alarm data research of Vehicle Radiation Portal Monitor (RPM)

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1. Background and Goal of the present work

Vehicle Radiation Portal Monitor (RPM) is the main radioactivity detection equipment in the custom port which can prevent illicit trafficking of nuclear and radioactive material. The SNSTC undertakes the IAEA CRP project "Building Fast Assessment Method of Initial Alarms from Vehicle Radiation Portal Monitor" from 2017 to 2019. We carried out a variety of experiments and collected many alarm data of nuclear material, radioactivity sources and natural radioactivity commodities in COE test field and custom port.

According to the analyse result of these alarm data, we can verify the relationship between the weight (or activity) and the γ count rate of RPM, study the impact of vehicle speed and load location to the γ count rate of RPM and identify the differences between the nuisance alarm and real alarm. Thus we can improve the effectiveness of TRACE (Tool for Radiation Alarm and Commodity Evaluation), and promote the assessment efficiency of initial alarms of RPM.

2. Alarm data collection

2.1. *Real alarm data collection in the COE test field*

In the COE test field, we use a linear automation moving system (LAMS) which carry different activity radioactive sources or nuclear material to pass through the RPM in the different heights and different speed, and record the γ alarm data of RPM.

There are 20 radioactive sources including industrial radioactive sources like Co-60 and Cs-137 etc. There are 9 nuclear materials like HEU. There are 5 heights, include the bottom, midpoint between middle and bottom, middle, midpoint between middle and top, top of the centre of detection area. There are 5 speeds, include 1 m/s, 2m/s, 3m/s, 4m/s and 5m/s.

Fig 1: Rear alarm data collection in the COE test field

We collected 4350 alarm data in total. Each radioactivity, each height and each speed will be tested 6 times.

2.2. *Nuisance alarm data collection in Yangshan custom port*

We collected the nuisance alarm data from the history alarm database in the Yangshan custom port, include the potassium hydroxide, ceramic flower pot and glass fibre mat etc.

Fig 2: Nuisance alarm data collection in Yangshan custom port

We collected 533 nuisance alarm data in total, involving 18 kinds of commodity.

2.3. *Real and nuisance alarm data collection in the COE test field*

In the COE test field, we use a truck with container which loads different weight potassium sulfate fertilizer, different radioactivity nuclear material and the combination of potassium sulfate fertilizer and nuclear material to pass through the RPM in different speed and different location, and record the γ count rate of RPM.

There are 4 weights of potassium sulfate fertilizer, include 0 ton, 1ton, 2 tons and 3 tons. There are 3 vehicle speeds, include 8km/h, 13km/h and 20km/h. There are 5 locations of nuclear material, include the centre, the midpoint of front side, rear side, left side and right side of the container.

Fig 3: Real and nuisance alarm data collection in the COE test field

We collected 870 alarm data in total. Each weight, each radioactivity and each speed will be tested 10 times.

3. Alarm data analyse and result

3.1. *The analyse result of real alarm data*

According to the real alarm data which we collected in the COE test field, we compared the γ count rate curve of different speed and different height. The Fig 4 and Fig 5 are the examples of the analyse result.

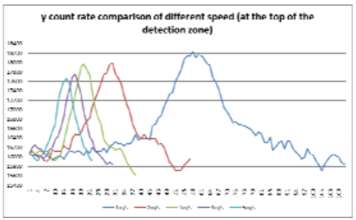

Fig 4: The γ count rate comparison of different speed（top）

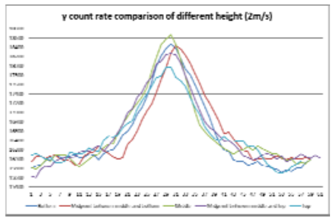

Fig 5: The γ count rate comparison of different height（2m/s）

Note 1: The radioactive sources is EU-152, and the activity is 3.76E+5 Bq

3.2. *The analyse result of nuisance alarm data*

According to the nuisance alarm data which we collected in Yangshan custom port, we get the alarm threshold value of TRACE for different commodity in Table 1. The Fig 6 and Fig 7 are the examples of analyse result.

ID	Commodity name	Green	Yellow	Red
1	potassium hydroxide	(0,1061)	(1061,1197)	(1197,+∞)
2	potassium fluoride	(0,1231)	(1231,1388)	(1388,+∞)
3	potassium nitrate	(0,464)	(464,565)	(565,+∞)
4	mono potassium phosphate	(0,615)	(615,791)	(791,+∞)
5	potassium bicarbonate	(0,565)	(565,704)	(704,+∞)
6	potassium sorbate	(0,459)	(459,600)	(600,+∞)
7	grinding wheel	(0,576)	(576,767)	(767,+∞)
8	abrasive cloth	(0,464)	(464,644)	(644,+∞)
9	firebrick	(0,607)	(607,881)	(881,+∞)
10	display ceramics	(0,202)	(202,295)	(295,+∞)
11	ceramic flower pot	(0,169)	(169,234)	(234,+∞)
12	ceramic flower pot	(0,165)	(165,226)	(226,+∞)
13	glass fiber chopped strands	(0,63)	(63,82)	(82,+∞)
14	glass fibre roving	(0,69)	(69,93)	(93,+∞)
15	glass fiber chopped strand mat	(0,63)	(63,82)	(82,+∞)
16	glass fibre mat	(0,77)	(77,104)	(104,+∞)
17	glass fibre	(0,61)	(61,79)	(79,+∞)
18	ceramic insulator	(0,598)	(598,828)	(828,+∞)

Table 1: The alarm threshold value of TRACE for different commodity

Note 2: (-∞,μ+σ) indicate Green alarm, (μ+σ,μ+2σ) indicate Yellow alarm, (μ+2σ,+∞) indicate Red alarm

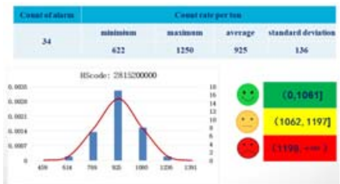

Fig 6: Analysis results of potassium hydroxide

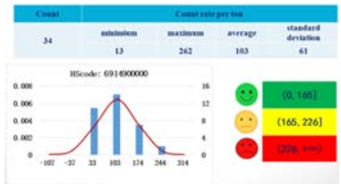

Fig 7: Analysis results of ceramic flower pot

3.3. *The analyse result of real and nuisance alarm data*

According to the real and nuisance alarm data which we collected in the COE test field, we verify the relationship between the weight (or activity) and the γ count rate of RPM, and identify the differences between the nuisance alarm and real alarm. The Fig 8 to Fig 11 are the examples of the analyse result.

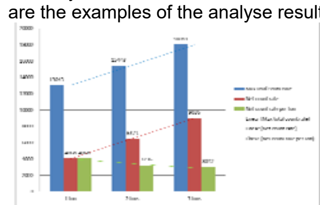

Fig 8: The max γ count rate comparison of different weight fertilizer

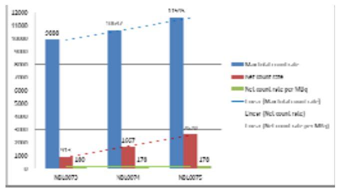

Fig 9: The max γ count rate comparison of different activity nuclear material

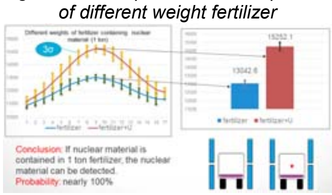

Fig 10: Analysis results example 1: nuclear material in 1 ton fertilizer

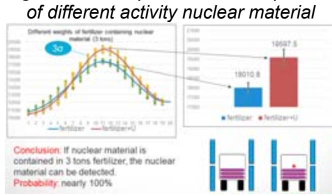

Fig 11: Analysis results example 1: nuclear material in 3 ton fertilizer

Note 3: The unclear material is U-235, and the activity is 1.470E+7 Bq

4. Conclusions and Acknowledgements

- The γ count rate in the different height of the RPM detection area is different. The value in the middle of the detection area is the largest.
- The γ count rate of RPM increase with the increase of the activity of nuclear material and the weight of fertilizer, and decreases with the increase of vehicle speed.
- If the activity of nuclear material is enough large, we can detect the nuclear material from the natural radioactivity commodity according to the γ count rate of RPM.
- The author gratefully acknowledges the helpful of GACC to the nuisance alarm data collection.