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WANO

REPORT
ON THE WANO MOSCOW CENTRE REGIONAL CRISIS CENTRE ACTIVITIES IN 2018

December 2018

LIMITED DISTRIBUTION

LIST OF ABBREVIATIONS

APNU		Automatics preventing unstable operation
ASP		Load sequencer
AWP	-	Automated workplace
AZ (EP)	-	Emergency protection
BBB		Backup bus bar
BN	-	Fast breeder reactor
BRU-A	-	Fast-acting steam dump valve to atmosphere
BSM		Fast power reduction
CPS		Control and protection system
DG		Diesel generator
EDE	-	Emergency drills and exercises
EGP	-	Heterogeneous loop-type power rector
IAEA	-	International Atomic Energy Agency
i.h.		In-house power
JSC	-	Joint stock company
MCL	-	Minimum controllable power level
MCP	-	Main circulation pump
NPP	-	Nuclear power plant
OO	-	Operating organisation (utility)
OPAS	-	Group for emergency support to nuclear power plants
SG	-	Steam generator
RBMK	-	Large-power channel-type reactor
RCC	-	Regional Crisis Centre
RCC FG	-	Functional group ensuring fulfilment of the Regional Crisis Centre functions
RF; RI	-	Reactor facility (installation)
ROM	-	Reactor power limiter system
SS	-	Safety system
SV	-	Stop valve
TG	-	Turbine generator

TSC	-	Technical Support Centre
VVER	-	Water-cooled, water-moderated power reactor
VNIIAES	-	Russian Scientific and Research Institute for Nuclear Power Plant Operation
URB (UPZ)		Fast power reduction system
WANO	-	World Association of Nuclear Operators
WANO-MC	-	Moscow Centre of the World Association of Nuclear Operators
ZZG		Phase-to-ground generator protection

CONTENTS

INTRODUCTION

This report has been prepared in keeping with Section 6 in the '2018 Action Plan of the WANO MC Regional Crisis Centre' [1].

The report discusses the key results of the Regional Crisis Centre operation in 2018 [1], in particular:

- the operation and provision of continued preparedness of the WANO MC RCC;
- elaboration of the RCC communication and data transfer lines with Level 3 RCC member OOs/NPPs (Belarus, Armenia);
- the updating of the RCC data bases on technical documentation, liaison officers, and emergency response resources intended for coping with emergency and mitigating accident consequences;
- the RCC actions undertaken together with other regional centres of the WANO;
- the results of the emergency drills and exercises conducted by the RCC member OOs/NPPs in 2018;
- the draft Action Plan for 2019.

1 General information and the RCC organisational structure

Starting with 2013, an effort has been under way to conclude bilateral agreements on the RCC participation between the WANO MC and the operating organisations.

As of December 2018, the WANO MC had 11 signed bilateral agreements on the RCC participation with the OOs/NPPs from Armenia, Bulgaria, Hungary, Iran, China, Russia, Slovakia, Ukraine, Finland, Czech Republic, and the Republic of Belarus (Fig. 1).

Categorization of the RCC participation levels is given in Attachment A.

1. Bulgaria (Kozloduy NPP) 2. Hungary (Paks NPP) 3. Slovakia (Slovenské Elektrárne) 4. Ukraine (NNEGC "Energoatom") 5. Finland (Fortum) 6. Czech Republic (CEZ)	1. Iran (NPPD) 2. China (JNPC, Tianwan NPP)	1. Armenia (Armenian NPP) 2. Russia (Rosenergoatom Concern, JSC) 3. Republic of Belarus (Belorussian NPP)
Level 1	*Level 2*	*Level 3*

Fig. 1 – Configuration of the bilateral agreements between the WANO MC and the RCC member OOs/NPPs

An effort is ongoing to conclude a bilateral cooperation agreement with the Kudankulam NPP (NPCIL, India).

The RCC member OOs operate nuclear units of the VVER, RBMK, BN, and EGP types. Fig.2 shows percentage of the nuclear unit types operated by the RCC member OOs. Most of the fleet are power units of the VVER-1000 and VVER-440 types. The current nuclear fleet may expand due to the construction and commissioning of mostly the VVER-1200, AES-2006 and VVER-TOI plants.

The number of the RCC member OOs /NPPs may increase if the bilateral agreements are signed for the Akkuyu (Turkey), El-Dabaa (Egypt), and Ruppur (Bangladesh) NPPs.

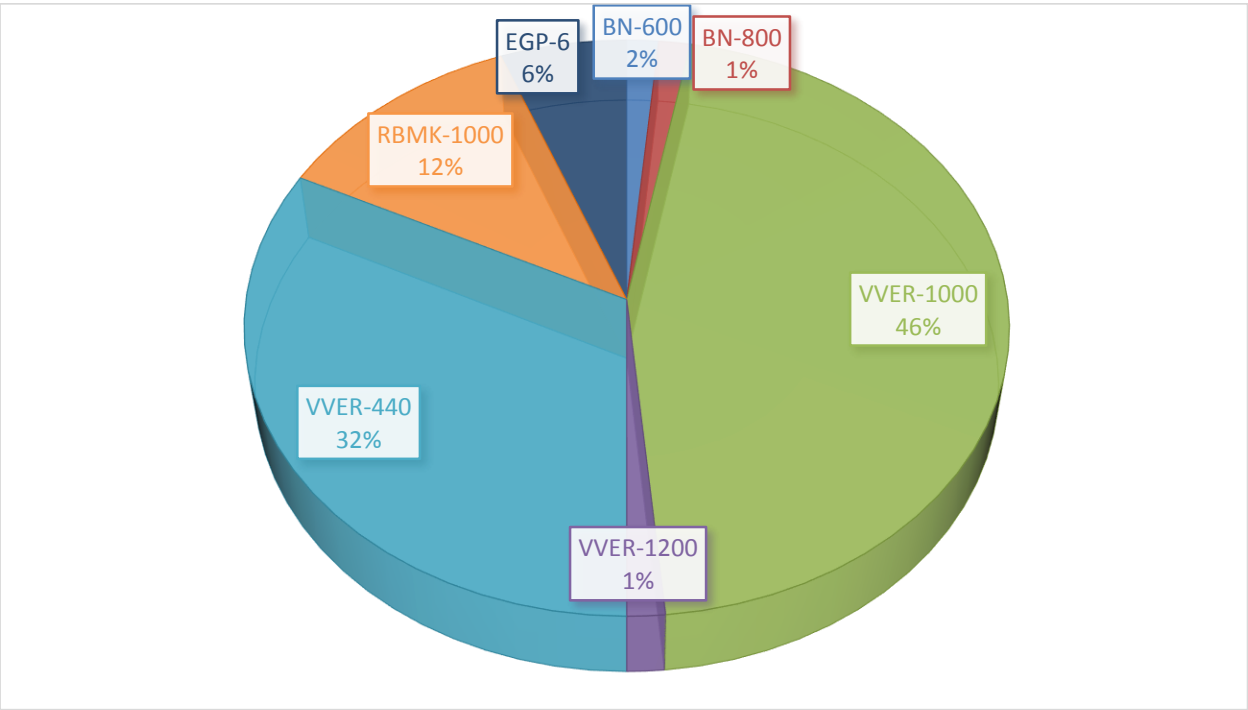

Fig. 2 – Nuclear fleet of the RCC member OOs/NPPs

2 The RCC operation

2.1 Reporting of NPP events

According to the 'Regulation on Information Exchange between Participants of the WANO Moscow Centre Regional Crisis Centre' [4], the following events should be reported to the Regional Crisis Centre:

- reactor scram;
- safety system actuation;
- safety system failure;
- degraded safe operation limits and/or conditions;
- loss of grid;
- extreme external events preventing normal operation of NPP;
- abnormal natural events;
- acts of terrorism;
  - NPP blockage by protesters;
  - fires and explosions at the NPP site;
  - other safety-significant events.

In 2018, the RCC received 38 reports on the safety-significant events. The list of the RCC NPP events reported to the Regional Crisis Centre in 2018 is given in Attachment B. The number of safety-significant events occurred at the RCC NPPs in 2014-2018 is shown in Fig. 3.

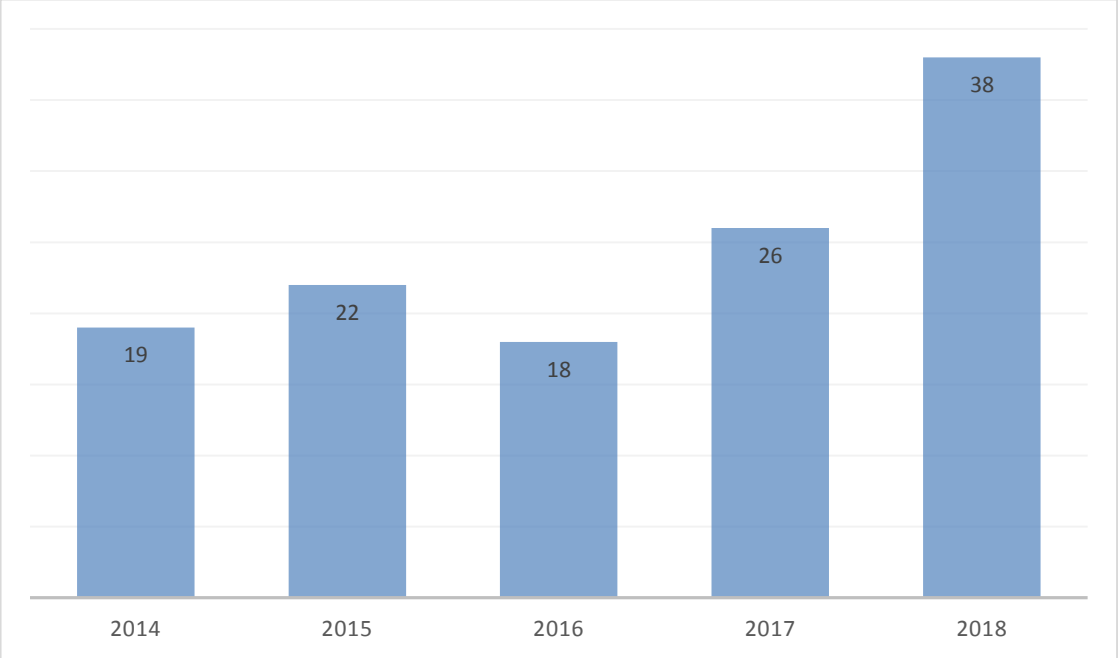

Fig. 3 – The number of the safety-significant events occurred at the RCC NPPs in 2014-2018

Thus, the total number of the safety-significant events at the RCC member OOs/NPPs occurred in 2018 exceeds that number in the period of 2014-2017. This actually points to the improvement in the information exchange (event reporting) between the OOs/NPPs and the RCC.

2.2 Maintenance of continued preparedness of the Regional Crisis Centre

Pursuant to the 'RCC Regulation' [3] and the 'Regulation on Information Exchange' [4], a procedure has been put in place to populate and update a data base on the liaison officers responsible for the RCC communication, including their e-mail addresses, phone and fax numbers. The access to this data base has been arranged for all RCC participant OOs/NPPs, via secured web resource at the official site of the WANO MC, at the following link: https://www.wanomc.ru/Secure/Programm/RCC/index.php.

The RCC operating experience in 2018 suggests that a key contributor to the improvement of the RCC performance is perfection of the RCC – OOs/NPPs communication and data transfer lines. The following relevant activities were conducted in 2018:

- weekly testing of the communication lines has been arranged as follows: every Monday, the RCC sends out a message on 'Weekly information about reported safety-significant events at the NPPs', and the RCC member OOs/NPPs acknowledge the receipt of the message;
- arrangements have been made to test videoconference communication in keeping with the schedule given in Table 1.

Table 1. Schedule for testing videoconference communication between the RCC and its OO/NPP participants

№	The OO/NPP participant of the RCC (country)	Time
1	Belarus NPP (Republic of Belarus)	Every first Friday of the month, at 10:30 Moscow time (MT)
2	Bushehr NPP (NPPD, Iran)	Every first Tuesday of the month, from 9.30 to 10:30 MT (from 10:00 to 11:00 local time)
3	NPPD (Iran)	Every first Monday of the month, from 10.00 to 11:00 MT (from 10:30 to 11:30 local time)
4	Tianwan NPP (JNPC, China)	Quarterly, on the first Thursday, from 10:00 to 11:00 Moscow time
5	Kozloduy NPP(Bulgaria)	Quarterly, on the first Friday, from 10:00 to 11:00 Moscow time
6	Paks NPP (Hungary)	Annually, before joint exercise of Paks NPP and RCC

- the effort was continued to arrange the communication and data transfer lines between the Armenian NPP and the RCC. Because of the delay in the commissioning of the on-site and off-site protected emergency response control points, the activities to connect the WANO MC RCC with the Belarus NPP will be implemented in the1st quarter of 2019;
- four emergency drills and exercises were conducted employing videoconferencing to communicate with the NPP stricken by simulated accident;
- during the emergency drills and exercises, the RCC and the Technical Support Centres communicated by way of videoconferencing, telephone and fax lines, and using the ftp server.

In 2018, the RCC together with the NPPD and the Bushehr NPP held a three-party videoconference. This is an evidence of the broad capabilities of the videoconference systems and of their robust performance.

As required by item 9 of the Minutes [2], the RCC Working Group members prepared and forwarded to the WANO MC the NPP information packages, including the description of the plant upgrades and the post-Fukushima equipment (Attachment C).

3 Emergency drills and exercises involving the RCC

One way of keeping the RCC continuously prepared for arranging information exchange is conduct of emergency drills and exercises. The emergency drills and exercises with the RCC participation allow practicing actions prescribed to the participants of the WANO Moscow Centre Regional Crisis Centre in the 'Regulation on Information Exchange' [2] when responding to a simulated accident at an NPP.

In 2018, the RCC took part in four emergency drills and exercises at the Rosenergoatom plants (Balakovo NPP, Kola NPP, and Leningrad NPP) and at nine plants of the member OOs /NPPs (Armenian NPP, Belarus NPP, Bushehr NPP, Kozloduy NPP, Loviisa NPP, Temelin NPP, Paks NPP, Zaporozhye NPP, and Mochovce NPP).

Noteworthy is that in 2018, the RCC FG had the first experience in sharing information during an emergency exercise at an RBMK plant. A multiunit accident was simulated in the emergency exercise at the Leningrad NPP on 25.12.2018, and the RCC FG translated and disseminated messages to the RCC participants in the format of the RCC OO /NPP templates.

In all, 49 emergency drills and exercises were held since the beginning of the RCC operation (Table 2).

In 2018, the first comprehensive emergency exercise with the RCC participation was successfully conducted at the Belarus NPP (on 03-04.10.2018). The exercise demonstrated the high proficiency of the staff responsible for the communication with the RCC, both in the stage of exercise preparation and during the information exchange itself.

Review of the data pertaining to the number of the emergency drills and exercises (EDE) at the nuclear plants with the RCC participation has shown that:

– no EDE with the RCC involvement have been conducted at the Bohunice NPP (Slovakia), Khmelnitsky and Yuzhno-Ukrainsk NPPs (Ukraine), Beloyarsk, Bilibino, Kursk and

Smolensk NPPs (Russia);

– despite the expansion of the RCC information exchange in 2017 to include the BN, RBMK and EGP plants, so far there have be no EDE with the RCC participation at the BN and EGP NPPs;

– despite the high proficiency of the staff responsible for the communication with the RCC, and in particular, for arranging the information exchange during EDE, there remain areas in need of improvement. In particular, these areas include 'Correct filling of information exchange templates and sequence of their transmission to the RCC', 'Use of valid templates', and the RCC participant confirmation of the receipt of the RCC information exchange templates during the EDE with the RCC participation (Table 3). The EDE with the RCC participation conducted at the Temelin NPP on 10.04.2018 was not appraised.

Table 2 – Number of EDE at the RCC member OOs/NPPs in 2013 - 2018

NPP	Number of EDE with RCC participation					
	2013	2014	2015	2016	2017	2018
Armenian				1	1	1
Bushehr				1	1	1
Dukovany			1		1	
Kozloduy		1		1	1	1
Loviisa	1	1		1	1	1
Mochovce		1	1			1
Paks			1	1	1	1
Temelin				1		1
Tianwan			1		1	
Balakovo			1	1	1	2
Belarus					1	1
Zaporozhye						1
Kalinin	1		1		1	
Kola		1			1	1
Novovoronezh			1		1	
Rivne					1	
Rostov			1	1	1	
Leningrad						1

Table 3 – Summary table of the results of the bilateral appraisals of the EDE with the RCC participation

Criterion/EDE	Armenian NPP 13.03	Loviisa 29.05	Paks 25.09	Bushehr 03.10	Belarus NPP 04.10	Zaporozhye NPP 14.11	Mochovce 22.11	Kozloduy 29.11
Adherence to the timeframe of forwarding messages to the RCC in accordance with the 'Regulation on Information Exchange'	SAT	SAT	SAT	SAT	SAT	SAT	SAT	SAT
The correctness of filling the information exchange templates and sequence of their submission to the RCC	NOF	NOF	NOF	SAT	SAT	NOF	SAT	SAT
The number of messages received and transmitted to the RCC	NOF	SAT	SAT	SAT	SAT	NOF	NOF	SAT
Data adequacy to enable understanding of the current situation at the NPP	NOF	SAT	SAT	SAT	SAT	SAT	SAT	SAT
Assessment of the correctness of the initial event description against the exercise scenario	SAT	SAT	NOF	SAT	SAT	SAT	SAT	SAT
Use of valid templates	NOF	NOF	NOF	SAT	NOF	SAT	SAT	SAT
Arrangement of the communication in the framework of drills and exercises (audio / video conferencing, e-mail, ftp - server)	NOF	SAT	SAT	NOF	SAT	SAT	SAT	SAT
Availability of backup communication lines	SAT	SAT	SAT	SAT	SAT	SAT	SAT	SAT
Provision of expert / advisory scientific and technical support to the affected OO/NPP	SAT	NOT	NOT	SAT	SAT	NOT	NOT	NOT
Provision of emergency response resources of the RCC members (human and materiel)	SAT	NOT	NOT	NOT	SAT	NOT	NOT	NOT
Confirmation of message receipt to the RCC	SAT	NOF	NOT	SAT	SAT	SAT	SAT	SAT

The results of all emergency drills and exercises with the RCC involvement were captured in relevant reports that have been posted at the WANO MC member web site together with the EDE participants commentary.

The review of the entire package of the emergency drills and exercises held in 2018 with the RCC participation, delivered the following positive findings:

- the information exchange between the OOs/NPPs, TSCs and the RCC, which is a key component in generating a shared information space for all RCC participants, has improved;
- the interaction between the OPAS group, TSCs, RCC and OOs/NPPs in the process of providing expert assistance to the nuclear plants has become faster and better coordinated;
- there have been almost no malfunctions of the communication means and data transfer lines.

During two RCC exercises – with the Bushehr NPP (Iran) on October 3rd and the Kozloduy NPP (Bulgaria) on November 20th, and during one exercise outside the MC scope – with the Diablo Canyon NPP (USA) on September 19th, 2018, the WANO MC practiced the information exchange with the WANO London Office, in keeping with the WANO Programme Guideline WPG15 'Emergency Response Support'. The purpose of the Guideline is to ensure the nuclear industry capability to provide consolidated and comprehensive support (i.e. share knowledge and technical expertise) to an event-stricken member to cope with a significant nuclear event and mitigate its consequences. The document also provides guidance on the communication protocols that should be established by the WANO members, Regional Centres and LO to facilitate the flow of information during emergency. After a simulated 'Site Emergency' was declared, appropriate notifications were sent to the WANO London Centre. These notifications, and later updates on the progression of the simulated accident, were transferred, via the London Office, to all WANO Regional Centres. Also, in accordance with the WPG 15 Guideline, the reports were forwarded to the IAEA and WNA (World Nuclear Association).

Pursuant to item 14 in [2], all OOs/NPPs were to provide information about the emergency drills and exercises conducted with and without the RCC participation. The RCC received this information from the Temelin NPP, Dukovany NPP, Kozloduy NPP, Paks NPP, Armenian NPP, Belarus NPP, Bushehr NPP, Tianwan NPP, Mochovce NPP and Bohunice NPP.

In 2018, the ratio of the number of EDE conducted with the participation of the RCC, to the number of EDE without the RCC participation was about 7%. This fact suggests that the RCC participants

have boosted their activities in the area of emergency preparedness and response.

Other OOs/NPPs – RCC participants did not provide information about their emergency drills and exercises. Meanwhile, all OOs/NPPs were advised of the initiation, progression and confinement of the accidents simulated in the emergency drills and exercises conducted with the RCC participation.

The key activity to be practiced in 2019 emergency drills and exercises is communication of events at the RBMK, BN and EGP plants to the RCC member OOs/NPPs, in keeping with document [4].

4 Implementation of the activities pertaining to the RCC operation

The list of the RCC-related activities conducted by the RCC member OOs/NPPs is given in Table 3.

Table 3- List of RCC-related activities

№	Date	Description	Participants
1	26.02-02.03.2018	Working meeting to share experience in the area of emergency planning and emergency preparedness. The experience gained will provide input to prepare and conduct emergency drills and exercises at the Belarus NPP, develop the "Action Plan for Protection of the Belarus NPP Personnel", arrange on-site and off-site emergency centre activities, organise training of emergency rescue units, and improve personnel skills in the confinement and coping with emergencies.	Kozloduy NPP, Belarus NPP
2	25-27.07.2018	Working meeting to share experience in the emergency planning and emergency preparedness.	Energoatom-Ukraine, Kozloduy NPP
3	2018	A new job position of the RCC liaison officer has been added to the Emergency Response Centre staff (one officer for each NPP - Dukovany and Temelin).	Dukovany NPP; Temelin NPP (CEZ), RCC
4	28.09.2018	Participation in a business game under the leadership of the Ministry of Emergency Management of the Republic of Belarus, which allowed testing various communication systems, routes and lines between the state organisations within the crisis centres system of the Republic of Belarus and the WANO Moscow Centre. The outcome of the participation in the business game was the practical confirmation of the previously adopted and approved information transfer algorithms (in accordance with the information transfer algorithms agreed by the Ministry of Emergency Management of the Republic of Belarus).	Belarus NPP
5	2018	Arrangement of comprehensive exercises in conjunction with relevant off-site organisations.	Bushehr NPP

5 The 14th meeting of the RCC Working Group and the draft Action Plan for 2019

When asked by the RCC to suggest themes for discussion at the fourteenth meeting of the RCC Working Group in 2019, the OOs/NPPs proposed the following topics:

a) the WANO website preparedness for publishing emergency reports (as per PCD 2016-01);

b) reporting on the receipt of communications as part of the information exchange during EDE with the RCC participation;

c) participation of the RCC OO/NPP representatives as observers in the National Exercise 'Protection 2019' at the Kozloduy NPP;

d) the schedule of the EDE with the RCC participation, containing the EDE themes, dates and time of conduct;

e) assessment and metrics of the OO/NPP emergency preparedness;

f) from the Bushehr NPP:

- arrangement, installation and maintenance of satellite communication systems based on the crisis centres. Alternative technologies and solutions used in other countries;
- development and use of interactive software for personnel training in the crisis centres;
- best international practices for the communication between emergency response organisations, and for the public notification in case of an accident.

The draft RCC Action Plan for 2019 is given in Attachment D.

CONCLUSION

In conclusion, it should be underlined that the principal activities included in the RCC 2018 Action Plan [1] have been fulfilled.

The RCC 2018 highlights include:

- a greater number of emergency drills and exercises conducted with the RCC participation. In 2018, the RCC participated in four emergency drills and exercises at Rosenergoatom's plants and in nine EDE at the plants of other RCC member OOs/NPPs;
- practicing the WANO MC – WANO London Office communication procedures and guidelines under the WANO Project 'Emergency Response Support' during the EDE at the Bushehr NPP (Iran), Kozloduy NPP (Bulgaria), and Diablo Canyon NPP (USA);
- translation into Russian of the information packages submitted in English to the RCC technical library for the following RCC member NPPs:
  - Kozloduy NPP (Bulgaria);
  - Paks NPP (Hungary);
  - Bushehr NPP (Iran);
  - Bohunice NPP and Mochovce NPP (Slovenské Elektrárne, Slovakia);
  - Dukovany NPP and Temelin NPP (CEZ, Czech Republic).

The main areas for further improvement of the Regional Crisis Centre activities are the need to:

- practice procedures for reporting events at the RBMK, BN and EGP plants to the RCC member OOs/NPPs, in keeping with the Ref. [4];
- conduct at least one emergency drill at each OO/NPP;
- arrange videoconferencing between the RCC and the OOs/NPPs.

The review of the RCC activities in 2018 has revealed robust performance of the WANO MC Regional Crisis Centre over the year, in particular, as regards expert / consultancy support to the OOs/NPPs.

REFERENCES

1. 2018 Action Plan of the Regional Crisis Centre (RCC).
2. Minutes of the RCC Working Group Meeting №13.
3. Regulation on Information Exchange between Participants of the WANO Moscow Centre Regional Crisis Centre.
4. Regulation on the Operation of the WANO Moscow Centre Regional Crisis Centre.
5. Regulation on the WANO Moscow Centre's Regional Crisis Centre.

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ATTACHMENT A

Levels of OOs/NPPs participation in the RCC

Level 1: Receiving OO/NPP notification on site area emergency or general site emergency; dissemination of information received and of other important facts to all other RCC participants; continued (every four hours) update of the RCC members on emergency progression at the affected NPP. The information is to be sent by e-mail, and, if necessary, to be confirmed by a phone call.

Level 2: Provision of conditions to enable scientific and engineering support to OO/NPP in case of site area emergency or general site emergency, including consultations, analytical evaluations and expert assistance. The communication channels include video and audio conferences, e-mail and other pre-agreed data transfer lines.

Level 3: Maintenance of sustained availability of data transfer lines and communication between the OOs/NPPs and the RCC; documentation transfer to the RCC technical archive, and on-line information transfer to the RCC. In case of site area emergency or general site emergency, the affected OO/NPP should communicate to the RCC any information related to the site area emergency or general site emergency, update this information every four hours, and request expert / consultancy assistance and/or technical support that should be provided in a full scope.

ATTACHMENT B

Events reported to the Regional Crisis Centre and disseminated to the RCC participants in 2018

№	NPP-Unit number, country	Date (dissemination)	Outline
1	Kalinin-2, Russia	02.01	Disconnection from the grid due to the damage to generator internals. BRU-A actuation in the transient.
2	Khmelnitsky-2, Ukraine	03.01	Disconnection from the grid to eliminate the medium leakage in the sealing surface of the control rod drive. The reactor was brought into a subcritical state.
3	Dukovany NPP-2 Czech Republic	28.12 (05.01)	The diesel generator 2QX tripped following the successful testing of load sequencer. Due to the long repair time of the diesel generator, Unit 2 was disconnected from the grid in compliance with the limits and conditions of safe operation. The diesel generator was repaired by now, its testing was successful, and the Unit is in the process of a start-up.
4	Rivne-2, Ukraine	19.01	Disconnection from the grid due to the AZ-1 activation during routine testing of reactor emergency protection, caused by a malfunction of the 2nd protection suite interlock.
5	Rostov-1, Russia	31.01	Turbogenerator disconnected from the grid by the 'Differential protection of in-house transformer №1'. The 6 kV in-house sections were switched to backup power. The reactor was unloaded to Nr = 35% by the fast power reduction system (UPZ) and the power limiter system (ROM). The causes are under investigation.
6	Kursk-4, Russia	18.02	A short circuit inside the in-house transformer 28T tank (TRNDS 63000/35) led to the disconnection of the transformers 28T and the unit transformer 6T by electrical relay protection and to the Unit disconnection from the grid, with actuation of the fast reactor power reduction system. The fire extinguishing automatics went off. No ignition was detected. The Unit is under an unplanned outage.
7	Kalinin-2, Russia	23.02	The turbogenerator of Unit 2 was disconnected from the grid by the secondary circuit process protection for high level in the condenser. Actuation of the reactor power reduction system; in a transition mode, actuation of the BRU-K and BRU-A. The causes are under investigation.
8	Rostov-4, Russia	07.03	Turbine trip by protection with vacuum break. The opening of the BRU-A 4TX50-80S05. Activation of regular alarms at the Main Control Room - 4 and the Emergency Shutdown Panel-4. The cause of the turbine trip is under investigation.
9	Armenian-2, Armenia	26.03	Oil leak from hydraulic shock absorber. Unit 2 was shut down to eliminate the leakage.
10	Rostov-1, Russia	28.03	The TG-1 was disconnected from the grid by 500 kV breakers V-10 and V-11, upon spurious actuation of automatics preventing unstable operation, due to the erroneous actions of electrical personnel during conduct of programme activities. The thermal power of the Unit was reduced by power limiter (ROM) to N_{th} = 40% N_{nom}. The BRU-A triggered. The cause is under investigation.
11	Khmelnitsky-1, Ukraine	03.04	At 15:02 on 03/04/18, Unit 1 of the KhNPP was disconnected from the grid by phase-to-ground circuit protection for generator stator coil.
12	Zaporozhye-6, Ukraine	08.04	Disconnection from the grid by automatic operation of the reactor emergency protection upon the trip of both turbine feedwater pumps.
13	Leningrad-3, Russia	01.06	Loss of power on the backup bus bar due to the trip of the backup transformer 3TR. The DG-5AB and 6AB started up according to the design algorithm without any problems. The cause for the disabling of the backup transformer 3TR is under investigation. The backup bus bars are powered from the transformer 4TR.

№	NPP-Unit number, country	Date (dissemination)	Outline
14	Khmelnitsky-2, Ukraine	08.06 (14.06)	Disconnection from the grid due to a spurious protection actuation of the KAG-24 generator circuit breaker. The reactor was automatically unloaded to 40% of N_{nom} by the fast power reduction system (UPZ) and the power limiter system (ROM). The interlocks and protections operated as designed. The causes are under investigation.
15	Yuzhno-Ukrainsk-2, Ukraine	14.06	Unloading and disconnection from the grid of Unit 2 due to the high temperature of the TG-2 bearing No. 12.
16	Kalinin-3, Russia	16.06	Detected signs of primary coolant leakage (more than 2 m^3/h feed-and-bleed mismatch in the primary circuit). The Unit unloading started upon urgent request, to identify and eliminate leakage in the primary pipeline.
17	Kozloduy-6, Bulgaria	28.06	During the testing of load sequencer in the 3rd train of safety system, the 6 BX breaker at Unit 6 failed to start up in cell No. 15. On 28.06.2018 at 09:55, the 1st load sequencer programme was activated. At the 15th second after loss of power, the DG 6GX started up, and the DG breaker failed to switch on to section 6BX. The DG 6GX breaker was replaced with a non-faulty one at 10:40.
18	Temelin-1, Czech Republic	03.07 (04.07)	The service water pump for essential consumers 1VF30D02 failed to provide adequate water supply during the load sequencer testing in the 3rd train of the safety systems at Unit 1. The 3rd train of all safety systems was taken out of operation. The identified cause was jamming of valve 1VF30S17 at the outlet of the pump 1VF30D02 (the valve got stuck during the load sequencer testing). The 3rd train of the service water for essential consumers was taken out of operation for valve repair / replacement. The estimated time of the 3rd train repair was no more than 48 hours.
19	Rivne-2, Ukraine	16.07	TG-4 disconnection from the grid by protection against damage to generator internals. Unit 2 was unloaded to 52% of N_{th}, with TG-3 remaining on load with N_e = 210 MW. The exact cause of the TG-4 trip is under investigation.
20	Kursk-2, Russia	02.08	The mode of fast power reduction (‘BSM’). The reactor was shut down, and the personnel switched off the sole running TG-4 due to a leak in the manhole in the automatic turbine control and protection system. The operation of the first protection suite 2TR under transient upon self-actuation of auxiliary machinery; switch-off of 2TR, start-up of DGs 6, 7, and 8 in sections 3RNB, 4RNA, 4RNB according to the design algorithm.
21	Kursk-4, Russia	19.08 (20.08)	Actuation of emergency protection (‘AZ’), fast power reduction (‘BSM’) upon high pressure in the reinforced leaktight compartment in the right half of the forced circulation circuit. The cause is under investigation.
22	Kalinin-2, Russia	06.09 (08.09)	During a comprehensive testing of the 1st train of safety system, after disconnection of the DG 2GV loads, the DG tripped by the high-temperature protection for the 1st bearing. The causes are under investigation.
23	Khmelnitsky-2, Ukraine	17.09	In the process of taking out of service the backup power supply bus JBP and the cells 22-24 in section 2VR for maintenance in accordance with the standard line-up checklist, the backup in-house transformers switched off with the resultant loss of power at all 6 kV in-house sections. Two backup diesel generators 1,3 (1 and 3 SS; the 2nd SS under maintenance) and ORDES-1,2 started up upon the loss-of-power’ signal. The DGs picked up the loads and connected to the section as designed. Once the cause was identified, the power supply to Unit 2 loads was restored. The 6kV in-house sections were linked to the standard power routes at 2:10.

№	NPP-Unit number, country	Date (dissemination)	Outline
24	Zaporozhye-2, Ukraine	23.09	The power unit was unloaded and disconnected from the grid for repair to eliminate a weld hole at the D_{eq} 57 mm pipeline in the MCP-3 self-contained loop. The reactor facility was unloaded to the minimum controllable level.
25	Balakovo-2, Russia	24.09	The actuation of emergency protection for the 1st and 2nd suites during load pickup at Unit 2 due to the loss of power supply to the CPS.
26	Rostov-2, Russia	14.10	The Unit load was reduced to N_e = 600 MW (N_{th} = 60% of N_{nom}) by the power limiter (ROM) and regular controllers. The cause of the unloading was the trip of the circulation pump '2CN-1' by protection for the thrust bearing temperature over 80°C.
27	Kursk-3, Russia	16.10	Reactor brought into a subcritical state by personnel using the fast power reduction ('BSM') button. The cause was the vapour in the reactor hall at Unit 3.
28	Yuzhno-Ukrainsk-3, Ukraine	17.10 (18.10)	Grid frequency controller moved from mode 1 to mode 3. Upon pressure increase in secondary circuit, the automatic reactor power controller moved from the reactor power control mode to control of secondary circuit pressure. This triggered automatic unloading of the Unit. The turbine stop valves closed due to the action of the process protection for secondary circuit pressure below 52 kgf/cm^2. The turbo generator was disconnected from the grid. Reactor parameters were stabilized at the reactor power level N_r= 5% N_{nom}, t_{av} = 278.2°C, $P_{1/2c}$ = 160/61 kgf/cm^2.
29	Kola-4, Russia	18.10	The diesel generator 4QW failed to start during the planned testing of the 2nd train of the emergency power supply system. The causes are under investigation.
30	Zaporozhye-4, Ukraine	18.10 (19.10)	Spurious actuation of emergency protection ('AZ') upon SG-1 level decrease, due to unstable operation of the SG-1 level measurement lines.
31	Zaporozhye-4, Ukraine	23.10	Diesel generator 2 (DG-2) unexpectedly switched off during the test
32	Leningrad-2-1, Russia	27.10	Actuation of reactor emergency protection ('AZ') upon low voltage in 10kV in-house sections due to a short circuit on the complete generator switch 10VAC10, with the unit transformer 10VAT10 disconnected by differential protection. The Unit is in a hot shutdown state. The causes are under investigation.
33	Leningrad-2-1, Russia	(20.11) 21.11	Actuation of the reactor emergency protection ('AZ') due to the SG-1 level drop to the AZ '- 650' setpoint. The reactor was brought into a subcritical state. The Unit is in a hot shutdown state. The causes are under investigation.
34	Mochovce-1, Slovakia	(20.11) 23.11	Following the Unit Shift Supervisor decision, the reactor was tripped at 21:35. The direct cause was electronic card failure in the second train of safety system.
35	Khmelnitsky-1, Ukraine	25.11 (26.11)	During the scheduled Unit shutdown for overhaul, the SG-2 level increased due to an unstable operation of the 1RQ50S02 controller. The TG stop valves closed upon the SG-2 level increase, and the Unit was disconnected from the grid. The power limiter (ROM) operated upon the closure of the TG stop valves.
36	Leningrad-1-2, Russia	12.12	The 2DG-2 was tripped by protection during planned testing. The cause is under investigation.
37	Khmelnitsky-2, Ukraine	13.12	The Unit was disconnected from the grid by the phase-to-ground generator protection 'ZZG-1'. The reactor was unloaded to the level of in-house demand. The 2VT transformer was found to have damage in the TG excitation system circuit.
38	Rivne-1, Ukraine	22.12	The emergency protection of the reactor triggered at Unit 1 upon signal of 2.8 kgf/cm^2 pressure differential in the reactor core, due to its spurious generation. The reactor was brought into a subcritical state. The causes are under investigation.

ATTACHMENT C

List of the OO/NPP upgrades including the post-Fukushima equipment

In keeping with the minutes of the RCC Working Group meeting № 13 [2], all OOs/NPPs were asked to send to the WANO MC information about the upgrades they had implemented, including the post-Fukushima equipment. The information received from the OOs/NPPs is given in Table C.1.

Table C.1 – Information about the upgrades at the OOs/NPPs, including:

Country	Plant	Implemented upgrades
Bulgaria	Kozloduy NPP	Seismic-resistant garages were put into operation to protect mobile diesel generators under severe weather conditions.
Hungary	Paks NPP	Upgrading of the Emergency Response Centre has been completed (in keeping with the action plan based on the stress-test results).
Slovakia	Mochovce NPP	Seismic resistance of the Emergency Response Centre has been reinforced
Slovakia	Bohunice NPP	SAM (Serverless application model) parameters and signals were added to the prediction and diagnostic source term evaluation software ESTE, which is used to tackle emergency response tasks.
China	Tianwan NPP	An operational support centre was set up on the basis of the old crisis centre, and is used as a remote collection point for shift personnel. A new Crisis Centre was built and put into operation.
Iran	Bushehr NPP	The old video camera used for video conferencing was replaced with a new one that provides image capture in three directions. An automated data transmission was arranged to send plant process parameters (temperature, pressure, etc.) to the Crisis Centre.

ATTACHMENT D

The WANO-MC Regional Crisis Centre (RCC) Action Plan for 2019

№	Activity	Timeframe	Owner	Comments
	1. Organisational activities, improvement of the RCC operation. The RCC documentation			
1.1	Conclude a bilateral Agreement between the RCC and the Kudankulam NPP (NPCIL, India)	in 2019	WANO MC, Kudankulam NPP (NPCIL, India)	
1.2	Meeting of the RCC Working Group	25-26.06.2019	WANO MC, REA, OO/NPP	
1.3	Develop the WANO MC RCC Action Plan for 2020	01.12.2019	WANO MC, OO/NPP, REA	
	2. The RCC operation			
2.1	Arrangement of the RCC operation in compliance with the RCC Statute, the RCC Regulation on Information Exchange, and the Regulation on the RCC Operation: – immediately report to the RCC general site emergency / site area emergency; – send to the RCC information about process and radiological parameters in case of general site emergency / site area emergency; – send to the RCC information about safety-significant events at an NPP; – test communication lines; – test communication with the RCC liaison officers; – test communication with national expert organisations and individual experts; – send the RCC data bases to the OOs/NPPs; – send the RCC communications, etc.	Continuously, as prescribed by the RCC documents	WANO MC, REA, OO/NPP, RCC	
2.2	Update the RCC data bases and send them to the WANO MC (RCC templates 1a, 1b, 1c, 1d, 1e) and templates 6-2, 6-3	31.01.2019	OO/NPP	
2.3	Produce the RCC data bases (RCC templates 1a, 1b, 1c, 1d, 1e) and templates 6-2, 6-3	28.02.2019	RCC	
	3. Communication lines, software and hardware			
3.1	Activities to arrange the communication and data transfer to the RCC from the Armenian NPP	In 2019	REA and Armenian NPP	
3.1.1	Provide equipment for the satellite communication project	December of 2019	Armenian NPP	

№	Activity	Timeframe	Owner	Comments
3.1.2	Conduct for the Armenian NPP a Technical Support Mission on arrangement of satellite communication (if necessary)	In 2019	WANO MC	
3.2	Fulfil recommendations concerning the improvement of the communication with the RCC and arrangement of the communication lines between the Belarus NPP and the RCC (outcome of the WANO MC Technical Support Mission at the Belarus NPP in October of 2016)	In 2019	REA and Belarus NPP	Communication channels are to be introduced by the commissioning of the on-site and off-site protected emergency response control points (crisis centers)
3.3	Arrange regular testing of videoconference communication with the OOs/NPPs under the third and second levels of the RCC participation, and optionally, under the first level.	During the year, under separate schedule	REA, WANO MC, OO/NPP	
	4. The RCC infrastructure			
4.1	The RCC technical documentation library: – submit technical documentation to the RCC (in Russian or in English), in compliance with the agreed list; – report changes in the OO/NPP technical documentation, and update the documentation kept in the RCC library in hard and soft copies; – translate into Russian the technical documentation submitted by the OOs/NPPs in English	In 2019 Upon receipt Upon receipt	Energoatom, Belarus NPP, RCC Armenian NPP, NPPD, JNPC, RCC REA, WANO MC, Armenian NPP, NPPD, JNPC	
	5. Drills and exercises			
5.1	The RCC FG participation as part of the OPAS team in the emergency drills and exercises conducted by Rosenergoatom (Russia)	According to the REA drills and exercises schedule	REA, WANO MC, RCC, OO/NPP	
5.2	Emergency drill/exercise at the Dukovany NPP (Czech Republic): – develop programme for the RCC participation in the international exercise; – the RCC participation in the exercise; – review results of the RCC participation in the exercise; prepare proposals based on the participation experience.	April May, 16 June	Dukovany NPP, RCC Dukovany NPP, RCC, OO/NPP RCC, OO/NPP	

№	Activity	Timeframe	Owner	Comments
5.3	Emergency drill/exercise at the Bushehr NPP (Iran): – develop programme for the RCC participation in the drill; – the RCC participation in the drill; – review results of the RCC participation in the drill; prepare proposals based on the participation experience.	April May, 17 June	Bushehr NPP, RCC Bushehr NPP, RCC, OO/NPP RCC, OO/NPP	
5.4	Emergency drill/exercise at the Armenian NPP (Armenia): – develop programme for the RCC participation in the drill; – the RCC participation in the drill; – review results of the RCC participation in the drill; prepare proposals based on the participation experience.	June July August	Armenian NPP, RCC Armenian NPP, RCC, OO/NPP RCC, OO/NPP	With WANO participation
5.5	Emergency drill/exercise at the Belarus NPP (Republic of Belarus): – develop programme for the RCC participation in the drill; – the RCC participation in the drill; – review results of the RCC participation in the drill; prepare proposals based on the participation experience.	September October, 10 November	Belarus NPP, RCC Belarus NPP, RCC, OO/NPP RCC, OO/NPP	
5.6	Emergency drill/exercise at the Mochovce NPP (Slovakia): – develop programme for the RCC participation in the international exercise; – the RCC participation in the exercise; – review results of the RCC participation in the exercise; prepare proposals based on the participation experience.	September October, 30 November	Mochovce NPP, RCC Mochovce NPP, RCC, OO/NPP RCC, OO/NPP	
5.7	Emergency drill/exercise at the Khmelnitsky NPP (Ukraine): – develop programme for the RCC participation in the drill; – the RCC participation in the drill; – review results of the RCC participation in the drill; prepare proposals based on the participation experience.	October November, 6-7 December	Energoatom, RCC Energoatom, RCC, OO/NPP RCC, OO/NPP	
5.8	Emergency drill/exercise at the Loviisa NPP (Finland): – develop programme for the RCC participation in the drill; – the RCC participation in the drill; – review results of the RCC participation in the drill; prepare proposals based on the participation experience.	October November December	Loviisa NPP, RCC Loviisa NPP, RCC, OO/NPP RCC, OO/NPP	With WANO participation

№	Activity	Timeframe	Owner	Comments
5.9	Emergency drill/exercise at the Kozloduy NPP (Bulgaria): – develop programme for the RCC participation in the international exercise; – the RCC participation in the exercise; – review results of the RCC participation in the exercise; prepare proposals based on the participation experience.	October - November To be defined	Kozloduy NPP, RCC Kozloduy NPP, RCC, OO/NPP RCC, OO/NPP	
5.10	Emergency drill/exercise at the Paks NPP (Hungary): – develop programme for the RCC participation in the international exercise; – the RCC participation in the exercise; – review results of the RCC participation in the exercise; prepare proposals based on the participation experience.	To be defined	Paks NPP, RCC Paks NPP, RCC, OO/NPP RCC, OO/NPP	
5.11	Conduct a long (2-4 days) open date emergency exercise with one of the RCC member NPPs	In 2019	REA, WANO MC, OO/NPP	
5.12	The RCC participation in the EPR exercises/drills with a simulated event at a WANO NPP (with unknown scenario and unannounced)	Totally 6 EDE in 2019	RCC	
5.13	Participation of the RCC members as observers in the national EPR exercise ‘Protection-2019’ at the Kozloduy NPP	The IVth quarter	Kozloduy NPP, WANO MC, OO/NPP	
	6. The RCC report for 2019			
6.1	Development of a draft 2019 RCC report	15.11.2019	WANO MC, REA	
6.2	Discussion of the draft 2019 RCC report	01.12.2019	WANO MC, OOs/NPPs	
6.3	Development of the final version of the 2019 RCC report to be submitted to the WANO-MC GB meeting	15.12.2019	WANO MC	

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