Radioactive source detection by vehicle radiation portal monitors considering background suppression

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Examination of o various standards and recommendations shows that RPM are usually tested for detection of radioactive sources under some idealized conditions that are greatly different from their field operation conditions.

Among main causes considerably complicating the detection of gamma sources by vehicle (and train) radiation portal monitors under field operation conditions is suppression of the natural gamma background measured by the monitor during the vehicle passage between pillars. The value of such suppression can be rather high reaching as much as 50% of the initial background level. The above mentioned standards and recommendations do not take into account these issues, and, in particular, what is the activity of radioactive sources which can be actually detected if the natural gamma background is considerably suppressed.

In the present paper the authors consider the effects of the natural gamma background suppression for vehicle radiation portal monitors installed at sites having different heights above the sea level, and describe results of first tests of a new advanced algorithm allowing the monitor to detect radioactive sources under high background suppression.

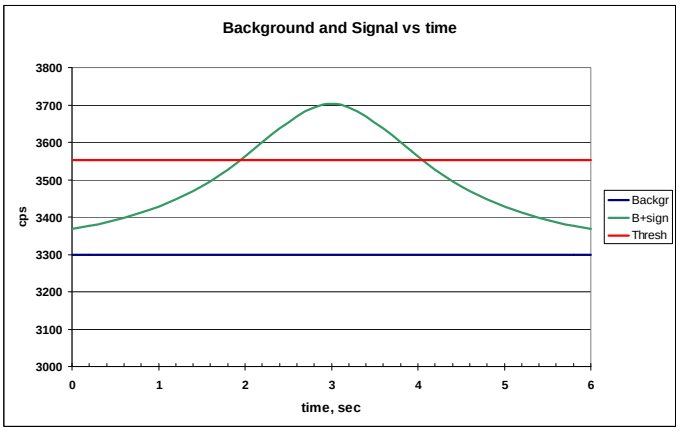
A vehicle radiation portal monitor of VM-250 type with a volume of plastic detectors about 18 liters has been chosen for the present research. This monitor meets the requirements of the IAEA recommendations.

Results and discussion

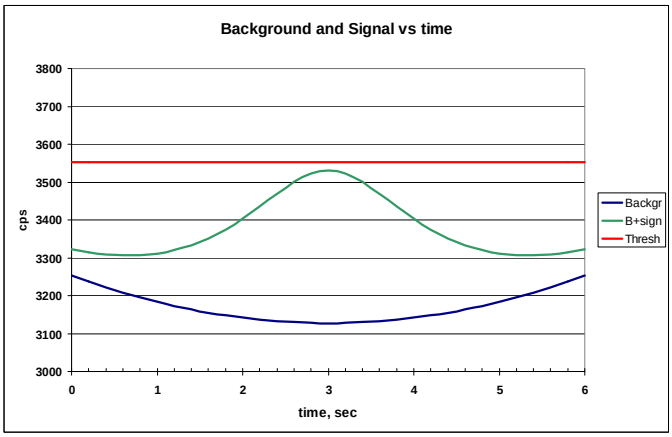
The research was carried out with a big truck transporting the common, not pressed scrap; the monitor was installed at a site situated at approx. the sea level. Special monitors and procedures are usually used for the radiation control of scrap. Nevertheless, there are also border crossing transportations of scrap, when its control is carried out directly at border cross points. We also used a truck with a water tank and the same RPM installed at site with an elevation approx. 1600 m above the see level

Site	**Site 1**	**Site** 2
Elevation	~ sea level	~1600 m
RPM	VM-250 AGN	
Distance between pillars	6.2 m	4.5 m
Gamma Background	1320 cps	3350 cps
Threshold value	4.4 "sigma"	4.4 "sigma"
Vehicle	Truck with scrap	Truck with water tank
Sources (net signal)	Cs-137 (6.4 sigma) Co-60 (7.1 sigma)	Cs-137 (9.4 sigma) Co-60 (11.6 sigma) Ba-133 (9.0 sigma)

As known, the traditional algorithm of the modern vehicle radiation portal monitors is based on the comparison of the signal measured during the truck passage with the threshold value which is usually set at 4-7 "sigma" which provides acceptable value of false alarms rate. The activities of used sources were chosen high enough to detect these sources at the threshold of 4.4 sigma without background suppression. But at even small background suppression (3 sigma; such suppression can be seen when a car moves through the monitor) such strong enough sources (net signal=7 sigma) become undetectable.



Simulated dependence of moving source signal on time without background suppression (net signal =7 sigma, suppression =0 sigma, threshold=4.4 sigma)



Simulated dependence of moving source signal on time with background suppression (net signal =7 sigma, suppression =3 sigma, threshold=4.4 sigma)

Experiments with the trucks show that and at the used distances between pillars the background suppression reached 5.4 sigma and 8.9 sigma for monitors installed at site 1 and site 2, respectively. It is evident, that we could not expect detecting the used moving sources with the traditional algorithm.

To solve this problem, we have elaborated a new advanced algorithm based on other principles compared to those of the traditional one. To compare the opportunities of both algorithms, we placed the chosen sources (Table 1) in trucks, and the trucks moved through the monitors when both algorithms worked. Each source at each location was moved 10 times.

Source detection by the monitor at site 1 (truck with scrap).

Passage	Cs-137			Co-60		
	Max. signal, sigma	Number of detections		Max. signal, sigma	Number of detections	
		Traditional algorithm	New algorithm		Traditional algorithm	New algorithm
1	2.45	0	10	3.55	0	10
2	1.60			2.18		
3	1.18			4.21		
4	1.46			2.98		
5	3.06			2.92		
6	1.65			2.95		
7	1.10			2.59		
8	2.81			3.31		
9	1.90			3.14		
10	2.18			2.98		

Source detection by the monitor at site 2 (truck with water tank).

Passage	Cs-137			Co-60			Ba-133		
	Max. signal, sigma	Number of detections		Max. signal, sigma	Number of detections		Max. signal, sigma	Number of detections	
		Tradit. algorit	New algorit.		Tradit. algorit .	New algorit.		Tradit. algorit .	New algorit .
1	1.41	0	10	4.54	2	10	0.18	0	10
2	0.51			3.5			-0.40		
3	0.28			1.46			-0.28		
4	0.82			2.43			-0.66		
5	1.65			3.59			-0.02		
6	-0.01			2.53			-0.14		
7	-0.76			3.08			-0.49		
8	0.61			4.31			-1.84		
9	0.94			4.87			0.25		
10	1.63			4.02			-2.25		

As seen from the above tables, the measured maxima of signals (as we expected) were small to detect sources using the traditional algorithm (only 2 detections per 50 passages). However, the new algorithm allowed the monitor to detect these sources 50 times per 50 passages. Note, that we did not see any false alarm when the trucks without radioactive source moved through the monitors (about 80 passages).

3. CONCLUSIONS

1. Even comparatively small background suppression can cause the phenomenon that even strong enough radioactive sources cannon be detected in the moving trucks using the traditional algorithm.

2. The new advance algorithm looks promising to solve this problem.

3. We presented only first experimental results of investigation of opportunities of this new algorithm and believe that these results suggest good advantage in the future.