Project «Zero Failure Level». Organization, State, Tasks

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ТОПЛИВНАЯ КОМПАНИЯ РОСАТОМА ТВЭЛ

РОСАТОМ

ГОСУДАРСТВЕННАЯ КОРПОРАЦИЯ ПО АТОМНОЙ ЭНЕРГИИ «РОСАТОМ»

PROJECT «ZERO FAILURE LEVEL»

Organization, State, Tasks

A. Ugryumov
Project manager

11-th International Conference
«Operation, modeling and experimental support of the fuel»
Varna, Bulgaria
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VVER Reactors

According to IAEA (PRIS base) today in the world there are 483 operating power units including 34 in Russia.

In Russia and countries of Europe and Asia under operation are:

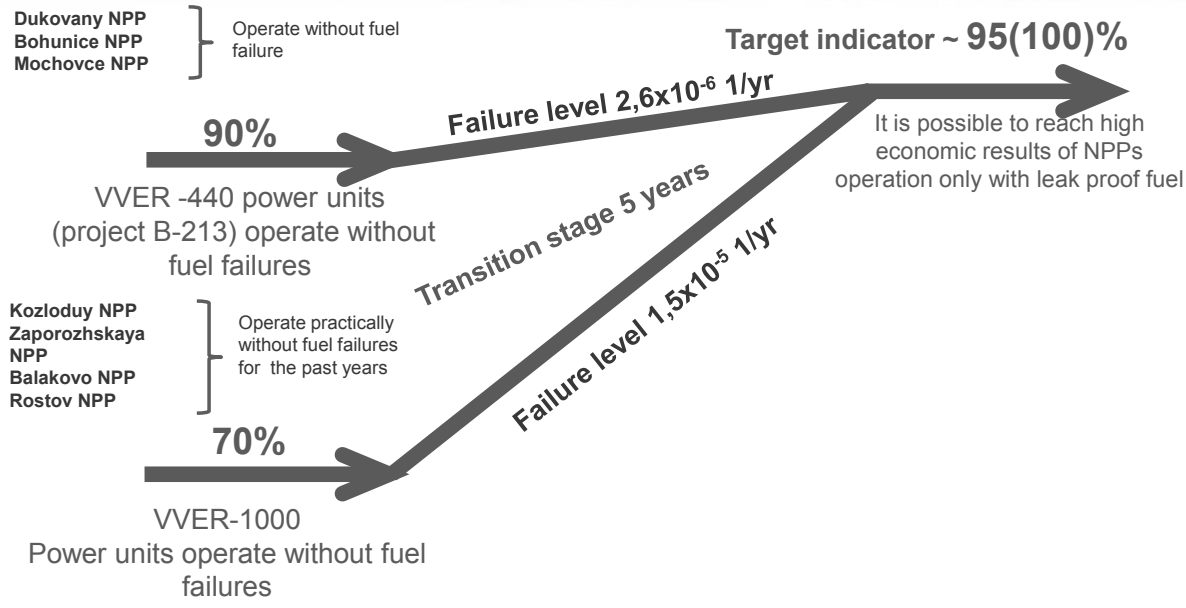
56 power units of NPPs with VVER reactors

33 VVER-1000 reactors

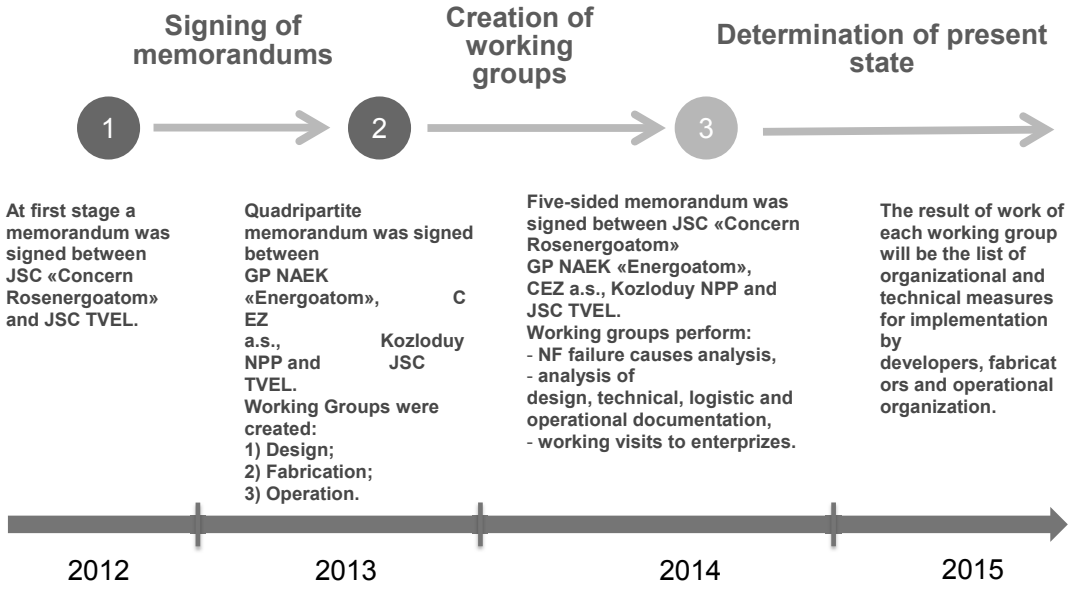
23 VVER-440 reactors

Just built and operated 71 power units with VVER reactors

2012
Share of VVER power units without fuel failure



PROJECT «ZERO FAILURE LEVEL»



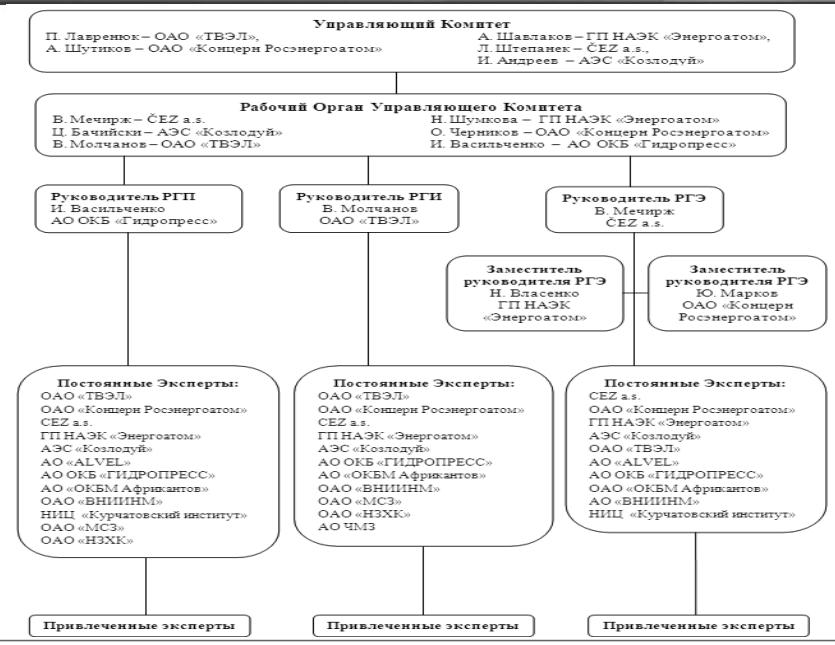
ORGANIZATIONAL ACTIONS

In 2014 basic documents were drawn:

- **«Five-sided memorandum on joint actions for achieving NF zero failure level». Participants of the project:**
  - **JSC «TVEL»;**
  - **JSC «Concern Rosenergoatom»;**
  - **GP NAEK «Energoatom» (Ukraine);**
  - **CEZ a.s. (Czech Republic);**
  - **Kozloduy NPP (Bulgaria).**
- **«Confidentiality agreement»**
- **Provision on the activities within the frames of the project «Zero failure level»**

  Structure of the project is approved, working groups are formed, working schedules are approved

ORGANIZATIONAL STRUCTURE



ACTIONS

The following experts take part in the project:

From TVEL:

- EDO Gidropress, OKBM Africantov, Kurchatovskiy Institute, VNIINM, Trinity, MSZ, NCCP, CMP; «ALVEL»

From Concern Rosenergoatom:

- Balakovo NPP, Kalinin NPP, Rostov NPP, VNIIAES, «Trinity»

From GP NAEK Energoatom:

- Zaporozhskaya NPP, Khmelnitskaya NPP, Rovenskaya NPP, Yuzhnoukrainskaya NPP, «KhFTI»

From CEZ a.s.:

- Temelin NPP, UJV REZ

Kozloduy NPP.

Actions taken:

- ✓ 37 meetings and discussions within the frames of the Managing Committee, Working bode iof the Managing Committee, Working Groups and working meetings of experts;
- ✓ Working visits of experts to MSZ, NCCP and CMP;
- ✓ Partnership visits to Kalinin and Balakovo NPPs.

VVER-1000 REACTORS IN COUNTRIES OF THE WORLD

33 VVER-1000 NPP power units are operated throughout the world:

Country	Number of operating power units
Russia	12 (10)
Ukraine	13 (12)
Bulgaria	2 (2)
Czech Republic	2 (2)
China	2
Iran	1
India	1

Within the frames of the project «Zero failure level» TVSA and TVS-2 and their modifications' operational experience is analyzed starting 2003 at 26 VVER-1000 power units (indicated in brackets).

«TREE OF FAILURES»
HIERARCHICAL LIST

- Fuel rod cladding damage (through fault)
- FA form change
- Sediments of fuel rod's surface
- Mechanical damage of FA elements
- FA elements corrosion
- Rejection features at incoming inspection
- Deviation of actual operational parameters from calculated ones
- Presence of foreign object in the core (without evident FA defects)

VVER-1000 FA FAILURE MAIN FEATURES

- **Change of geometrical form**
- **Mechanical damage**
- **Leaking**

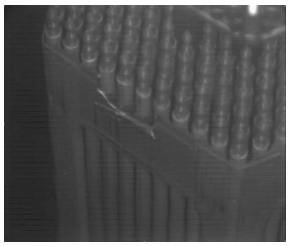
CHANGE OF FA GEOMETRICAL FORM

- Starting 2008 at Ukrainian NPP significant bending of TVSA have been detected. Similar phenomenon was detected at Kozloduy and Kalinin NPPs.
- Cause – significant axial efforts on FA from PTU (FA over compression) at existing in-vessel internals design of VVER-1000.
- Way of optimization of efforts value – adjusting of protrusion of PTU pads over MRC
- Additional actions:
  - introduction of wire with *Ø5,1 мм вinstead of Ø5,6 мм into the spring cartrige of the top nozzle;*
  - *repositioning of FA from one core sector to another*

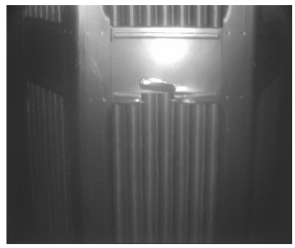
Action taken confirm the correctness of adopted decisions – FA bending problem is practically solved at NPPs

FA MECHANICAL DAMAGE

- Damage of «flat» rims of SG of TVSA-ALFA during loading-unloading of FA during maintenance in 2009,2010, 2011 at Kalinin NPP unit 1.
- After changing of design of SG from «flat» rim to Kremlin wall starting 2010 there were no damages of SG rims of TVSA-ALFA after 2010.



FA № **ЕД 01772**
on 8-th SG bending outside and torn top part of the rim

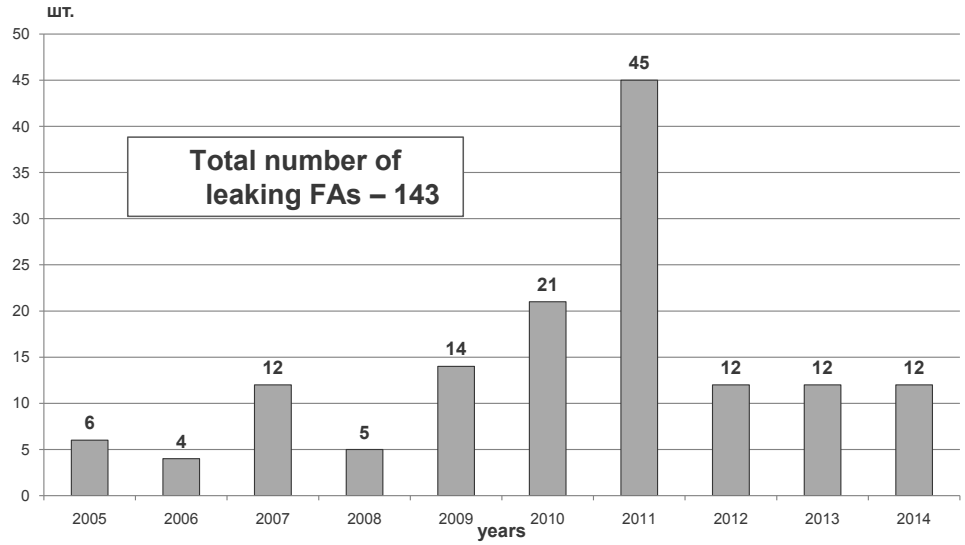


FA № **ЕД 01785**
on 2-nd SG in lower part of the rim tearing and bending outside protruding 2 мм

FA № **ЖЕД0817**
on 4-th SG tearing of the top part of the rim

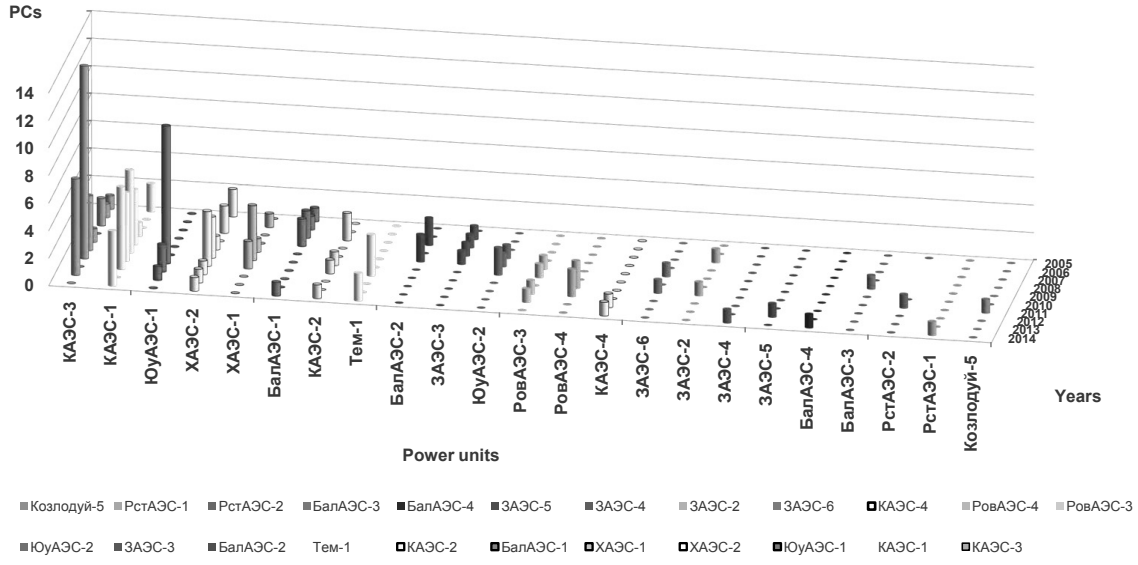
FA № **ЕД01044**
on 3-d SG tearing of the top part of the rim

LEAKING FAs (1)
FAILURE MAIN FEATURE



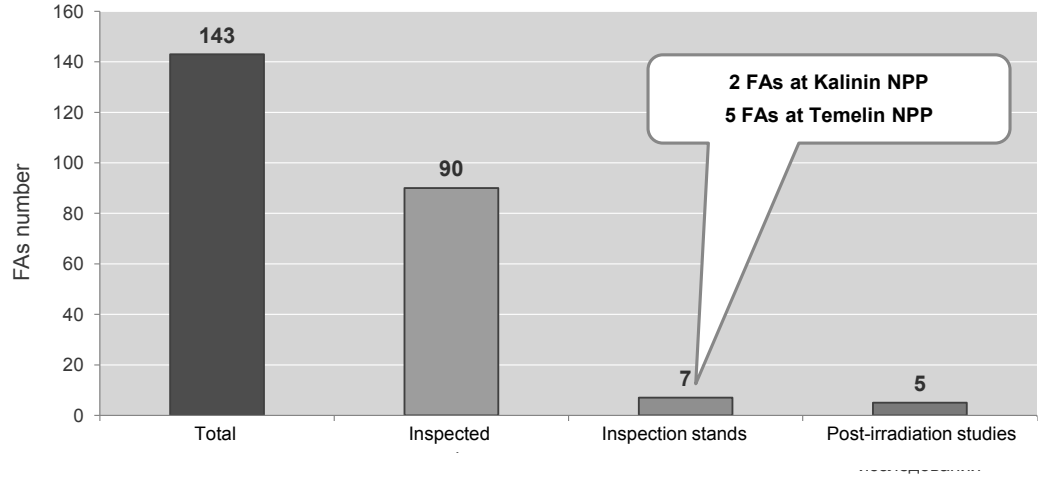
Yearly distribution of leaking FAs

LEAKING FAs (2)



Distribution of leaking FAs per power units

LEAK PROOF FAs (3)



Cope of examination of leaking fuel assemblies

LEAKING FUEL ASSEMBLIES (4)

1. FA inspection in the mast of refueling machine is least informative method of identification of leaking fuel rod in the FA.
2. Inspection stands present at NPP allow to quickly inspect the FA and to identify the leaking fuel rod with the help of ultrasonic inspection system. But during inspections on inspection stands the cause of fuel rod leakage was not detected unambiguously not even in one inspected FA.
3. The Most informative method of inspection of leaking FAs is the post irradiation examination in hot chambers of NIIAR that allow :
   - To explicitly identify the leaking fuel rod;
   - To obtain complete information about the state of the leaking fuel;
   - To establish the cause of leakage.

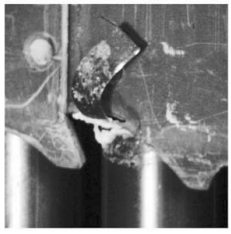
   To perform examination in hot chambers a lot of time (up to 4 years) and material resources are required.

POST IRRADIATION EXAMINATION OF LEAKING FUEL ASSEMBLIES VVER-1000 (1)

№	FA index	Unit, NPP	FA type	Average burn up, MWt days/kgU	Number of fuel cycles	Year of fabrication	Year of examination	Cause of leakage
1	ЕД0463	KlnNPP-1	ТВСА-У	53,73	5	2003	2010	Fretting damage
2	К0523	KlnNPP-3	ТВСА	4,57	1	2003	2010	debris-damage
3	390900407	BlkNPP1	ТВС-2	18,19	1	2003	2008	
4	ЕД0710	KlnNPP-1	ТВСА	14,84	1	2004	2007	
5	ЖЕД0719	KlnNPP-1	ТВСА-5М	65,40	5	2004	2012	

POST IRRADIATION EXAMINATION OF LEAKING FUEL ASSEMBLIES VVER-1000 (2)

ТВС-2 0407



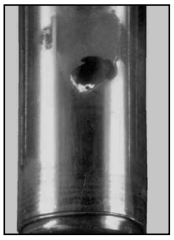
Foreign object and through debris damage of the fuel rod

External view of the leaking fuel rod (winding zone)

ТВС 0719

ТВСА 0523

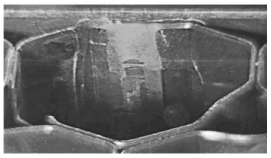
ТВСА 0710



Through debris damages of fuel rods

ТВСА-У 0463

Fuel rod is uplifted



AVG cell is damaged

MAIN TASKS

- Analysis of influence of parameters connected with nuclear fuel management and operation at NPPs on operational reliability of the nuclear fuel;
- Development of technical project of FA inspection stand;
- Analysis of interconnection between parameters of boundary conditions of FA and fuel rod operation;
- Development of means and methods of FA and its components inspection;
- Assurance of absence of foreign objects in coolant of the first loop at NPP;
- Introduction at NPPs of FAs with antidebris filter.

CONCLUSION

- Organizational and technical actions are completed.
- Significant part of works per stage «Determination of current state» is fulfilled.
- Systematic cause of the main feature of failure – leaking of FA- is the debris damage of fuel rod cladding with foreign objects.
- It is important to equip NPPs with modern means of FA inspection and means of extraction of foreign objects.