Developing Safer Demining Handtools in Zimbabwe

This article reports on an R&D programme in Zimbabwe that led to the development of safer demining handtools. The programme is an example of the way in which small changes can make the deminers' work safer.

by Andy Smith, *AVS Consultants*

Introduction

A research and development program to design, develop, demonstrate and test a wide range of Personal Protective Equipment (PPE) was initiated by the U.S. Army Communication and Electronics Command (CECOM), Night Vision and Electronics Sensors Directorate (NVESD), Humanitarian Demining Program in 1999 – 2000. In a conceptual breakthrough, the PPE included safer demining handtools as an integral component of the personal protection scheme. The contractor, Andy Smith (AVS Consultants), conducted this effort in Zimbabwe, a mine-affected developing country, with the side effect of establishing an indigenous production capability and realistic conditions in which to test and evaluate. The contractor and author of this paper, AVS, retains no interest (commercial or otherwise) in exploiting these results. The U.S. Army CECOM, NVESD point of contact for this effort is Charles Chichester at charles.chichester@nvl.army.com. The programme involved close collaboration with a company in the small industrial sector of Harare, Zimbabwe. That company is currently producing the tools.

Inappropriate Tools Maim and Kill

A study of recorded demining accidents revealed that deminers frequently suffer severe injury when the tools they are using are unsafe. They fail by being so short that the user's hand is inside the most violently disruptive part of the blast, or by breaking up and becoming fragments when a detonation occurs.

The picture to the right shows a range of tools commonly used in demining around the world. Many were designed for another purpose, and there is compelling evidence that almost all of them are unsafe for use in demining. Some of those that were designed for demining are also unsafe.

It is not only the users' hands that suffer. At least five deminers have died after part of their handtool struck them. Parts of tools have so severely damaged the upper arm that amputation was needed. Parts of brittle handles have pierced the user's chest cavity. The head of a garden trowel has sliced the user's face in half—injuries from which he later died. The mangled head of the yellow-handled garden trowel (shown on the right) was discovered inside a deminer after he arrived in hospital.

Design Rules

The following design criteria were adopted for making appropriate *excavation* tools. Tools used during other demining activities may not have the same requirements.

1. The user's hand should be at least 30cm from the point of any tool. Some argue that this is too long for the user to control. I suggest they try because this is not the case.

2. The materials used must be sufficiently malleable for the tool to distort in any AP blast mine detonation.

3. The tool must be constructed so that it does not readily separate into component parts in any AP blast mine detonation—this usually means that the shaft must be taken right through the handle.

4. The tool should be designed so that it is easiest to use at a low angle to the ground by a kneeling or squatting deminer, so encouraging the user to keep his hand beneath the fragment cone associated with many detonations.

5. Whenever possible, the tool should include a blast-guard for the hand using it.

It is not specified that tools should be designed for one-handed use, but this is recommended in order to expose only one hand to risk. Also, prodders designed for two-handed use put the "guide-

■ (Left) Commonly used demining tools—most of which are unsafe.
(Below) Inappropriate tools that have featured in accidents.

hand" too close to the blast and invite the use of excessive force.

The excavation tools that were developed during the programme meet the above requirements but are not presented as the "answer." There is no doubt that they could be improved upon ergonomically, and I challenge design engineers to do that now.

There is a "downside" for purchasers. I do not believe that it is possible to design tools with blast-resistant characteristics that are also very hard wearing. If you use the tools shown here, you will have to budget to replace the blades regularly.

The materials I used were E304 stainless steel, Medium/High Density polyethylene (MDP) and mild steel. These are all very inexpensive and widely available. Mild steel parts were galvanised or chromed to inhibit rust.

The Pick-Prod

Made from a "T" section of mild steel, the Pick-prod blade is 31cm long. It can be used to pick at the ground with considerable force without the blade bending. In softer ground, a twisting movement breaks up the ground more efficiently than a bayonet. The blade extends through the handle.

Ground broken up with this tool should be removed using the Excavator or Mini-spade. The Pick-prod weighs around 0.5kg (1.2 lbs). In tests pressed against PPM-2, MAI-75 and PMD-6 mines, the blades distorted as intended.

■ The Pick-prod after blast tests.

The Pick-prod complies with the design rules in the following ways:

1. The user's hand is at least 31cm from the point of tool.
2. The materials distorted in AP blast mine tests.
3. The tool did not separate in AP blast mine tests.
4. The tool is easiest to use at a low angle to the ground by a kneeling or squatting deminer.

The MIT Profile Needle-Probe

This tool is based on the common demining probe or "prodder." With a 40cm long blade, the shaft is 8mm stainless steel that extends through the handle and has been reduced to 5.5mm in one plane. The tool blade is almost oval in cross-section, but actually has flat sides as shown on the right.

The tool is designed to be used with a forward thrust by one hand. The forward movement is followed by a rotating action to reduce friction, then a further forward thrust to move deeper into the ground. The "oval" concept was published by a demining research group led by David Levy at MIT.

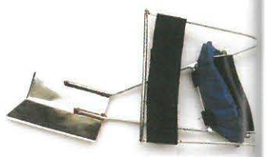
The complete tool weighs around 0.4kg (12oz). In blast tests, pressed against against PPM-2, MAI-75 and PMD-6 mines, the probes distorted as intended. The basic design has also performed well in more than a dozen actual demining accidents.

The MIT Profile Needle-Probe complies with the design rules in the following ways:

1. The user's hand is at least 40cm from the point of tool.
2. The materials distorted in AP blast mine tests.
3. The tool did not separate in AP blast mine tests.
4. The tool is easiest to use at a low angle to the ground by a kneeling or squatting deminer. The length of the tool obliges a kneeling/squatting deminer to work with their hand at a low angle to the ground.

■ The MIT Profile Needle-Probe after blast tests

The "Excavator"



Designed as an alternative to the pick-axe or hoe commonly used in demining, this unconventional tool is used with a forward thrust, followed by a sideways sweep to remove the loosened spoil. The sideways sweep puts strain on the user's wrist. To avoid this, the tool is extended so that a sideways movement is supported against the fore arm. Starting well back from the centre of the detector reading, the user digs a downward slope towards the reading. If a mine is present (and horizontal), the side of the mine will be exposed.

The Excavator folds in half for easy transportation and weighs 0.9kg (2lb). In blast tests, the blade was distorted as intended and the metal structure, welds and fixings survived without visible damage. The handguard needed to be revised (the one in the middle of the post-blast test picture is the final version).

The "Excavator" complies with the design rules in the following ways:

1. The user's hand is 35cm from the point of tool.
2. The materials used distorted in AP blast mine tests.
3. The tool did not separate in AP blast mine tests.
4. The tool is easiest to use at a low angle to the ground by a kneeling or squatting deminer. It is virtually impossible for a deminer in that position to use it to dig vertically.

■ The "Excavator" after blast tests

The Mini-Spade

The Mini-spade is a small excavation tool designed to remove spoil loosened with the Pick-prod or the MIT profile probe, or to dig entire excavations in sand. It is designed so that it cannot be used vertically and is ineffective on hard soils that have not first been prodded. The shaft extends through the handle.

The tool is designed to flex when excess force is applied, making it difficult to use for excavation of spoil that has not already been loosened—a process that would involve the risk of digging beneath a mine and detonating it with upward pressure. The complete tool weighs around 0.7Kg (1.5 lbs). After blast tests with the blade beneath PPM-2 and PMD-6 mines, the tool had distorted as designed.

The Mini-spade complies with the design rules in the following ways:

1. The user's hand is 37cm from the point of tool.
2. The materials distorted in AP blast mine tests.
3. The tool did not separate in the AP blast mine tests.
4. The unconventional shape of the tool obliges a kneeling/squatting deminer to work with their hand at a low angle to the ground.

■ The Mini-spade after blast tests

The Demining Brush

There is no evidence that any accident has occurred while using the paint brushes commonly seen in demining tool sets. They are used to brush away the final soil sticking to the side of a mine or suspicious object. However, paint brushes are not designed for this purpose. They are far too short for safety, and the bristles are usually too soft to perform their function well.

The Demining Brush uses a 40cm section of malleable stainless steel pipe with bristles set into it at both ends. A simple reversible tool, the Demining Brush has stiff "yard-broom" bristles at one end and softer hand-brush bristles at the other. In blast tests, the bristles of the brush were placed on top of a mine. The bristles were burnt off.

The Demining Brush complies with the design rules in the following ways:

1. The user's hand can be at least 30cm from the point of tool.
2. The materials burnt or distorted in AP blast mine tests.
3. The tool did not separate in AP blast mine tests.
4. The tool's length makes it easiest to use at a low angle to the ground by a kneeling or squatting deminer.

While the tool performed as designed, it would be possible to add a central disk as a hand-guard (providing protection to whichever end was held).

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er blast tests

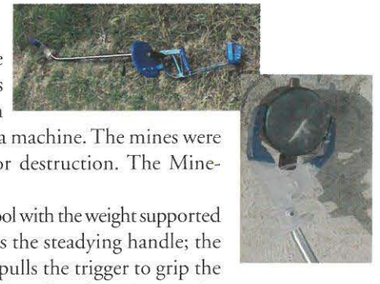
The Demining Trowel

The Demining Trowel is a variant on the gardening trowel that often features in a deminer's toolkit. It is used to remove loose spoil and to excavate in soft ground. The shaft of the tool extends through the handle and keeps the user's hand at least 30cm (12in) from the tip of the tool. The demining trowel is in widespread use but has not been blast tested.

The Demining Trowel complies with the design rules in the following ways:

1. The user's hand can be at least 30cm from the point of tool.
2. The tool is made using the same materials and methods as those that were blast tested, so it is expected to stay in one piece during AP blast mine detonations.
3. The tool's length makes it easiest to use at a low angle to the ground by a kneeling or squatting deminer. The complete tool weighs around 0.6kg (16oz).

The Mine-Grab



During the programme, the team was asked to develop a means of picking up mines that had been deposited on the ground surface by a machine. The mines were to be moved to demolition pits for destruction. The Mine-grab was the result.

The Mine-grab is a two-handed tool with the weight supported by the fore arm. The left hand holds the steadying handle; the right hand rests in the support and pulls the trigger to grip the mine. The grabbing head is angled so that the mine can be approached from the side while the user stands upright.

It turns over, positions and picks up mines with relative ease and keeps them over a meter away from the man doing so. Assuming he has frontal protection and a visor, he should survive an AP blast detonation without serious injury. I recommend long rubber knee-pads to extend a frontal apron to the ground when working while standing.

In tests, we detonated a mine in the jaws of the grab. The polycarbonate jaws burnt up, but the shaft and the handle were unmarked.

The Complete Tool Bag

To make the tools more attractive to the manufacturer to advertise and sell, we designed a bag and filled it with everything that a deminer might need. The bag itself is made from waterproof canvas reinforced with polycarbonate. The lining has pockets for all the tools, held in place with Velcro straps. The bag can be used as a "suitcase" or a backpack. Several demining groups are now using the excavation tools. ■

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