Armenia Stress Tests Peer Review (20th to 24th June 2016)

Executive summary

Introduction

In the aftermath of the Fukushima accident, the EU has been a world leader in carrying out "comprehensive risk and safety assessments" (so called **"Stress Tests" (STs)**) of all its nuclear power plants

From the very beginning the EU has invited interested non EU countries as well to cooperate and to take part in the STs exercise. As an outcome of the meeting of 23 June 2011 with Commissioner Oettinger, Deputy Ministers of Energy and senior representatives of the Ministries of Energy and national authorities responsible for nuclear energy of the Republic of Armenia, the Republic of Belarus, the Republic of Croatia, the Russian Federation, the Swiss Confederation, the Republic of Turkey and the Ukraine, in cooperation with the EU, confirmed their willingness to undertake on a voluntary basis comprehensive risk and safety assessments ('stress tests'), taking into account the specifications agreed by the European Commission and the **European Nuclear Safety Regulators Group (ENSREG)** on 24 May 2011.

At that time Armenia was not ready to take directly part in the EU Stress Tests process like Ukraine and Switzerland did. But with the support of two projects financed by the European Commission in the frame of the **Instrument for Nuclear Safety Cooperation (INSC),** the **Armenian Nuclear Power Plant (ANPP)** and the **Armenian Regulatory Authority (ANRA)** started to prepare their STs reports with the intention to perform thereafter an independent Peer Review process to assess them.

As a result, in August 2015, ANRA submitted its **National Report (NR)** on the STs of the ANPP to the Directorate-General for Energy of the European Commission for peer review. As a result of the desktop review of the NR, around 200 written questions were posted by the **Peer Review Team (PRT)** and were answered by ANRA/ANPP prior to the PRT's country visit. In addition ANRA and ANPP provided several specific reports related to initiating events.

Similarly to the arrangements during the EU STs, the most relevant information available on the PRT was published on the ENSREG Website[1].

The Peer review took place in Armenia from the 20th to the 24th June 2016. A team of 10 EU experts (8 from EU Member states which had been nominated by ENSREG members and 2 from the European Commission) were forming the PRT. During this visit, the willingness to share information and the great openness in all discussions of ANRA and ANPP representatives in particular during the visit to the nuclear power plant is to be especially highlighted.

Peer Review Team's general comments on the Armenian National Report

The NR complies with the EU STs specifications. It did not cover volcanic hazards. Due to the specific geological situation in Armenia the PRT decided to integrate the review of volcanic hazards in the scope of the peer review. Adequate information regarding this additional topic was provided during the peer review.

The NR identifies cliff edge effects and presents a series of safety improvement measures.

[1] http://www.ensreg.eu/armenia-stress-test

After the Fukushima accident, the programme on safety improvement measures has been revised by ANRA. At present, ANPP is in the process of implementing this programme.

Similarly to other first generation Nuclear Power Plants (NPPs) the original ANPP design basis did not include most of the modern requirements. Nevertheless, the criteria against which the safety assessment was performed during the recent licencing activities and within the STs reflect some of the new requirements. It is nevertheless recommended that ANRA considers formalizing the requirements according to the WENRA Reference Levels (RLs), in particular the one related to severe accidents.

ANPP has never been subject to a Periodic Safety Review (PSR) in full compliance with the IAEA standards. Some issues that were found during the STs might be expected to have been identified (and eventually rectified) through a comprehensive PSR, as it is recommended by ENSREG. The PRT recognises that the obligation for conducting a PSR is established in article 20 of the Armenian Atomic Act, and that the PSR is expected to be undertaken following the completion of the licencing process for the life time extension. Nevertheless the PRT recommends to define the scope of the future PSR in line with IAEA standards and to include the review of site related phenomena.

Topic 1: ASSESSMENT RELATIVE TO EARTHQUAKES, FLOODING AND OTHER EXTREME WEATHER CONDITIONS

The geological situation of Armenia is characterized by its location at the collision zone between the Arabic and Eurasian tectonic plates with high crustal deformation rates, abundant active faults, and numerous quaternary volcanoes. This geodynamic framework and the past experiences with numerous severe earthquakes such as the 1988 Spitak earthquake require putting particular emphasis on seismic safety.

In the past, ANPP and ANRA have undertaken continued efforts to ensure and improve the seismic safety of the ANPP. The PRT appreciates this process, which is in line with the WENRA (2014) requirement of continuous improvement, and encourages proceeding with it. It is suggested to base the process on a set of comprehensive national regulatory requirements for external hazards, which should be developed considering the WENRA (2014) Reference Levels.

With respect to the protection concept for the current seismic design basis of the ANPP it appears that adequate protection against Design Basis Earthquakes (DBEs) with a horizontal Peak Ground Acceleration (PGA_H) = 0.35 g is presently in place and that some margins are available. The PRT, however, expresses reservations on the reliability of the current design basis value of PGA_H = 0.35 g. These reservations are due to the Probabilistic Seismic Hazard Analysis (PSHA) 2011 which revealed a DBE of PGA_H = 0.42 g for the occurrence probability of 10^{-4} per year. This value shall be considered as an updated ANPP design basis for planning and implementing improvement measures. Structures, Systems and Components (SSCs) important to safety shall be upgraded to this level.

The PRT further suggests to complement the 2011 PSHA by (i) a review of the maximum magnitude M_{max} values which are regarded to be underestimated when compared to other recent seismic hazard assessments, and (ii) detailed investigations of the active faults close to the site using integrated paleoseismological techniques.

In respect to flooding, the “dry site concept” adequately protects against most external water sources. This is regarded a strong safety feature. The rainfall design basis (1 year return period) value, which was based on Russian Standard (SNiP), is not consistent with current international standards. However, recent calculations showed that the drainage system capacity could cope with a rainfall corresponding to a frequency of 10^{-4} per year.

The PRT recommends to consider improving the volumetric protection of the Diesel Generator System (DGS) basement against flooding. The PRT also recommends to consider improving the DGS basement drainage system to ensure it can function adequately in all scenarios for which the Emergency Diesel Generators (EDGs) or the Additional Emergency Cooling System (DAR) are needed

(Loss of off-site power (LOOP), earthquake). Areas for potential improvements also include the provision of adequate mobile devices.

The PRT suggests defining clear design basis requirements for meteorological hazards and hazard combinations, which are based on the severity of design basis events with non-exceedance probabilities of 10^{-4} per year. Design basis requirements should be anchored in binding regulatory documents.

The PRT recommends to consider improving the robustness of the Demineralised Water System (BZOV) against low temperature up to the design basis (-40°C).

Vulnerabilities have been identified for external flooding and for extreme weather conditions. A number of possible corrective actions are under consideration by ANRA. The NR contains a list of measures to increase robustness, which have been already partly implemented. For the remaining measures an implementation schedule has been established by ANPP and monitored by ANRA. The PRT acknowledges and supports these measures.

The ANPP site is located in the vicinity of three capable, but currently inactive volcanoes. The site is subjected to the hazards of pyroclastic density currents, lava flows, and opening of new vents, which are considered site exclusion conditions at the site selection stage according to the IAEA SSG-21. A high-quality volcanic hazard study completed in 2011 identified probabilities of about 10^{-6} to 10^{-7} per year for the listed phenomena. Effects of these hazards cannot be mitigated and are consequently considered as cliff edges.

The 2011 study further determined the probability of tephra fallout and pyroclastic projectiles with about 10^{-5} to 10^{-6} per year. The development of a protection concept for the existing NPP for these hazards appears to be feasible.

In order to increase the safety of the existing NPP the PRT recommends to develop plans to respond to potential volcanic activity at Ararat, Aragats, and the Shamiram plateau, and to establish a monitoring of these volcanoes in the framework of national civil protection programmes.

Topic 2: ASSESSMENT RELATIVE TO LOSS OF ELECTRICAL POWER AND LOSS OF ULTIMATE HEAT SINK

The VVER-440 reactors of ANPP belong to the so called “Generation I” reactor types. Nevertheless, the reactor type VVER-440, here as VVER-440 (V-270), possesses design features leading to a “sedate” operational as well as accidental behaviour. The design has some safety merits not found in most other types of PWR in operation. Large coolant inventory establishes a valuable time buffer for corrective actions in abnormal events, where the balance between residual heat production and coolant supply has been lost.

It can be stated, that in the cases of Station Black-Out (SBO) or loss of Ultimate Heat Sink (UHS), a graded approach exists, with measures which are pertinent in general to make ANPP relatively resistant in the case of these events. There are different actions planned to extend the available time for heat removal from the core and the Spent Fuel Pool (SFP), without need for any external action or support.

Nevertheless ANPP is located in a geographic region with high external hazards especially in respect to earthquake. Due to this fact it is an indispensable prerequisite for the reliable function of the SSCs necessary for the measures discussed above, that the integrity of these SSCs, flowpaths and buildings can be ensured and that their safety relevant active parts can be kept operational in case of such events.

In respect to the power supply, the PRT recommends the implementation of the intended improvements of safety systems necessary to cope with postulated events. The PRT recommends especially strengthening the fuel supply for the EDGs. The PRT also recommends to consider addressing the lack of diversity of the EDGs and DAR DG (same type, same building, same age), the ability for recharging the batteries and the assurance for cooling the SFP of unit 2.

It is further recommended that the improvement measures to increase the safety for LOOP, SBO and loss of UHS, proposed by the licensee and amended by the regulator are declared as mandatory, with defined schedules for their implementation.

Topic 3: ASSESSMENT RELATIVE TO SEVERE ACCIDENT MANAGEMENT

Despite of various programmes of international aid and support, the progress in Severe Accident Management (SAM) programme development and implementation is quite slow and delayed in respect to the original schedules. Various essential issues are unsolved.

In respect to SAM the current level of safety of ANPP is clearly lower than the EU average. However, this level will increase in near term due to the introduction of Severe Accident Management Guidelines (SAMGs) expected in 2017. Only in the mid-term, with the implementation of the activities pursuant to "Stress Tests" recommendations, ANPP can reach an acceptable level.

Therefore the PRT highly recommends carrying out all planned activities in respect to severe accident management (hardware and procedures/guidelines) as soon as possible.

Regarding SAMGs the development and implementation of guidelines for shutdown states and SFP should be initiated and finalised.

In respect to hardware modifications especially enhancements of the Emergency Core Cooling System, containment tightness, hydrogen monitoring and control as well as containment spray system should be treated in priority.

Future outlook

The PRT considers it as necessary that ANRA develops a National Action Plan containing all identified safety improvement measures and schedules for their implementation. It suggests that the safety measures identified, including the implementation schedules, are established as regulatory requirements. The PRT further recommends that the National Action Plan should be reviewed in the same way as the National Action Plans of European countries.