Post Blast Nuclear Forensics of a Radiological Dispersion Device Scene

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"Green Field" (GF) project conducting in Israel, between the years ’06-‘14, aimed at increasing the preparedness for outdoor terrorism events, where a radioactive (RA) material is dispersed by an explosive charge. Under the project framework a wide experimental program was established and conducted. The experimental plan included set of about 150 detonation tests that were done in order to close some gaps of knowledge mainly relating to the “source term” characterization. Experiments were done using wide range of different source term parameters. Among these are: explosive types, dispersed materials (both, stable simulants and short live radio isotopes), device geometries, ground surfaces, detonation heights and orientation, atmospheric stability situations etc. Field data collection and documentation used some of the “state of the art” detectors, cameras etc. Based on a comprehensive data analysis and complementary simulations, a methodology for post blast forensic using data collected from the close vicinity of the detention point was developed.

1. Introduction

Realistic source term characterization plays as a “necessary condition” for reliable atmospheric dispersion model predictions. Source term characterization means all the necessary input data needed for the initiation of the atmospheric transport model. This include the final RA particles size distribution, the isotopes involve (single or a mix), the cloud top height (“effective height”- where it is in a thermal equilibrium with the ambient atmosphere), and the distribution of particles along the cloud up to the effective height. Much of the final health and environmental consequences of an explosive RDD event depend on these parameters.

Cloud top height is a function of the explosive type and amount, the surface below HE charge, the local atmospheric stability above the detonation point and the local wind speed.

Particles size distribution following detonation depends the explosive type used (less on the amount), the surface below the detonation, the type(s) of the RA material(s) and the device geometry.

Particles distribution along the cloud is a function of the cloud vertical velocity up to the effective height (depend the HE type, atmospheric stability, wind speed etc.) and the fraction of aerosols out of the total RA material.

The main idea behind the offered “post blast nuclear forensics (NF)” process is that much of the essential data needed for reliable nuclear forensics can be collected from the arena just few meters around the detonation point without looking for long distance downwind deposition.

The immediate area around the detonation point (“ground zero”- GZ) is rich enough to supply much of the necessary data for reconstruct a reliable picture of the event. This include the RA material(s) involved, the HE type and amount and the device geometry.

The data collecting process is of an extreme importance for that. Here there is a citation from the ITWG guidelines for evidence collection: “Obtaining reliable NF conclusion is only possible if the entire process from sample collections at the incident site through the analysis and data interpretation is laboratory controlled and technically rigorous”.

Data collecting include smears from the ground below detonation (for radiation spectroscopy, particles size distribution, particles morphology and agglomerates, HE chemistry etc.), measured dimensions of craters below detonation and evidences on the cloud height, if possible.

Once the RA material(s) type(s) and the size distribution are recover (SEM and EDS) one can conclude about the device geometry (the terrorists capabilities). Other classical forensic

information relating the HE can be easily concluded by the police demolition units. This include the type and amount of the HE used.
Figure 1 present SEM pictures of particles sample from the GZ area of detonation tests where stable CsCl (left) and $SrTiO_3$ (right) powders were dispersed.

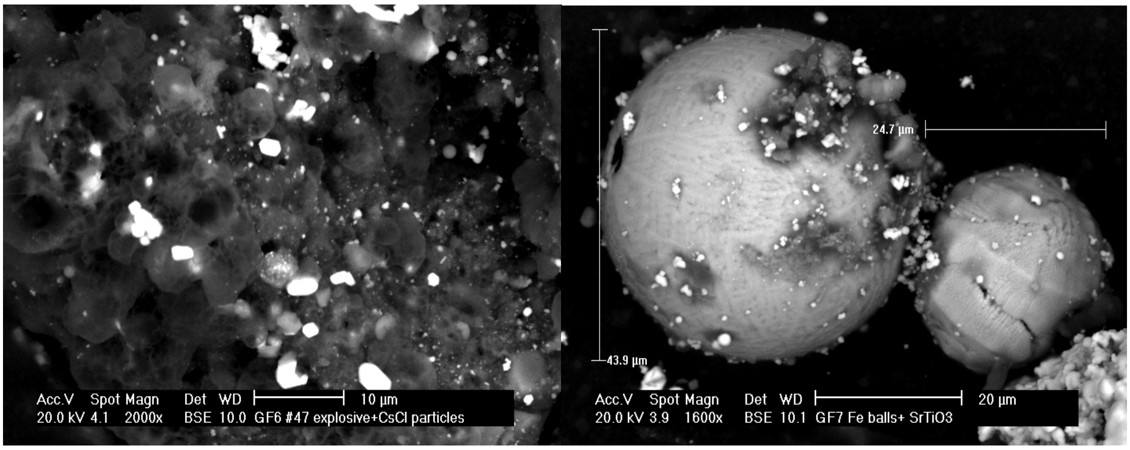

Fig. 1: SEM pictures of smear samples collected from a GZ point of two tests where stable CsCl and $SrTiO_3$simulant sources were dispersed in “dirty bomb” like event.

One can see that in the case of the CsCl test there is a large amount of unburned explosive remnants which evident a deflagration rather than detonation situation. The CsCl final particles remained almost as before the “detonation” with no shock sintering evidence.
On the right picture there are $SrTiO_3$ particles that were agglomerated to Fe sintered balls of the electric wires used for the detonation. In both of the cases the RA particles size distribution can be measured and compared to the original used in order to be able to conclude the possible device geometry and the quality of detonation.
Fig. 2 present an example of two caters remains after detonation tests on asphalt and steel surfaces. The amount of ambient dirt entrained into the fireball is highly depending on the surface type below the detonation. In a case where no dirt entrained the fraction of fine aerosols created (respirable and non respirable) will be higher than for the case “dirty shots” where agglomerates of RA particles and ambient dirt will change the size distribution.


Fig. 2: Craters remained following detonation of the same charge on different surfaces types: Steel (clean) on the left and Asphalt (dirty) on the right.

Figure 3 present the predicted detonation (TNT) cloud top heights for different local atmospheric conditions and HE amounts, based on a model developed for such an events [1, 2].

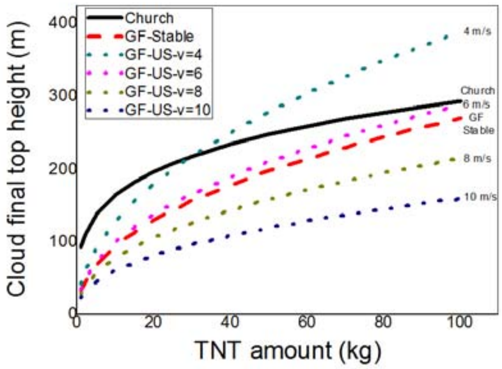

Fig. 3: Cloud top height for different HE amounts and micro-meteorology situations.

3. Summary

Reasonably reliable post detonation nuclear forensics can be made based on a simple data collection out of the immediate area around the GZ point. HE type and amount, RA mix and device geometry can be concluded out of this analysis.

References

1. Hotspot 2.07.2, Health physics and atmospheric dispersion code, LLNL-USA, Sep. 2011. See also in Hot Spot user guide Sharon et al.
2. A. Sharon, I. Halevy, D. Sattinger, I. Yaar, Cloud rise model for RDD events, Atmospheric Environment 54 (2012) 603-610.