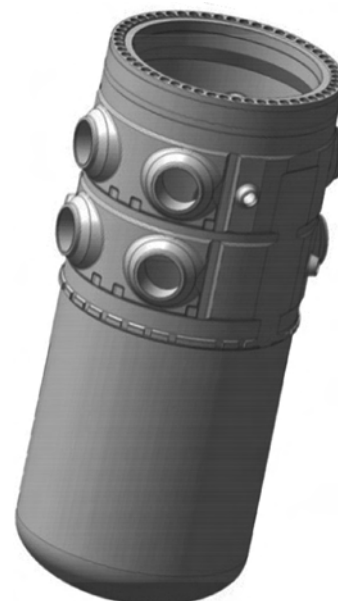


Fig. 3. Model of RPV for SU NPP unit 1

It is quite natural that special attention has been paid to safety substantiation of this component and that national and international scientific and technical support organizations were involved into assessment of the safety substantiations.

From IAEA side, Project UKR/4/014 “Implementing Plans for LTO of NPP” was organized to verify the brittle fracture (BF) calculation results that were presented by the Utility in the framework of safety substantiation for brittle fracture calculation of RPV of SU NPP Unit 1. Another independent BF calculation was performed by SSTC NRS with the Ukrainian Institute for Problems of Strength and confirmed acceptability of the Utility results.

Based on the state review, the lifetime of SU NPP Unit 1 RPV was extended for 10 years until the next periodic safety review.

In order to keep the degradation of safety-related equipment, systems and components (caused by ageing, wear, corrosion, erosion, fatigue etc.) within acceptable limits, technical state evaluation served the basis for SUNPP to develop an ageing management program (see Fig. 4) and take necessary actions to support the operability and reliability of equipment, systems and components.

Results of ageing management activity are reflected in the safety factor “ageing”. Under state review, the safety factor “ageing” was evaluated by SSTC NRS jointly with the Regulatory Authority (SSM) of Sweden. The results and comments of the joint review on the safety factor “ageing” were finalized by SUNPP and approved by the Ukrainian Regulator.

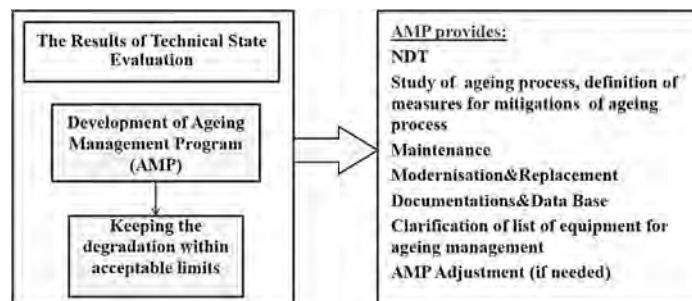


Fig. 4. AMP development

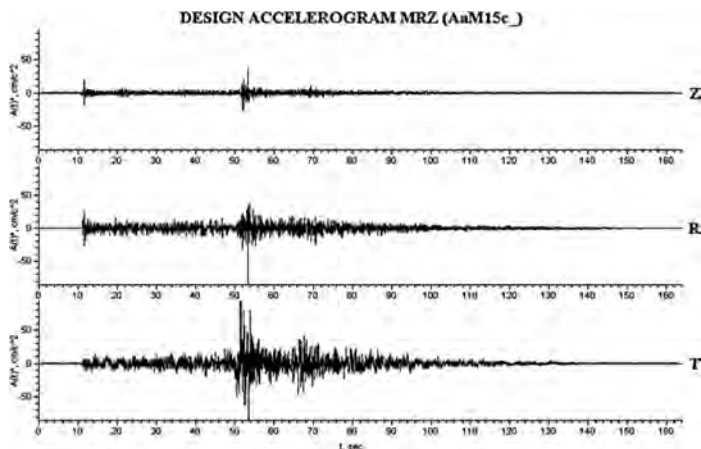


Fig. 5. Three-component time history of SSE from Vrancea zone (without margin)

30 % safety margin to PGA and long-term instrumental investigation. Finally, PGA was taken to be $0,093g \cdot 0,3 + 0,093g = 0,12g$. Seismic resistance of structures, systems and components was reassessed in the framework of periodic safety review.

According to the Ukrainian regulation [2], NPP design shall use equipment qualified to perform safety functions during the operational period under conditions that significantly change including accidents. Equipment should be qualified for harsh environmental conditions and seismic events (see Fig. 6). Results of SUNPP equipment qualification are presented in correspondence with the PSRR chapter “Equipment Qualification” and are shown in Fig. 5.

Before the state review of the PSRR chapter “Equipment Qualification”, SSTC staff attended a series of international (IAEA, NRI Rez, Tecnatom (Spain) etc.) workshops, on-the-job training sessions, etc. in order to enhance experience and practice in the field. Results of the state review of the PSRR

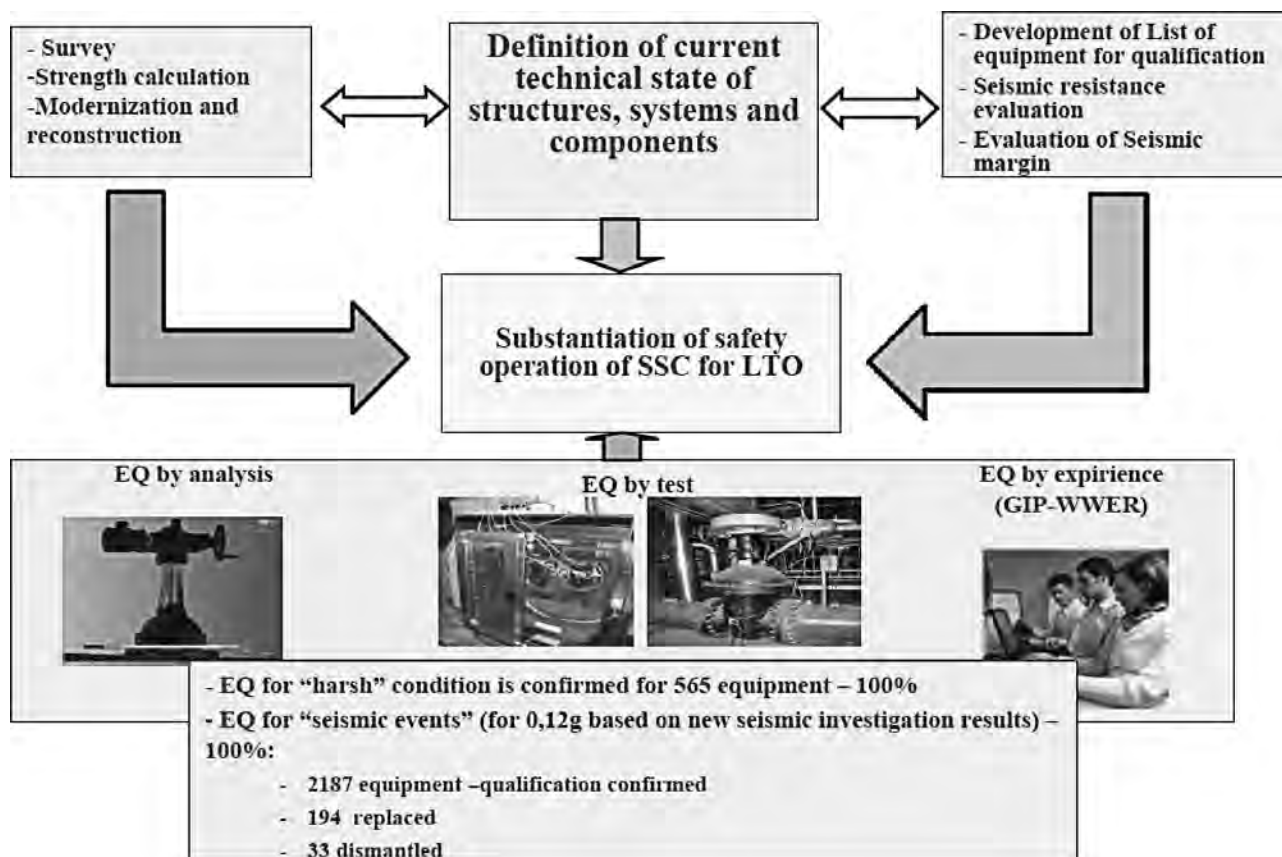


Fig. 6. Equipment qualification process

State-of-art investigation of seismic safety of the SUNPP site in accordance with SSG-9 [7] and instrumental measurements (e.g. see Fig. 5) demonstrating that peak ground acceleration (PGA) increased almost twice ($0,05g \Rightarrow 0,093g$) in comparison with design.

The investigation results have also been analyzed under the state review by SSTC NRS jointly with NRI Rez (Czech Republic), SEC NRS (Russian Federation), US NRC and ITER (Italy).

The joint review revealed a lack of statistical data due to the short period of instrumental investigation and slight deviation from SSG-9 recommendations. Correspondingly, in order to eliminate the identified deficiencies, the SUNPP proposed

chapter “Equipment Qualification” confirmed acceptability of equipment qualification and the chapter was approved by the Ukrainian Regulator.

Upgrade Package. National and international experience and practice, IAEA recommendations, safety investigations, lessons learnt from Fukushima accident etc. require safety improvement. All measures to improve safety of SUNPP unit 1 are included in the Upgrade Package (see Fig. 7.)

The Upgrade Package is the “Joint Safety Improvement Program for Ukrainian NPPs” (approved by joint resolution of the Utility and Regulator). Results of the Upgrade Package were presented in PSRR based on local safety analysis report for each measure. Technical evaluation and review of some

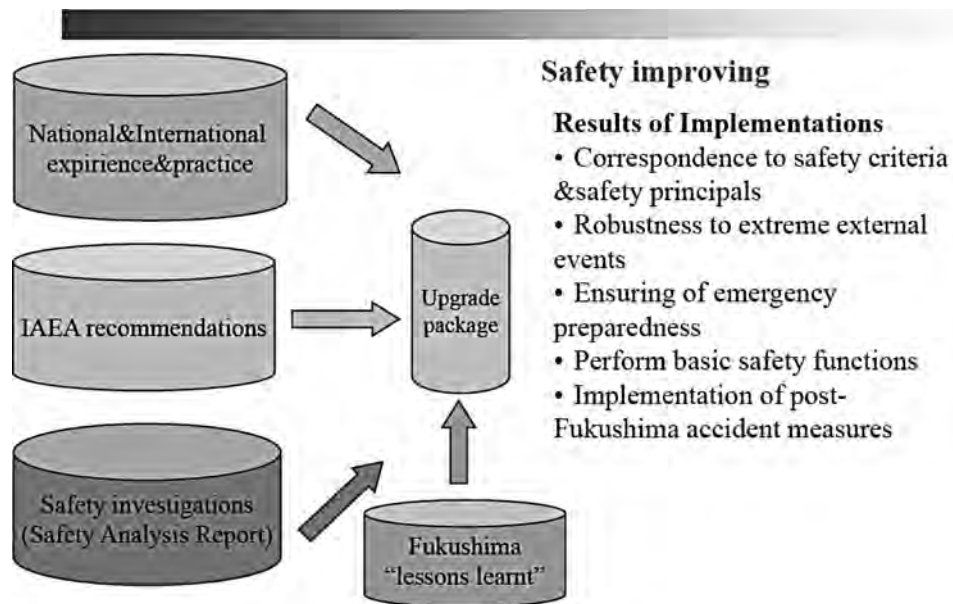


Fig. 7. Main results of Upgrade Package

measures were conducted by SSTC NRS jointly with experts from GRS (Germany), IRSN (France), STUK (Finland) and other organizations involved.

Lessons Learnt from the Fukushima-Daiichi Accident. It is necessary to point out that the following lessons learnt from the Fukushima-Daiichi accident were taken into account in the framework of SUNPP unit 1 preparation for long term operation to the maximum extent by implementing measures such as: feeding of “critical” loads from 0.4 kV mobile diesel generators; feeding of the spent fuel pool by mobile pumping units from alternative water reservoirs; service water supply by mobile pumping units from alternative water reservoirs; organization of containment venting.

Based on the activities performed under SUNPP unit 1 preparation for long term operation and review and analysis of respective documentation by the Regulatory Authority and scientific and technical support organizations, it has been ascertained that:

the defined core damage frequency and large release frequency meet safety criteria;

power unit resistance to natural hazards and their combinations is confirmed (SAR, PSRR, “stress-test” results);

“post-Fukushima” measures and defined safety margins are implemented.

Conclusions

Granting a license for long term operation of SUNPP unit 1 has become possible owing to joint and efficient activities of the group of technical support organizations in review of documentation on long term operation substantiation.

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