Results of several fiels tests simulation a radiological emergency situation in case of misuse of radioactive materials during a terrorist attack

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Abstract:

During recent years, the assessment of possible radiological consequences of a terrorist attack associated with a release of radioactive substances (RaS) has been in the focus of interest of specialists in the field of the emergency preparedness and radiation protection. Suitable tools for these analyses are applications of mathematical and physical models and simulation of the attack under “realistic” conditions. The paper summarizes the experiments, in which a RaS (Tc-99m solution) was dispersed over a free area with the use of an industrial explosive. Detection methods and techniques employed in these tests are described. The obtained data are used for a model inter-comparison exercise organized by IAEA project EMRASS II.

1 INTRODUCTION

Model calculations focused on the assessment of possible effects of terrorist attacks with the use of the RaS method are being carried out in a number of countries. Different variants of the use of RDDs are simulated with the aim to refine systems of the emergency preparedness: to provide timely detection of the event, evaluation of its consequences and effective reactions. We have carried out set of field tests, in which RaS were dispersed in the polygon. Tthe aim of experiment was to accumulate reliable data sets and information on the distribution of radionuclides dispersed by the explosion, which could be used for testing models currently available or being developed. The different field tests were carried out - from the simplest geometric conditions (free area/terrain) to complex ones (simple building, indoor space), which could make it possible to evaluate dispersion of RaS and irradiation of persons. All the tests were performed in test polygon of the National Institute for Nuclear, Chemical and Biological Safety, and were based on an authorisation by the State Office for Nuclear Safety and by Mining Office. The employees participating in the tests were equipped with standard clothing TYVEC, and with personal film and electronic dosemeters. After the each test was completed personal doses of researchers were evaluated and were negligable.

2 FIELD TESTS

2.1 Materials and Method

As the suitable RaS and carrier was used radionuclide Tc-99m (eluate of $NaTcO_4$ in 0.9% sodium chloride solution). This radionuclide was chosen due to its suitable physical characteristics (140-keV gamma-rays, half-life of 6 h). Different amounts of the RaS carrier were tested, too. Based on preliminary experiments 350 g of the PERMON 10T industrial explosive was chosen. In the first tests, the radionuclide was diluted into 1.5 litre of the carrier - water coloured with potassium permanganate in a cylindrical glass vessel (in next carrier volume was of about 6 ml situated in a spherical glass container). The scenario of the dispersion of the RaS by the explosion in the free area and at a selected solid angle was used. Dose rates in the area contaminated were measured by portable instruments, the dose rate and surface activity distributions in the given area were established with the use of a commercially available code. Surface activities were determined (paper filters set horizontally on a polygon area and on vertical columns, filter activities were measured by the semiconductor gamma-ray spectrometry). At chosen sites aerosols were sampled for the determination of the volume activity with the sampling devices (SENYA, Sierra Misco) as well as cascade impactors (Sierra, Andersen). The impactors were used (three 6-stages and one 8-stages impactors) for the determination of the aerosol particle size distribution. To measure temporal and spatial variations of aerosol concentration set of laser nefelometres (DustTrak) were used with integration time of 1s for all the experiments. Measuring equipment involved also infrared imaging technology (thermo camera) recording the time development of the recorded scene before and after the controlled explosion, and weather-monitoring station for detecting and recording metrological parameters (wind speed and direction, humidity and temperature).
For processing of the surface activity distribution, the SAGA open-source software (System for Automated Geoscientific Analyses) was used.

Fig.1 The geometry of exlosion

Fig.2 combined booby-trap explosive system

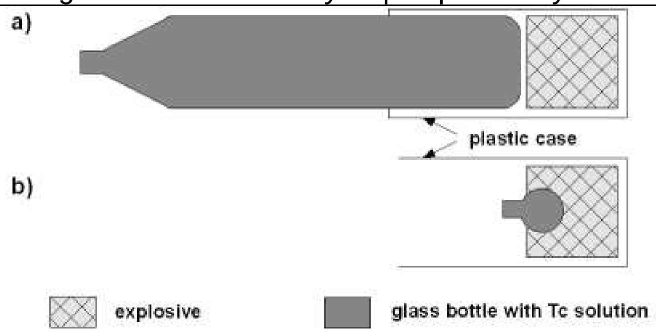
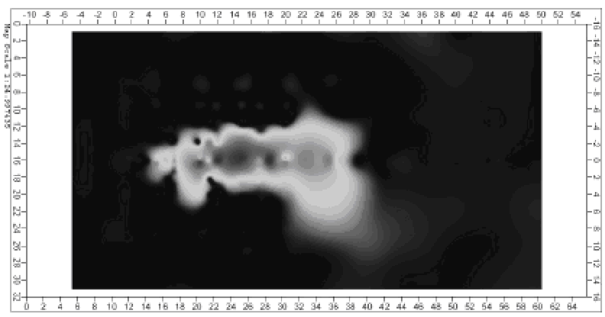


Fig.3 Test: after explosion

Fig.4 Deposit after explosion



2.2 Results and discussion

The exposure pathways at a radiological attack needs to be considered: external exposure by RaS dispersed to environment (terrain, air) and internal exposure by inhalation of RaS dispersed in air. The field tests were focused on modeling of the possible exposures, the system of measurements is able to provide spatial and temporal data for models validation. The results showed the important role of carrier/explosive ratio.

Fig.5. Field experiment, place of measurement	Fig.6. On site after explosion measurements

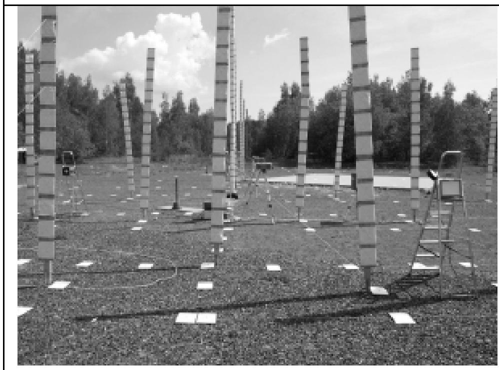



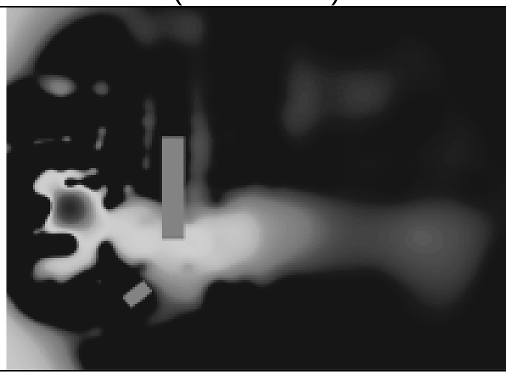
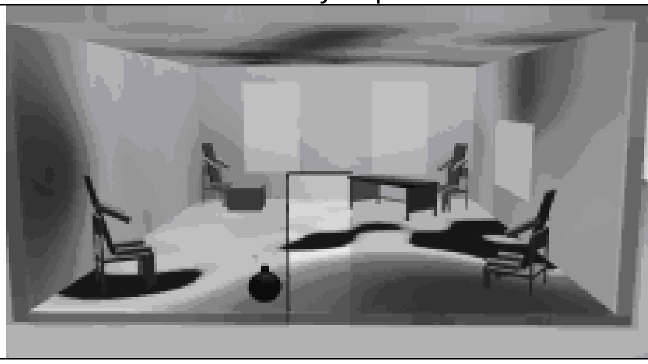
Fig.7. Field experiment (2 obstacles)	Fig.8. Deposit after explosion (2 obstacles)
	
Fig.9. Field experiment : bus	Fig.10. Experiment : explosion in the bus
	

Fig.11. Experiment : explosion in the house	Fig.12. Explosion in the house – evaluation of radioactivity deposition
	

3. CONCLUSION

Data obtained in field tests offer the complex source of information for analysis of the distribution of surface and volume activities and weight concentrations of aerosols. It is understandable that the results are strongly dependent on the actual meteorological situation at the time of the RaS release under otherwise identical conditions. The results obtained by the laser nefelometers indicate that the spread of aerosols is driven by the explosion pressure wave up to a distance of 50 m. For model validation is necessary to provide more detailed instantaneous meteorological data. In the planned field tests we would like to focus on more complex geometries: closed spaces - residences, bus - and comparison of test results with mathematical and physical models.
The obtained data are used for a models inter-comparison organized by IAEA project EMRASS II.

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