FEDERAL ENVIRONMENTAL, INDUSTRIAL AND NUCLEAR SUPERVISION SERVICE OF RUSSIA (ROSTECHNADZOR)

# Significant Events in Rostechnadzor Activity Regarding WWER-type NPPs Operation within the Period from September 2015 up to July 2016

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- **Changes in Regulatory Legal Acts in the Field of Atomic Energy Use**
- **Management of an NPP equipment and pipelines lifetime (including the non-replaceable equipment)**


# The Status of the Russian Power Industry

| Nuclear Power Plants Under Operation | |
|---|---|
| Pressurized-water reactors | VVER-1000 – 12 units, VVER-440 – 6 units. |
| Channel-type boiling water reactor | RBMK-1000 – 11 units, EGP-6 – 4 units. |
| Fast breeder reactor | BN-600 – 1 unit. |
| **Shutdown for Preparation for Decommissioning / under Decommissioning Stage** | |
| Channel-type boiling water reactor | AMB-100 – 1 unit AMB-200 – 1unit. |
| Pressurized-water reactors | VVER-210 – 1 unit, VVER-365 – 1 unit. |
| **Under Commissioning Stage** | |
| Pressurized-water reactors | VVER-1200 – 1 unit (physical start-up) |
| Fast breeder reactor | BN-800 – 1 unit (power start-up) |
| **Under Construction Stage** | |
| Pressurized-water reactors | VVER-1200 – 5 units, VVER-1000 – 1 unit. |
| **Siting is in Progress** | |
| Pressurized-water reactors | VVER-1200 – 11 units. |
| Fast neutron reactor with lead coolant | BREST-OD-300– 1 unit. |
| Fast neutron reactor with lead-and-bismuth coolant | SVBR-100 – 1 unit. |

# New Power Units Commissioning

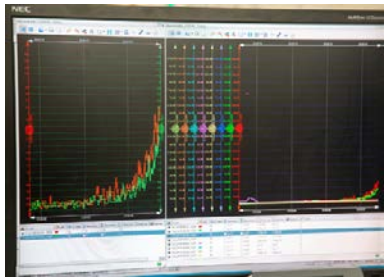
Novovoronezh NPP-2, Unit No.1 with VVER-1200-type reactor

Beloyarsk NPP Unit No. 4 with BN-800 reactor type

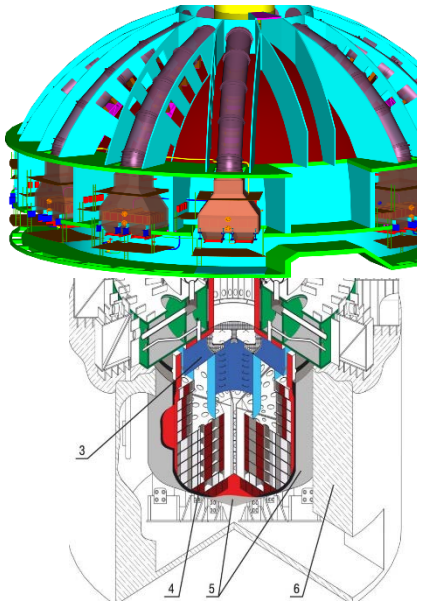
# Novovoronezh NPP-2, Unit No.1

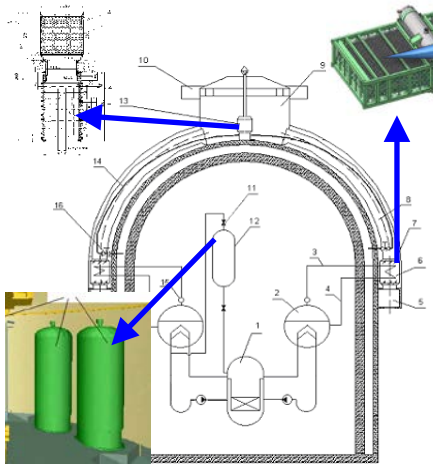
Construction

Core loading



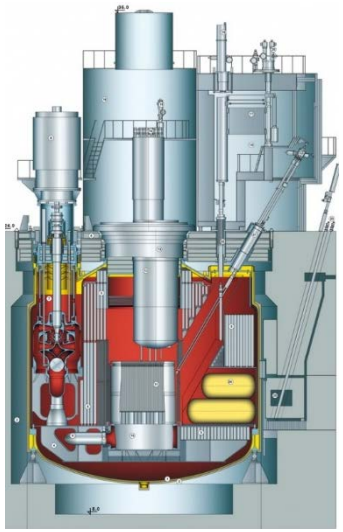
Minimum controlled power



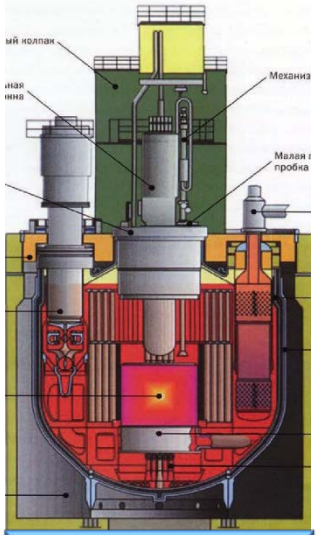


Unit No. 1 of Novovoronezh NPP-2 is equipped with the double-walled containment, the systems for passive heat removal from reactor, the core catcher and special engineering means for the BDBAs management

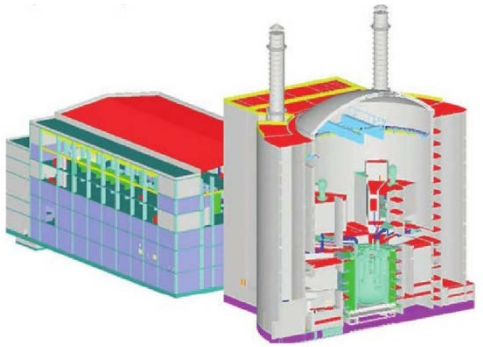
# Unit No. 4 of Beloyarsk NPP



BN-600



BN-800



BN-1200 design

# NPPs of WWER-type with Rostechnadzor Licenses for the Extended Lifetime (as of June 30, 2015)

| Nuclear power plant name, Power unit No. | Reactor type | Installed capacity MWt (el) | Date of the license granting | License validity |
|---|---|---|---|---|
| Balakovo -1 | VVER | 1000 | 18.12.2015 | 18.12.2045 |
| Kola-1 | VVER | 440 | 18.03.2010 | 06.07.2018 |
| Kola--2 | VVER | 440 | 18.03.2010 | 20.12.2019 |
| Kola--3 | VVER | 440 | 05.02.2016 | 31.12.2026 |
| Kola--4 | VVER | 440 | 08.10.2014 | 07.12.2039 |
| Novovoronezh -3 | VVER | 417 | 24.02.2010 | 29.12.2016 |
| Novovoronezh-4 | VVER | 417 | 24.02.2010 | 29.12.2017 |
| Novovoronezh-5 | VVER | 1000 | 25.09.2015 | 25.09.2025 |
| Kalinin-1 | VVER | 1000 | 27.06.2014 | 28.06.2025 |

# Preparation for the Lifetime Extension of WWER-type units

| Nuclear power plant | Unit No. | Reactor type | Date of commissioning, year | Expiration of the designed lifetime, year | Deadline for the extended lifetime, year |
|---|---|---|---|---|---|
| Balakovo NPP | 2 | VVER-1000 | 1987 | 2017 | 2047 |
| | 3 | VVER-1000 | 1988 | 2018 | 2048 |
| | 4 | VVER-1000 | 1993 | 2023 | 2053 |

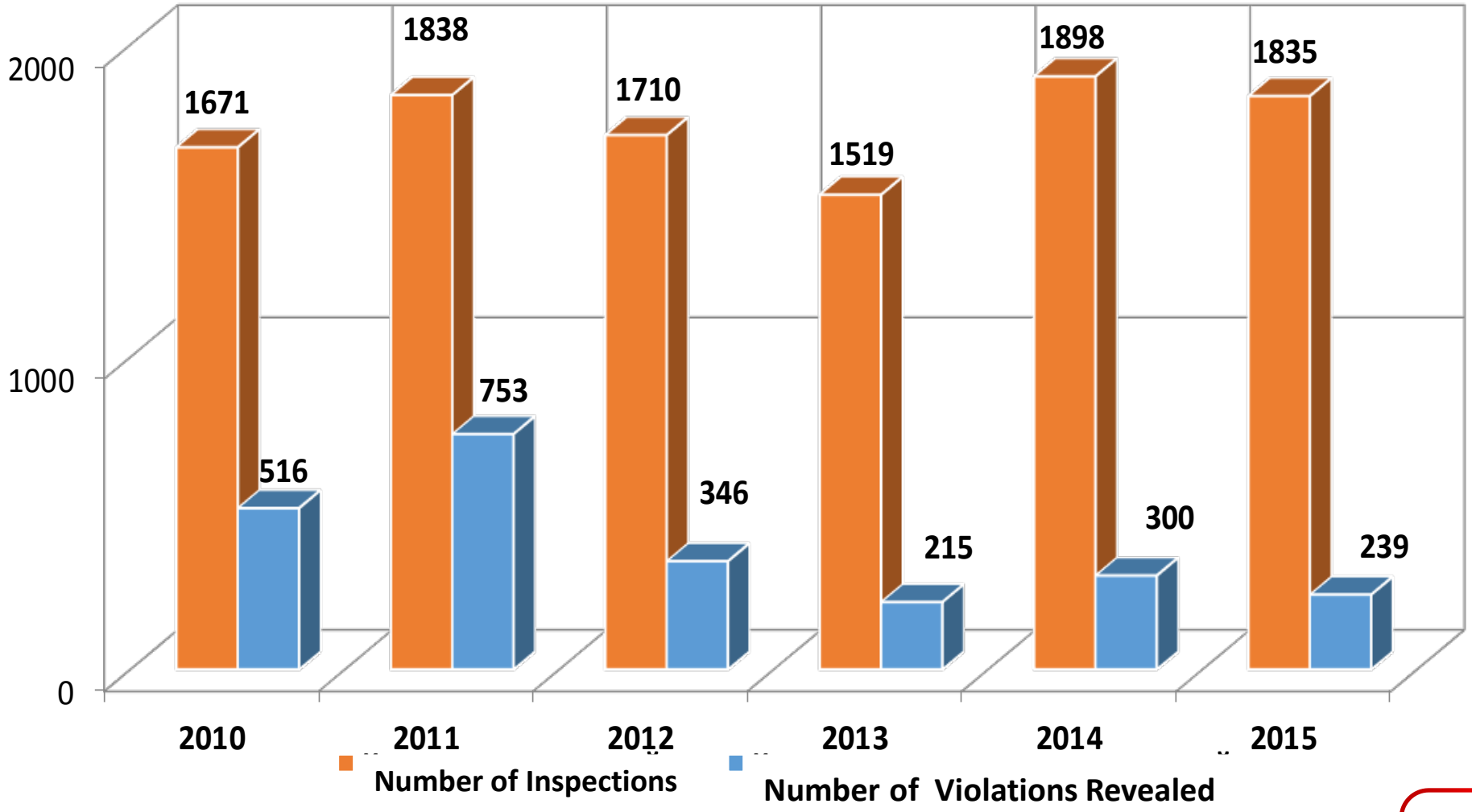
# Licensing Activities

- "Administrative Regulation on Implementation of the State Function of Licensing Activities in the Field of Nuclear Energy by Federal Environmental, Industrial and Nuclear Supervision Service"
- In 2015:

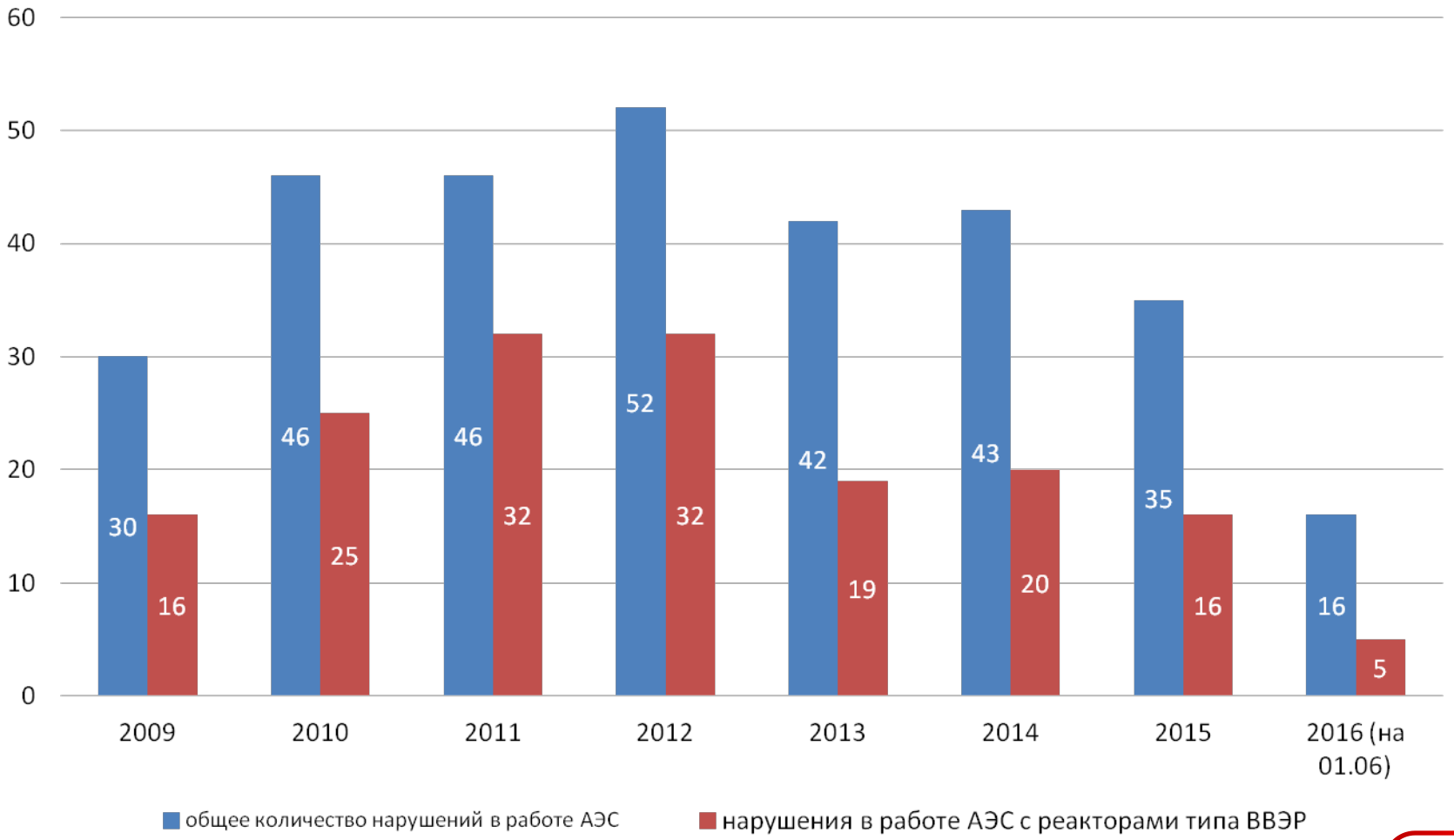
42 licenses issued to the operating organizations and to organizations which carry out designing, construction, NPP units equipment manufacturing or which implement safety review

233 changes to license conditions, 22 times Rostechnadzor refused granting the licenses following the conclusions from safety reviews that the safety of a facility and (or) the licensed types of activity was not ensured and (or) documentation provided by the Applicant was not in compliance with the legislation of the Russian Federation.

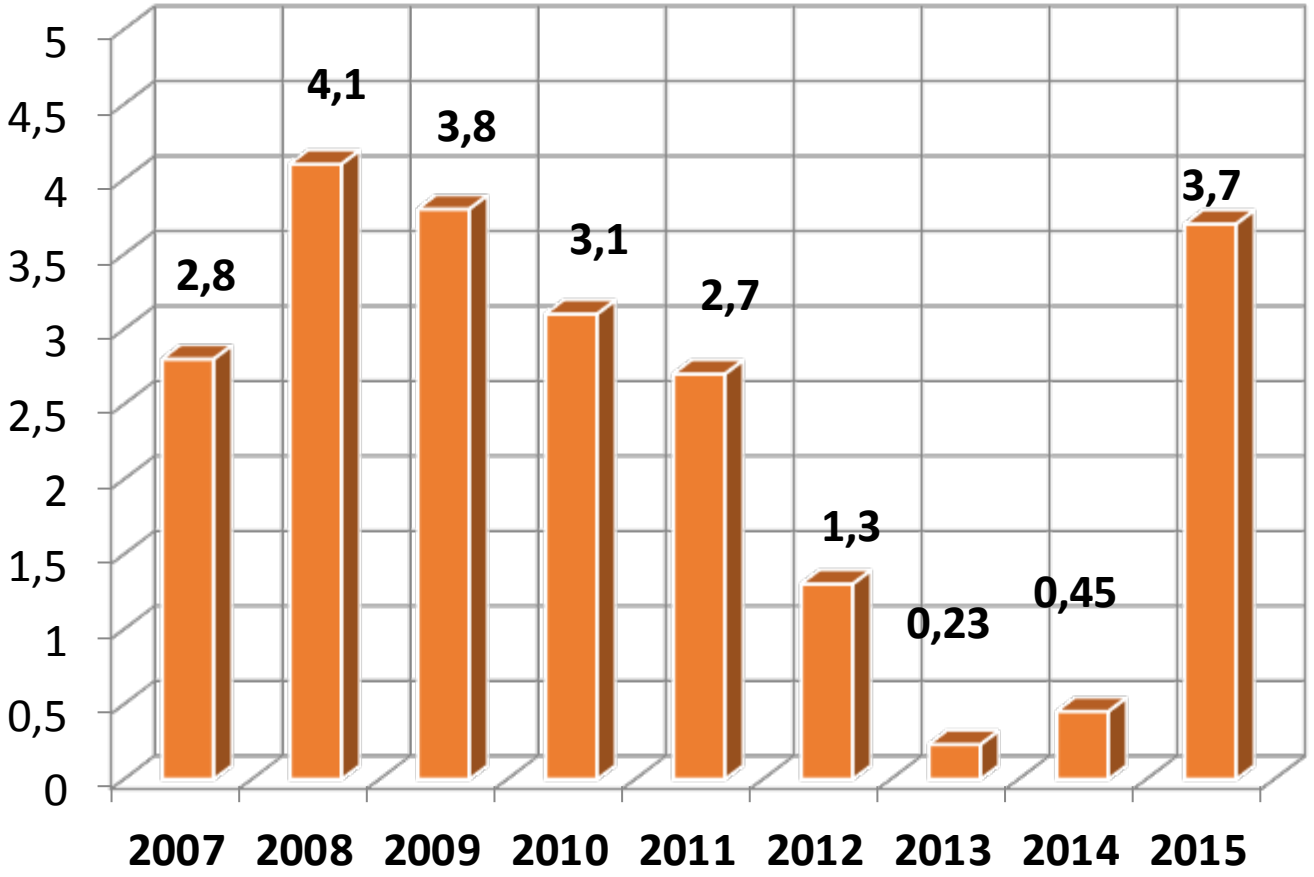
# Inspections performed at VVER-type NPPs



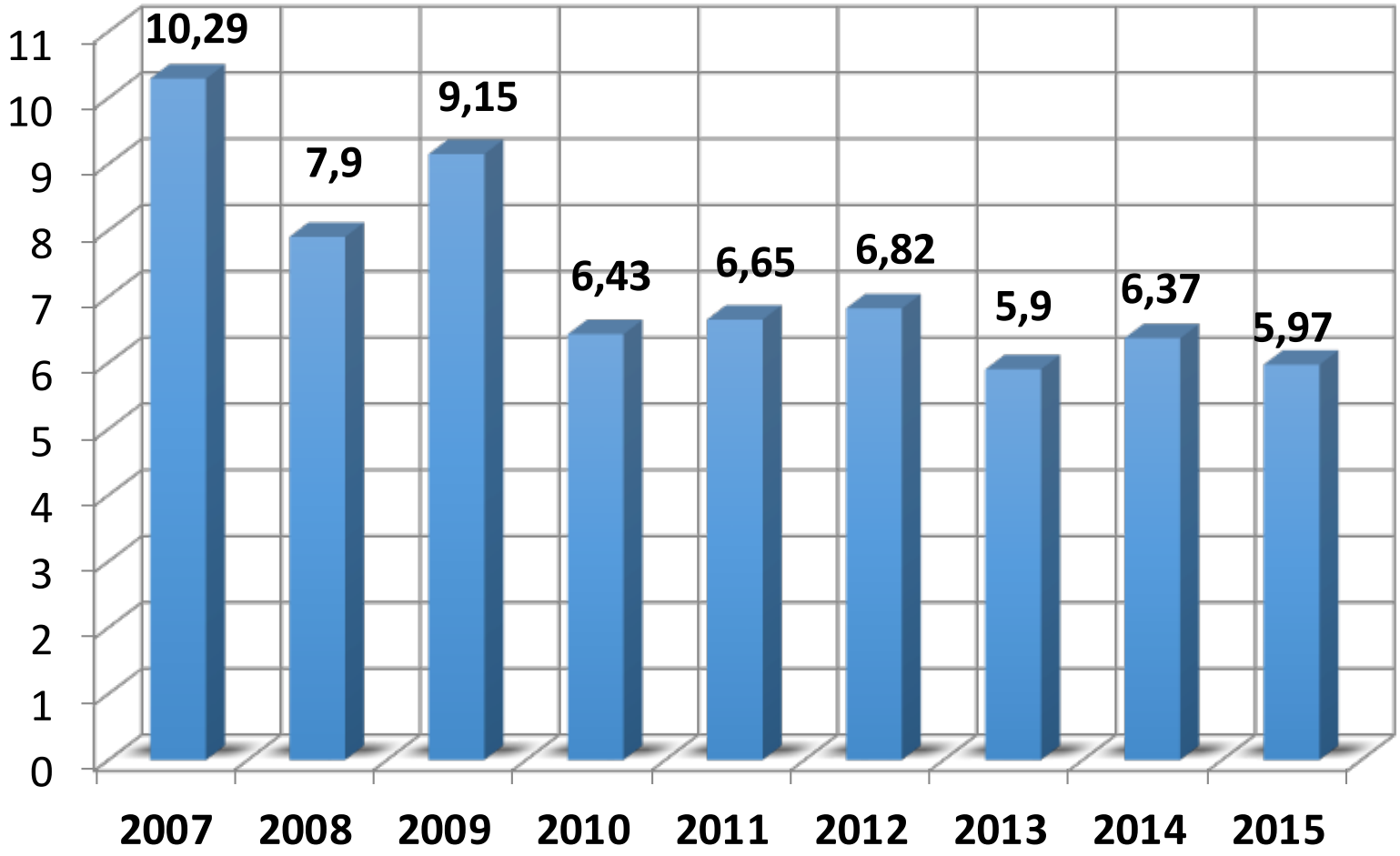
# Dynamics of NPP Operational Events
(including WWER-type power units)



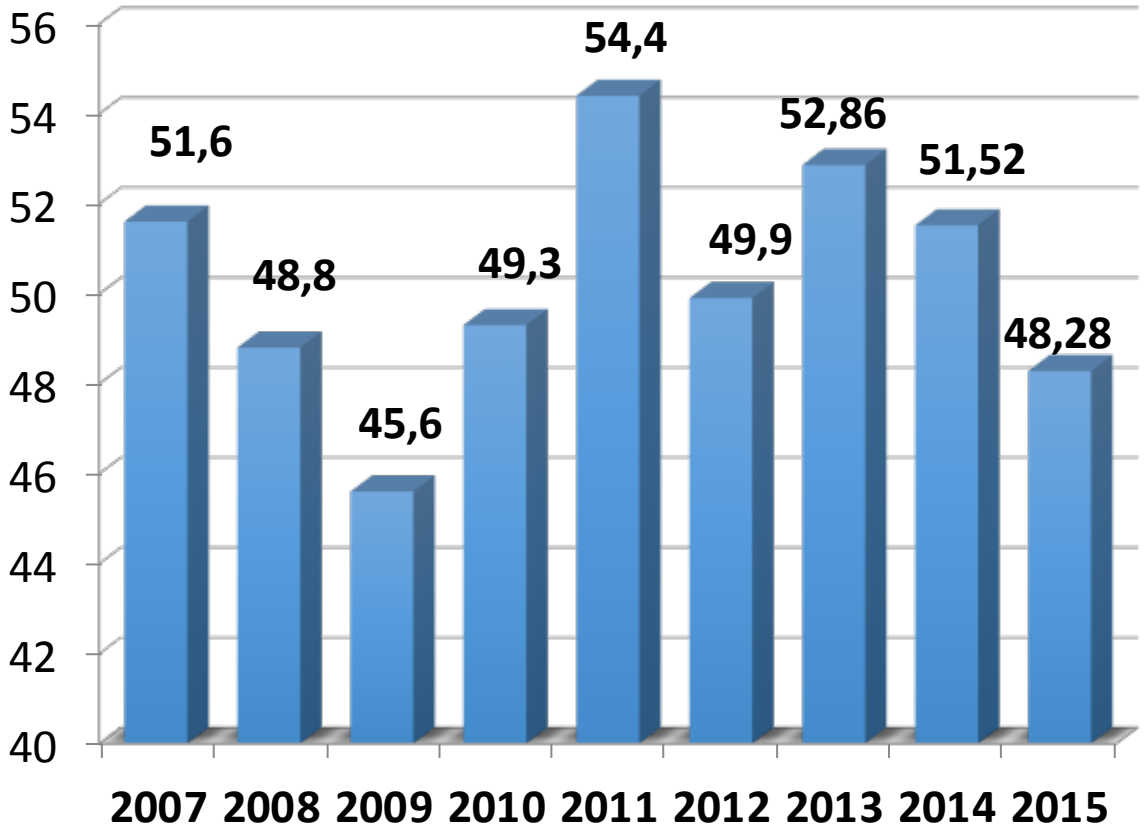
# Averaged Annual Emissions of Inert Radioactive Gases at WWER-type NPPs (% of the permissible value)



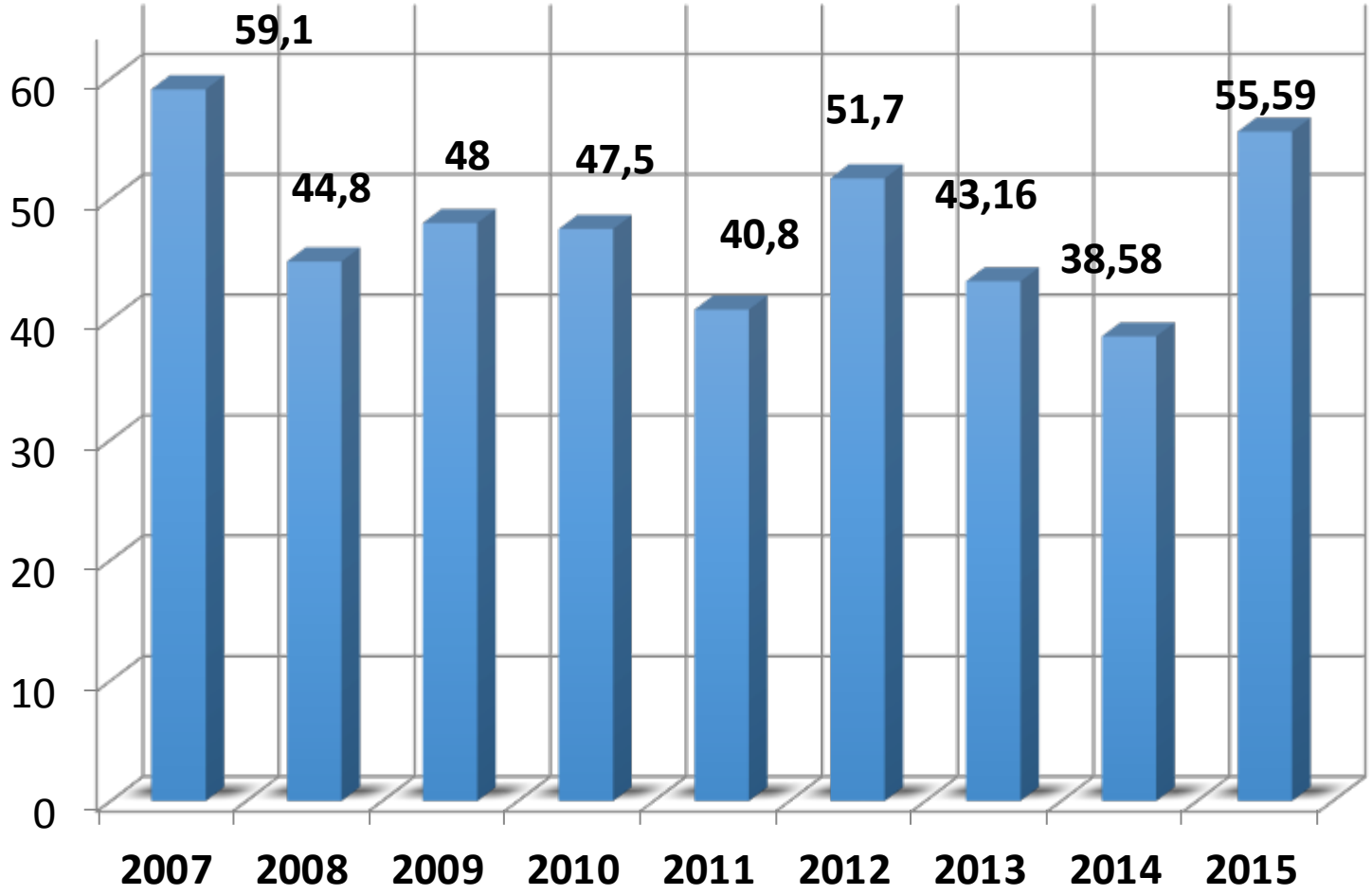
# Dynamics of Personnel Collective Dose at WWER-type NPPs (pers.·Sv)



# Loading Capacity of Liquid RW Storage Facilities at WWER-type NPPs (% of total capacity)

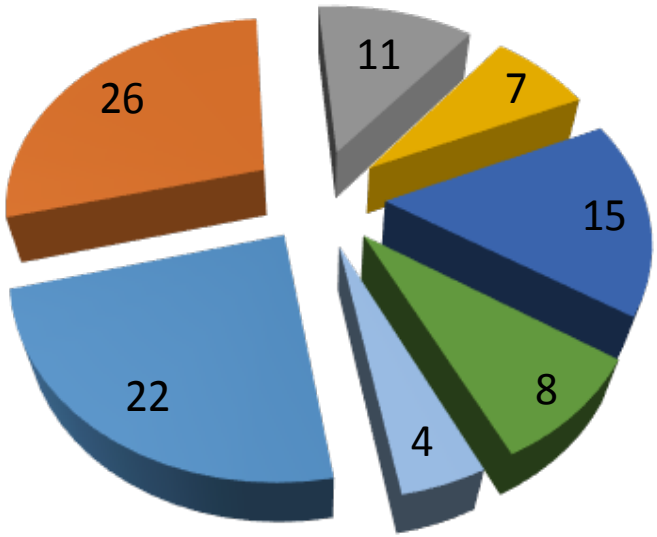


# Loading Capacity of Solid RW Storage Facilities at WWER-type NPPs (% of total capacity)



# Changes in Regulatory and Legal Acts in the Field of Atomic Energy Use

# The System of Federal Rules and Regulations in the Field of Atomic Energy Use




- General Regulatory Documents (22)
- Nuclear Power Plants (26)
- Nuclear Research Installations (11)
- Nuclear Installations of Ships (7)
- Nuclear Fuel Cycle Facilities (15)
- Radwaste Management (8)
- Radiation Sources (4)

**In total: 93 FRRs**

- *in force – 93 FRRs*
- *Under development or revision – 50 FRRs*

# Changes in Regulatory and Legal Framework

- **New revisions of 9 regulations are put into force (among them "General Safety Provisions for Nuclear Power Plants", NP-001-15)**

- **4 new regulations and 2 new safety guides are developed and put into effect**

# General Safety Provisions for Nuclear Power Plants, NP-001-15

## Main Changes to the Document

"General Safety Provisions for Nuclear Power Plant" (NP-001-15) - is the upper-level document. Revised for the first time since 1997.

Main changes to the document:

- terminology updating
- NPP safety
- specific aspects of defense-in-depth concept
- target reference points
- safety analyses
- classification of systems and elements
- safety culture
- reactor coolant circuit
- introduction of new concepts
- addressing the "Fukushima-Daiichi" NPP accident lessons
- confirmation of NPP equipment compliance with design characteristics
- NPP unit decommissioning
- etc.

# NP-001-15, General Safety Provisions for Nuclear Power Plants Structure and Terminology

**Main modifications to documents' structure:**

- The section dedicated to the state management in the field of the use of atomic energy is excluded
- Requirements to NPP unit decommissioning are addressed in a separate section

**Terminology updating:**

- The number of terms is broadened from 80 up to 100
- Gives definitions of the following terms:

  - Probabilistic Safety Analysis
  - Robustness
  - Software certification and others.

# NP-001-15. Main Changes to Document. Conditions to Ensure NPP Safety

Conditions when NPP satisfies safety requirements:

- NPP radiological impact on personnel, public and environment in the course of normal and abnormal operation (including the design-basis accidents) should not lead to the exceeding of the established exposure doses for personnel and public and to exceeding of emissions/discharges limits
- NPP radiological impact on personnel, public and environment is being limited in case of the BDBAs
- The probability of accidents at NPP is limited (the new one).

New condition is harmonized with the IAEA safety standard (SF-1):

- Aiming to ensure the highest levels of safety that can reasonably be achieved, the measures to restrict the likelihood of events that might lead to accidents are to be undertaken.

# NP-001-15. Main Changes to Document. Defense-in Depth Concept

New requirements to DiD at a nuclear plant:

Adoption of all reasonably achieved measures to provide:

- the independence of the DiD levels from each other
- prevention of a barrier damage due to the damage of other barriers as well as several barriers damage resulting from the same impact

**Defense-in-Depth Levels**

**Level 1** NPPs siting conditions and prevention of normal operation violations

**Level 2** Prevention of design-basis accidents due to normal operation systems

**Level 3** Prevention of design-basis accidents progression into the BDBAs due to safety systems

**Level 4** BDBAs Management

Level 5 Emergency Planning

**Physical barriers on paths of radioactive substances and ionizing radiation spreading into environment:**

- **fuel matrix;**
- **fuel rod cladding;**
- **reactor coolant circuit boundary**
- **containment**
- **biological shielding**

# NP-001-15. Main Changes to Document. Safety Analyses

NP-001-15 includes:

- requirements to deterministic and probabilistic safety analyses (when to be presented, what to be covered, the way to be performed)
- requirements to the design-basis accidents and the BDBAs assessment
- requirements to the drawing up of the initiating events list needed for assessment of the design-basis accidents and the BDBAs;
- requirements to the development of measures on the BDBAs management

**New clarification:** measures on the BDBAs management are to be developed regardless of the probability of accident.

- requirements to accounting of a single failure by safety systems of a NPP

# NP-001-15. Main Changes to Document. Target Reference Points of NPP Safety

**Target reference points in respect to NPPs safety are:**

- not-exceeding of the severe accident total probability, which is equal to $10^{-5}$ for every unit within 1 year
- not-exceeding of the large-scale emergency release total probability equal to $10^{-7}$ for every unit within 1 year interval
- not-exceeding of the severe accident total probability equal to $10^{-5}$ for on-site nuclear fuel storage facilities, (which are not included into NPP units) within 1 year interval (the new one)

**SNF storage facility at Smolensk NPP**

The new target reference point of NPP safety reflects the fact that a nuclear accident with significant radiological consequences may occur not only at the NPPs units, but also at the on-site nuclear fuel storage facilities.

# NP-001-15. Main Changes to Document. Classification of Systems and Elements

Criteria for referring a system or an element of normal operation as safety-important are modified:

A system and/or an element of normal operation is safety-important when:

- their failure leads to deviation from NPP normal operation or
- impedes the elimination of NPP normal operation deviation,
- and upon this the conditional probability of such failure progression into the severe accident is equal to $10^{-6}$ and more.

The classification of systems and elements per their purpose is broadened:

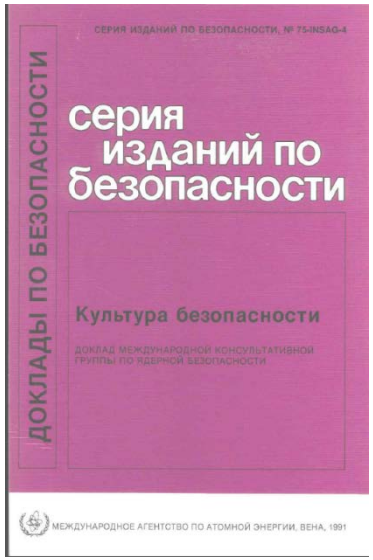
**The systems and elements of special engineering means for the BDBAs management are introduced** in addition to systems and elements of normal operation and the safety-related systems and elements.

# NP-001-15. Main Changes to Document. Safety Culture

The definition of the concept “Safety culture” is in line with the IAEA standards (for example, INSAG-4).

The new definition reflects that the safety culture is an assembly of characteristics in respect to both individuals and organizations.

A very important aspect for successful formation and maintaining of effective safety culture within organization is added:

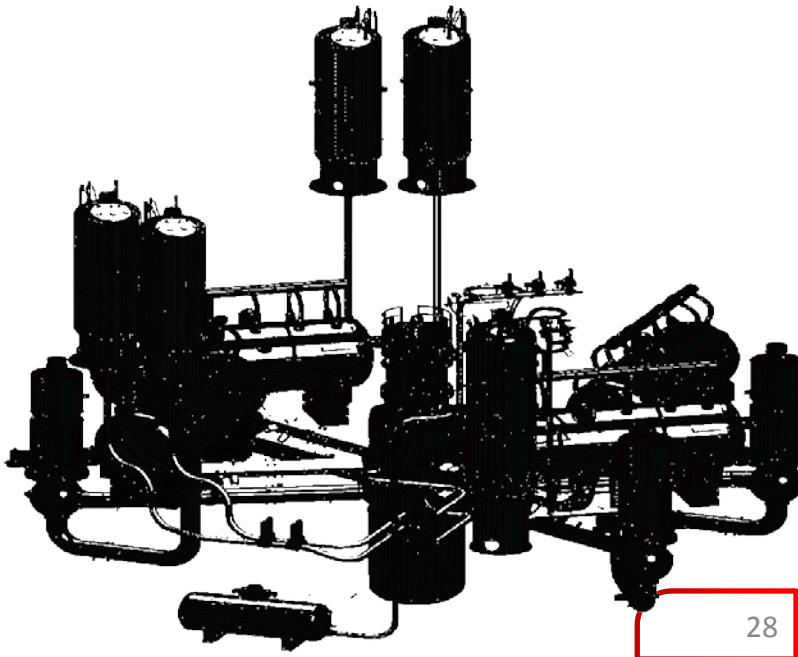



**Formation by the management of all levels of an atmosphere of confidence and particular approaches to the collective work along with the NPP personnel social and living conditions, when the primary need for a favorable attitude in respect to the safety of a nuclear plant is being formed.**

# NP-001-15. Main Changes to Document. Reactor Coolant Circuit

Requirements to the reactor coolant circuit have been expanded:

- the requirement regarding the inadmissibility of the primary coolant leak beyond the NPP containment boundaries at the actuation of devices which protect the reactor coolant circuit from overpressure has been clearly stated
- requirements to use the 'LBB' concept at the designing of reactor coolant pipelines have been added
- requirement to exclude the negative impact of heat insulation of reactor coolant circuit pipelines on the efficiency of safety systems
- requirement to prevent accumulation of explosive concentrations of gases in the primary equipment and lines.



# NP-001-15. Main Changes to Document. New Concepts

- The concept **“control for the reasons of safety”** is introduced, which is a new concept for the integrated control of a nuclear plant. It has been entered into the IAEA member-states practice for the last 10 years. It envisages considerable modernization of the control systems so that all control elements are linked to their impact on NPP safety.
- The new concept **“severe accident precursor”** is introduced. It is a part of emergency sequence, which does not result in a severe accident, but is a warning sign (a precursor) about the significant challenges facing the safety. The new revision of OPB is completed with the requirements to the operating organization in the part of severe accidents’ predecessors accounting.

# NP-001-15. Main Changes to Document. Addressing the "Fukushima-Daiichi" lessons learnt

New requirements are introduced which account the lessons drawn from the "Fukushima-Daiichi" NPP accident:

- Requirements to special engineering means for the BDBAs management:

**Availability; design; protection; control; performance check; protection against common cause failures; efficiency to manage the accident which originates simultaneously at all units of multi-unit NPP.**

- the requirements about the necessity to develop measures on accidents management in case of simultaneous occurrence of the BDBAs at several NPP units and other nuclear facilities on-site;
- the requirement to provide in the NPP design the engineering means to monitor NPP and reactor installation status under accidents conditions (including severe accidents) along with means on post-accident monitoring;
- the permissibility conditions for the controlled release of radioactive substances beyond the boundaries of the reactor containment are established: such release may be performed only to prevent the containment damage on condition of the appropriate measures on radiological protection of public implementation.

# NP-001-15. Main Changes to Document. NPP Decommissioning

The requirements to a nuclear plant decommissioning are addressed in the separate section.

The format for NPP decommissioning consideration under siting, designing, construction and operation is established.

The planning of a NPP decommissioning is to be performed at all stages of a nuclear plant lifetime by development and improvement of the decommissioning concept, which is to be provided in NPP SAR.

NP-001-15 includes requirements to:

- programmable digital means applied in the safety-important systems and elements
- to the water chemistry
- demonstration of hydrogen explosion protection and some others.

# Management of an NPP equipment and pipelines lifetime (including the non-replaceable equipment)

# Regulatory and Legal Basis for an NPP Equipment Lifetime Management (including the non-replaceable equipment) at Operation and Lifetime Extension of a Power Unit (1/2)

Two documents of the level of Federal Regulations and Rules in the filed of atomic energy use are introduced:

- NP-084-15, Unified Inspection Procedures for Base Materials, Weld Joints and Build-Ups in the Course of Operation of Equipment, Pipelines and Other Elements of Nuclear Power Plants
- NP-096-15, Requirements to Resource Management of Equipment and Pipelines of Nuclear Power Plants.

**establish requirements to the scope, methods and frequency of NPP equipment and pipelines base metals and weld joints inspection and to the lifetime management covering the ageing processes control of major equipment, including the non-replaceable equipment.**

General requirements to lifetime management of NPP equipment are provided by the NP-001-15 and the NP-089-15. For instance, NP-001-15 establishes the operators' responsibility for NPPs' equipment lifetime management.

# Regulatory and Legal Basis for an NPP Equipment Lifetime Management (including the non-replaceable equipment) at Operation and Lifetime Extension of a Power Unit (2/2)

Requirement provided by the NP-096-15:

- "..operating organization should provide information for collection, processing, analysis, systematization and storage during the entire lifetime of NPP equipment and pipelines; the operating organization should maintain database on damages, their accumulation and propagation, along with ageing mechanisms, failures and violations in operation and operational modes (including transients and accident situations) in the correspondence with the programme on NPP equipment and pipelines lifetime management".

Requirements to an NPP power unit lifetime extension:

- NP-017-2000: extension criteria and requirements to the scope of the required research;
- "Administrative Regulation on Implementation of the State Function of Licensing Activities..": requirements to the set of safety justification documents.

Requirements from NP-017-2000 are specified in several safety guidelines: RB-027-04, RB-028-04, RB-029-04, RB-030-04, which include Rostechnadzor recommendations regarding comprehensive survey of an NPP power unit, demonstration of residual lifetime of its elements; analysis of non-compliances of a power unit against the requirements of regulatory documents in force and the experience feedback.

# NPP Equipment Lifetime Management in the Course of Operation

**Updating of the Programme on lifetime management**

**2. Implementation and optimization of lifetime management**

*Preparation, co-ordination, maintenance and adjustment of lifetime management works:*

- *requirements to regulatory documents and safety criteria;*
- *measures provided by regulatory documents;*
- *description of co-ordination mechanisms;*
- *increase of the lifetime management efficiency following the self-assessment and review.*

**Mitigation of the expected degradation**

**3. Operation of equipment (pipelines)**

*Degradation mechanisms management:*

- *operation in compliance with the established procedures and documents;*
- *water chemistry control;*
- *surrounding area monitoring;*
- *Records keeping (parameters and operational history).*

**5. Maintenance**

*Degradation effects management:*

- *preventive maintenance;*
- *corrective maintenance;*
- *optimization of the spare parts range;*
- *replacement and keeping of maintenance and repair services records*

**1. Studying of ageing and degradation processes**

*Information behind the lifetime management:*

- *Materials, their properties and manufacturing methods;*
- *operational conditions and loads;*
- *degradation mechanisms and zones;*
- *degradation and failures consequences;*
- *research outcomes;*
- *operation experience;*
- *Background of inspection and maintenance;*
- *Methods to mitigate /slow-down;*
- *The current status/detector*

**4. Survey, monitoring and engineering status assessment**

*Revealing and assessment of degradation:*

- *tests and inspections;*
- *pre-operational and operational control;*
- *observations;*
- *revealing of leakages, vibrations monitoring;*
- *availability assessment;*
- *database updating*

**Mitigation of degradation mechanisms**

**Checking of degradation mechanisms**

# Equipment Lifetime Management at Extension of an NPP Power Unit Operation (1/2)

**The availability of necessary residual lifetime of non-replaceable equipment of an NPP power unit** is one of the key factors to determine the possibility and duration of an NPP unit operation during the extended lifetime.

Measures to demonstrate the safety of NPP lifetime extension:

- comprehensive survey of an NPP unit
- to prepare Programme on an NPP power unit preparation to lifetime extension

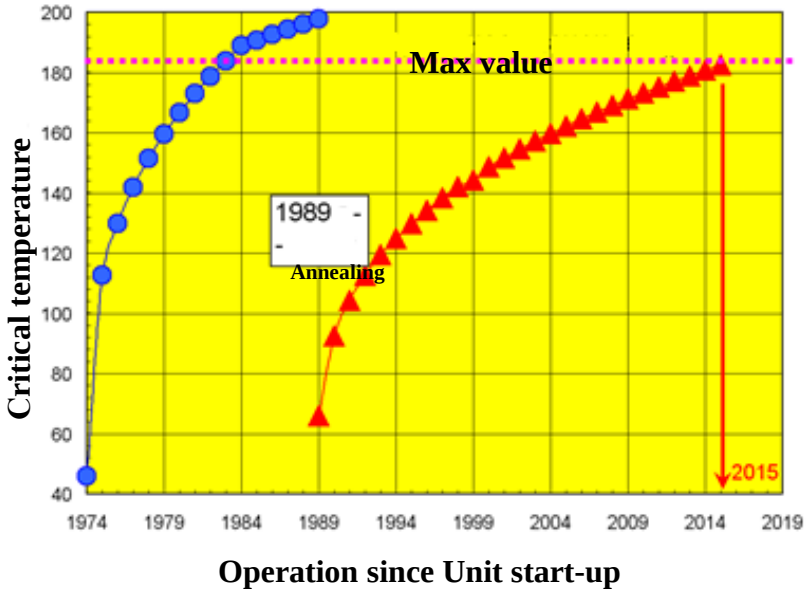
**should involve the implementation of research to define the residual lifetime of non-replaceable elements of an NPP power unit along with the building structures, foundations, buildings and structures; defining and realization of necessary measures to increase the residual lifetime of these elements.**

- to prepare an NPP power unit for operation during the extended lifetime, including demonstration of safety and residual lifetime of elements; replacement of equipment, which lifetime expired, and, if necessary, modernization or backfitting of an NPP power unit.

# Equipment Lifetime Management at Extension of an NPP Power Unit Operation (2/2)

Expert evaluation regarding the DBTT change of welded joints at RPV, Kola NPP, Unit No.4.

Based on the conclusions from review performed in 2009 by SEC NRS, the possibility to extend the reactor vessel lifetime beyond the design following the brittle fracture resistance criterion was confirmed only up to the year 2015 (whereas the operating organization requested greater duration of the extended lifetime).




The operating organization performed additional researches (templates sectioning) to demonstrate the possibility of this reactor vessel operation after 2015. Following the consideration of conclusions from additional analyses of safety, the period of Kola NPP, Unit No.2 operation was extended up to December 2019.

# Thank you for attention!