20 лет РОСЭНЕРГОАТОМ

ОАО «Российский концерн по производству электрической и тепловой энергии на атомных станциях»

Realization of compensatory measures at JSC "Concern Rosenergoatom" NPPs after accident at Fukushima NPP

Reported by:

Deputy Director General –

Director for Production and NPPs Operation

JSC "Concern Rosenergoatom"

A.V. Shutikov

23-25 May 2012, Moscow

Impact of accidents on the concept of nuclear safety ensuring

Accident in Three Mile Island, USA, March 1979

- Reactor core destruction
- Partial meltdown of fuel
- Radioactive substances are mainly inside
- Leak of radioactive water to NPP site

Chernobyl accident, USSR, April 1986

- Severe destruction of reactor core
- Meltdown of fuel
- Contamination of large areas with radioactive substances
- Long-term negative impact on people health
- Psychological impact on society (public)

Nuclear community response

1. Revision of human factor role
2. Implementation of PSA
3. Safety systems improvement
4. Emergency planning enhancement

1. Change of approach to regulation of nuclear safety and NPP designing
2. Creation of international conditions of nuclear safety (Nuclear safety convention)
3. Development of new principles of safety
4. Introduction of safety culture concept
5. Implementation of new level of protection: Accident Management

Safety fundamentals

LEGISLATION

- Federal laws (responsibility principles)
- Codes and standards
- Availability of national authorization system (independent regulation)

SAFETY CULTURE

- Prioritization
- Human factor

Knowledge base about processes and occurrences

TECHNOLOGY (technical provisions for safety)

Defense-in-depth principle

- Multiplicity of safety barriers
- Multiplicity of levels of safety barriers:
  - preventable accidents
  - mitigation of consequences (accident management)

Purpose: prevention of hazardous radiation exposure to individuals and environment due to accidents

Three main technical functions of NUCLEAR SAFETY achievement

- **Maintaining of control over chain nuclear fission reaction**
- **Heat removal from nuclear fuel**
- **Retention of radioactive substances within barriers**

Two main principles of functions realization

- **Principle of accident prevention**
- **Principle of accident mitigation**

Lessons learned from Chernobyl

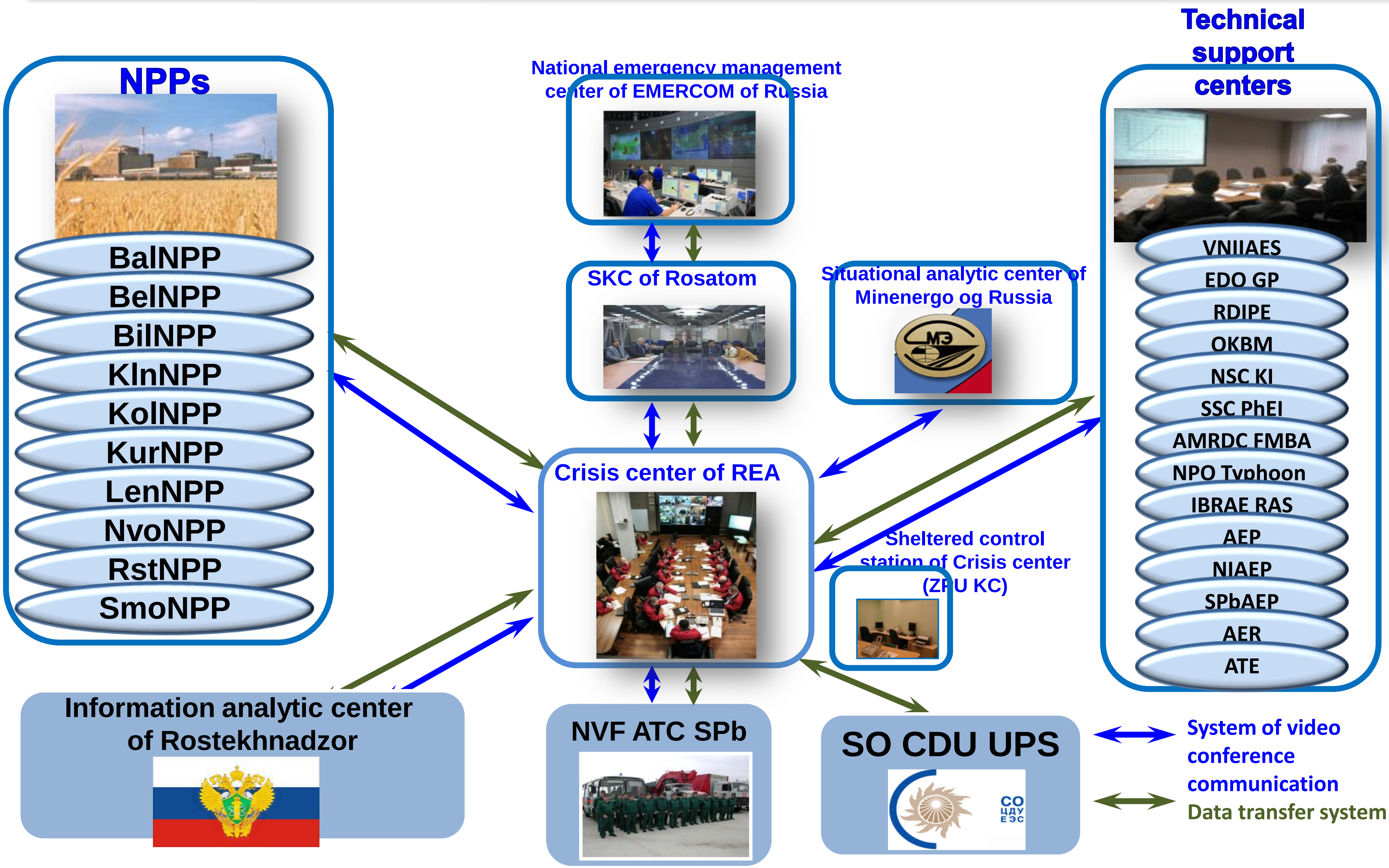
- **Safety became a main priority in activities of Operating organization:**
  - **As early as during the first years after accidents high-priority measures aimed at safety improvement were realized in all reactor facilities equivalent to Chernobyl facility.**
  - **Analysis of NPP designs was performed with participation of international experts, safety problems were defined, programs of their solving were drawn up. System of emergency response was created.**

Mobile emergency diesel generator of Novovoronezh NPP

ECCS Balloons

Simulator of Leningrad NPP Training center

Emergency response system of Russian nuclear power plants



Actualization of safety problems

Events at Fukushima NPP in Japan

Level 7 according to INES scale

Nonsufficient efficiency of measures taken for exclusion of severe accidents

Effects of extreme external natural disasters and their combination

New momentum for NPPs safety review on global level

Conclusions from lessons of Fukushima accident

Staff and management of NPP and Operating organization should focus on immediate actions to prevent and mitigate severe accidents

Reserve of resistant to natural disasters technical means should be stocked at each power unit in order to provide power and water supply needed for cooling of reactor and spent nuclear fuel.

!

Restoration of power and water supply for nuclear fuel cooling down during the first hours after station blackout is key criterion of success

Operating organization, executive power bodies and international organizations and general public should be timely informed about the event at NPP. Involvement of aid from government and international community is ensured.

Methodology of Russian NPPs security status assessment under emergency conditions

Assessment

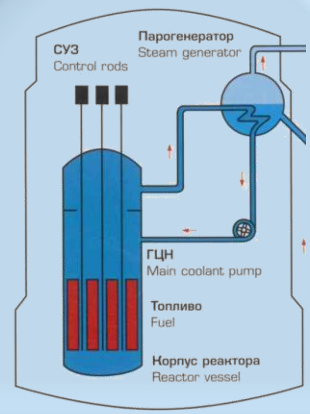
Failure to perform safety functions of regular systems

Supplementary failures of equipment

Non-succesful emergency response

Reliability

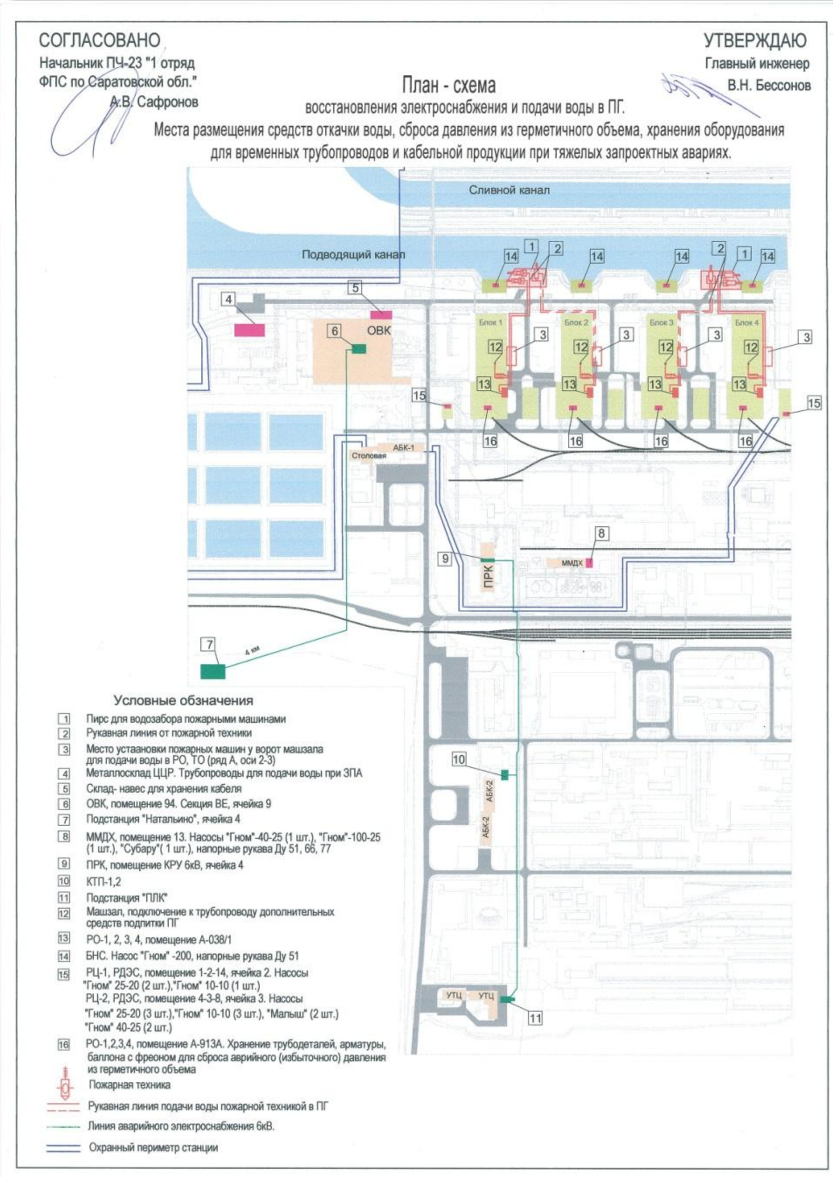
DEFENSE IN DEPTH



Previously accumulated deterministic experience of assessment of consequences of beyond design basis accidents

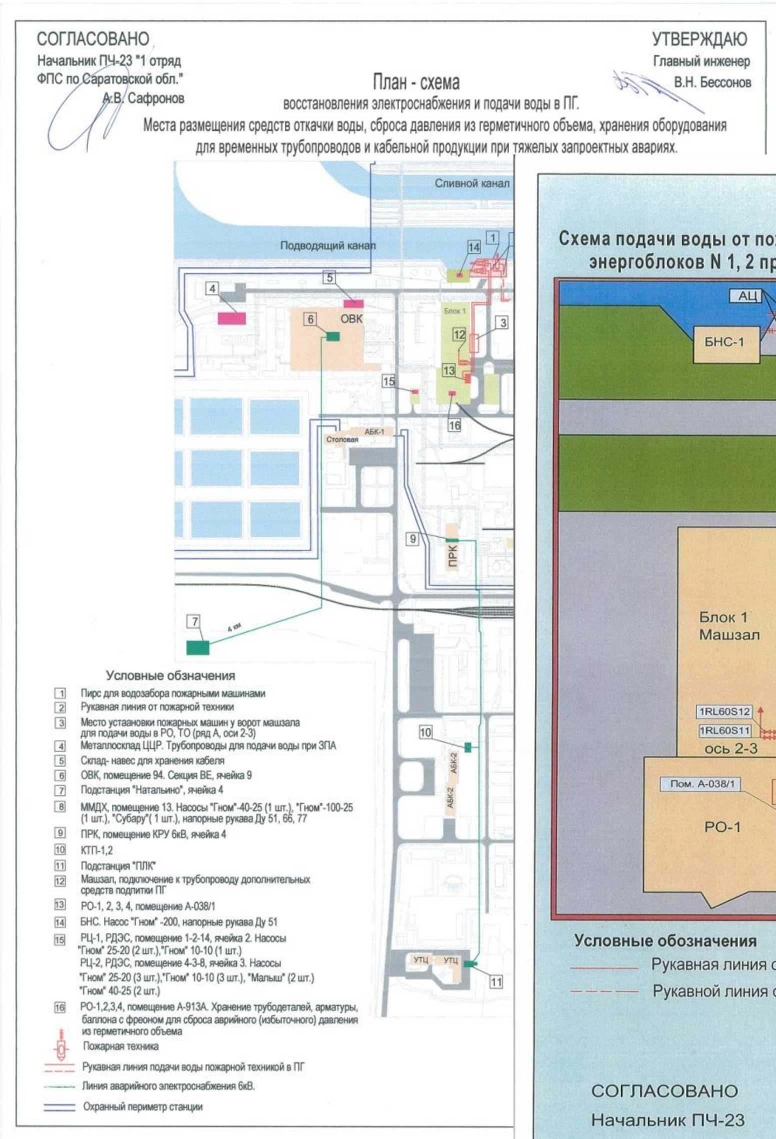
Supplementary measures of management of beyond design basis accident

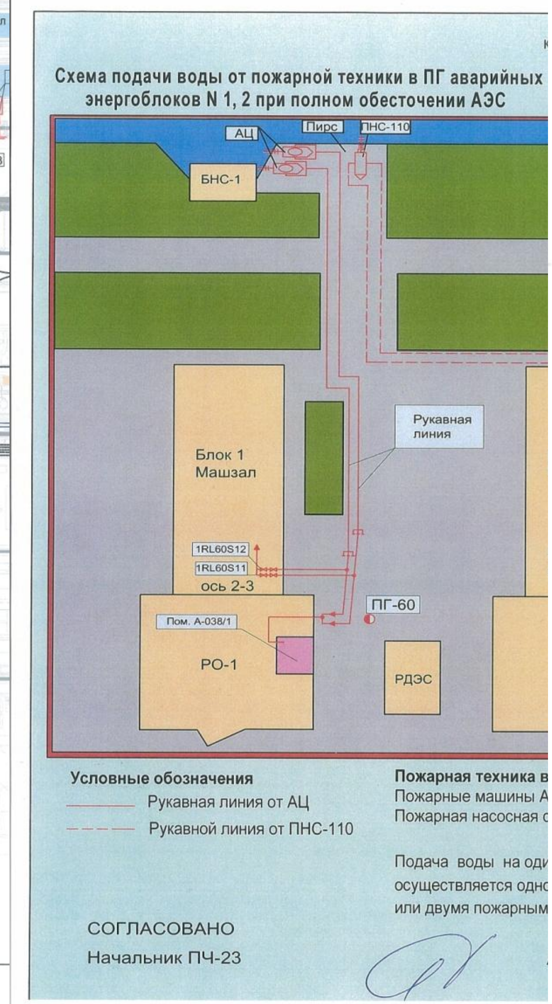
Measures on development and improvement of emergency response documentation



- **Personnel action sheet under condition of BDBA are developed and approved at NPP:**
  - Loss of external power supply and all DG failure ;
  - Hydrogen formation and pressure excess within containment
  - Lack of possibilities to supply water into SG foreseen in design;
  - Risk of угроза затопления of reserve diesel generator statin, main pumping station and minus elevations of NPP units etc.

Examples of personnel action sheets under conditions of beyond design basis accident





Открытое акционерное общество
«Российский концерн по производству электрической и тепловой энергии на атомных станциях»
(ОАО «Концерн Росэнергоатом»)
Филиал ОАО «Концерн Росэнергоатом»
«Балаковская атомная станция»
(Балаковская АЭС)

УТВЕРЖДАЮ
Главный инженер
В.Н.Бессонов
04.05, 2011г.

Карта действий №ЦВ-1-12/390
персонала при тяжелых запроектных авариях.
УДАЛЕНИЕ ВОДОРОДА ИЗ ГЕРМЕТИЧНОГО ОБЪЕМА.

1. Карта действий (КД) вводится в действие по команде НСБ при необходимости удаления водорода из герметичного объема при ликвидации тяжелых ЗПА и обесточении энергоблока.
2. Порядок действий персонала.

№ п/п	Действие персонала	Исполнитель (должность)	Контролирующее лицо (должность)
1.	После получения информации об обесточении энергоблока в течение не более 30-ти минут принять меры по открытию с БУЗ или со сборки задвижек электроприводной арматуры TL22S09. Электросхему TL22S09 разобрать в открытом положении.	НСЦТАИ	НСЦВ
2.	Открыть вручную гермоклапаны TL22S01,02,(03,04,05,06),08	МХУ ЦВ	НСЦВ
3.	Подорвать вручную гермоклапан TL22S07 для удаления водорода через систему TL22 в вентрубу	МХУ ЦВ	НСЦВ

3. Ожидаемый результат:
Концентрация водорода в ГО ниже предельно допустимых значений.

Начальник ЦВ — С.Н. Трофимов

Согласовано:

1-й ЗГИэ — А.М. Сиротин

ЗГИосо — Ю.В. Свежинцев

НЦТАИ — А.Н. Морев

В.А. Ямщиков 99537

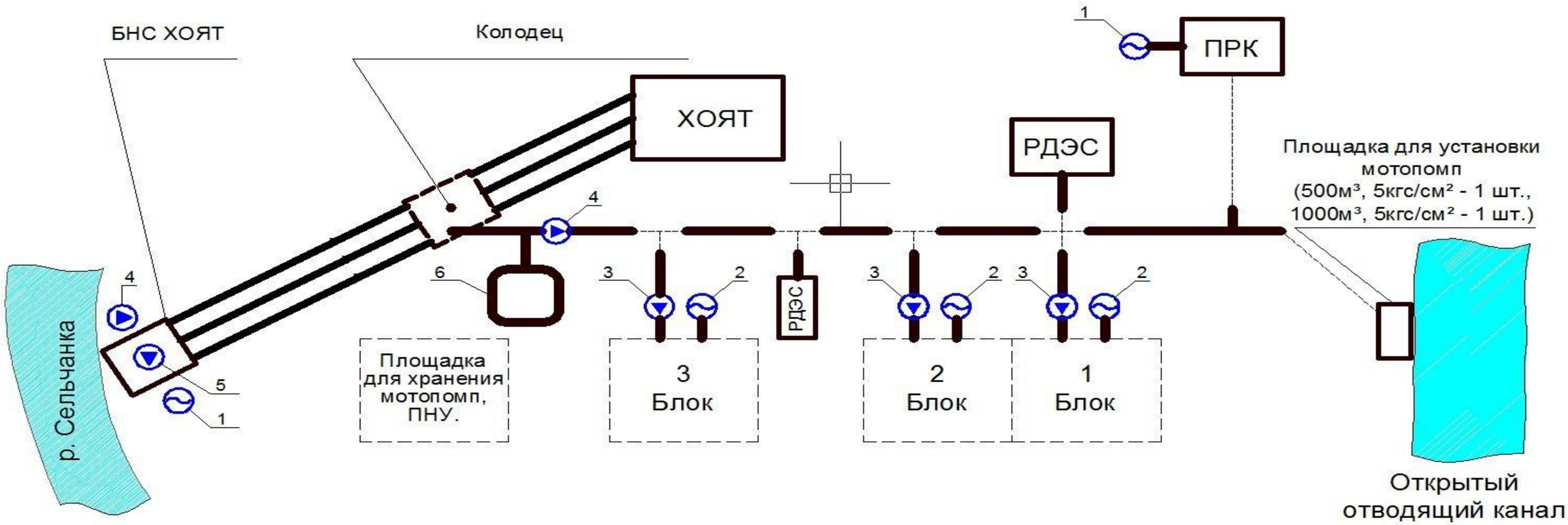
Measures of safety improvement at Russian NPPs to resist extreme external impacts

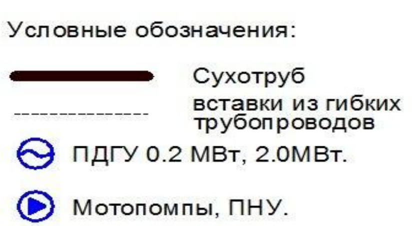
Ensuring power supply

- **Drawing up and implementation of supplementary circuits of power supply from portable diesel generators (N = 2.0 and 0.2 MW) to the following equipment:**
  - Pumps and valves (water supply to reactor, reactor pools, storage pool of spent nuclear fuel and OCXOT);
  - Main control room, emergency control panel;
  - Complex system of monitoring and control, safety controlling system-T and other control systems;
  - «Emergency» I&C;
  - Emergency lighting
- **Power supply reliability enhancement**
  - Mounting of additional lines from external sources – power systems;
  - Improvement of internal backup (redundancy)

Strategy of supplementary equipment use

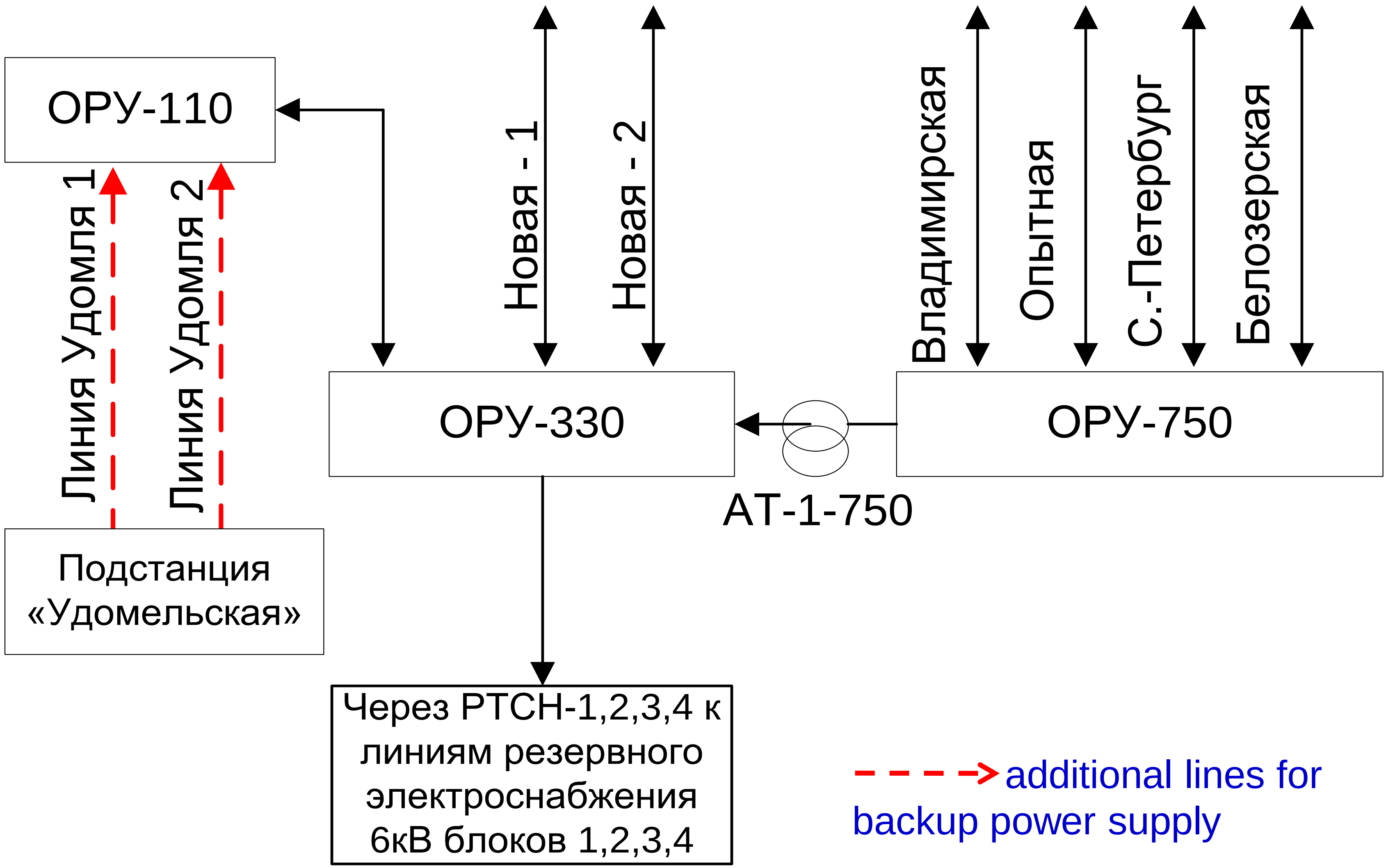
Example of Smolensk NPP





Поз.	Наименование	Примечание
1	Передвижная дизель-генераторная установка (ПДГУ)	W=0,2 МВт.
2	Передвижная дизель-генераторная установка (ПДГУ)	W=2,0 МВт.
3	Передвижная насосная установка (ПНУ)	Q=150м^3, P=90кгс/см^2.
4	Мотопомпа	Q=500м^3, P=5кгс/см^2.
5	Штатный насос подачи охлаждающей воды на нужды ХОЯТ (6 шт.)	Q=160м^3, H=140м.в.ст., N=90кВт.
6	Емкость аккумулирующая	V=500м^3

Improvement of power supply reliability by means of arrangement of backup lines (example of Kalinin NPP)



Measures to improve safety of Russian nuclear power plants under extreme external impacts

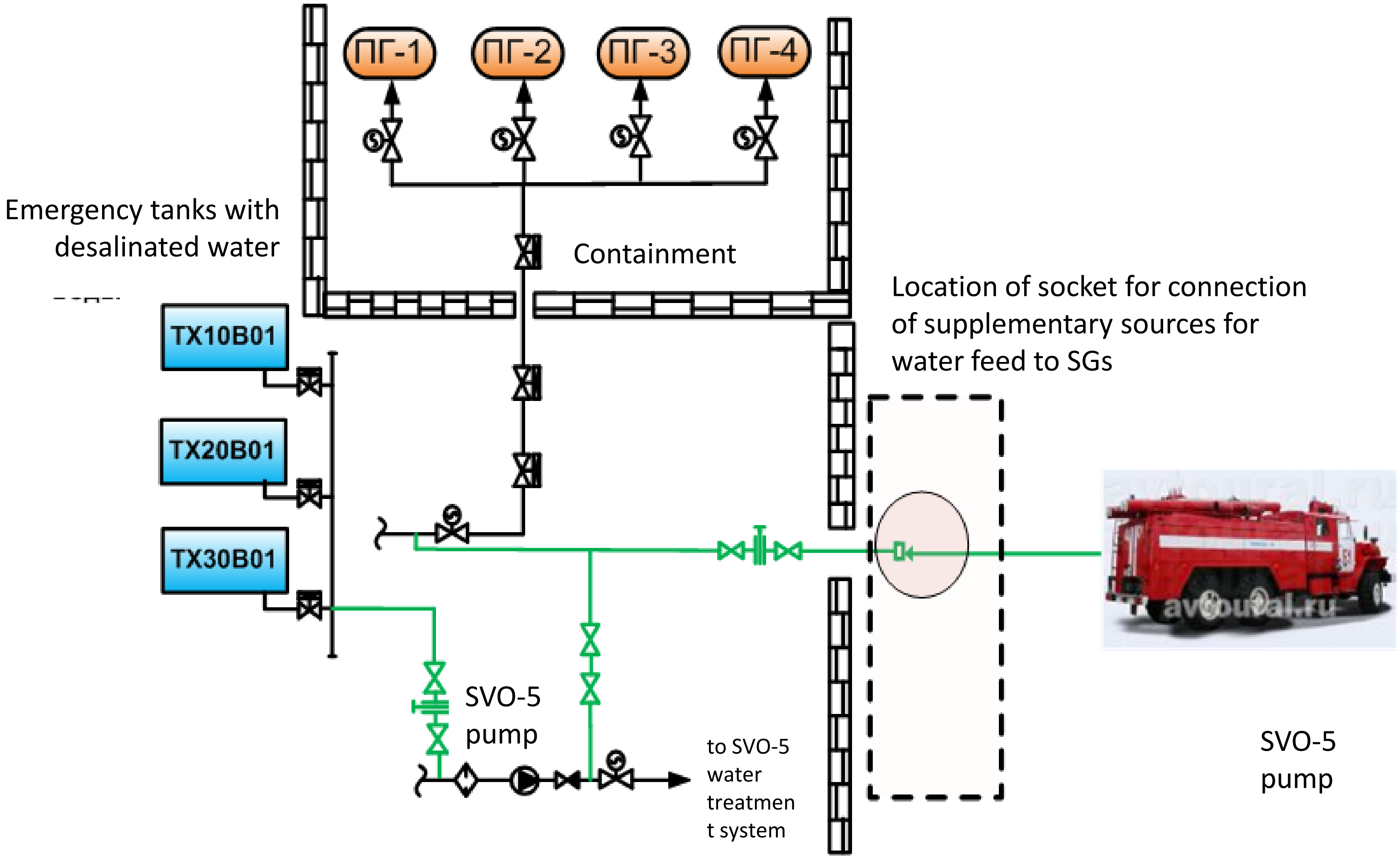
Heat removal

- Design and implementation of additional circuits for supply of water in the reactor, steam generators, at-reactor ponds and cooling ponds using:
  - Portable diesel pumps and motor pumps;
  - Fire-fighting truck with water tank;
  - Regular systems of fire suppression with water;
  - Natural and artificially created reserve water sources

- Implementation of system for metal cladding cooling of spent nuclear fuel pond walls.

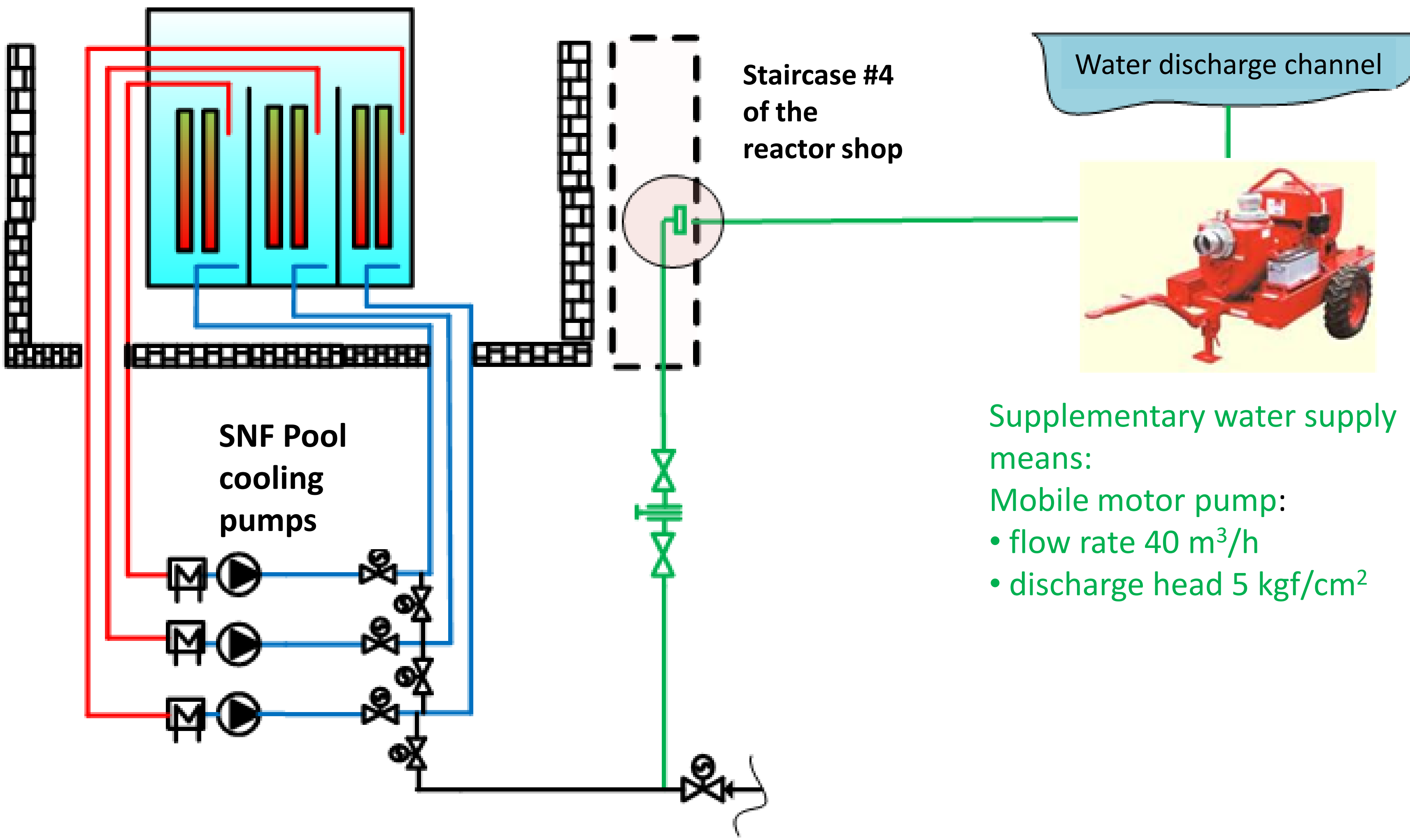
Scheme of water supply to SG of VVER ВВЭР-1000 from fire fighting vehicles

Backup system for water supply to SG from fire fighting vehicles, motor pumps



Scheme of water adding to storage pond of VVER-1000 using motor pump

Backup system of water supply to storage pond using motor pump



Supplementary water supply means:
Mobile motor pump:
- flow rate 40 m^3/h
- discharge head 5 kgf/cm^2

Diagram of primary circuit makeup and ensuring of heat removal of VVER-1000 using supplementary sources and mobile means

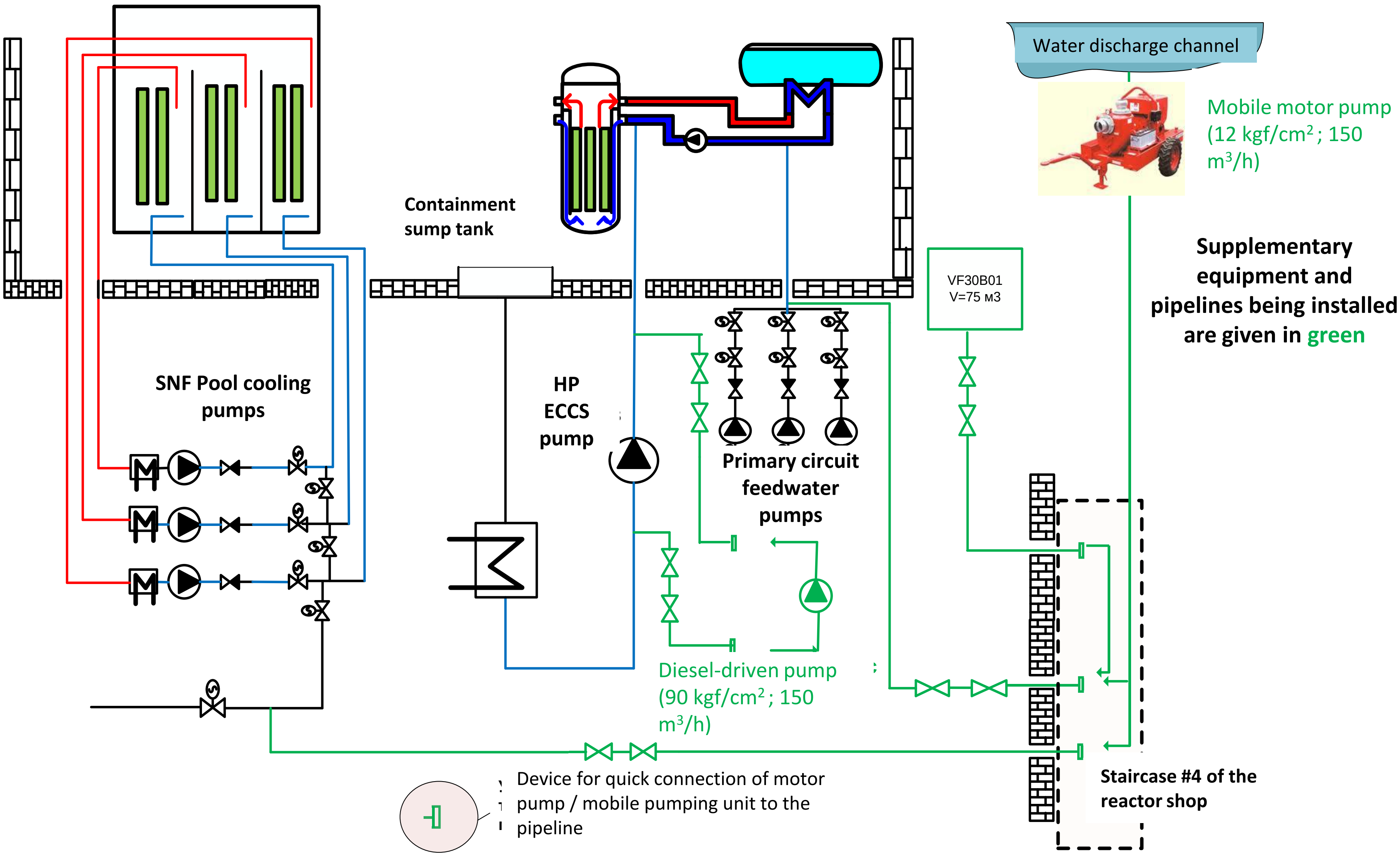
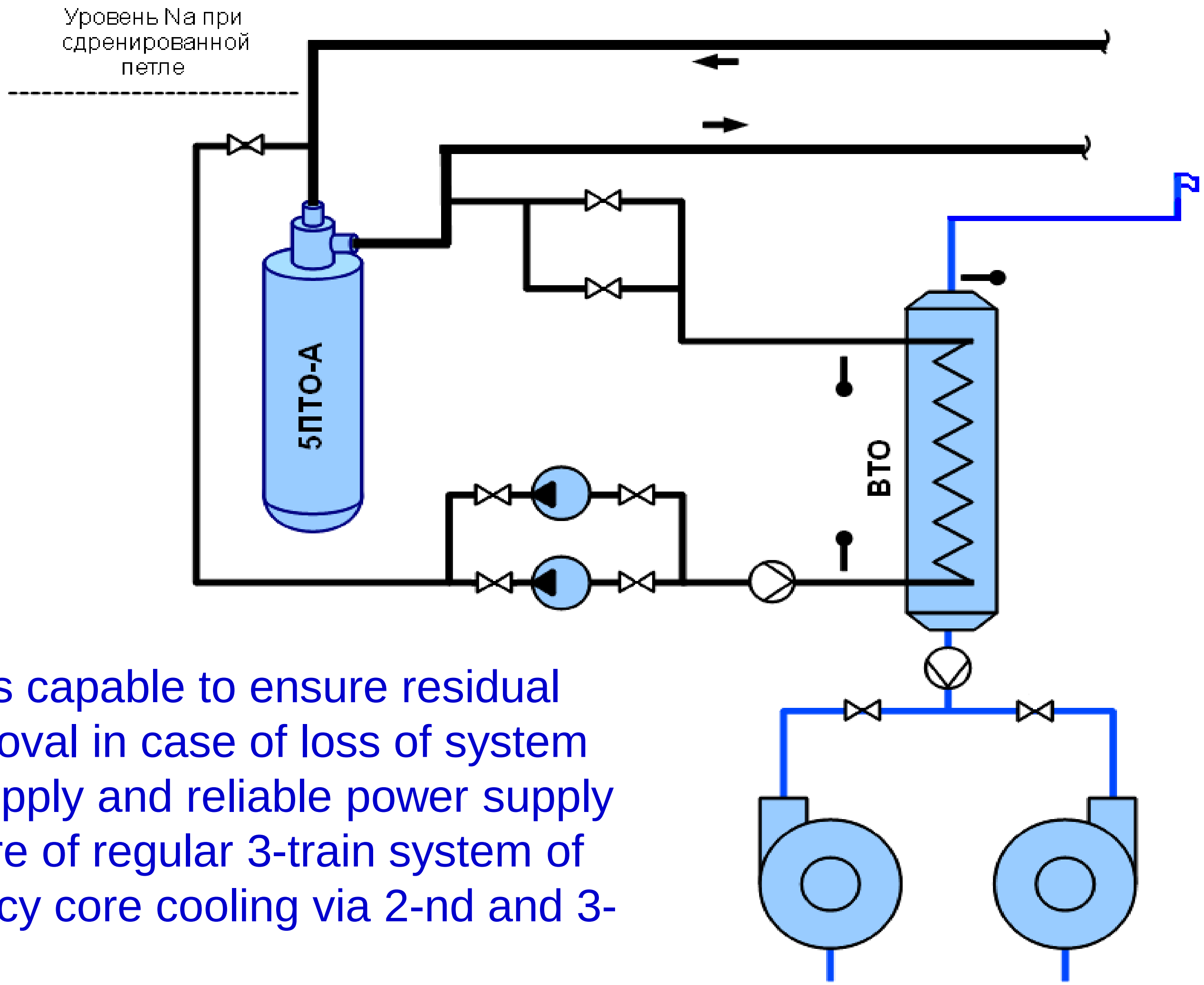


Diagram of additional system of emergency core cooling (ECCS-VTO) of Unit 3 Beloyarsk NPP (BN-600)

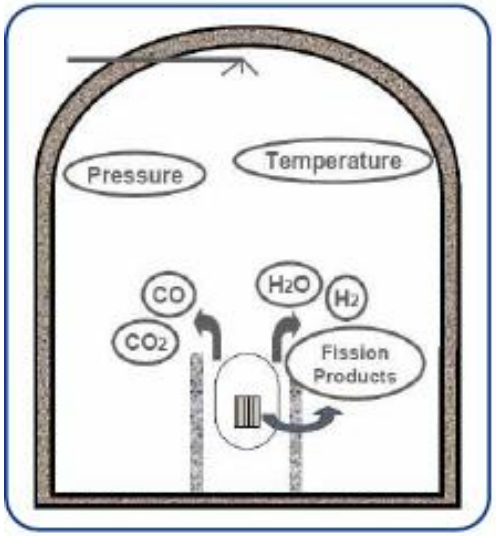


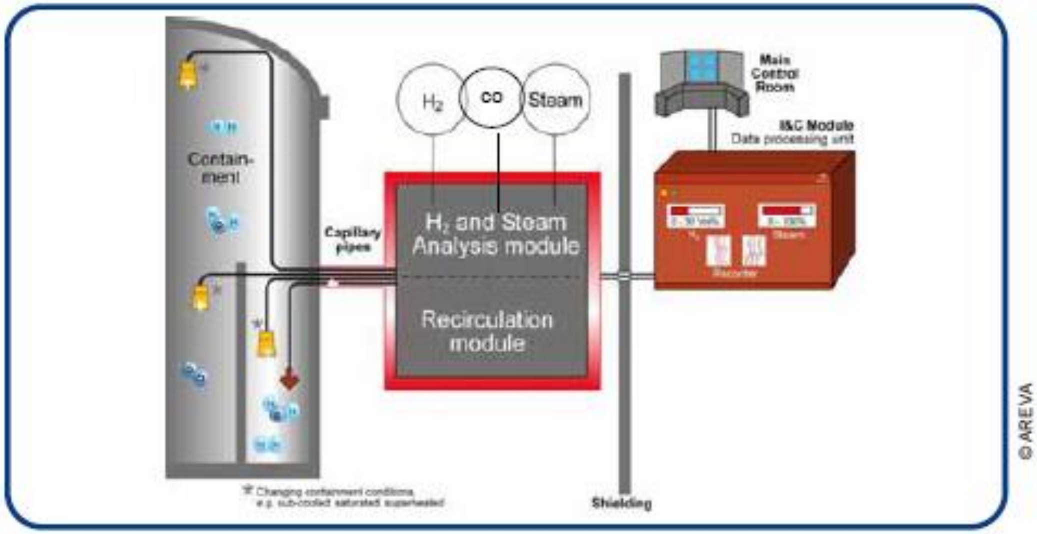
System is capable to ensure residual heat removal in case of loss of system power supply and reliable power supply and failure of regular 3-train system of emergency core cooling via 2-nd and 3-rd circuit.

ECCS- VTO will be put into operation during the outage 2012.

Explosion prevention measures

Implementation of systems for hydrogen concentration monitoring at VVER NPPs





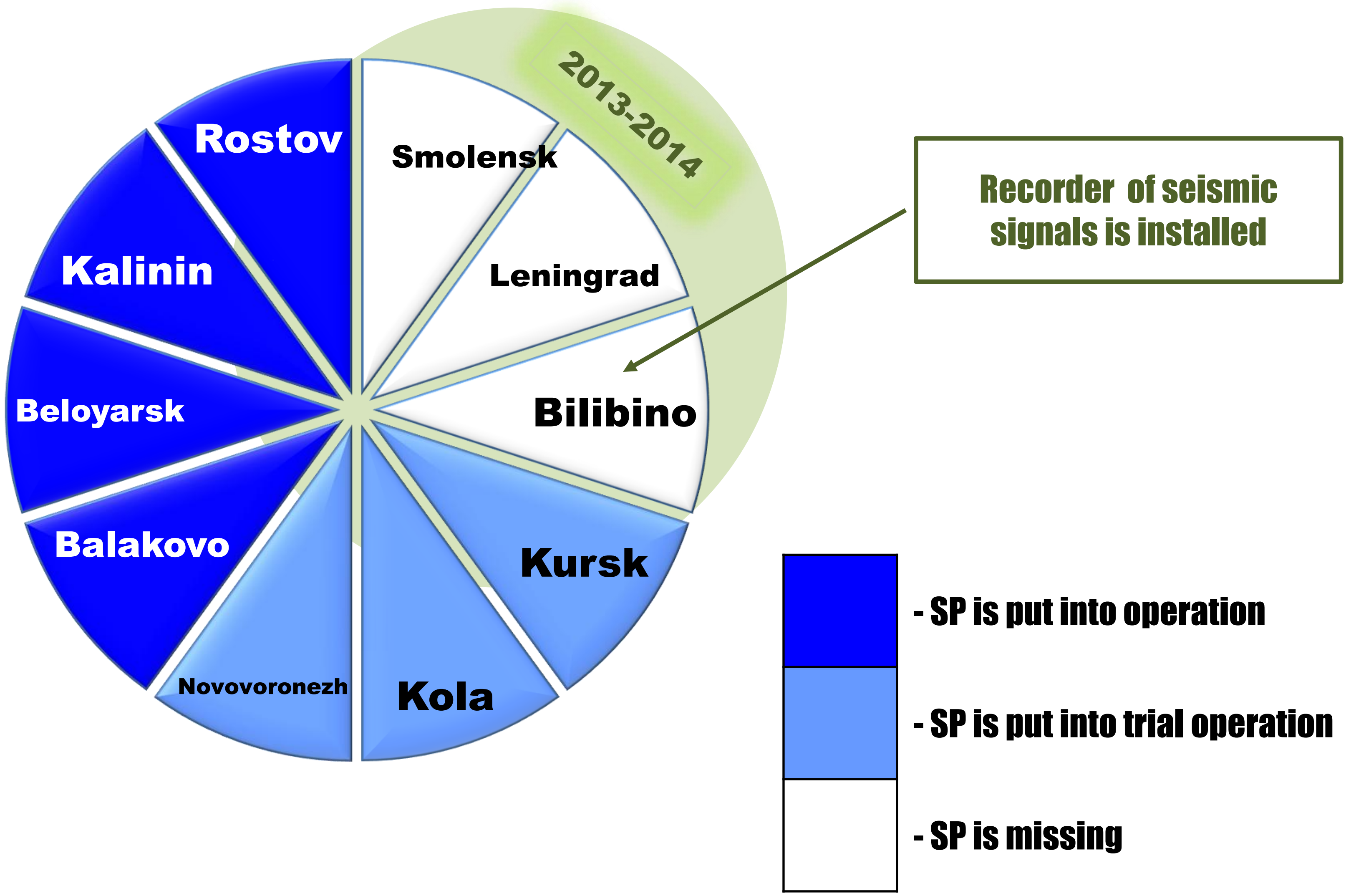
Equipping of VVER NPPs with passive catalytic hydrogen recombiners

Measures to improve safety of Russian nuclear power plants under extreme effects of external events

Seismic safety improvement

- Introduction of seismic protection system of reactor facility (reactor trip in case of earthquake);
- Data refinement about seismic micro zoning of NPP sites;
- Performing of qualified analysis of data specified in the design about seismic loads onto reactor facility, storage pool, SF storage facility and other equipment of systems important for safety;
- Updating of seismic resistance category of NPP components;
- Implementation of measures to improve seismic resistance of equipment, building structures of NPPs (detachment, reinforcement, etc.).

Implementation of seismic protection (SP) at NPP

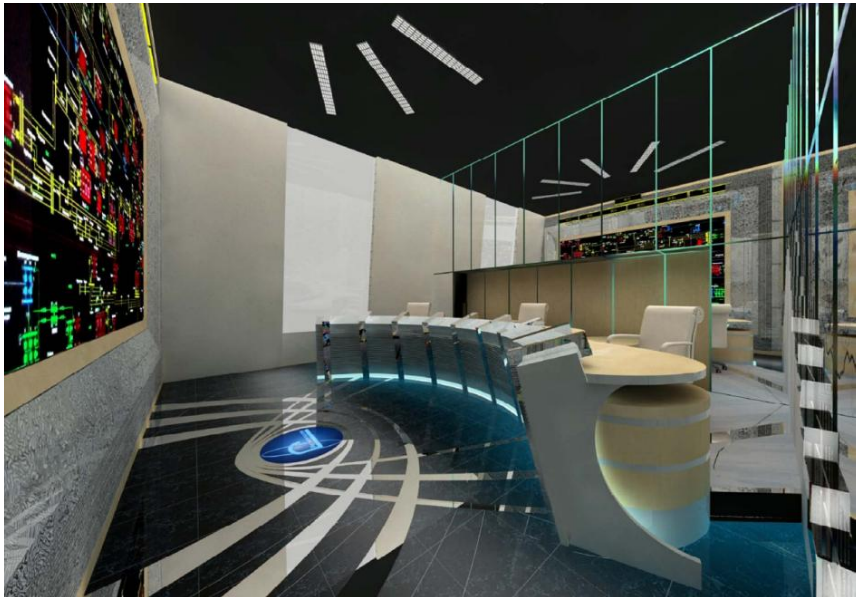


Measures to improve emergency response interaction

- Modernization of communication infrastructure of Technical Support Centers, Crisis Center and NPP;
- Organization of portable control stations and portable communication stations at NPPs;
- Creation of regional Crisis Center of WANO-MC

Regional Crisis Center (RCC)

Central information and control panel of RCC



Functioning modes

- Everyday operation
- Higher state of readiness
- Emergency

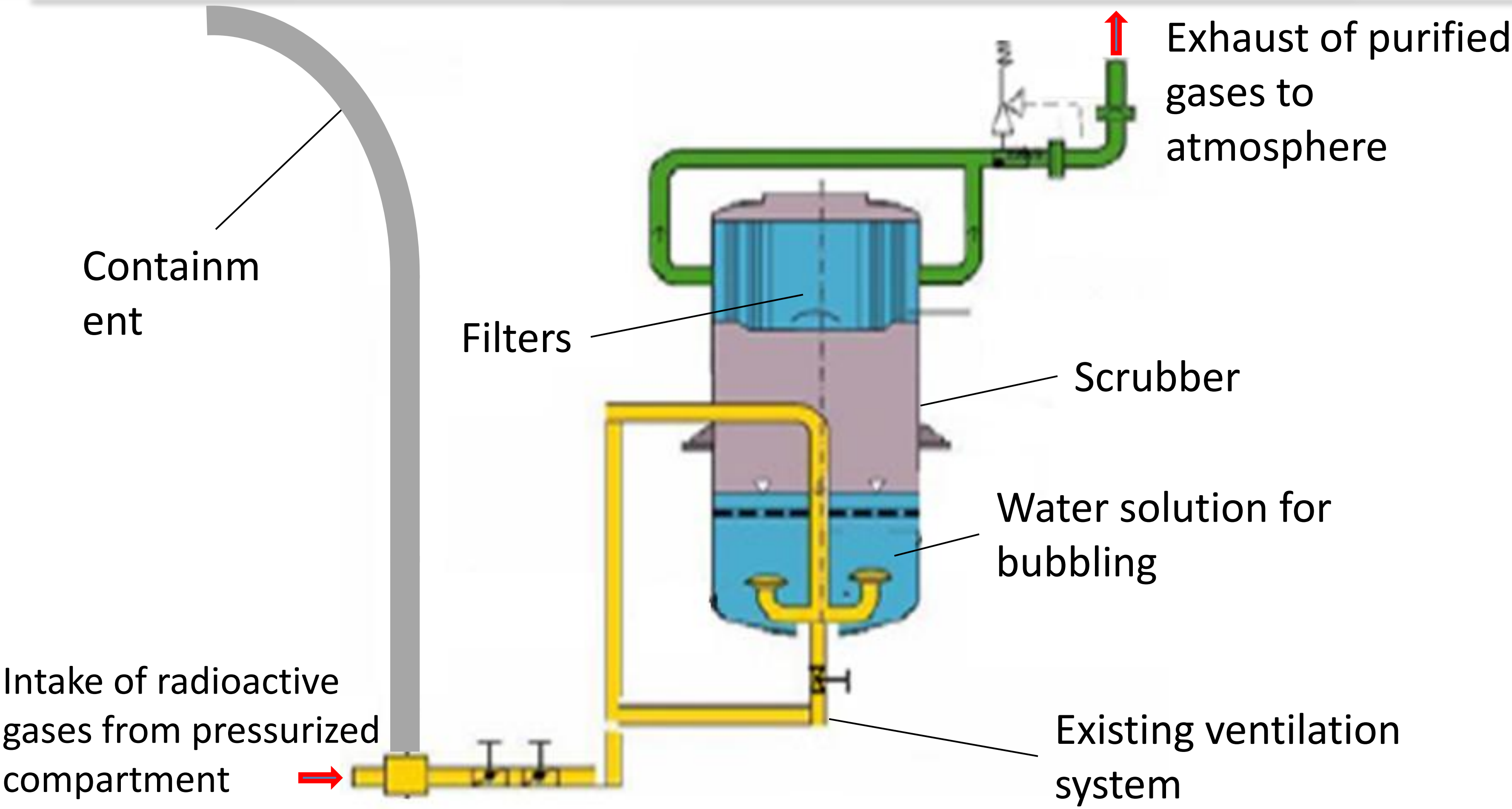
- Main task of RCC is to provide expert/consultant support and engineering support in case of emergency situation or accidents at power units of WANO-MC with VVER reactors
- RCC creates a common information and expert space in order to ensure response of aiding service (OPAS) if technical assistance is requested from foreign NPPs
- Permanent readiness of RCC to emergency response is ensured by CC forces.

Decisions under development

Forming of technical requirements for:

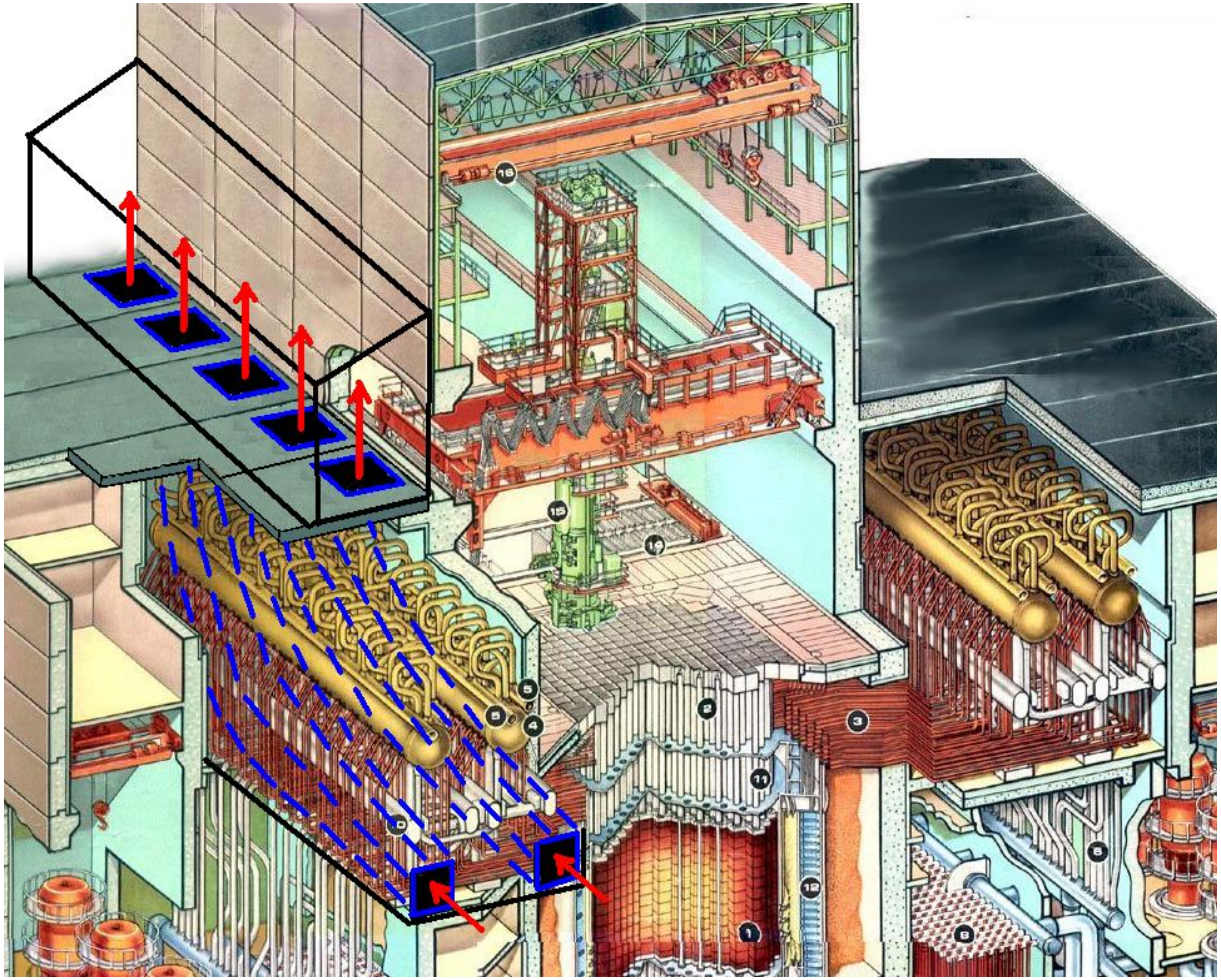
- System of emergency filtered release of gases from containment
- «emergency» I&C, designed for operation under BDBA conditions
- Air cooling system of RBMK with use of existing systems
- Passive heat removal system SPOT-IK (for VVERs)

Explosion prevention measures



Introduction of emergency exhaust of gases from reactor containment at VVER-1000 power units

Air cooling of RBMK

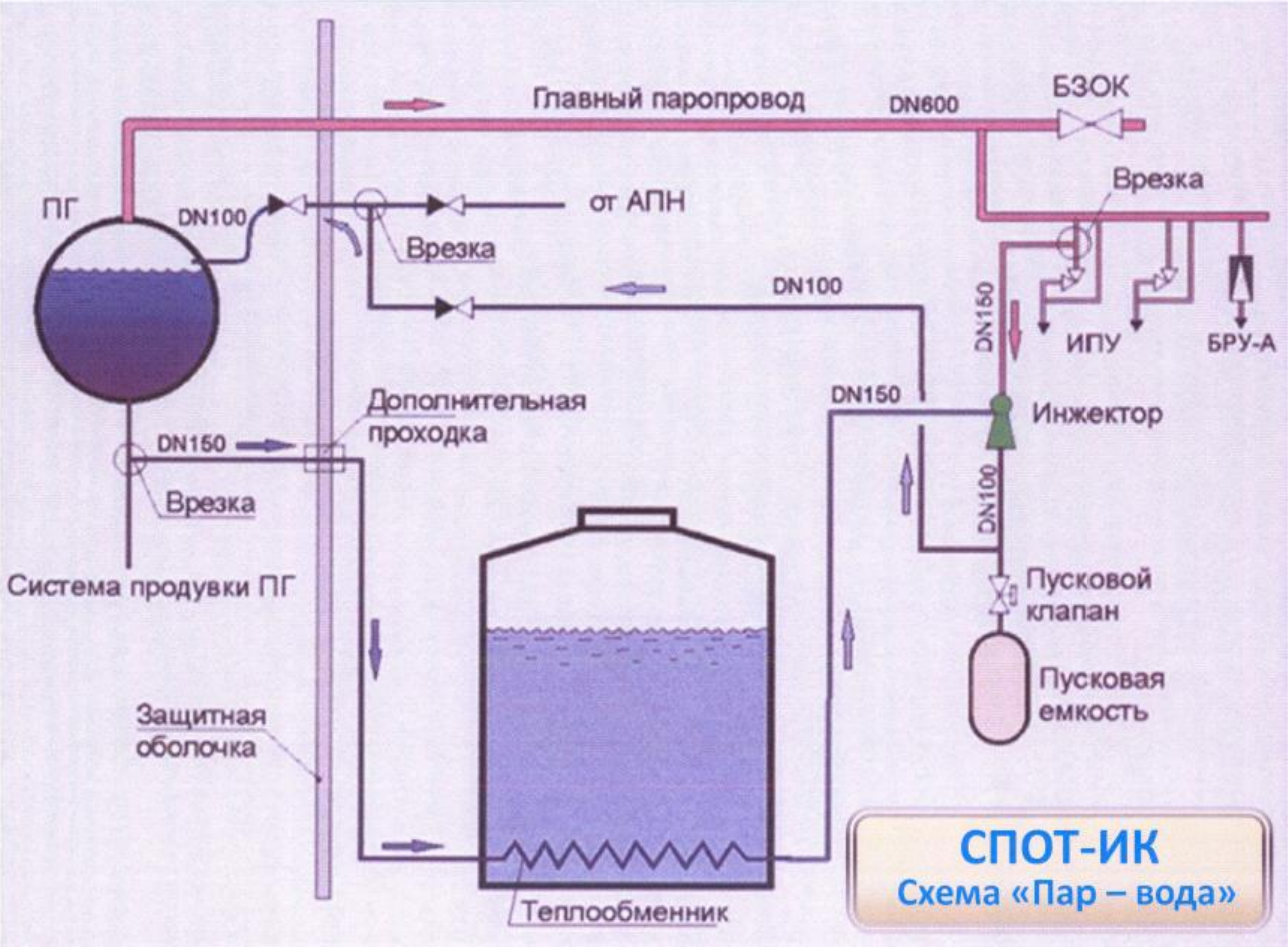


Passive system principle.

Natural air circulation.

Input: via BS premises.
Output: via system of blowout panels on the roof of main building.

Connection diagram of passive heat removal system SPOT-IK for VVER-1000



Measures to develop and improve emergency response documentation

- Updating of emergency procedures SBEOPs (instructions for emergency response, ILA, and BDBA management manual, RUZA) as supplementary design solutions are implemented;

- Standard manuals on severe accidents management (RUTA) for VVER-1000 and RBMK NPPs have been developed and put in force;

- Development and implementation of manuals on severe accidents management (RUTA) for all Russian power units.

VVER-TOI NPP

Defense against external effects

hurricane, tornado

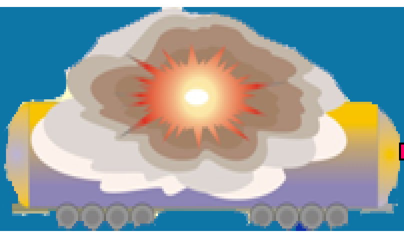
Design wind speed is 56 m/s (Roofs torn off houses, large trees snapped or uprooted, boxcars overturned , moving autos pushed off the roads)

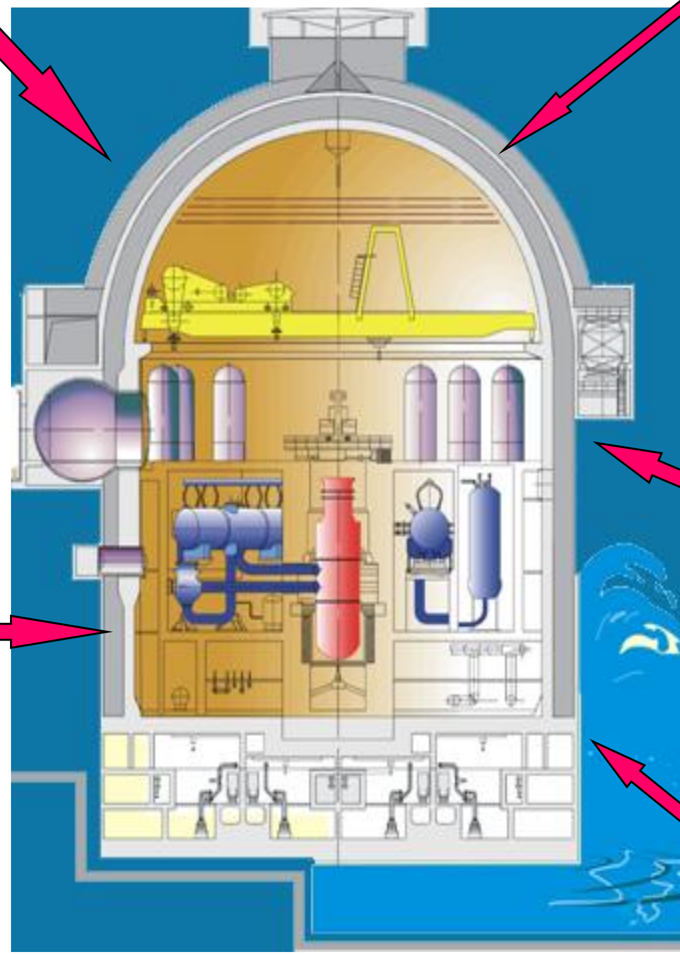
Aircraft crash

BASIC CASE :
20.0 ton with velocity of 200 m/s
Option: 400,0 ton

Shock wave

blast pressure 30 KPa





Earthquakes

BASIC CASE
DBE – 7 magnitude according MSK-64
OBE – 6 magnitude
Option:
DBE – 9 magnitude according MSK-64
OBE – 8 magnitude

Flood, storms

Conditions of any specific site are considered

LONG-TERM LOSS OF POWER SUPPLY AND WATER SUPPLY

CONCLUSION

Additional design solutions scheduled for realization will contribute to NPP sustainability and self-supportability up to 5 – 10 days.

- **Engineering solutions of modern Russian designs, aimed at ensuring safety comply with post-Fukushima requirements and have references.**

THANK YOU FOR ATTENTION!