OCCUPATIONAL EXPOSURE DYNAMICS IN DIFFERENT TYPES OF RUSSIAN NUCLEAR POWER PLANTS

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Abstract

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 IAEA International Basic Safety Standards (BSS, Safety Series 115) 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 the modern Russian regulations in the radiation protection area.

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

It was very pressing item for different types of Russian NPPs: VVER, RBMK, others. However, situation with RBMK-1000 (11 operating units at 3 sites) was the most critical. By the end of 1996, for example, average annual collective dose per RBMK unit was 9.36 man Sv and individual doses of 861 persons exceeded 20 mSv.

The paper describes the changes in occupational exposure indicators for different types of Russian reactors from the end of the last century up to the present time.

Russian Commercial Nuclear Power Plants

The total list of the Russian commercial nuclear power plants, including the brief information about reactor type, output in MWe, date of first power and time of decommissioning (for some of them), is shown in Table 1.

There are 15 operating VVER type reactors (9 units of VVER-1000 MWe and 6 units VVER-440 MWe), 11 operating RBMK type reactors (all units with the output 1000 MWe each) and 5 custom-built reactors (1 unit BN - fast breeder reactor - of 600 MWe and 4 operating EGP type reactors - water-graphite channel type reactor with 12 MWe power each). Thus 31 commercial reactors are totally operated in the Russian Federation nowadays. Moreover, 4 units are at the different stages of decommissioning.

All Russian NPPs centralized management 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 to provide scientific and technical support in the area of NPP operation, based on the development and implementation of the new instrumentation and methods, aimed at increasing of NPP safety, reliability and economical efficiency.

Table 1: List of the Russian commercial nuclear power plants

NPP	Reactor type and output in MWe	First power
Balakovo	Unit 1, VVER-1000	1985
	Unit 2, VVER-1000	1987
	Unit 3, VVER-1000	1988
	Unit 4, VVER-1000	1993
Kalinin	Unit 1, VVER-1000	1984
	Unit 2, VVER-1000	1986
	Unit 3, VVER-1000	2004
Kola	Unit 1, VVER-440	1973
	Unit 2, VVER-440	1974
	Unit 3, VVER-440	1981
	Unit 4, VVER-440	1984
Novovoronezh	Unit 1, VVER-210	1964 reactor is at the stage of decommissioning since 1984
	Unit 2, VVER-365	1969 reactor is at the stage of decommissioning since 1990
	Unit 3, VVER-440	1971
	Unit 4, VVER-440	1972
	Unit 5, VVER-1000	1980
Volgodonsk	Unit 1, VVER-1000	2001
Kursk	Unit 1, RBMK-1000	1976
	Unit 2, RBMK-1000	1979
	Unit 3, RBMK-1000	1983
	Unit 4, RBMK-1000	1985
Leningrad	Unit 1, RBMK-1000	1973
	Unit 2, RBMK-1000	1975
	Unit 3, RBMK-1000	1979
	Unit 4, RBMK-1000	1981
Smolensk	Unit 1, RBMK-1000	1982
	Unit 2, RBMK-1000	1985
	Unit 3, RBMK-1000	1990
Beloyarsk	Unit 1, AMB-100	1964 reactor is at the stage of decommissioning since 1981
	Unit 2, AMB-200	1967 reactor is at the stage of decommissioning since 1989
	Unit 3, BN-600	1980
Bilibino	Unit 1, EGP-12	1974
	Unit 2, EGP-12	1974
	Unit 3, EGP-12	1975
	Unit 4, EGP-12	1976

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

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

In accordance with the requirements of the Russian radiation protection normative documents, published in 1995-1996, 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 Russia.

The 1996-1999 transient period of time 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 2007 are shown in Table 2.

Table 2: Some occupational radiation protection indicators of Russian reactors in 1996 and 2007

Kind of indicator	Reactor type	1996	2007
Average annual individual dose of plant personnel and contractors, mSv	VVER	2.0	0.9
	RBMK	7.0	2.2
	Custom-built	3.9	1.5
	All reactors	4.8	1.6
Number of plant personnel and contractors exceeding 20 mSv individual dose, persons	VVER	68	0
	RBMK	861	0
	Custom-built	37	0
	All reactors	966	0
Average annual collective dose per unit, man Sv	VVER	1.7	0.9
	RBMK	9.4	3.4
	Custom-built	1.3	0.5
	All reactors	4.3	1.6

Occupational exposure dynamics for some discrete characteristic periods is analysed below.

Plant personnel and contractors individual doses

The average annual individual doses at Russian operating reactors for the years 1994-2007 are summarized in Figure 1.

Submitted data analysis shows that for the period 1994-2007, the values of average annual individual dose at VVER reactors decreased at about three times and at RBMK reactors decreased at about four times.

One of the most important indicator for individual doses analysis is the distribution of the number of plant personnel and contractors over the definite intervals of the annual individual dose. Data, described this distribution for different type of reactors in 2007, are shown in Figure 2.

As it can be seen from the data in Figure 2, the annual individual dose less than 1 mSv has got approximately 80% from the total number of plant personnel and contractors. Moreover, the distribution analysis for the years 2000-2007 shows some tendency to the increasing of plant personnel and contractors number with annual individual dose less than 1 mSv for all types of reactors (Figure 3).

Another important indicator, described the status of occupational radiation protection at the plant, is the number of plant personnel and contractors with the annual individual dose more than 20 mSv. Dynamics of this indicator for the years 1997-2007 is shown in Figure 4.

According to the data in Figure 4, starting from 2006, there are no events of exceeding the annual individual dose 20 mSv at all Russian reactors.

Figure 1: Average annual individual doses at different types Russian reactors for the years 1994-2007

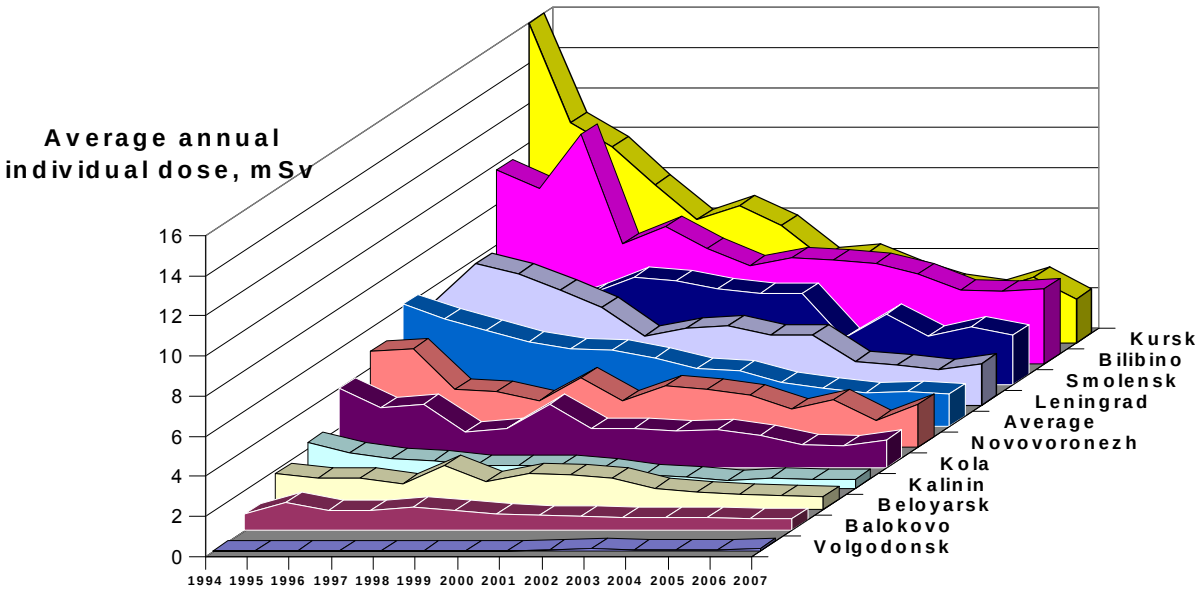


Figure 2: Distribution of the number of plant personnel and contractors according to the intervals of the annual individual dose for 2007, in %

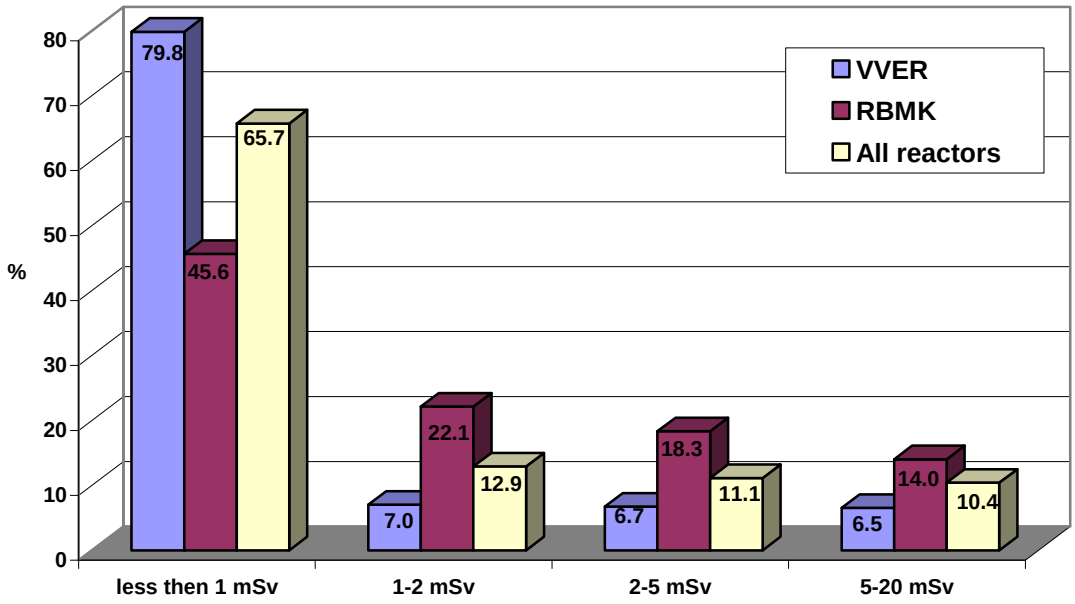


Figure 3: Evolution of the total number of plant personnel and contractors with the annual individual dose less than 1 mSv for the years 2000-2007, in % from total

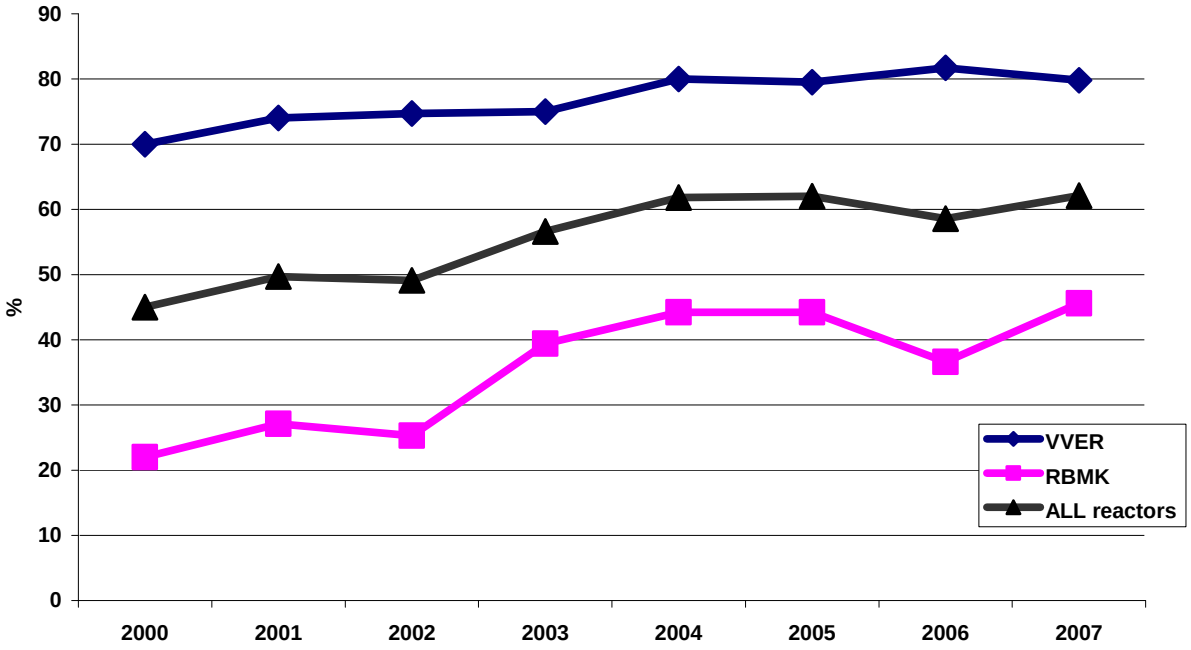
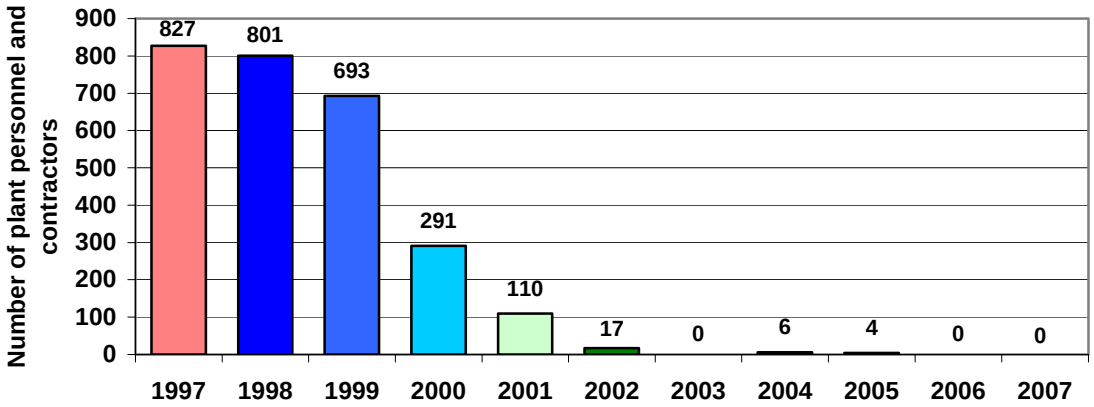
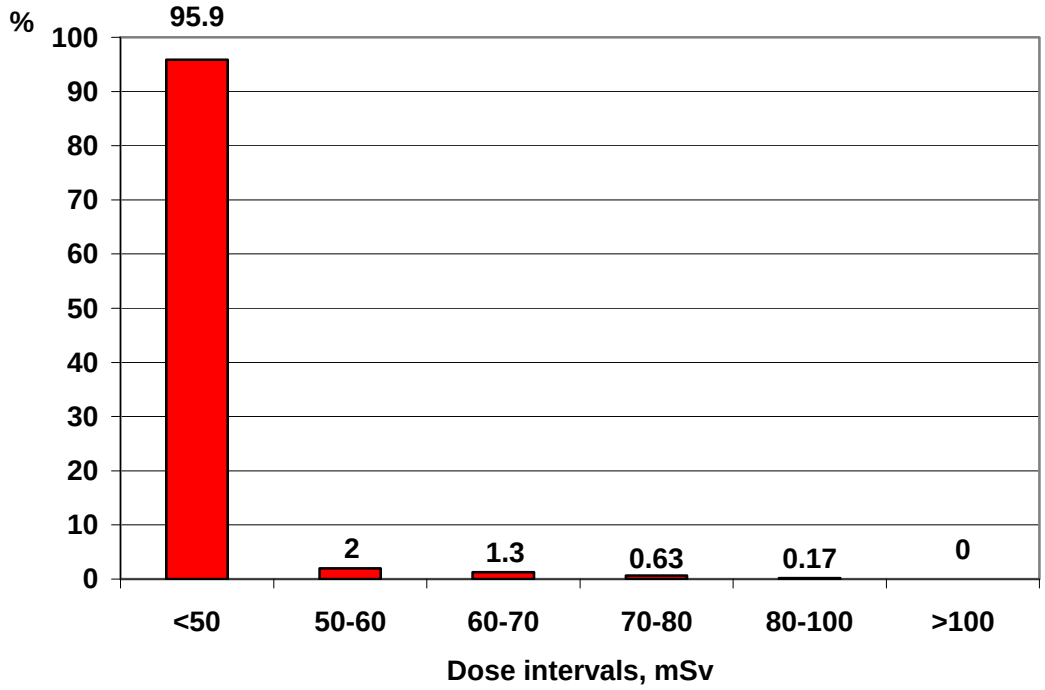


Figure 4: Number of plant personnel and contractors with the annual individual dose more than 20 mSv for the years 1997-2007



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

Figure 5: Distribution of the number of plant personnel and contractors according to accumulated individual dose for the years 2003-2007

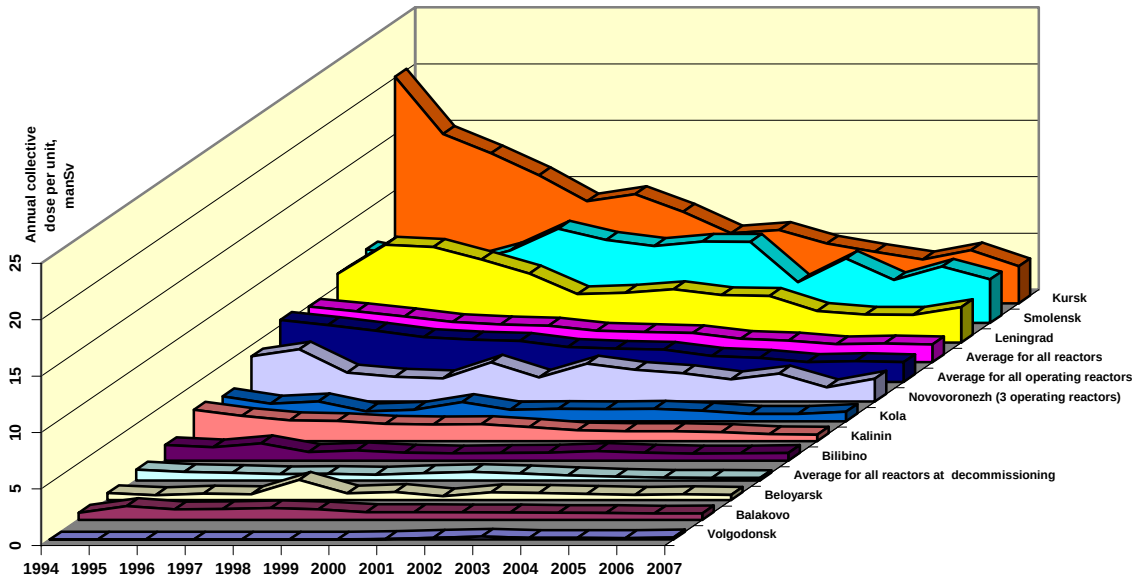


Plant personnel and contractors collective doses

The average annual collective doses per unit at Russian operating reactors for the years 1994-2007 are summarized in Figure 6.

Analysis of the data shows that in 2007, the average annual collective dose per unit for all operating reactors is 2.6 times lower than in 1996 (the beginning of the transient period to more strict national radiation requirements) and 1.8 times lower than in 1999 (the end of the transient period).

Figure 6: Average annual collective doses per unit at different types Russian reactors for the years 1994-2007



Conclusion

In the years 1996-2007, as a result of the implementation the considerable organizational and technical activities, the levels of occupational exposure at different type of Russian reactors were substantially decreased. Nowadays, occupational radiation protection indicators are fully correspond with the requirements of the national radiation protection regulation which is based on the ICRP Publication 60 and the IAEA BSS 115.