Contamination control at the exit from radiation controlled area and NPP site at Bohunice NPP

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Introduction

Bohunice Nuclear Power Plant is situated in south - western part of Slovakia about 50 km away from Bratislava. There are four PWR reactors 440 MWe each - two units with reactors VVER - 230 (V1 NPP) and two units with VVER - 213 (V2 NPP) (Table 1).

Table 1 Bohunice NPP - list of reactor units

Name	Unit	Operation
V1	PWR, Unit 1, VVER-230	1978
	PWR, Unit 2, VVER-230	1980
V2	PWR, Unit 3, VVER-213	1984
	PWR, Unit 4, VVER-213	1985

The original design of four reactor units at Bohunice NPP came from seventies years of 20th century. The same was valid for radiation protection instrumentation.
The process of safety improvement and operational reliability started immediately after the units commissioning. Based on the result of internal experience and international review missions (OSART, WANO,...) a large attention was put in contamination control at the radiation control areas boundaries, personal and vehicle gate site.

Contamination monitors at RCA boundary

The layout of hot and cold change rooms was rebuilt in order to enhance their hygienic status and to unify the previous multiple entry/exit points into only one controlled point. There are two different contamination monitors at the exit from RCA. The measuring of surface contamination of clothes is performed by original Russian contamination monitors (RZB-04-04, RUSSI-1) at the first monitoring point. The second monitoring point includes the contamination monitors for personnel dressed only in underwear (APM3A) and the activity monitors (CPO) for the small objects taking out of radiation controlled area. The modernisation of the contamination monitors was made only for contamination control of personnel.
The modernization of the contamination monitors at the exit from radiation controled areas began in 1998. The innovated system of contamination measurement at RCA exit was put in operation in May 2001.

Description of monitors

RUSSI-1, RZB-04-04 monitors

The old RUSSI-1 and RZB-04-04 monitor uses fifteen detectors split into front and back panel, each detector contains two GM tubes type SBT-10. Contamination alarm levels can be set for individual detector. There are entry/exit barriers, the measuring time is more than 5 second and the active monitoring area is 1071 cm^2 . The detection surface and the dead spacing between detectors are main disadvantages of those monitors.
At present the old beta gamma monitors are used for contamination control of individuals wearing overalls at the entrance to the hot changing room. The calibration source is Sr^{90} and 3 Bq/ cm^2 is the alarm level set for each individual detector.

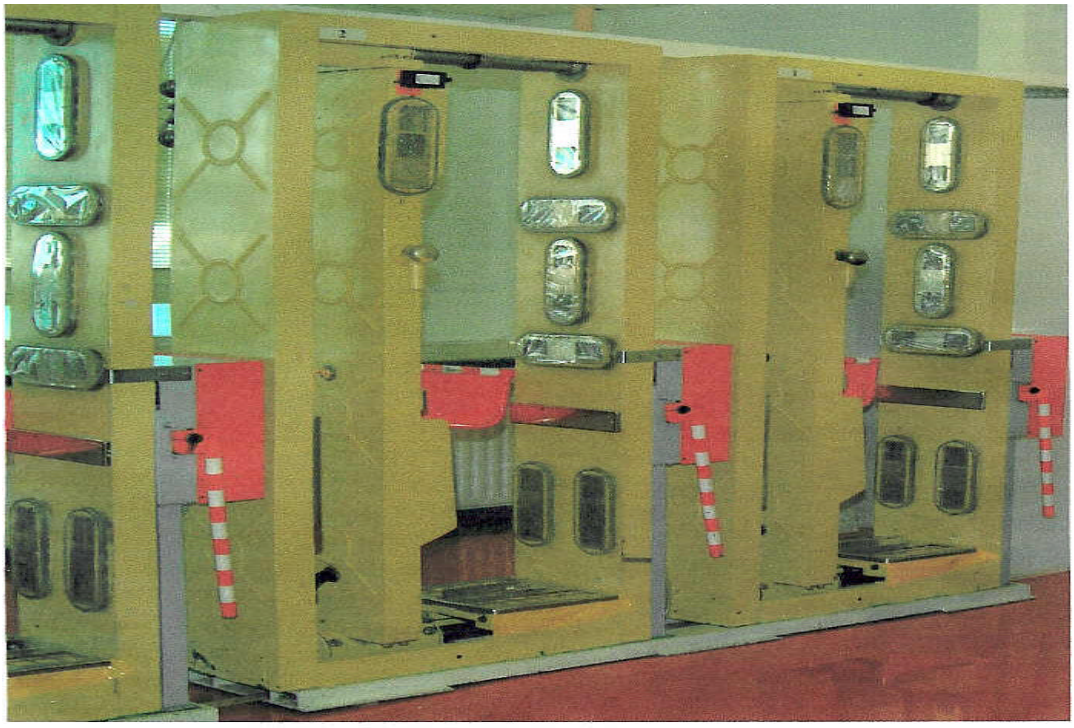


Fig. 1: RUSSI-1 monitors

APM 3A monitor

APM-3A is two steps alfa , beta and gamma-ray sensitive whole-body monitor. There are large gas flow proportional detectors split into some internal compartments for monitoring the hands, body, feet, head and small objects. The monitor comprises twenty four large area LFP-800 detectors and two LFP-330 detectors. The active monitoring area is 32 000 cm^2 for the body and 3200 cm^2 for small objects. There are entry/exit barriers, foot, hands and body photosenzors and reader for ID cards. The control takes place in two steps: body front and one side first, then back and other side. The measurement time is more than eight second for one step.
The APM-3A monitors are used for monitoring of the surface contamination of personnel at the exit from the hot changing-room. The alarm set point is 45 Bq for each detector as well as for sum-zone. Radioisotope ^{137}Cs is used for calibration. The APM-3A is highly-sensitive monitor with an excellent coverage of body surface.

CPO monitor

The CPO uses two large area scintillation detectors (1225 cm^2 each) in the top and bottom sites. There also is the lead shielding (25 mm), entry/exit barriers and audible warning.
The CPO monitors measure the small objects taking out of radiation controlled area. The calibration is performed by ^{60}Co and the alarm level is 90 Bq. The complex of APM-3A and CPO monitors creates the radiological contamination barrier at the exit from the hot changing-room which is the RCA boundary.

Fig. 1: CPO and APM-3A monitors

Activity monitor at NPP site (personal gate)

Several instruments PM7 had been integrated into the overall security system of NPP. The condition for integration was to do not restrict the number of passing people. The PM7 monitor is equipped with the plastic scintillation detectors and with the lead shielding. Scintilators are distributed partly in each pillar (left, right) and in top and bottom part of the monitor. The RDA (Reliable Detectable Activity) of PM7 monitors lies within the interval (9.2 – 10.4) kBq for ^{137}Cs (dotted source in the middle of the monitor).

The innovated system of contamination measurement at the personal and vehicle site gates was put in operation in January 1998.

Fig. 1: PM7 monitors

Experience with installation

PM 7

The measuring algorithm of PM7 had been accommodated during the installation in order to facilitate fluent passing of the personnel through the monitors.

APM-3A

There were larger problems with the control of the P10 gas flow of APM-3A monitors because the gas supply system is situated outside the building.

Immediately after the putting the monitors into the operation a large number of shoe soles contamination had been indicated by those monitors. Those shoes are used only for passage from the hot to the cold room. The main cause of the contamination was the superposition of the small contamination existing on the floor of the hot change room on the shoes' soles. The accepted corrective actions were: more frequent washing of the hot change rooms floors and positioning of the deco foils at the entrance to the hot change rooms

Site gate contamination

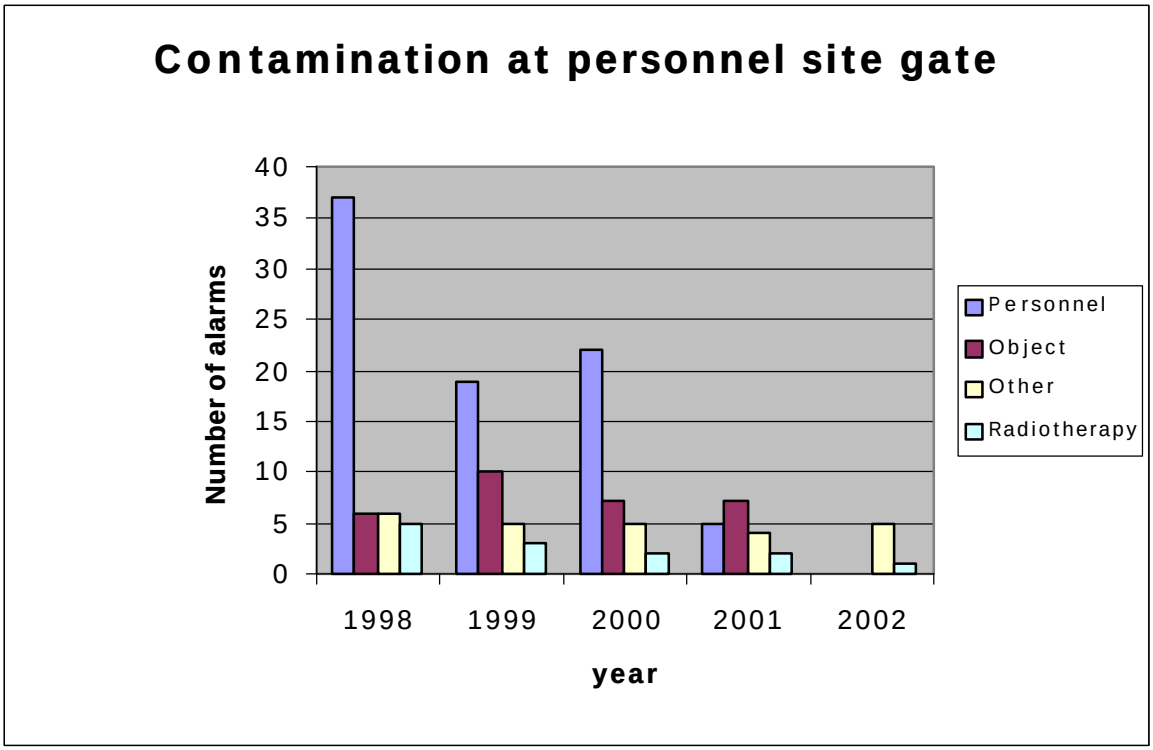
The events of the contamination at the site gate of the NPP are logged from 1998 when the personnel and vehicle contamination monitors were put in operation. In this paper there are only events revealed by PM 7 personal monitors reported.

The contamination review is divided into two periods.

The first period from 1st January 1998 to 1st June 2001 is characterised by the fact that the modernisation of the contamination monitoring equipment at the exit from RCA had not been finished yet and thus still the old monitors RUSSI-1 and RZB 04-04 had been in operation.

In the second period (1st June 2001 - 28th February 2002) the old monitors were replaced by new ones APM 3A.

The number of contamination found during the first period is in the table 2.



Year	No of personnel contamination	No of object contamination	Other	Radiotherapy
1998	**37**	**6**	**6**	**5**
1999	**19**	**10**	**5**	**3**
2000	**22**	**7**	**5**	**2**
2001	**5**	**7**	**4**	**2**
2001-2002 after the modernis.	**0**	**0**	**5**	**1**

Table No.2

The contamination events were divided into the four groups.

1. Personnel contamination - the group contains all the events caused by worker's surface body contamination, his/her dressing or internal contamination.
2. Object contamination - contamination of objects, things wearing by personnel
3. Other - contamination found at the entry to the NPP site which are brought from other sites or caused by natural contamination
4. Radiotherapy - usually found at the entry

Installation of the monitors PM 7 at the personal site gates, which replaced the previous old insufficient monitors, had the large influence into management of the radiation contamination control at the exit from RCA as well as to the evaluation of the radiation knowledge of the plant personnel, contractors and visitors. The RP training process had been analysed and improved and personnel was provided by relevant information. This is why the number of contamination events during the following years decreased.

Analysis of the events revealed:

- More than 70% events of personnel contamination was caused by insufficient characteristics of old equipment RZB-04-04 a RUSSI-1 at the exit from RCA
- Less than 30% of personnel contamination was caused by human error - by violation of RP rules at the exit from RCA
- Up to 60% of events was caused by the contractors workers
- Up to 80% of all events was found at JE V-1 which was caused by a large extend of reconstruction works during the reconstruction and the higher contamination of the primary circuit
- All contamination events represent only negligible risk on the human health (the maximum found activity moved around the kBq)

After the 1st June 2001 no exceeding of activity alarm due to the real contamination has been registered at personal site gates of Bohunice NPP. The fact can be explained by higher radiation awareness of the personnel and mainly by finishing of the replacing of the personal contamination monitors at the exit from radiation controlled areas.

Conclusion

The first event of contamination at the personal site gates was found after the installation of monitors PM 7. The main cause of the taking out of the contamination from the RCA was the insufficient monitoring equipment at the RCA boundary. The problem was eliminated by replacing old monitors through new ones - APM 3A and by the completing of CPO monitors