Armenian NPP
DESIGN AND SAFETY PRINCIPLES

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ANPP is located in the western part of Ararat valley 30 km west of Yerevan close to Metsamor town
The ANPP consists of two WWER-440 (V-270) power units, seismically upgraded V-230 models.

Unit 1 was commissioned in 1976 and Unit 2 in 1980, respectively.

Units 1 and 2 were shutdown in February and March, correspondingly in 1989.

In 1993 the Government of Armenia made a decision on restart of ANPP Unit 2.

Unit 2 was connected into power grid in 1995.

Unit 1 remains in long-term shutdown.

The design lifetime of Unit 2 expires in September 2016. On April 19, 2012, the Government of Armenia adopted a Decision on the ANPP Unit №2 lifetime extension.

Decision is taken to built new nuclear unit at the same site.
POWER GENERATION IN ARMENIA

- Thermal (gas): 40%
- Nuclear: 18%
- Hydro: 42%

Thermal (gas) - Nuclear - Hydro
The design of the ANPP Units had been developed in the 60-th.

A primary circuit ND32 mm leak was considered as a design basis accident.

The safety systems are of two-train design with consideration of the single-failure principle.

The accident localization system of the Unit includes hermetic compartments (confinement) designed for excess pressure where reactor and radioactive coolant circuit are located.

The hermetic compartments are equipped with sprinkler system designed for steam condensation, iodine fixation, and heat removal during accidents.

In the hermetic compartments, load safety devices were foreseen.
The ANPP SSC seismic stability is ensured with implementation of the following main design solutions:

- Seismic design of the SGs;
- Main reactor equipment (SG, RCP, MSV, and pressurizer piping) is additionally fixed with hydraulic snubbers in order to reduce stresses occurring in the support structures due to seismic effects;
- In addition to the pressurizer support fixing to the basement additional fixing of the pressurizer body upper part is implemented with four pull rods;
- The RCP-310 was replaced with RCP-317 (inertial, seismic resistant);
- Two-train seismic resistant system for emergency feedwater supply to primary circuit is installed;
- Additional (compared with V-230) emergency high and low pressure cooldown system by secondary side is installed;
- The Industrial Seismic Resistant Protection System was installed.
MAIN SAFETY PRINCIPLES

Large volume of primary coolant and large stock of secondary circuit water in steam generators allows passive long-term cooling of core.

High quality of primary components, and consequently, low probability of primary circuit pipeline breaks.

Main stop valves are located on hot and cold legs of each of primary circuit six steam generators enabling a loop isolation, if needed.
Until 1988 (before the Spitak earthquake) multiple safety improvements were performed at the ANPP. The concept of the ANPP Unit 2 safety upgrading before its restart was based on the following:

- Additional study of the ANPP site seismic and volcanic risks in compliance with up-to-date methodologies;
- Seismic qualification of the Unit buildings and SSC responsible for nuclear and radiation safety in regard to seismic conditions of the ANPP site;
- Establishment of independent safety trains;
- Extension of design basis accident due to primary circuit leak from ND32 to ND100;
- Implementation of Leak-before-Break concept for primary circuit pipelines ND200 and more.
Since the decision of RA Government in 1993 on restart of operation the stage-by-stage approach has been accepted for ANPP Unit 2 safety upgrading.

A short-term two-stage programme was developed to implement safety upgrading activities.

**I stage**  The activities implemented before the restart and during 3 years after initiation of Unit 2 restart activities.

**II stage:**  The activities implemented following the completion of I stage.

The implementation of short-term two-stage programme was started during Unit 2 maintenance and recovery activities and was completed by the end of 1997.
In 1998 a “List of ANPP Unit 2 Safety Upgrading Activities was developed. The main objectives to be achieved with implementation of the “List” activities:

- elimination of non-compliances with current safety standards, first of all, in regard with safety important aspects and/or decrease of these non-compliances effect on safety by means of implementation of compensating activities;
- enhancement of reliability of safety important systems, equipment, components;
- decrease of common cause failure probability;
- implementation of IAEA recommendations on WWER NPP safety upgrading.
In the revision of the “List…” a previous activity experience was considered as well as:

- IAEA TECDOC-640 “Ranging of WWER-440/230 NPP safety issues”;
- Performance and activities implemented at similar NPPs in RF and Eastern Europe countries;
- International projects on WWER NPPs safety analysis.
Based on the results of deviation from safety standard documents,

Recommendations of interagency committee on the ANPP units examination following the Spitak earthquake in 07.12.88,

Recommendations of FRAMATOM and EDF experts,

Experience on safety upgrading concept applied at Novovoronezh NPP units 3 and 4, and Kola NPP units 1 and 2,

Suggestions of NIIAEP, OKB Gydropress, Kurchatov Institute scientific center, VNIIAES, and Rosenergoatom Concern,

Significant scope of modernizations were implemented at the Unit 2 during preparation to restart and in the course of operation up to now.
EMERGENCY POWER SUPPLY SYSTEMS

- Reconstruction of I category power supply design circuit.
- Replacement of accumulator batteries with seismic resistant VARTA accumulator batteries.
- Modification of II category 6kV uninterruptible power supply circuit. Each 6kV section is connected to two 1600kW diesel generators. Two-channel power supply system is installed for safety systems.
- Installation of Secondary Emergency Cooling system.
- Modification of DG and load sequencer automatics system.
CONTROL AND MONITORING SYSTEMS

- Installation of two sets of reactor protection and control according to neutron flux parameters based on up-to-date instrumentation.

- Separation of emergency protection due to technological parameters into two independent sets.

- Replacement of instrumentation of reactor protection system and safety systems control with seismic resistant systems;

- Replacement of IVM-500. Installation of SPDS.

- Installation of emergency reactor vessel level and steam phase control system.

- Installation of primary-to-secondary leak detection system.
TECHNOLOGICAL SYSTEMS

- Installation of MSIV on main steam lines.
- Installation of two-channel cooling water system for essential loads (ELCS).
- Installation of additional emergency system for feedwater supply to steam generators with diesel pump.
- Justification of Leak-before-Break concept application for the Unit 2. Implementation of three diverse systems of primary circuit leak detection.
In 1970, proceeding from the experience of earthquake consequences in Gazli (Middle Asia, M = 7, 3) in the design documentation of the main buildings (Reactor Hall, Boron Unit, Auxiliaries Building) an intensification (rising) factor $k = 2.7$ was additionally used.

As a result of comprehensive engineering-seismological researches, the PGA for ANPP site was estimated to be between $0.35g$ and $0.4g$ for peak anticipated earthquakes.
For the period of 1993-1995, activities aimed at ANPP site seismic hazard assessment have been implemented according to the Seismic Resistant NPP-s Designing Standards PNAEG-5-006-87 and IAEA recommendations 50 SG-S-1, and the following basic conclusions were made:

- The ANPP site is situated in the middle of solid tectonic block; there is no tectonic break under the site;
- The peak accelerations for the ANPP site are expected to be $0.21g$ for $50\%$ and $0.34g$ for $84\%$ of confidence.
In regard with decision of the RA Government on the ANPP Unit 2 restart in 1993 the IAEA recommended to consider the following three important aspects:

- identification of the site geological stability;
- identification of the ground seismic movement force;
- development of comprehensive seismic re-evaluation programme.

The first two items were completely implemented and agreed with IAEA experts by the Unit restart in 1995.
In view of the seismic re-evaluation implementation the IAEA developed a special document IAEA Technical Guideline/RU-5869 aimed at the ANPP Unit 2 seismic safety re-evaluation.

In 1999 the Technical Guideline was approved by ANRA and ANPP as a basis for implementation of seismic re-evaluation.

It was established new level of seismic safety – Review Level Earthquake, corresponding to 84% confidence level at PGA = 0.35 g.
Seismic re-evaluation includes three main stages:

- development of Safe Shutdown Equipment List (SSEL), and calculation of Floor Response Spectra (FRS) for installation places of components;
- analysis and evaluation of SSEL components for seismic stability and identification of weak places;
- analysis of identified deficiencies and their safety impact. Identification of activities for their elimination.
MODERNIZATIONS

In 2008 the following activities were implemented:

- The 446 easily-performed reinforcements (upper anchorage of cabinet boards, fixing of board doors, connecting of adjacent cabinets and boards, reinforcing the equipment racks and stands, etc.);

- The vulnerabilities of cable routes were reinforced through installing additional vertical racks and horizontal limiters;

- All the identified deficiencies on pipelines supports, that were considered to be easily-performed reinforcements, were also eliminated;

- Later the ceilings of MCR-2 and PCS-2 were modernized.
MODERNIZATIONS

During outage – 2012, snubbers were installed (30 pcs total), as well as additional support structures (hard cross-bars, spring beat limiters, sliding, guiding) were installed on ANPP pipelines.

As a result of the above mentioned activities, an adequacy of all the SSEL components to the RLE was achieved.

As a consequence of this, it became possible to establish the completion of Seismic Reassessment Program in 2012.
STRESS TESTS REQUIREMENTS

Following the earthquake in Japan in 2011 and the accident at Fukusima NPP, the ANPP proceeded to performing stress tests.

Upon agreement with ANRA, the Review Level Earthquake with PGA = 0,35g remained as a seismic safety design level.

For the BDB earthquake, an earthquake with PGA = 0,47g, corresponding to the excess possibility 10-5, was used pursuant to the new seismic hazards curves, obtained for 2009-2011 within the framework of PSHA for new Unit.
STRESS TESTS BASIC CONCLUSIONS

Based on the stress test results, the following conclusions were made:

The minimum value of HCLPF, determined on the basis of the results of the SSEL complete scope review constitutes 0.57g.

The minimum level of seismic resistance for ANPP structures, ensuring the integrity of the confinement is ~ 0.74g. This value corresponds to reinforcement of the pipeline penetrations from the confinement.
Due to the known objective reasons, the construction of a new NPP in Armenia may be launched no earlier than 2018. Usually the duration of such facilities construction is around 6-7 years, i.e., the commissioning of the ANPP's replacing capacity is not expected before 2025.

In this situation, in order to refrain from repetition of the 1989-1995 energy crisis, on April 2012, the Government of Armenia adopted a Decision on the ANPP Unit №2 lifetime extension.
The main provisions of the lifetime extension procedure are described in the Conceptual Program of the ANPP Unit 2 lifetime extension.

The Conceptual Program formulates preliminary verification of the principled possibility for the ANPP Unit 2 lifetime extension:

The summary assessment of the current technical condition of the irreplaceable components and their residual life, as well as the ANPP Unit 2 safety condition, didn’t reveal fundamentally insolvable problems which would prevent the decision-making on the ANPP Unit 2 lifetime extension outside its design life.

In regard to the scheduled activities and availability of safety upgrading programs, ensuring of required safety of the ANPP Unit 2 outside its design life seems to be quite realistic.
MSIVs ON SG 1-6 STEAMLINES
COOLING PONDS
FIRE RESISTANT COVERING FOR METAL STRUCTURES
NEW SG PILOT-OPERATED SAFETY VALVES
PRIMARY CIRCUIT PILOT OPERATED SAFETY RELIEF VALVE OF PRESSURIZER
COMPRESSOR FOR PERIODIC CONFINEMENT TESTS
SG snubber with rated load capacity of 170 ton
RCP-317, Snubber – 3ps.
Rated load – 100 ton
MCR – antiseismic structures installed on the top of cabinets and panels
0.4kV switches fixed to building civil structures
Additional antiseismic structures installed in the main building.
Turbine building - additional external fixtures of the concrete panels
Turbine Hall, 14.7m, Snubbers installed on HELB piping