ANALYSIS OF OCUPATIONAL EXPOSURE INDICATORS AT DIFFERENT TYPES OF RUSSIAN NUCLEAR POWER PLANTS

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Abstract

The paper describes the changes in occupational exposure indicators for different types of Russian Nuclear Power Plants (VVER, RBMK, custom-build) from the end of the last century up to the levels reached in 2008. It also presents the analysis of the performed organizational and technical measures and discusses the planned activities, which should be implemented in the nearest future.

At the end of the last century, a number of new normative documents and standards related to the radiation protection of Nuclear Power Plants were developed, legislated and published in the Russian Federation. These documents are based on the main aspects of ICRP Publication 60 and International Basic Safety Standards and cover all significant fields of radiation protection. It should be mentioned that new dose limit 100 mSv averaged over defined periods of 5 years instead of earlier fixed 50 mSv per year is just one change from the set of substantial modifications in the contents of modern regulations.

Practical implementation of these new regulations required the development of the interconnected activities aimed at decreasing of utilities employees and contractors occupational exposure.

It was very pressing item for all types of Russian NPPs and particularly for RBMK-1000 MWe (11 operating reactors at 3 sites). For example, by the end of 1996, the average annual collective dose per RBMK unit was 9.36 man Sv and individual doses of 861 persons exceeded 20 mSv. In the year 2008, the average annual collective dose per RBMK unit was 3.23 man Sv and there was no individual dose exceeding 20 mSv at RBMK as well as at all Russian reactors.

Russian Commercial Nuclear Power Plants

At present time, there are 31 operating reactors at 10 Nuclear Power Plants in the Russian Federation. According to reactor type and output, these reactors can be categorized:

- 9 units of VVER-1000 MWe reactors;
- 6 units of VVER-440 MWe reactors;
- 11 units of RBMK-1000 MWe reactors;
- 5 units of custom-build reactors (1 unit BN - fast breeder reactor - of 600 MWe and 4 EGP type reactors – water - graphite channel type reactor with output 12 MWe each).

Moreover, 4 reactors (2 units at Novovoronezh NPP and 2 units at Beloyarsk NPP) are in different stages of decommissioning.

Centralized management of all Russian NPPs is executed by one operating utility – Concern Energoatom (till September 2008 – Concern Rosenergoatom). Concern Energoatom is fully responsible for providing all aspects of operational safety at Russian NPPs.

The main task of All-Russian Research Institute for Nuclear Power Plants Operation (VNIIAES), which was established in 1979, is to provide scientific and technical support in the area of NPP operation, based on the development and implementation of the new instrumentation and methods for increasing of NPP safety, reliability and economical efficiency.

Analysis of utilities employees and contractors occupational exposure at Russian NPPs with different type of reactors

In the Russian Federation, the process of providing occupational radiation protection is treated as the essential part of the plant total operational safety.

In accordance with the requirements of the Russian radiation protection normative documents published in 1995-1996, the main aspects of ICRP Publication 60 and IAEA BSS 115 recommendations were defined as the national legislative act. Since 01 January 2000, effective dose 100 mSv per five successive years with the provision that it should not exceed 50 mSv in any single year was determined as the main dose limit in occupational exposure. Since 1961 until 01 January 2000, the main dose limit in occupational exposure was fixed 50 mSv of annual equivalent dose in the Soviet Union and later in the Russian Federation.

The transient time period from 1996 till 1999 was specially planned for development and practical implementation of organizational and technical activities to meet the new more strict occupational radiation requirements. Some characteristic radiation data at the beginning of this transient period and in 2008 are shown in Table 1.

Table 1: Evaluation of occupational radiation protection indicators at Russian reactors in 1996 and 2008

Kind of indicator	Reactor type	1996	2008
Average annual individual dose of plant personnel and contractors, mSv	VVER	2.0	0.8
	RBMK	7.0	2.0
	Custom-build	3.9	1.7
	All reactors	4.8	1.5
Number of plant personnel and contractors exceeding 20 mSv individual dose, persons	VVER	68	0
	RBMK	861	0
	Custom-build	37	0
	All reactors	966	0
Average annual collective dose per unit, man Sv	VVER	1.7	0.7
	RBMK	9.4	3.2
	Custom-build	1.3	0.7
	All reactors	4.3	1.5

Occupational exposure tracking for some discrete characteristic time periods is provided below in this paper.

Individual doses of utilities employees and contractors

The average annual individual doses at Russian operating reactors for the years 1994-2008 are summarized in Figure 1.

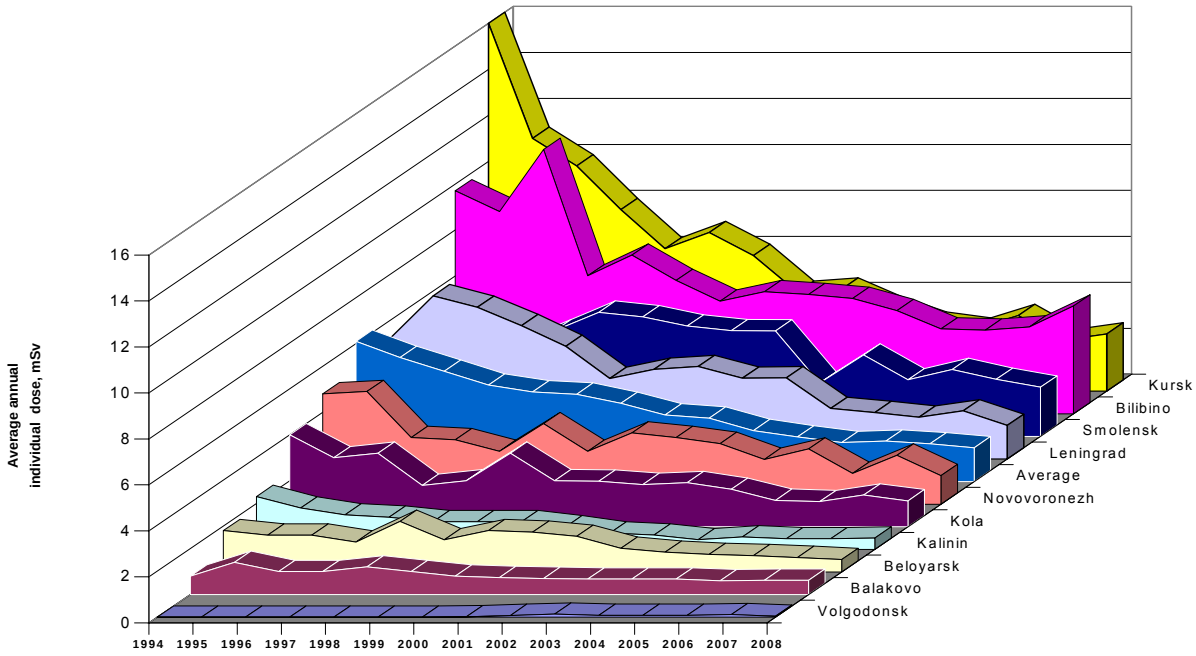

Figure 1: Average annual individual doses at Russian reactors for the years 1994-2008

Data analysis shows that for the period 1994-2008 (15 years) the values of average annual individual dose decreased at:

- 3.8 times for VVER type reactors;
- 4.4 times for RBMK type reactors;
- 2.2 times for custom-build reactors.

One of the most important indicators for individual doses analysis is the distribution of the number of utilities employees and contractors over the definite intervals of the annual individual doses. Data described this distribution for different types of reactors in 2008 are shown in Figure 2.

As it can be seen from the data in Figure 2, the annual individual doses less than 1 mSv have got more than 60% from the total number of utilities employees and contractors. Moreover, the distribution analysis for the years 2000-2008 shows some tendency to the increasing the number of utilities employees and contractors with annual individual doses less than 1 mSv (Figure 3).

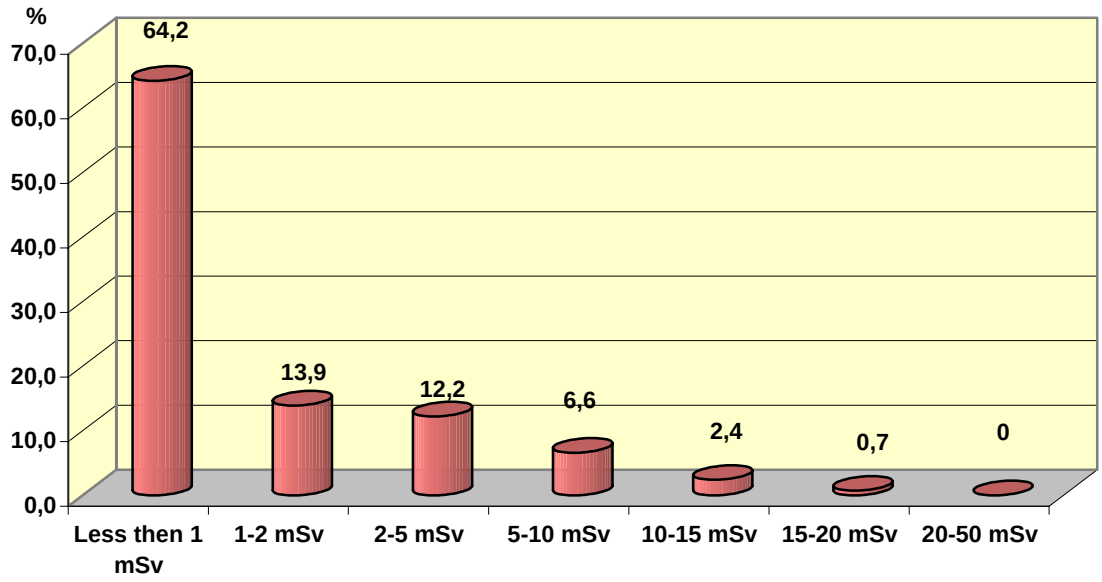

Figure 2: 2008 distribution of the number of utilities employees and contractors according to the intervals of the annual individual doses, in %

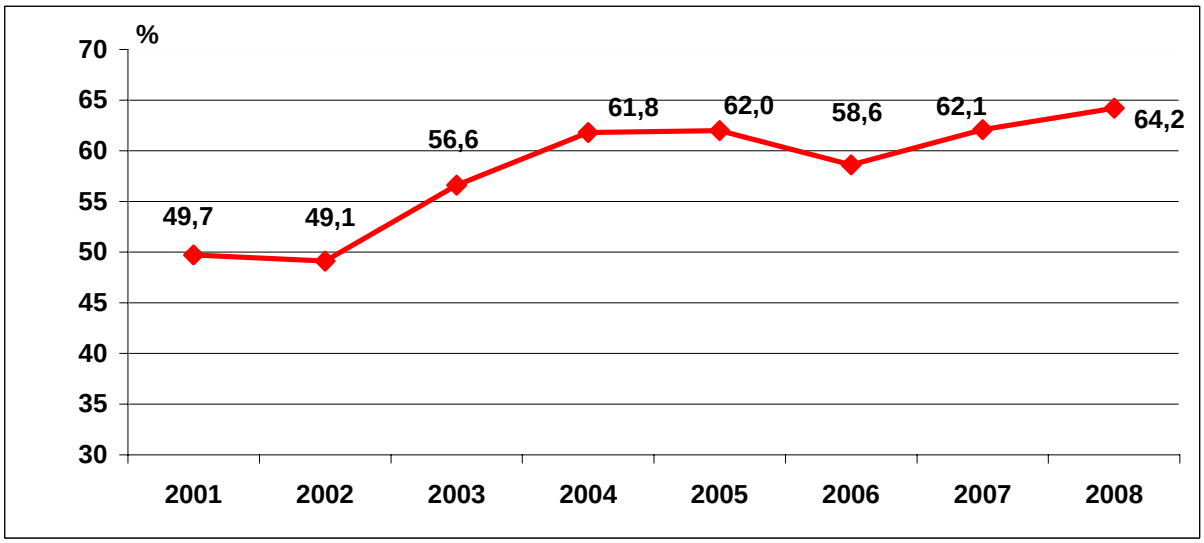

Figure 3: Evolution of the total number of utilities employees and contractors with the annual individual dose less than 1 mSv for the years 2001-2008, in % from total

Other important indicators, described the status of occupational radiation protection at the plant, are the amounts of utilities employees and contractors with the annual individual doses more than 10 mSv and 20 mSv. As shown in Figure 4:

- starting from 2006, there are no events of exceeding 20 mSv at all Russian reactors;
- total number of utilities employees and contractors with the annual individual doses more than 10 mSv decreased from 1465 in the year 2006 to 1080 in the year 2008.

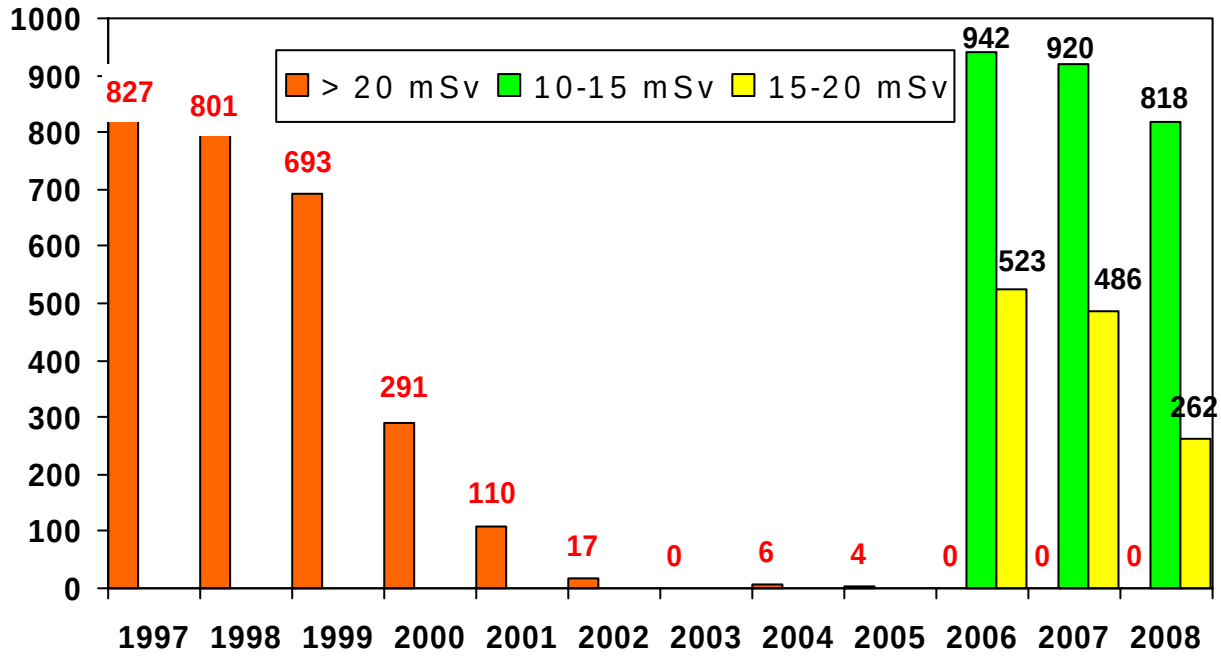

Figure 4: Number of utilities employees and contractors with the annual individual dose more than 10 mSv and 20 mSv for the years 1997-2008

Taking into account that since 01 January 2000 the occupational exposure main dose limit is 100 mSv per five successive years, the considerable attention during performance of individual exposure monitoring at Russian plants is focused at the control of accumulated individual dose for the five year periods. The analysis results for the last five years period (from 2004 till 2008) is shown in Figure 5.

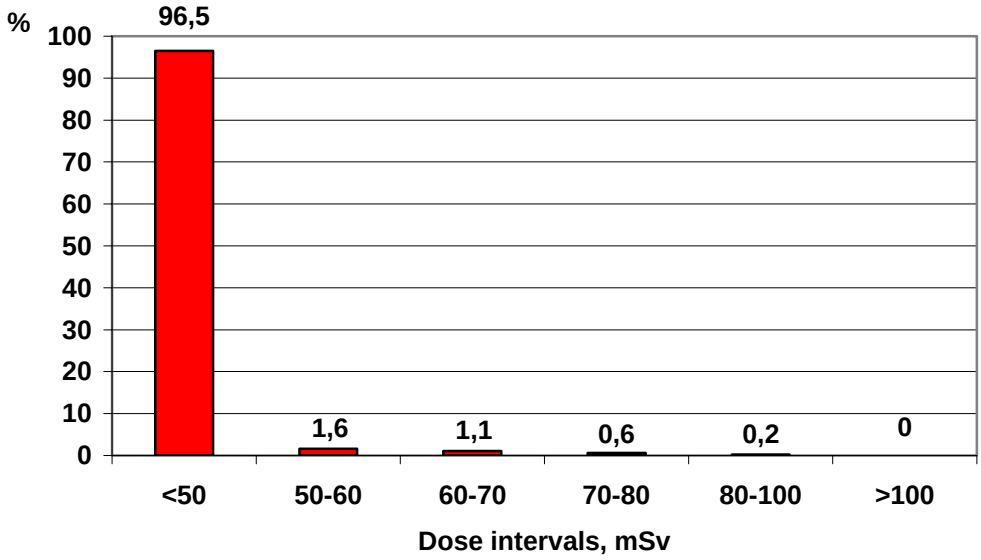

Figure 5: Distribution of the number of utilities employees and contractors according to accumulated individual dose for the years 2004-2008

Utilities employees and contractors collective doses

The average annual collective doses per unit at Russian operating reactors for the years 1994-2008 are summarized in Figure 6.

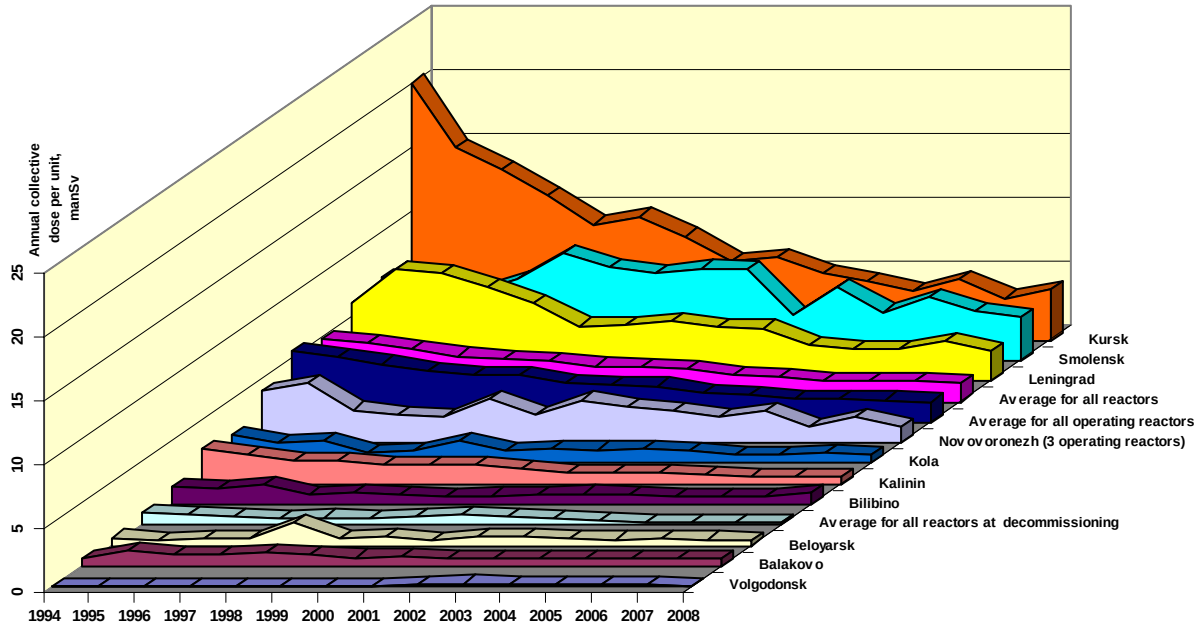

Figure 6: Average annual collective doses per unit at Russian reactors for the years 1994-2008

Analysis of the data shows that in 2008 the average annual collective dose per unit for all operating reactors is 2.8 times lower than in 1996 (the beginning of the transient period to more strict national radiation requirements) and 1.9 times lower than in 1999 (the end of the transient period).

Analysis of the organizational and technical measures aimed at improvement of occupational radiation protection at Russian plants

In the year 2008, the special 2005-2008 Programme for Optimization of Occupational Radiation Protection at RBMK type reactors was finished.

The final measures, performed in the frames of this Programme in 2008, included:

- implementation of the procedure of annual collective dose estimation for all Russian plants;
- development of the standard programme for occupational exposure optimization at the stage of preparation to the planned outage at RBMK type reactors;
- development of the standard programme occupational exposure analysis following the planned outage at RBMK type reactors;

- development of the standard programme aimed at providing occupational radiation protection during the specially radiation dangerous works;
- implementation of the computer based system for providing of periodical monitoring of radiation situation.

The new Programme, aimed at the further optimization of occupational exposure at Russian plants over the period 2010-2014, was developed by Concern Energoatom in the end 2008-beginning 2009.

According to this new Programme, the main planned activities can be distinguished:

- improvement of organizational performance of radiation dangerous works;
- reducing of radiation levels in general areas and plant equipment;
- time saving procedures for utilities employees and contractors;
- improvement of technical methods and instrumentation for radiation monitoring performance.

The main expected results from realization of the new Programme include the following:

- increase the level of occupational radiological protection at NPPs;
- individual doses optimization;
- optimization the number of irradiated workers.

Conclusion

In the years 1996-2008, as a result of the implementation the considerable organizational and technical activities organized by Russian operating utility-Concern Energoatom, the levels of occupational exposure at different type of Russian reactors were substantially decreased. In 2008, the main occupational radiation protection indicators at Russian NPPs are fully correspond with the requirements of the national and international radiation protection regulations.