Updated National Action Plan upon Stress-Test Results

State Nuclear Regulatory Inspectorate of Ukraine

Kyiv
2020

INTRODUCTION

In June 2011, Ukraine joined the European initiative of conducting stress tests at nuclear power plants in EU member states and neighboring countries (Stress Test Declaration). The stress tests were performed at Ukrainian NPPs in compliance with the stress test specifications agreed by the European Commission (EC) and ENSREG (13 May 2011, Declaration of ENSREG, Annex 1: EU Stress Test Specifications). The stress tests were focused on:

- Zaporizhzhya NPP units 1-6 (WWER-1000/320) and dry spent nuclear fuel storage facility (DSF) located on the Zaporizhzhya NPP site;
- Rivne NPP units 1, 2 (WWER-440/213) and units 3, 4 (WWER-1000/320;
- South Ukraine NPP unit 1 (WWER-1000/302), unit 2 (WWER-1000/338) and unit 3 (WWER-1000/320);
- Khmelnitsky NPP units 1, 2 (WWER-1000/320;
- Chornobyl NPP units 1-3 (spent fuel pools) and interim spent fuel storage facility (ISF-1) located on the Chornobyl NPP site.

The State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) submitted the National Report developed in line with ENSREG recommendations to the EU Stress Test Secretariat on 30 December 2011 to be peer reviewed further.

ENSREG set forth results from the peer review of stress tests for EU states and neighboring countries (Ukraine and Switzerland) in the summary peer review report and country-specific reports.

The peer review country report for Ukraine concluded that the National Report of Ukraine complied with the ENSREG specifications, provided sufficient information to understand the design basis for external natural events, and identified adequate measures to compensate for safety deficiencies revealed. In addition, it was pointed out that previously planned NPP safety improvements should be completed.

The summary EC documents developed upon the peer review of stress tests and approved by the EC on 3 October 2012 set forth recommendations for the SNRIU to monitor, in a systematic manner, implementation of the measures identified upon stress tests by the operating organization. Along with recommendations for the SNRIU, the EC documents also outline good practices revealed in the peer review process.

In order to monitor the implementation of safety improvements at Ukrainian NPPs identified in the stress test and peer review processes, the SNRIU Board convened on 20 November 2012 to hold an open meeting. The SNRIU Board identified additional safety improvements related to severe accident management to take into account peer review recommendations.

The National Action Plan was developed at the beginning of 2013 to implement recommendations of the peer review of stress tests at Ukrainian NPPs and to ensure that the operating organizations take safety improvements identified upon stress tests and the SNRIU efficiently monitors this process.

The ENSREG summary report upon results of the workshop held on 22-26 May 2013 to discuss national action plans (ENSREG National Action Plans Workshop. Summary Report) indicated the following conclusions on the National Action Plan of Ukraine:

- The National Action Plan of Ukraine complied with the ENSREG recommendations on the format of national action plans and covered all necessary aspects;
- There were no open issues or additional questions for Ukraine upon the workshop.

The National Action Plan of Ukraine (2013) was updated in compliance with the recommendations provided in the 'ENSREG Post-Fukushima National Action Plans Workshop 20-24 April 2015. Terms of Reference'.

It should be noted that the number of safety improvement measures did not change for the operating NPPs and Chornobyl NPP in the updated National Action Plan; the scope of measures remained unchanged as well.

The National Action Plan is revised and updated by the SNRIU on a permanent basis. For this purpose, the information set forth in the National Action Plan was updated in 2015, 2017 and 2020 to show the progress of planned measures. New measure No. 33 'Implementation of a Reactor Pressure Vessel External Cooling System' was added to the National Action Plan in 2020. The deadline of the new measure is 31 December 2021.

Part I "Safety Improvement Measures" of the updated National Action Plan provides a list of measures identified by the National Action Plan upon Stress-Test Results (2020) for the operating NPPs and Chornobyl NPP with renewed information on the status and schedule of measures.

Part II "Status of Safety Improvement Measures" of the updated National Action Plan presents information on the implementation of planned measures, specifically: a brief description of the planned scope for implementation, status of implementation (more detailed information is provided for completed measures) and current schedule are provided for each measure.

A series of measures included in the National Action Plan are implemented in the framework of the Comprehensive (Integrated) Safety Improvement Program for Ukrainian NPPs (C(I)SIP). The program was extended by the Cabinet of Ministers of Ukraine in 2019 until 2023 because of delays in obtaining the EBRD/Euratom loan for partial funding of C(I)SIP, difficulties in tenders for equipment purchase and expansion of the program with post-Fukushima measures.

Taking into account the current situation and the relationship between measures under the National Action Plan and C(I)SIP, timeframes for a number of measures in the Updated National Action Plan were extended.

The Annex to the updated National Action Plan contains the National Action Plan upon Stress-Test Results (2017).

ABBREVIATIONS

C(I)SIP	Comprehensive (Integrated) Safety Improvement Program for Ukrainian NPPs
ChNPP	State Specialized Enterprise 'Chornobyl NPP'
CLMS	Coolant Level Monitoring System
DG	Diesel Generator
DSS	Decision Support System
EC	European Commission
ECR	Emergency Control Room
Energoatom	National Nuclear Operator 'Energoatom'
EOP	Emergency Operating Procedure
EU	European Union
IAEA	International Atomic Energy Agency
ISF	Interim Spent Fuel Storage Facility
KhNPP	Khmelnitsky Nuclear Power Plant
MCR	Main Control Room
NPP	Nuclear Power Plant
PAMS	Accident and Post-Accident Monitoring System
PAR	Passive Autocatalytic Hydrogen Recombiner
PSA	Probabilistic Safety Assessment
RNPP	Rivne Nuclear Power Plant
SAMG	Severe Accident Management Guideline
SFA	Spent Fuel Assembly
SFP	Spent Fuel Pool
SG	Steam Generator
SSE	Safe Shutdown Earthquake
SUNPP	South Ukraine Nuclear Power Plant
UARMS	Unified State Automated Radiation Monitoring System in Ukraine
VS	Ventilation Stack
WWER	Water-Cooled Water-Moderated Power Reactor
ZNPP	Zaporizhzhya Nuclear Power Plant

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Part I. Safety Improvement Measures

Table 1.1 Measures Identified upon Stress Tests at Operating NPPs

No.	Measure / activity	Recommendations at European level	Recommendations at national level	Schedule/Status		
				[1]WWER-440/213	[2]WWER-1000/320	[3]WWER-1000/302, 338
	Natural Hazards					
1.	Equipment qualification (harsh environments and seismic* impacts)	(5), (6), (11), (13)	[1], [2]	completed/ completed	completed/ 2020 ongoing	completed/ completed
2.	Seismic resistance of structures, systems and components important to safety	(5)	[1], [2]	2023/2023 ongoing	2020/2023 ongoing	completed/ completed
3.	Consideration of a full range of initiating events for all reactor and SFP states in PSA	(5)	[1], [2]	completed/ completed	completed/ 2020 ongoing	completed/ completed
4.	Implementation of a seismic monitoring system at NPP sites	(10)	[1], [2]	SUNPP – 2012/completed ZNPP -2020 /ongoing RNPP - 2017/completed KhNPP - 2022/ongoing		
	Loss of Safety Systems (Loss of Power and/or Ultimate Heat Sink)					
5.	SFP makeup and cooling in long-term station blackout conditions	(14), (17), (23), (24), (26), (27), (28)	[1], [2]	completed/ completed	completed/ completed	completed/ completed
6.	SG makeup and cooling in long-term station blackout conditions	(14), (17), (24), (26), (27), (28)	[1], [2]	completed/ completed	completed/ completed	completed/ completed
7.	Improved reliability of emergency power supply	(15), (16), (17), (18), (22), (24), (26), (27), (28)	[1], [2]	–	–	completed/ completed

[1] RNPP unit 1/unit 2

[2] Pilot unit (ZNPP-1) / final period for implementation of the measures at all power units of this design.
According to national safety regulations, a measure is first implemented at the pilot power units with reactors of each design and then at other units taking into account the pilot experience

[3] SUNPP unit 1/unit 2

No.	Measure / activity	Recommendations at European level	Recommendations at national level	Schedule/Status		
				[1]WWER-440/213	[2]WWER-1000/320	[3]WWER-1000/302, 338
8.	Emergency power supply in long-term loss of power	(15), (16), (17), (18), (22), (24), (26), (27), (28)	[1], [2]	completed/ completed	completed/ 2021 ongoing	–
9.	Functionality of group A equipment fed from the service water system in case of water discharge in spray ponds	(17), (24), (26), (27), (28)	[1], [2]	completed/ completed	completed/ completed	–
10.	Functionality of group A equipment fed from the service water system in case of failure of ventilation cooling towers and/or service water supply pumps	(17), (24), (26), (27), (28)	[1], [2]	–	–	completed/ completed
11.	Provision of instrumentation during and after accidents (accident and post-accident monitoring system)	(18)	[1], [2]	completed/ completed	completed/ 2020 ongoing	completed/ 2020 ongoing
12.	Development, technical justification, validation and implementation of symptom-oriented EOPs for management of design-basis and beyond design-basis accidents (low power and shutdown states)	(19), (23)	[1], [2]	completed/ completed	completed/ completed	completed/ completed
13.	Detailed analysis of primary system makeup in case of loss of power and/or ultimate heat sink	(20)	[1], [1]	completed	2020 ongoing	2020 ongoing
14.	Replacement of self-contained air conditioners by those qualified for harsh environments and seismic impacts	(22)	[1], [2]	completed/ completed	completed/ 2022 ongoing	completed/ completed
15.	Habitability of MCR and ECR in design-basis and beyond design-basis accidents (installation of iodine filters)	(22)	[1], [2]	completed	–	–
Severe Accident Management						
16.	Severe accident analysis. SAMG development	(39), (41)	[1], [2]	completed/ completed	completed/ completed	completed/ completed
17.	Prevention of early containment bypassing in case of molten corium spread to the containment	(31), (32)	[1], [2], [1]	–	completed/ 2020 ongoing	completed
18.	Implementation of a containment hydrogen control system for beyond design-basis accidents	(31), (32), (41), (11)	[1], [2]	completed	completed/ 2020 ongoing	completed/ completed

No.	Measure / activity	Recommendations at European level	Recommendations at national level	Schedule/Status		
				[1]WWER-440/213	[2]WWER-1000/320	[3]WWER-1000/302, 338
19.	Development and implementation of hydrogen mitigation measures for beyond design-basis accidents	(31), (32), (41)	[1], [2]	2023/2023 ongoing	completed/ completed	completed/ completed
20.	Implementation of a containment venting system	(31), (32), (41)	[1], [2]	2023/2023 ongoing	2020/2021 ongoing	completed/ completed
21.	Analysis of the strategy for possible corium confinement within the reactor pressure vessel	(31), (32)	[1], [1]	completed	2023 ongoing	2023 ongoing
22.	Analysis of the need and possibility to qualify power unit components that may be involved in severe accident management for harsh environments	(31), (32), (33)	[1], [1]	2021 ongoing	2021 ongoing	2021 ongoing
23.	Detailed analysis and development of conceptual solutions on management with large volumes of contaminated water	(42)		2022 ongoing	2022 ongoing	2022 ongoing
24.	Seismic evaluation of buildings and systems of the on-site emergency center and their robustness in severe accident conditions	(43), (44)		2020 ongoing		
25.	Analysis of severe accident phenomena based on available experimental data and improvement of computer models	(44)	(5)	2024 planned	2024 planned	2024 planned
Additional Topics and Activities						
26.	Harmonization of Ukrainian nuclear and radiation safety regulations with WENRA reference levels: a) self-assessment; b) development of a harmonization action plan	(31)		completed		
27.	Self-assessment of the nuclear safety regulation system using the new IAEA instrument – SARIS	(103)		completed		
28.	Provision of mobile laboratories to ZNPP and SUNPP	(110)		SUNPP – completed, ZNPP – 2023		
29.	Development of the concept and plan for the unified state automated radiation monitoring system of Ukraine (UARMS)	(110), (114), (120)		ongoing		
30.	Long-term (more than 24 hours) emergency training for all response parties, including central executive authorities, to test the knowledge transfer procedure in conditions of shift work of emergency staff	(113)		conducted annually		
31.	Implementation of the RODOS system	(115)		2017 completed		

No.	Measure / activity	Recommendations at European level	Recommendations at national level	Schedule/Status		
				[1]WWER-440/213	[2]WWER-1000/320	[3]WWER-1000/302, 338
32.	Modernization of the SNRIU Emergency Response and Information Centre	(121)		2017 completed		
33.	Implementation of a reactor pressure vessel external cooling system	(31), (32)	[1], [1]	2021 ongoing	-	-

Table 1.2 Measures Identified upon Stress Tests at Chornobyl NPP

No.	Measure / activity	Recommendations at European level	Recommendations at national level	Status	Schedule
1.	Installation of an additional level control device in 1 (2) fuel assembly cooling pools-1, 2 for emergencies related to level water decrease below marks 19, 22	(18)	[3], [4]	completed	2012
2.	Calculation analysis of buildings of nuclear safety category 1 to determine safety margins and potential failures under loads induced by a tornado of class F 3.0	(13)	[3], [4]	completed	2016
3.	Calculation analysis of buildings of nuclear safety category 1 to determine safety margins and potential failures under seismic loads	(13)	[3], [4]	completed	2015
4.	Seismic resistance analysis of ISF-1 SFP lining	(23), (30)	[3], [4]	completed	2015
5.	Analysis of stability and potential failures of VS-1 under SSE and tornado	(23), (30)	[3], [4]	completed	2014
6.	Nuclear safety justification for the spent fuel pools of units 1, 2 with 250×110 mm arrangement of SFAs (as reserve for one ISF-1 compartment)	(23), (30)	[3], [4]	completed	2012
7.	Justifying calculation of the maximum fuel cladding temperature taking into account potential radiological consequences from wet SFA storage	(23), (30)	[3], [4]	completed	2013
8.	Development of an action plan to improve the emergency preparedness system in case of beyond design-basis accidents caused by natural hazards, including emergency response measures in case of damage of the building and leakage of SFP	(26), (28), (34), (38), (39)	[3], [4]	completed	2012
9.	Amendment of the ChNPP accident and emergency response plan (32P-S) to improve emergency preparedness	(26), (28), (34), (37), (39)	[3], [4]	completed	2012
10.	Development of measures on prompt access of emergency teams from Slavutych by alternative routes in case of damage of Slavutych–ChNPP railroad tracks caused by SSE	(34)	[3], [4]	completed	2012
11.	Modernization of the ISF-1 radiation monitoring system to ensure neutron flux density monitoring	(18), (30)	[3], [4]	completed	2012
12.	Additional radiation monitoring of exposure dose rate of the container car in ISF-1 during spent fuel transport	(18)	[3], [4]	completed	2012
13.	Replacement of the UDZhG-04R detector with an RWM-02 detector for the instrumentation channel for monitoring the activity concentration of service water after heat exchangers in ISF-1 spent fuel pools	(18)	[3], [4]	completed	2013
14.	Power supply to ISF-1 essential equipment fed from mobile DG	(15), (16), (26)	[3], [4]	completed	-
15.	Purchase of a new container car for SFA transport	(30)	[3], [4]	completed	2018

No.	Measure / activity	Recommendations at European level	Recommendations at national level	Status	Schedule
16.	Revision of the ISF-1 safety improvement plan	(23), (30)	[3], [4]	completed	2012
17.	Introduction of the topic “multiple failures of regular systems and equipment in severe weather conditions” into the 2012 training program for ChNPP staff of certain positions for detailed theoretical elaboration of the training scenario	(26), (28), (34), (108)	[3], [4]	completed	2012
18.	Introduction of the topic “multiple failures of regular systems and equipment in severe weather conditions” into the 2012 training program (Section 14) for practical exercise by staff of all shifts	(26), (28), (34), (108)	[3], [4]	completed	2012
19.	Psychological training of staff intended to increase resilience to psychological stress, develop self-control, composure and promote mutual aid and cooperation	(38), (122)	[3], [4]	completed	2012
20.	Implementation of a system for psychological selection and training of individuals involved in severe accident management, similar to the system for selection of operating personnel	(38)	[3], [4]	completed	2012

References

1. Comprehensive (Integrated) Safety Improvement Program (C(I)SIP), approved by Cabinet Resolution No. 1270 dated 7 December 2011.
2. SNRIU Board Resolution No. 13 dated 24-25 November 2011 “On results of the targeted safety reassessment of operating NPPs and ZNPP dry spent fuel storage facility in the light of the events at Fukushima-1”.
3. SNRIU Board Resolution No. 12 dated 3 November 2011 “On result of the targeted safety reassessment of Chornobyl NPP units 1-3 and Interim Spent Nuclear Fuel Storage Facility in the light of the events at Fukushima-1”.
4. Safety Improvement Plan for ChNPP Nuclear Installations.
5. SNRIU Board Resolution No. 14 dated 20 November 2012 “On the progress in implementation of measures based on stress-tests results for operating NPPs”.

Part II. Status of Safety Improvement Measures

Section 1. Status of Measures Identified upon Stress Tests at Operating NPPs

This Section provides information on the status of measures identified upon stress tests at the operating NPPs and presented in Table 1.1 of Part IV "Plan for Implementation of Safety Improvements" of the National Action Plan upon Stress-Test Results (2013).

Area: Natural Hazards

Item 1. Equipment qualification (harsh environments and seismic impacts)*

This measure is intended to confirm the operability of NPP systems and components and their capability to perform safety functions under seismic events and harsh environments (high temperature, pressure, radiation, moisture etc.) that may occur in design-basis accidents. Compensatory measures or replacement are envisaged for equipment whose qualification has not been confirmed. The associated technical decisions have been agreed/are planned to be agreed with the SNRIU (if needed, for ZNPP-5,6).

Measure has been completed for ZNPP-1,2,3,4; RNPP-1,2,3,4; KhNPP-1,2; SUNPP-1,2,3.

Schedule for ZNPP-5,6: 2020.

Item 2. Seismic resistance of structures, systems and components important to safety

This measure is intended to ensure resistance to earthquakes of at least 7 magnitudes on the MSK-64 scale (but not less than 0.1 g peak ground acceleration) for equipment, piping, buildings and structures required to perform critical safety functions (provide for safe reactor shutdown and keep the reactor in safe state, remove heat from the reactor core and spent fuel pool, prevent radioactive releases to the environment).

The input data for assessing the seismic resistance of equipment, piping, buildings and structures of all NPP units have been agreed by the SNRIU.

Stage I of the measure has been completed for ZNPP-3,4; RNPP-3,4; KhNPP-1,2; SUNPP-1,2,3.

Stage II: seismic resistance assessment upon seismic monitoring (if necessary).

Measure has been completed for SUNPP-1,2,3.

Schedule: ZNPP-1-6 – 2020, RNPP-1-4 and KhNPP-1,2 – 2023.

Item 3. Consideration of a full range of initiating events for all reactor and SFP states in PSA

This measure is intended to perform probabilistic safety assessments of levels 1 and 2 for a full range of initiating events (including natural hazards) for all regulated states of the power unit, covering both the reactor core and spent fuel pool.

Measure has been completed for ZNPP-1,2,3,4; RNPP-1,2,3,4; KhNPP-1,2; SUNPP-1,2,3.

Schedule for ZNPP-5,6: 2020.

Item 4. Implementation of a seismic monitoring system at NPP sites

This measure is intended to implement systems for continuous seismic monitoring in order to determine actual seismic characteristics of NPP sites. The monitoring results and numerical parameters for predicted seismic events will be used to plot new accelerograms and obtain ground response spectra for the design-basis earthquake (DBE) and safe shutdown earthquake (SSE).

SUNPP site: measure has been completed (on-site seismic monitoring system was commissioned in 2012). According to seismic monitoring, the assessed seismic resistance is not required to be revised.

RNPP: measure has been completed. The on-site seismic monitoring system was installed and commissioned. According to seismic monitoring, the assessed seismic resistance is not required to be revised.

ZNPP: on-site seismic monitoring system was installed and commissioned. The results of seismic monitoring are to be obtained in 2020.

KhNPP: system has been commissioned.

Schedule for measure completion: 2022.

Area: Loss of Safety Systems (Loss of Power and/or Ultimate Heat Sink)

Item 5. SFP makeup and cooling in long-term station blackout conditions

This measure is intended to ensure SFP emergency makeup through a series of actions to connect a mobile pumping unit to restore forced water circulation in SFP with boric acid solution from tanks and emergency makeup of SFP from on-site water supply sources. It is needed to:

- perform calculations to justify characteristics of the mobile pumping unit (MPU) to ensure SFP makeup during the time required to restore design-basis systems;
- supply equipment;
- install special-type connectors to enable connection of MPU hydrants to on-site water supply sources and pressure piping of the SFP cooldown system and/or piping of emergency SFP makeup from the spray system;
- develop and introduce emergency procedures for use and connection of MPUs.

The concept for implementation of this measure for all power unit designs was developed by the operating organization and agreed by the SNRIU; pilot power units are RNPP-2, SUNPP-1 and ZNPP-1.

Measure has been completed at all power units: ZNPP-1,2,3,4,5,6; RNPP-1,2,3,4; SUNPP-1,2,3; KhNPP-1,2.

Item 6. SG makeup and cooling in long-term station blackout conditions

This measure is intended to connect mobile units to supply feedwater to SG and requires to:

- analyze potential water discharge to SG from turbine compartment deaerators at the maximum flow rate in long-term station blackout conditions;
- supply equipment;
- take actions to connect MPU for emergency SG makeup from on-site water sources, including:
  - calculations to justify MPU characteristics;
  - installation of special-type connectors to enable connection of MPU to any on-site water source and to the pressure side of the SG emergency makeup system;
  - development and implementation of emergency procedures for use of MPU for SG makeup and emergency heat removal from the core through SG.

Potential recriticality and coolant leak through the main coolant pump sealing shall be taken into account in implementation of the measure.

The concept for implementation of this measure for all power unit designs was developed by the operating organization and agreed by the SNRIU; pilot power units are RNPP-2, SUNPP-1 and ZNPP-1.

Measure has been completed at all power units: ZNPP-1,2,3,4,5,6; RNPP-1,2,3,4; SUNPP-1,2,3; KhNPP-1,2.

Item 7. Improved reliability of emergency power supply (SUNPP-1,2)

Item 8. Emergency power supply in long-term loss of power (other power units)

This measure is intended to take a series of actions to connect a mobile diesel generator to recover power supply to systems that can be used to inject water to the primary side and spent fuel pools, as well as to monitor and perform critical safety functions, ensure remote control of valves and emergency lighting, including:

- calculations to justify characteristics of the mobile diesel generator;
- equipment supply;
- connection of the mobile diesel generator to buses of the emergency power supply system of category 1 to energize design-basis pumps for high-pressure emergency boron injection, SFP cooldown pumps, uninterruptible power supply sources and systems required for monitoring of emergency processes;
- development and implementation of emergency procedures for use of the mobile diesel generator.

The concept for implementation of this measure for all power unit designs was developed by the operating organization and agreed by the SNRIU; pilot power units are RNPP-2, SUNPP-1 and ZNPP-1.

Measure has been completed for ZNPP-1,2,3,4,5; RNPP-1,2,3,4; KhNPP-1,2; SUNPP-1,2.

SUNPP-3: equipment has been connected according to regular scheme; the second connection point for the mobile DG is additionally required to be arranged before the equipment is put into commercial operation.

ZNPP-6: a 0.4 kV mobile DG was purchased and connected according to non-regular scheme to safety system busbars). The 0.4 kV mobile DG is planned to be connected at ZNPP-6 according to regular scheme in 2021.

Item 9. Functionality of group A equipment fed from the service water system in case of water discharge in spray ponds

This measure is intended to take a series of actions for emergency supply of service water to essential loads by a mobile pumping unit from the NPP circulation water cooling system or other available water sources including:

- determination of an optimal list of loads that require emergency supply of service water from the mobile pumping unit (MPU);
- calculation to justify MPU characteristics to ensure water supply within the period required to restore operation of design-basis systems;
- equipment supply;
- development and implementation of emergency procedures for MPU use and connection.

The concept for implementation of this measure for WWER-440/213 and WWER-100/320 units was developed by the operating organization and agreed by the SNRIU; pilot power units are RNPP-2 and ZNPP-1.

This measure is not envisaged for SUNPP units 1, 2 (WWER-1000/302, 338) since their design includes ventilation cooling towers instead of spray ponds.

Measure has been completed at all power units: ZNPP-1,2,3,4,5,6; RNPP-1,2,3,4; KhNPP-1,2; SUNPP-3.

Item 10. Functionality of group A equipment fed from the service water system in case of failure of ventilation cooling towers and/or service water supply pumps

This measure is intended to take a series of actions to provide cooling water to standby DGs, equipment and mechanisms needed for reactor cooldown in loss of normal power supply buses and failure of essential service water supply system.

The concept for implementation of this measure for WWER-1000/302, 338 was developed by the operating organization and agreed by the SNRIU. The pilot power unit is SUNPP-1.

SUNPP-1,2: measure has been completed (HRC-110 pumping station was purchased, necessary installation actions were taken, operating documentation was amended, testing was performed, procedure for alternative water supply from MPU to essential loads (with water intake from two possible sources: water intake pools of ventilation cooling towers or off-take/intake recirculation water channel of the Tashlyk reservoir) was developed, personnel were trained).

Item 11. Provision of instrumentation during and after accidents (accident and post-accident monitoring system)

This measure is intended to:

- install features to monitor coolant overheating at fuel assembly outlet, under the reactor head assembly and in hot legs of reactor coolant piping within an extended temperature range;
- introduce features to monitor coolant level above the core in emergencies;
- install features to monitor hydrogen concentration in the containment during accidents;
- conduct additional analysis to determine the minimum required list of signals for accident and post-accident reactor monitoring;
- introduce emergency instrumentation with an extended measurement range for monitored process parameters;
- introduce a data storage system for conditions of design-basis and beyond design-basis accidents (black box).

WWER-440 units (RNPP-1,2): measure has been completed, PAMS has been commissioned.

WWER-1000 units: the concept for implementation of this measure was developed by the operating organization and agreed by the SNRIU; SUNPP-1 and ZNPP-1 are pilot units.

Measure has been completed for ZNPP-1,2,3,4,5; RNPP-1,2, 3,4; KhNPP-1,2; SUNPP-1.

Schedule:

2020: ZNPP-6, SUNPP-2, 3.

Item 12. Development, technical justification, validation and implementation of symptom-oriented EOPs for management of design-basis and beyond design-basis accidents (low power and shutdown states)

Measure has been completed for Ukrainian NPPs (symptom-based EOPs for low power and shutdown states have been developed and implemented).

Item 13. Detailed analysis of primary system makeup in case of loss of power and/or ultimate heat sink

This measure is intended to carry out a detailed and comprehensive analysis of the need for makeup of the primary system in case of accidents involving loss of power supply and/or ultimate heat sink. The analysis is to address potential accident progression scenarios in which loss of power and cooling water will make primary system makeup impossible. Hence, the use of mobile sources for primary system makeup shall be considered as a compensatory measure. Upon results of the analysis, additional measures for primary system makeup shall be revised as appropriate and additional technical features shall be determined.

WWER-440 (V-213): measure was completed in 2016.

WWER-1000 (V-320 and V-302/338): reports have been developed; they are currently under revision to incorporate validated data on the operation of design-extension equipment at NPP units in the calculational and analytical justifications. Thermal hydraulic models have been prepared for computer analysis and approaches to the concept of primary system makeup in the event of an accident with loss of power supply and/or ultimate heat sink for all NPP sites have been developed. In this connection, the timeframes for the measures have been extended to 2020.

Schedule for WWER-1000 (V-320 and V-302/338): 2020.

Item 14. Replacement of self-contained air conditioners by those qualified for harsh environments and seismic impacts

KhNPP-1,2 and RNPP-4: measure was completed long before approval of the National Action Plan as part of post-commissioning measures.

Measure has been completed for ZNPP-1,3,4; SUNPP-1,2,3, RNPP-1,2,3:

Schedule:

2020: ZNPP-5; to be extended to 2021 for ZNPP-2;

2022: ZNPP-6.

Item 15. Habitability of MCR and ECR in design-basis and beyond design-basis accidents (installation of iodine filters)

This measure was intended only for WWER-440/213 power units.

The measure was completed (2011 – RNPP-1; 2012 – RNPP-2).

Area: Severe Accident Management

Item 16. Severe accident analysis. SAMG development

This measure is intended to develop severe accident management guidelines for operation at rated power as well as for low power and shutdown states. The guidelines shall be aimed at severe accident management both in the reactor core and spent fuel pool.

The measure has been completed for all NPP units.

Item 17. Prevention of early containment bypassing in case of molten corium spread to the containment

SUNPP-1,2: measure has been completed (appropriate analytical justifications were developed, enclosing concrete structure was installed on the way of potential corium spread, operating documentation was amended, in particular, regarding the position of doors in the lower part of the reactor concrete vault and in the room for reactor pressure vessel inspection during operation (closed doors are needed for shielding but they must not be locked to hinder spreading of the main corium part in case of an accident).

Measure has been completed for ZNPP-1,2,3,4,5,6; RNPP-1,2,3,4; KhNPP-1; SUNPP-1,2,3.

Schedule:

2020: KhNPP-2.

Item 18. Implementation of a containment hydrogen control system for beyond design-basis accidents

This measure is intended to implement a hydrogen control system in the containment to ensure continuous monitoring and recording of hydrogen concentration (including post-accident period), which shall comply with qualification requirements for operation during design-basis and beyond design-basis accidents with loss of primary coolant and under seismic events.

Measure has been completed for ZNPP-1,2,3,4,5; RNPP-3,4; KhNPP-1,2; SUNPP-1,2,3;

Schedule for NPP-6: 2020.

Item 19. Development and implementation of hydrogen mitigation measures for beyond design-basis accidents

This measure is intended to install passive autocatalytic hydrogen recombiners in the containment for safe mitigation of hydrogen during design-basis and beyond design-basis accidents leading to severe core damage.

Measure has been completed for ZNPP-1,2,3,4,5,6; RNPP-3,4; KhNPP-1,2; SUNPP-1,2,3;

Schedule for RNPP-1,2: 2023.

Item 20. Implementation of a containment venting system

This measure is intended to:

- develop and implement a technical decision on forced filtered containment venting;
- supply and install equipment;
- develop a procedure for emergency containment venting in case of a severe accident, amend severe accident management guidelines.

In development of the system design, it is necessary to:

- perform appropriate calculations to confirm the effectiveness of containment pressure decrease, effectiveness of filtration of the vented medium, taking into account the need to minimize radioactive contamination of the environment;
- ensure that the system remains operational in station blackout conditions.

The concept for implementation of this measure was developed by the operating organization and agreed by the SNRIU; pilot power units are SUNPP-1 and ZNPP-1.

The design of SUNPP-1,2 systems provides for ‘dry’ filtration of the steam/gas mixture with location of filters in the containment. These systems use combined filters whose housings include two types of filter material: one (metal fibers) for retention of aerosols and the other (silver-doped zeolite sorbent) for retention of radioactive iodine.

Since the filters are installed inside the containment, the environmental parameters (temperature, pressure, density) in the filters are the same as in the containment. This design solution minimized the size of the filters and prevented condensation of steam in the filters in system startup by elimination of the equipment heating stage. Accordingly, a hydrogen mixture that can cause deflagration or detonation of the gas mixture in the system cannot be generated since a part of water vapors is condensed.

Two-stage filtration systems are under implementation at ZNPP-1,2,3,4,5,6, RNPP-3,4, KhNPP-1,2 and SUNPP-3. These systems use filters (Venturi scrubbers) including two types of filter material: one (cleaning mixture) to retain aerosols and radioactive iodine and the other (metal fibers) to finely filter aerosols that may remain after the first stage.

As of today, filtered containment venting systems have been introduced into commercial operation at SUNPP-1,2. At other power units, the existing steel sheet piping has been replaced by seamless steel piping and necessary installation activities have been done. Skoda filtering equipment has been delivered. Efforts under the second stage are ongoing (holes and niches in walls are being made, support structures are being fixed). Welding activities to install scrubbers (filters) are under way at ZNPP-2, RNPP-3, KhNPP-1 and SUNPP-3.

Schedule:

2020: ZNPP-1,2,3,4,5,6; RNPP-3; KhNPP-2; SUNPP-3;

2021: RNPP-4, KhNPP-1;

2023: RNPP-1,2.

Item 21. Analysis of the strategy for possible corium confinement within the reactor pressure vessel

WWER-1000: A guideline for analysis has been developed, MELCOR and RELAP/SCDAPSIM codes have been supplemented and a list of representative severe accidents has been cross-verified, selected and justified. Reports with analysis of the strategy for corium confinement in the WWER-1000 (V-320 and VB-302,338) pressure vessel in severe accidents were developed. The analytical reports have been returned for revision to take into account international studies under the IVMR HORIZON-2020 program.

The schedule has been extended to 2023.

WWER-440 (RNPP-1,2, V-213): measure has been completed, the measure implementation report has been agreed by the SNRIU.

Schedule for completion at WWER-1000 (V-302/V-338, V-320): 2020.

Item 22. Analysis of the need and possibility to qualify power unit components that may be involved in severe accident management for harsh environments

Stage 1: completed; List of Installed Equipment Involved in Severe Accident Management and Subject to Qualification for Harsh Environments for NPP Units was agreed by the SNRIU with letter No. 15-46/5313-4201 dated 23 April 2019;

Stage 2:

• Evaluate the initial and current qualification of equipment included in the List of Installed Equipment Involved in Severe Accident Management and Subject to Qualification for Harsh Environments for NPP Units;

• After the initial and current qualification is assessed, the method will be selected to upgrade the qualification of equipment with unidentified qualification taking into account the analysis carried out with C(I)SIP measure 19105 aimed at implementing the strategy for corium confinement in the reactor pressure vessel.

Schedule for completion of Stage 2: 2021.

Item 23. Detailed analysis and development of conceptual solutions on management with large volumes of contaminated water

The detailed analysis carried out by Energoatom in 2012-2019 indicates that the volumes and characteristics of contaminated water substantially depend on the selected strategy for management of severe accidents (design basis and beyond design basis) and on the progression of emergency processes. Considering a high level of uncertainty in the development of conceptual solutions, the SNRIU proposed Energoatom to treat the obtained data as preliminary (letter No. 15-41/13325-14025 dated 13 November 2019), apply these data to plan measures and strategies for liquid radwaste management and continue estimates of potential volumes of radioactive water generated in severe accidents involving computer analyses in 2020-2022, taking into account international experience.

Energoatom performed calculations to determine the specific activity and amounts of water that can be generated in a beyond design basis accident for WWER-1000/V-302/V-338, WWER-1000/V-320 and WWER-440/V-213. The reports were submitted to the SNRIU for information on implementation of the measure under the National Action Plan upon Stress-Test Results. Based on preliminary analysis jointly with SSTC NRS experts, the SNRIU returned the report for revision. At the joint meeting on 20 October 2017 involving the SNRIU and SSTC NRS, it was decided to develop a concept for implementation of all

activities under the measure 'Detailed Analysis and Development of Conceptual Solutions on Management with Large Volumes of Contaminated Water' to establish the analysis scope, stages and deadlines.

Energoatom submitted the draft of the revised Concept of Activities for the Measure 'Detailed Analysis and Development of Conceptual Solutions on Management with Large Volumes of Contaminated Water' and responses to additional comments of SSTC NRS experts on the above Concept with letter No. 10165/18 dated 26 July 2019 to the SNRIU (in response to SNRIU letter No. 15-41/7587-8028 dated 19 June 2019). After verifying the resolution of comments in the revised Concept for completeness and correctness, the SNRIU proposed Energoatom to consider the revision of the Concept to be completed and the data and proposals on further planned activities and approaches to be preliminary (letter No. 15-41/13325-14025 dated 13 November 2019). At the same time, estimates of potential volumes of radioactive waste in severe accidents involving computer analyses are of first priority and shall 'serve as a basis for planning liquid radwaste management strategies and developing monitoring devices' and for drafting appropriate conceptual solutions.

The efforts are planned to be continued in 2020-22.

Item 24. Seismic evaluation of buildings and systems of the on-site emergency center and their robustness in severe accident conditions

SUNPP site: seismic resistance at a level of 0.15g for structures of the central control room and 0.18g for the on-site emergency center is provided, habitability of the center in severe accident conditions is ensured.

SNRIU Order "On Amendment of Requirements for the On-site and Off-site Emergency Centers" No. 201 of 9 December 2016, registered in the Ministry of Justice of Ukraine on 28 December 2016 by No. 1725/29855, requirements were established for location of the on-site and off-site emergency centers "so that emergency response processes can be controlled on the NPP site if infrastructure is damaged in close vicinity to the plant as a result of low-level internal events, external events and/or their combination" and the following basic safety conditions are met: … "confirmation of seismic resistance of structures and equipment of the NPP emergency center in safe shutdown earthquake".

In accordance with Section I para. 6 of these Requirements, "the schedule and scope of activities to bring the NPP emergency centers that are under operation, construction, upgrading or design into compliance with these Requirements are established and justified by the operating organization upon agreement with the State Nuclear Regulatory Inspectorate of Ukraine".

At present, seismic resistance of buildings housing the emergency centers is ensured at all operating NPPs of Ukraine. The efforts undertaken to confirm the seismic resistance of emergency center systems have been completed. Currently, planned compensatory measures are being implemented to ensure seismic resistance of all components of the NPP internal emergency centers in conditions of safe shutdown earthquake.

Schedule for completion at ZNPP, RNPP, SUNPP and KhNPP: end of 2020.

Item 25. Analysis of severe accident phenomena based on available experimental data and improvement of computer models

Energoatom has developed 'Program of Activities on Analysis of Severe Accident Phenomena' PM-T.0.41.414-15 and implements it under regulatory supervision through the Energoatom Scientific and Technical Center. The following has been performed:

- International experience in analysis of severe accident phenomena and development of a matrix incorporating available experimental data was analyzed. This will allow more detailed analysis of severe

accident phenomena, revision of the computer models used in the development of symptom-oriented emergency operating procedures, emergency operating procedures and severe accident management guidelines and development of new models for updated code versions.

- Computer models for pilot units ZNPP-1, SUNPP-1 and RNPP-1 were developed within study of the potential criticality phenomenon in severe accidents in order to determine the multiplication factor and potential for the formation of local critical masses at different severe accident phases for the reactor core and spent fuel pool.

- Existing experiments for in-vessel severe accident phenomena acceptable for WWERs were selected in analysis of in-vessel phenomena. Recommendations on modeling of the studied phenomena taking into account international experience in analysis of severe accident phenomena were collected.

- In analysis of ex-vessel severe accident phenomena, restrictions of the existing computer codes should be defined and recommendations should be made on correct modeling of the phenomena. A table of experiments acceptable for description of phenomena for WWERs in the ex-vessel severe accident phase has been developed.

- For further activities, MELCOR code versions 1.8.6 and 2.1 were introduced into the List of Codes Allowed for Application at Energoatom to Justify Safety of Nuclear Installations as of 1 February 2020 (Energoatom Order No. 157-r dated 17 February 2020).

Reports 'Analysis of International Experience in Study of Severe Accident Phenomena', 'Systematization and Development of Experimental Data Matrix', 'Analysis of In-Vessel Severe Accident Phenomena Using Existing Experimental Data' and 'Analysis of Ex-Vessel Severe Accident Phenomena Using Existing Experimental Data' were submitted to SNRIU (Energoatom letter No. 200/41 dated 8 January 2020).

Report 'Development of Reactor and SFP Models and Their Optimization in the MCNP Neutronic Code for ZNPP-1, SUNPP-1 and RNPP-1. Sensitivity Analysis of Reactor and SFP Severe Accident Models' was submitted to the SNRIU (Energoatom letter No. 199/41 dated 8 January 2020).

Additional Topics and Activities

Item 26. Harmonization of Ukrainian nuclear and radiation safety regulations with WENRA reference levels:

a) self-assessment;

b) development of a harmonization action plan

In order to implement this measure, the SNRIU:

- carried out self-assessment for compliance of national nuclear safety regulations with the "WENRA Reactor Safety Reference Levels 2008" in the framework of a EC technical assistance project and conducted peer review of the self-assessment involving experts from regulatory authorities of Czech Republic, Slovakia, Finland and Bulgaria;

- "WENRA Safety Reference Levels for Existing Reactors. Update in relation to lessons learned from TEPCO Fukushima Daiichi accident" in the framework of activities along will all WENRA member states and conducted respective peer reviews.

The results of these activities are reflected by the SNRIU in annual rule-making plans agreed by the SNRIU.

Item 27. Self-assessment of the nuclear safety regulation system using the new IAEA instrument – SARIS

Self-assessment of the nuclear safety regulation system using the new IAEA instrument SARIS is carried out by the SNRIU on a systematic basis: persons responsible for different regulatory areas are appointed, questionnaires are updated in the light of new IAEA publications. In particular, results of self-

assessment in the emergency preparedness and response area for compliance with IAEA GSR Part 7 were used in revision of the national plan of response to nuclear and radiation accidents in 2019.

Item 28. Provision of mobile laboratories to ZNPP and SUNPP

SUNPP site: two mobile radiological monitoring laboratories based on off-terrain vehicles were purchased and supplied in 2012; trial operation stage is ongoing.

ZNPP site: activities are ongoing in the framework of C(I)SIP measure 14401 (ARMS) with deadline in 2023. Ordering Plan No. 02/01 dated 7 June 2017 was concluded with the Research and Production Company 'Automation and Mechanical Engineering' for the manufacture and supply of ARMS equipment (supply and commissioning of two mobile radiological laboratories based on off-road vehicles are planned for 2023).

Item 29. Development of the concept and plan for the unified state automated radiation monitoring system of Ukraine (UARMS)

This measure is implemented to comply with the Cabinet Resolution "On Approval of the Action Plan for Development of a Unified Automated Radiation Monitoring System by 2015" to ensure radiation safety and radiation monitoring based on automated collection, transfer and analysis of actual data on radiation situation on the territory of Ukraine as well as to predict the development of radiation situation to support activities of state authorities at all levels and assess transboundary transfer of radioactivity inside and outside the country.

The draft UARMS concept was developed, its interdepartmental discussion took place, but it was not approved and other measures of the above-mentioned Action Plan were not implemented because of administrative changes in the structure of executive bodies; in particular, the Ministry of Emergencies and State Health and Epidemiological Service were liquidated, subordination of the State Agency of Ukraine on Exclusion Zone Management changed, a new structure, State Service of Ukraine for Food Safety and Consumer Protection, was established, etc.

Functions of the state system of environmental radiation monitoring are performed by hydrometeorological posts of the Ukrainian Weather Center of the State Emergency Service of Ukraine, whose activities are coordinated by the Minister of Internal Affairs of Ukraine.

In the framework of European Commission projects, a forecasting center was established at the Ukrainian Weather Center. This center uses numerical weather forecasts and JRODOS automated decision support system. Since 2016, the Ukrainian Weather Center transmits data from Ukraine on the gamma dose rate to the European Radiological Data Exchange Platform EURDEP.

Information can be found at https://remap.jrc.ec.europa.eu/GammaDoseRates.aspx

Item 30. Long-term (more than 24 hours) emergency training for all response parties, including central executive authorities, to test the knowledge transfer procedure in conditions of shift work of emergency staff

These long-term exercises are conducted in Ukraine annually at one of the NPPs in compliance with the schedule agreed by the SNRIU. For example, full-scale training at Khmelnitsky NPP was conducted from 31 May to 2 June 2016 to test interaction plans in case of diversions and the NPP emergency plan, involving participation and interaction of protection, security, defense and response forces at different levels. On 4-5 October 2017, training at Rivne NPP was conducted on a conditional accident scenario including a combination of external events. In addition, with support of the Defense Threat Reduction Agency of the U.S. Department of Defense, command and staff exercises were conducted to test interaction between response forces at the regional level at South Ukraine NPP in December 2016 and command and staff exercises were conducted at the state level on a conditional accident scenario at Zaporizhzhya NPP on 5-7 September 2017.

In the framework of the action plan for the functional subsystem 'Nuclear and Radiation Safety' of the Unified State Civil Protection System and Ukraine participation in international ConvEx (2b–3) exercises, the procedures for interaction with other central executive bodies and departments that participate in measures of emergency response to nuclear and radiological incidents within their competencies and obligations (agreements) on interaction with the SNRIU, particularly the State Emergency Service of Ukraine, Security Service of Ukraine, Ukrainian Weather Center, Ministry of Health of Ukraine, State Service of Ukraine on Food Safety and Consumer Protection etc., will also be tested and verified at national and regional levels.

Item 31. Implementation of the RODOS system

On 30 2016, the RODOS decision support system was officially presented in Ukraine at the State Emergency Service of Ukraine with participation of representatives from the European Commission, SNRIU, Energoatom Company, National Academy of Sciences of Ukraine and other agencies.

http://www.kmu.gov.ua/control/uk/publish/article?art_id=249152554&cat_id=249891310

http://mvs.gov.ua/ua/news/1750_V_DSNS_vidbulasya_prezentaciya_sistemi_RODOS_Ukraina_VIDEO.htm

http://www.nas.gov.ua/UA/Messages/news/Pages/View.aspx?MessageID=2407

The RODOS DSS was introduced into commercial operation in January 2017.

The RODOS DSS is used within Ukraine participation in international exercises, such as ConvEx-3 exercises on 21-22 June 2017, in annual full-scale exercises at NPPs and for estimate, forecast and public notification in case of actual events, such as an unknown source of ruthenium-106 in September-October 2017, fires in natural ecosystems in the exclusion zone in April 2020 etc.

The RODOS decision support system in Ukraine was checked and verified with results of other countries during the international IAEA ConvEx-3 emergency exercises based on a scenario of a conditional accident at Paks NPP (Hungary) on 21-22 June 2017.

In addition, JRODOS computer codes were used by Ukrainian experts in interaction with IRSN and BfS to assess the origin of the ruthenium-106 release in September-October 2017.

In the framework of a EC project (December 2016 – July 2018), the RODOS decision support system was applied in the Chornobyl exclusion zone, which included development of specific models for atmospheric and water transport for the Shelter, ChNPP cooling pond (in the event of tornado) and ISF, forest fires on radioactively contaminated areas etc.

In the period of forest fires in the exclusion zone in April 2020, the RODOS DSS was used on a regular basis for estimates and forecasts. The forest fire module based on the LASAT local atmospheric transfer model and implemented at the SNRIU emergency information center in 2018 was applied for the estimates.

The RODOS DSS is planned to be used for forecast and estimates in full-scope exercises at RNPP (28-29 October 2020).

Item 32. Modernization of the SNRIU Emergency Response and Information Centre

The SNRIU Information Emergency Center (IEC) was modernized under an infrastructural project within the Global Partnership Against the Spread of Weapons and Materials of Mass Destruction with support of the Defense Threat Reduction Agency of the U.S. Department of Defense from July 2016 to December 2017. Within the IEC modernization project, the system for communication with NPPs was replaced by modern technologies, power supply system was replaced (including repair of the standby power source, diesel generator), IEC computer equipment and software were updated, etc.

Establishment of a standby emergency center was not considered in this project.

Item 33. Implementation of a reactor pressure vessel external cooling system

Upon implementation of the C(I)SIP measure 'Analysis of the Strategy for Possible Corium Confinement within the Reactor Pressure Vessel' for WWER-440, new measure No. 31103 'Implementation of a Reactor Pressure Vessel External Cooling System' was introduced for RNPP-1,2. Technical specifications and a conceptual technical solution (CTS) were developed in the framework of this measure.

CTS No. 111-055-TR-RTs-1 'On Implementation of a Reactor Pressure Vessel External Cooling System for V-213 Units' was agreed with the SNRIU. A contract has been concluded with VUEZ a.s. for supply of a reactor pressure vessel external cooling system for RNPP-1,2 with supply deadline of 31 December 2020. According to the contract, the supplier undertakes, besides equipment supply, to develop and appropriately agree calculational and analytical justification for the modification, a safety analysis report for the modification and a working project on integration of the equipment into the plant design.

Schedule for RNPP-1,2: 2021.

Section 2. Status of Measures Identified upon Stress Tests at Chornobyl NPP

This Section provides information on the status of measures identified upon stress tests at Chornobyl NPP and presented in Table 1.2 of Part IV "Plan for Implementation of Safety Improvements" of the National Action Plan upon Stress-Test Results (2013).

All spent nuclear fuel of the Chornobyl NPP, including damaged one, is currently placed in the SFP of the interim spent fuel storage facility (ISF-1). Therefore, the main efforts of the operating organization are focused on implementation of safety improvement measures at ISF-1. The SNRIU agreed "Decision on Declaration of ChNPP Units 1, 2, 3 as Radioactive Waste Management Facilities in the Decommissioning Process" No. 6-OSE-2016 of 28 September 2016.

Item 1. Installation of an additional level control device in 1 (2) fuel assembly cooling pools-1, 2 for emergencies related to level water decrease below marks 19, 22

Completed (in 2012)

Additional control of water level to prevent its potential emergency decrease is ensured in the spent fuel pools of units 1 and 2.

Item 2. Calculation analysis of buildings of nuclear safety category 1 to determine safety margins and potential failures under loads induced by a tornado of class F 3.0

Completed (in 2016)

The ISF-1 building and overpass structures between the solid and liquid waste storage facility and ISF-1 were examined and certified in 2015. The defects revealed in structures were eliminated during 2016. Calculations of ISF-1 building and overpass structures between the solid and liquid waste storage facility and ISF-1 for a combination of loads including seismic events of 7 magnitudes (which is higher than SSE) and tornado of class F 3.0 have shown that the resistance of ISF-1 load-bearing structures under the above events will be ensured.

Item 3. Calculation analysis of buildings of nuclear safety category 1 to determine safety margins and potential failures under seismic loads

Completed (in 2013)

Calculations of ISF-1 structures related to nuclear safety category 1 testify that ISF-1 SFP civil structures can resist seismic events of 7 magnitudes (MSK-64 scale), while the safe shutdown earthquake for the ChNPP site is 6 magnitudes.

Item 4. Seismic resistance analysis of ISF-1 SFP lining

Completed (in 2013)

Calculations of ISF-1 SFP lining testify that it can resist seismic events of 7 magnitudes (MSK-64 scale), while the safe shutdown earthquake for the ChNPP site is 6 magnitudes.

Item 5. Analysis of stability and potential failures of VS-1 (ventilation stack for units 1 and 2) under SSE and tornado

Completed (in 2014)

Inspections and analyses of ventilation stack VS-1 justified its lifetime extension for 20 years as it will be able to resist a seismic event of 6 magnitudes (safe shutdown earthquake) and a tornado of class F 1.5. This is acceptable because units 1 and 2 are radwaste management facilities.

Item 6. Nuclear safety justification for the spent fuel pools of units 1, 2 with 250×110 mm arrangement of SFAs (as reserve for one ISF-1 compartment)

Completed (in 2012)

Nuclear safety justifications using the burnup credit approach for SFPs of units 1 and 2 allowed determining the arrangement of SFAs in SFPs of units 1 and 2 if emergency unloading of one of the ISF-1 SFP compartments is required.

Item 7. Justifying calculation of the maximum fuel cladding temperature taking into account potential radiological consequences from wet SFA storage

Completed (in 2013)

Additional analysis of fuel cladding cooling in ISF-1 storage conditions was carried out.

Item 8. Development of an action plan to improve the emergency preparedness system in case of beyond design-basis accidents caused by natural hazards, including emergency response measures in case of damage of the building and leakage of SFP

Completed (in 2012)

Emergency notification procedures and emergency response actions in case of potential structural collapse were improved.

Item 9. Amendment of the ChNPP accident and emergency response plan (32P-S) to improve emergency preparedness

Completed (in 2012)

Based on analysis of natural hazards, the ChNPP accident and emergency response plan was revised as appropriate.

Item 10. Development of measures on prompt access of emergency teams from Slavutych by alternative routes in case of damage of Slavutych–ChNPP railroad tracks caused by SSE

Completed (in 2012)

Procedure for delivery of emergency team personnel by motor vehicles from Slavutych to ChNPP (as alternative routes relative to railroad transport) was developed and implemented.

Item 11. Modernization of the ISF-1 radiation monitoring system to ensure neutron flux density monitoring

Completed (in 2012)

Neutron flux density monitoring (within the radiation monitoring system) is envisaged for process rooms and areas for management and storage of spent nuclear fuel.

Item 12. Additional radiation monitoring of exposure dose rate of the container car in ISF-1 during spent fuel transport

Completed (in 2012)

Additional detectors for monitoring of exposure dose rate were installed in the container car storage area in ISF-1 building.

Item 13. Replacement of the UDZhG-04R detector with an RWM-02 detector for the instrumentation channel for monitoring the activity concentration of service water after heat exchangers in ISF-1 spent fuel pools

Completed (in 2013)

Implementation of RWM-02 detector also provides for monitoring of radionuclide activity in service water supplied to ISF-1, thus allowing the contribution of ISF-1 to the total ChNPP discharges to be calculated.

Item 14. Power supply to ISF-1 essential equipment fed from mobile DG

Completed (in 2011)

The mobile DG is placed on the ChNPP site and is ready to be connected to ISF-1 in-house power supply system.

Item 15. Purchase of a new container car for SFA transport

Completed (in 2018).

A railroad container car was delivered to ChNPP for transport of packaging with spent nuclear fuel. Acceptance tests of the container car were performed. The packaging was certified.

Item 16. Revision of the ISF-1 safety improvement plan

Completed (in 2012)

The ISF-1 safety improvement plan was revised to remove measures that had been already completed and analyzed in the ISF-1 safety analysis report.

Item 17. Introduction of the topic "multiple failures of regular systems and equipment in severe weather conditions" into the 2012 training program for ChNPP staff of certain positions for detailed theoretical elaboration of the training scenario

Completed (in 2012)

Item 18. Introduction of the topic "multiple failures of regular systems and equipment in severe weather conditions" into the 2012 training program (Section 14) for practical exercise by staff of all shifts

Completed (in 2012)

Item 19. Psychological training of staff intended to increase resilience to psychological stress, develop self-control, composure and promote mutual aid and cooperation

Completed (in 2012)

Training on the psychology of actions in extreme situations was introduced on a systematic basis for relevant groups of personnel.

Item 20. Implementation of a system for psychological selection and training of individuals involved in severe accident management, similar to the system for selection of operating personnel

Completed (in 2012)

Psychological examination of emergency team leaders is underway.

Annex. National Action Plan upon Stress-Test Results (2017)