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Trials of the CED Air-Spade, Kandahar, Afghanistan, July 1998

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The air spade trails was carried out over four days from 26th – 30th July 1998.

NOTE: For our convenience, we have not followed the manufacturer's convention of calling the whole assembly the Air-Spade and also calling the cutting lance the Air-spade. In this document the whole assembly is the Air-spade and the cutting lance/spade assembly is the "lance".

Arrival and assembly

The Air-spade arrived at the Regional Mines Action Centre Office in Kandahar at about 4 p.m. on the 26th, having been held up in Islamabad customs for several days. Its packing had been too big for the aeroplane from Islamabad and it had been repacked at UNOCHA for the second stage of its journey. At first it arrived on its own – without the two boxes of fittings that would make it useful – but they were found at another office (wrongly delivered). The manifest was checked and the listed contents found to be present.

The detailed manual for the compressor requires that it have a run-in period with its valves open, but there are no instructions on how to achieve this. In the absence of instructions, we assumed that no special "running-in" procedures were necessary, and that any such procedures that were required had been carried out prior to the compressor being fitted into the Air-spade.

The Air-spade fittings (handles, hose and lance) were assembled and it was filled with oil and petrol. It started with the first pull of the 11HP lawn-mower motor. The choke almost made it stall and it transpires that it does not need the choke to be left on in this climate. The air temperature at the time was 42°C.

To check the pressures, we tried cutting a sunken patch of ground that fills when it rains then dries out smooth and hard (it has not rained for months). The ground is not driven or walked on, so is uncompressed and can be expected to simulate an undisturbed mined area in the city. Under the smooth skin on top is a mess of broken plaster and rubble. The spade broke into it reasonably well but would not cut deeply. It did not run properly, dropping to 35 PSI on the gauge when cutting. The manual says to "adjust the cable control connection to the engine throttle", but not how or where to make that adjustment.

Andy Smith, who had used the Air-spade in the US, expressed surprise over its low performance and undertook to study the manual to see whether performance enhancing adjustment was possible.

The manual is largely a compilation of the engine and compressor manuals, with nothing very clear about the connection between the two and the controls. The Air-spade is designed for the operation of the motor throttle and compressor pressures to be automatic, of course, but when the machine is not operating to its design specification, adjustments are necessary. The laminated pages of "operating instructions" supplied were welcome, but impossible for the locals to follow (self taught in English, the expression "parallel to axis of bowl" caused confusion, for example). There was no laminated sheet on adjusting the machine to perform within its design parameters (see under the heading "suggestions").

27th Air-spade Tests, Day 1
TEST 1

The test was intended to determine the Air-spade's ability to cut "ground" and clay spoil in the residential area of Kandahar city.

The mine site (No.106, residential, manual/mechanical)

An area within the city comprising several ruined buildings that were both heavily mined and mortared and rocketed. Manual deminers assisted where appropriate by a backhoe have so far found a total of 205 pieces of UXO have been found , and 108 PMN mines (also 70,637 recorded fragments). Work was started on the area on 12th August 1997 and 9,837 sq meters have been cleared of the total of 16,566. No deminer incidents have occurred to date. Elapsed time means that the cleared area has been rained on and sometimes driven over by the backhoe. The surface of the ground is dust over several thin skins (approx. 1cm) of Loess. Loess is fine dust from the arid plains of China that is blown over the Himalaya where the change in air temperature has it drop on Afghanistan. It is a yellowish ochre colour that, after wetting, dries to an almost impervious surface that is surprisingly hard.
Mixed with water and sun-dried it is as hard as biscuit fired pottery – and has a "glaze" that makes it impervious to all but a sustained "winter" rainstorm.

When we arrived a grenade had just been partly uncovered among back-hoe spread "spoil"..

The Air-Spade

Andy Smith had studied the manual and made adjustments to the machine. He succeeded in making the upper (larger) pressure gauge (the "compressor discharge pressure gauge") read 40 when the spade was working. The operating parameters require it to read between 40 and 45 so it was deemed to be working within its "proper operating level" range. When not working it read 65, not 60 as indicated in the manual. The lower gauge, mounted on the compressor itself, read 35 but the significance of this was not known. The machine seemed very noisy and the connection of the silencer box was checked but did not seem to be faulty. The engine backfired once every time it was turned off. The quality of the petrol here is unlikely to be good.

The conditions

The air temperature was 42° at 10.30 A.M. and we measured the ground temperature at 49-50°. The maximum ground surface temperature in this area (measured in 1994 by Roland Harke of WFP-UNDP as part of an investigation of unexpected tyre failures) is 65°C, occurring over the June/July/August summer months. The maximum air temperature in those months is 51-52°C (it got to about 47°C that day). There is no moisture content obvious in this ground, although some scrubby grass has self-seeded in clumps.

Cutting tests

We tried cutting what the demining team call "medium" hard ground. This is flattened spoil/rubble that has been compacted by the back-hoe driving over it. The spade was surprisingly ineffective at cutting "flat" areas. It broke the surface layer of Loess relatively easily, broke erratically through any lower levels and then could not cut to any depth.

We tried cutting softer ground, being spoil that had been moved by the backhoe but not driven over. The performance was disappointing (see video), with it taking a long time to achieve a jagged depth.

On both ground types we used both "lances" supplied, with their original "low altitude" nozzle fitted.

Using a simulated Type 72 Chinese minimum metal AP mine containing an original pressure plate "spring", we tried to use the spade to "trigger" the mine. The latex cover was split but the mine could not be triggered.

General

We ran the machine for 30 minutes in total (sometimes stopping and starting it to move it or fit the second lance). While it was running, the head of one handle-bolt split laterally (see photograph). When we first moved the spade, one rubber foot fell off. It was vibrating a lot on the dusty and uneven ground. There is no convenient level ground to stand it on within several kilometers of the site. Even the road is "rather uneven".

Conclusion

The Air-spade, as configured, cannot usefully cut the ground and clay spoil in the residential area of Kandahar. The Air-spade is unlikely (if not unable) to trigger the firing mechanism of a Type 72 Chinese AP mine.

Air Spade Tests, Day 2
TEST 2

The test was intended to determine whether the altitude at Kandahar was affecting the Air-spade's cutting ability. Kandahar is reported to be at around 900 meters above sea level – roughly equivalent to the 3000 feet changeover of nozzles indicated by CEG. The test was also intended to determine whether ambient temperature affected the performance of the device.

The test site

The same residential area within the city used on the previous day.

The Air-spade

Andy Smith had checked over the lance controls and found nothing to adjust. It started easily and ran well, but again seemed rather noisy. Andy Smith used a long handled tool to "listen" to the moving parts and could hear no evidence of unusual "clatter and rumble". The engine backfired once every time it was turned off.

Conditions

The ambient temperature is reported to affect adversely the performance of all generator motors here. Accordingly we tried the Air-spade at six in the morning at the same site. The air temperature was 27°C.

Cutting tests

We repeated the tests of day one with the original low altitude nozzle on the longer lance supplied, and the performance was substantially the same.

We replaced the nozzle with the high altitude nozzle (slightly narrower aperture). We tried cutting what the demining team call "medium" hard ground, softer piles of spoil, and the face of a "pit". We found no improvement in performance: there may have been a slight reduction in cutting ability over its performance with the original nozzle.

After replacing the original nozzle, we tried the spade's ability to cut the relatively soft, sun-baked brick from which the old buildings are constructed (newer buildings have kiln fired bricks). The spade did cut flakes from the wall but its performance was not fast.

General

On changing the nozzle we found there was no tool capable of gripping the flat sides of the nozzle among those tools supplied. The demining team was starting work, and a suitable wrench was borrowed.

Conclusion

The ambient temperature did not seem to affect the Air-spade's performance. The fitting of a high altitude nozzle did not improve the Air-spade's ability to cut hard ground.

Test 3

The test was intended to determine whether the air-spade could cut softer ground in the Kandahar region more successfully.

The test site

"Soft" ground in Kandahar. This was a grassed area with "molehill" spoil. Rats and moles burrow beneath the ground, so it is thought of as "soft". Being grassed, it is also relatively moist (although not obviously so). Andy Smith tried tried to push a screwdriver into this ground using both hands and considerable effort – but could not push it beyond 3cm deep.

The Air-spade

The Air-spade was set up with the low-altitude nozzle. It started well. It backfired once every time it was turned off.

Conditions

The air temperature was 44°C (shade).

Cutting tests

The spade was used on the grassed area with little effect. We tried to cut a patch of dry earth between the grass clumps and again there was very little effect. The ground was aerated, but the roots of the grasses held it together and it was not possible to make a hole. We moved the spade to a mole-hill and it raised clouds of dust as it blew the spoil aside.

Using a screwdriver to break through the ground and the air-spade to excavate the loosened ground, we made a hole in which to place a PMN mine that had no detonator or main charge, and where the firing pin was "cocked". (Our thanks to DAFA for the use of the training mine.)

The air-jet from the Air-spade was played back and forth across the rubber top of the mine for about 90 seconds. On inspection the mine had "fired". The mine had been "armed" fifteen minutes previously and we suspected that a curious Afghan might have "fired" it before the test. We reset the mine and the test was repeated. This time the mine was not triggered.

Curious to find out whether the presence of a large impervious area on top of the mine might lead to a concentration of pressure, we placed a flat stone on top of the mine and the jet was played across the top for about 90 seconds. Again the mine was not triggered. We removed the detonator plug and fired the mine very easily by hand to check that it had not jammed.

Conclusions

The "soft" ground we had uncovered was not significantly easier for the Air-spade to cut.
The Air-spade is at least unlikely (and probably unable) to trigger a PMN mine when in use.

Test Four

This was to have been a "live" test using a PMN mine with its detonator in place. We decided that it was not necessary to take all the precautions necessary when making a possible detonation because the air-spade could not expose such a device under these conditions.

The Air-spade Tests, Day 3
Test Five

This test was devised to determine whether moisture content in the soil made a significant difference to the air-spade's cutting ability.

The test site

The site was the watered garden of the main UN regional office building. This garden is watered daily (sometimes twice) and grows flowers. The selected area was a bed with the surface dry and crazed but in which roses were growing.

The Air-spade

The Air-spade was set up with the low-altitude nozzle. It started easily, with some choke (turned off immediately). There was evidence of oil around the base of the engine, but no sign of a blown gasket. The levels in both the engine and the compressor were good. It was thought that there may have been some seepage while the machine was being lifted in and out of the trucks The machine seemed much quieter inside the city. . The engine backfired once every time it was turned off.

Conditions

The air temperature was 42°C (shade).

Cutting tests

The Air-spade successfully excavated soil to a depth of 12 centimers with an ease that was (in Andy Smith's opinion) similar to its performance when used on hard ground in the US. The excavated soil was not noticeably moist.

The Air-spade was then used to cut the compacted area where UN trucks are parked and washed daily. It cut the ground far more easily than in the residential area.

Conclusions

It seems that the moisture content of the ground plays a significant part in the air-spade's efficiency as a cutting tool. Even a small (not visible or tangible) water content makes the excavation process much easier.

Further Testing

The Manager of the Regional Mine Action Centre (Andrew MacAndrew) is of the opinion that the air-spade could be useful in the delicate excavation of UXO. Two UXO teams will be deployed in Kandahar not before December 12th this year. He offered to issue it to those teams for them to assess its uses in those circumstances.

Andy Smith trained Reuben McCarthy in the running and maintenance procedures for the Air-spade. Mr McCarthy is a Program Officer employed by the demining agency DAFA. A University educated Australian, he is working for DAFA on a local salary, and so not employed by the UN.
Mr McCarthy undertook to carry out further tests with the air spade (in co-ordination with Andrew MacAndrew) to determine areas of utility within the local demining sphere.

The machine and selected spares were left with DAFA. Some tools were left at the Regional Mine Action Centre. A list of equipment left at DAFA was signed by Mr McCarthy.

Comment on design and ease of use

The Air-spade fits easily into the restricted loadbay of a four seater Toyota. It takes four men to lift it in and out, and special ramps would be needed to roll it into place (planks would have to be too long to be carried in the same loadbay).
One intake air-filter protrudes well beyond the frame and is vulnerable to damage during transit. The Air-spade's "frame" prevents removal of the other intake filter cover – so preventing easy replacement of that filter.
The handles are uncomfortable (deminer opinion) and became very hot to touch in the strong sun. It took three men to move the Air-spade around on a fairly "flat" urban area.
The engine backfired once every time it was turned off. The quality of the petrol here is unlikely to be good.
A dust mask is an essential addition to the protective wear in this area.
If the frame included "Tie-points" to make it easy to rope down in the back of the pickup it would help with transit. If those robes were attached to the frame, they would be less likely to be "borrowed" for other uses.
If the handles are to be used to wrap the hose around during transit and storage, a guard should be fitted to prevent the hose pressing against the exhaust and being burned.

Every time the machine was loaded, the Afghans pushed it into the loadbay so that the unprotected intake filter pressed against the glass in the rear of the cab. Either filter redesign or frame redesign to allow ease of maintenance and prevent damage to the covers is recommended.

Suggestions

While the following were not asked for, it was felt that their inclusion might enhance the deployment of the air-spade in other mined areas.

Tools

Although most tools were provided, the small adjustable wrenches (two types) would not open wide enough to be used as nozzle wrench. A nozzle spanner should be included to prevent them being damaged if frequent changes are anticipated.

Durability

The ability to stand the air-spade on a level base cannot be guaranteed in field conditions – and would be rare in Afghanistan. If it requires this to limit vibration, it may be wise to attach motor and compressor to a subframe and attach that to the main frame/bed with rubber engine mounts.

Manual

The manual is a compilation of the engine and compressor manuals, with nothing very clear about the connection between the two and the overall controls. This is all meant to be automatic, of course, but when the machine is not operating to its design specification, adjustments are necessary. A brief operator's guide covering the main adjustment points is included in writing, but some of the names of parts are not indicated on any general schematic drawing. The suggested revised guide should be largely pictorial. The Afghan driver/mechanic who helped to assemble the device could not make sense of the technical English in the manual. Andy Smith's experience as a technical instructor on development projects leaves him convinced that all useful literature must be a step-by-step introduction with many photographs or drawings so that a person who is only functionally literate in English can find it useful. Highly intelligent but under-educated personnel are common among demining field operatives and the entire manual should be targeted at them, especially those sections covering necessary adjustment, maintenance and predictable repair needs.

Cutting Force

We believe that the Air Spade's utility would not be significantly reduced if it cut with greater force and speed, but carried some risk of detonating a sensitive device: in Afghanistan it is starting the excavation of a detector reading that it most difficult, not finishing it. If the spade could be supplied with different nozzles (quick-change), one for making the initial cut and another for slowly extending it, that might be ideal.

Interim Conclusions

The air-spade's inability to cut Loess and clay rubble from residential sites was disappointing. The impervious hardness of the Loess and the clay rubble appears to have been responsible. We believe that the air-spade may have a useful application in places where the time taken to expose a UXO is not paramount and it can be assisted with some delicate use of handtools. It appears that it may make that fraught process both easier and safer.

The hardness of the ground and the density of the clay are probably almost unique to Afghanistan. We believe that (as currently configured) the air-spade may have wider application in other areas – and might also have wider application here if its power were increased.

In our opinion, the 40 PSI air spade is unable to set off an undamaged or booby-trapped PMN or a Type 72 anti-personnel mine even if the mine were concealed at an unexpected angle.