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Bringing the minefield to the detector: updating the REST concept

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Abstract

REST is a vapour collection technology with many potential detection applications, including area reduction in demining. As part of a broader programme of research on mine detection animals, the GICHD is supporting a range of research initiatives on REST. The key elements of REST are identified as sampling (procedure and equipment); storage, transfer and handling of filters; training of the detector; and ensuring reliability in the analysis process. Recent contributions to understanding of each of these elements are reviewed. REST has great potential as an area reduction technology, but challenges that must be overcome before it will be implemented include conservatism in the demining industry, funding constraints, limited interest in REST as a research problem, limited expertise and capacity, and defined standard operating procedures.

1. Introduction

REST (Remote Explosive Scent Tracing) is a process of taking scent from a source for remote analysis. The scent is obtained by vacuuming air through a filter, which retains molecules of the target substance. Filters are then analysed by animals who have been trained to identify positive filters in an array. Filter testing can take place at any distance from the sampling location, as the filters are easily transported.

The REST concept was originally developed in South Africa and used for drugs and explosives detection at borders and elsewhere. It was modified for mine detection by Mechem (a South African government subsidiary) who used it operationally in the early 1990's for road clearance in Mozambique and Angola (as MEDDS, Mechem Explosives and Drugs Detection System). REST proved to be fast and efficient, and justification for its use included the finding of anti-vehicle mines in roads that had previously been cleared using manual techniques [1]. It is therefore surprising that such a promising and operationally proven technology was not embraced and further developed by the mine clearance industry worldwide. In reality, the reverse occurred, with REST remaining isolated and essentially unknown in Southern Africa, and falling into disuse.

Worldwide, there are currently four agencies with REST detection capacity for mine detection. Two are research agencies (NOKSH in Norway, 4 dogs; APOPO in Tanzania, 12 rats), one is a broadly based humanitarian aid agency which is currently rebuilding its programme (Norwegian Peoples Aid in Angola; about 7 dogs), and one is commercial (Mechem in South Africa; about 10 dogs). Mechem has recently been using its resources to support research on an artificial nose project (Nomadics, Fido), and in June 2003 introduced its technology to Afghanistan for road clearance. Along with some ongoing development of filter detection in several European countries for other purposes, these agencies represent the entire capacity available in the world today for filter detection.

The GICHD runs a multi-facetted programme of research aimed at improving the overall quality of mine detection animals (see Bach *et al*., this volume). REST is a central element of this programme because of its potential for rapid area reduction in minefields. The development of REST has been restricted by inadequate or poorly documented research, secrecy, and possibly by conservatism in the demining industry. In this report we identify the key elements of REST, review research currently underway to address those elements, and speculate on the future operational use of the technology. Many of the issues were identified and discussed at a workshop held in February 2003 in Tanzania, and reviews of that workshop can be found in [2] and [4].

2. Key Elements of REST

REST is unlikely to be embraced by the demining industry until it is a proven technology. Such proof depends on testing and preferably optimization of each of the key elements of REST. Those elements are:

- The sampling technique
- The sampling equipment and filters
- Storage and transportation of filter cartridges
- Training of the detector
- Methods to ensure reliability in the final analysis process.

2.1. Sampling Technique and Equipment

Currently, two general sampling techniques have been used. Both were originally developed by Mechem, and have received little further development by other agencies. The first involved mounting filters in vacuum tubes on the front of a mine-protected vehicle, allowing the samplers direct access to the minefield. This technique was found to give a poor sampling coverage because the filters sit just above the ground at the front of the vehicle, cannot be moved in an arc over the ground, and proximity to the ground is quite variable in rough terrain. The technique is now rarely used, if it is used at all.

The second technique uses a portable vacuum machine (driven by a small petrol engine) attached to a long sampling tube with the filter in the end. Although giving better coverage of the minefield, this technique exposes the operator and assistant to unacceptable risk. To date, it has only been used on roads (where the sampling personnel can follow in the tracks of a vehicle) or in test fields for research purposes (Fig. 1). An additional problem is contamination introduced onto the filter by exhaust from the petrol engine (a small modified two stroke chainsaw engine). Handling, storage and transport of fuel and oil for the engine are severe problems because of the potential for contaminating filters (for example because both fuel and filters must be transported in one vehicle).

Figure 1. A sampling team working behind a Casspir mine protected vehicle. The vehicle also carries front-mounted vacuum tubes.

Sampling is undertaken by a 2 or 3 person team, where one person operates the vacuum machine, and the other one or two change the filters and keep records. The sampler walks slowly forward, moving the head of the vacuum tube back and forth across the ground, ensuring even coverage of all of the ground surface to be sampled (Fig. 2). Filters are changed after an interval of one to several minutes, depending on the scale of sampling.

A simple but potentially important development would be to use an electric (battery powered) pump, if the appropriate weight, power and battery life can be developed. Such pumps already exist, although they are considerably more expensive than the petrol version and they have not yet been field trialed in REST applications.

Variables that are normally standardized during sampling, are the rate of sampling (60 litres/min air flow through the filter), the equipment used, the sampling procedure, and the procedures for handling filters (which are designed to minimize contamination). To date, none of these variables has been standardized as a result of careful testing of alternatives. 60 liters/min was originally chosen by Mechem as an appropriate vacuum rate for sucking air out of a car (for drugs and explosives detection). Anecdotal studies by several agencies suggest that subsequent detection success may not be sensitive to vacuum rate, but the appropriate research remains to be done.

Figure 2. Producing a matched pair of filters in a test minefield. The sampler carries a backpack on which the vacuum pump is mounted, and walks slowly forward passing the tube over the ground in an arc.

The importance of vegetation as a reservoir of target molecules is much discussed, but remains unresolved. It appears that the greatest source of molecules is from surface and disturbed dust, rather than from free-floating vapour [3].

2.2. The Filter

Despite its importance, filter technology has received little attention. The filter must have the two competing characteristics of adsorbing target molecules during collection, and desorbing those same molecules during testing. The only filter to have been used operationally (originally developed by Mechem) uses a coarse plastic coated PVC mesh ("flywire") coiled around a solid PVC core. It is believed that adsorption is onto the mesh, and desorption is of molecules attached to the PVC core, suggesting a two stage process with the mesh acting as a reservoir of molecules (V. Joynt, personal communication). Once exposed for testing, the core discharges molecules, and after a period of time will "run down". One the filter is resealed, the core recharges from the mesh as a new internal equilibrium is established. Thus the filter can be tested repeatedly over many days.

Recent tests of a variety of commercially available filter materials by APOPO (in Tanzania, Fig. 3a) suggested that most were similar to, or better than, the Mechem filter [4]. "Better" here refers to the reliability with which the APOPO rat detectors found known positive filters and does not refer to characteristics of the filter materials.

Figure 3a. Filter materials tested by APOPO with original Mechem filter on left.
Figure 3b. CSIR filter (top), original Mechem filter (middle) and IVEMA filter (bottom).

Alternative filters which are compatible with analysis by Gas Chromatography have been developed by FOI (Sweden) and the CSIR (South Africa). The CSIR has also developed a modified Mechem filter designed to be simpler to handle (Fig. 3b), and IVEMA in South Africa has developed a filter from alternative materials (third from left in Fig. 3a and bottom in Fig. 3b).

It appears that TNT and related molecules should be regarded as "sticky", and that several different filter materials could be used. There is unlikely to be a "best" filter, although more tests are needed. The ability of the filter to tolerate clogging with particles such as dust or pollen may be an important aspect of its design, and long term storage and recharge/discharge issues will be relevant to some applications, but not all.

2.3. Environmental Conditions

It is now known that variability in environmental conditions affects detectability of mines for animal sensing systems in the field (reviews in [5], [6]). It is reasonable to assume that this variability affects filter samples in similar ways.

Research by NOKSH in Bosnia (reported at this conference by Fjellanger *et al*.) and by APOPO in Tanzania [4] indicates that decreasing humidity at time of sampling is linked to increasing probability of detection. It appears that there should be a minimum temperature at time of sampling of about 15ºC, although no link with temperature has been found above that minimum. High temperatures (>30°C) limit the ability of animals (and filter sampling teams) to work in the field, but may not affect detection issues for REST. Higher temperatures are generally linked to lower humidity, thus may even facilitate detection. Rainfall events, dew and flooding events adjust the availability and distribution of target molecules [6], although these may be less significant for REST than for field searching animals.

3. Storage and Transportation

Central to successful storage and transport is an impervious cartridge case for the filter, maintenance of high standards of cleanliness at all stages of the process, isolation from potentially contaminating sources (such as explosives or other chemicals), and sterile handling of filters. For example, filter production teams are not usually deployed full-time, and necessarily share their time and resources (such as vehicles) with other operational requirements. Examples of situations that might introduce contamination are: i) the vehicle in which filters are transported was used the previous day to transport explosives; ii) the team were handling explosives yesterday and are wearing the same overalls for working with filters today; iii) filters and fuel for the pumps are transported in the same vehicle; iv) unused filters are stored for weeks in the same locker as paints or solvents. These are examples that we have seen. There are presumably many others.

4. Training and Testing

Originally, testing was done outside, but all organisations undertaking REST now conduct testing in controlled laboratory environments and handle all filters so as to minimize the chance of cross-contamination. Thus testing can be done in standardized conditions of temperature and humidity, and with a minimum of distractions and air flow.

Original training of the animal detector takes 6-9 months (example of a training programme in [7]). Once the animal is operational, all testing includes rigorously applied randomization procedures to eliminate the possibility of giving the animal "clues", and internal controls to check for reliability (false positives and misses).

The availability of molecules on REST filters is so low that independent checks of the detector using artificial procedures such as sniffing devices or gas chromatography is often impossible. The animals used for REST operate at sensitivity levels well below the concentrations currently detectable by such machines [6].

For dogs, two different training and testing concepts are currently in use. Direct comparisons between these procedures have not been undertaken. Both appear to achieve the objective of detecting positive filters with high reliability. The principle of a carefully conceived and rigorously applied training concept is fundamental, and the details of that concept need further attention.

REST appears to be an ideal use of African pouched rats (*Cricetomys gambianus*) because of the ease with which they can be maintained and utilized (Fig. 4) [8]. Currently, rats are still in training and have not been tested operationally using filters from real minefields. They are being used as research tools for experimental testing of alternatives in test fields.

Figure 4. A Cricetomys rat searching an array of filters

5. The Future of REST

For demining applications, the greatest potential of REST is for area reduction – a concept in which land is declared free of explosives and can therefore be released for economic or other use. If REST can be proven to the point where it is the only technique required to declare the land free, then it could have a dramatic impact on the cost-efficiency of demining. The introduction of REST (MEDDS) to Afghanistan for road clearance in 2003 will include attempts at such validation, and is an excellent opportunity to assess the reliability of REST technology for this application.

Before that objective is achieved, the issues described above should be addressed by research, and an array of operational restrictions must be discussed and resolved. In particular, there is a need to develop internationally accepted standard operating procedures, accreditation procedures for REST testing agencies, and funding resources to encourage development and use. The Afghanistan programme therefore represents a situation in which urgency and economic and political realities are forcing the tail to wag the dog. However, realistically, this example is typical of how much of demining technology undergoes development and it should be embraced as an opportunity.

The demining industry is naturally conservative, and is unlikely to embrace REST technology quickly, even once it is proven. Set-up costs are high, and available expertise is limited. The most likely path to implementation will be for a small number of demining agencies to establish a sampling capacity (which is cheap and easy), and use a centralised testing facility that is funded either by an imaginative sponsor, or as a research facility.

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