[Extract from report submitted to US Army CECOM NVESD in 2000,]

Testing

Testing of the equipment featured in this report took place in minefields in Angola, Mozambique and Zimbabwe. The tests were of the users' opinion of the equipment and of its ability to withstand AP blasts. The picture on the right shows the range of mines used in the tests at which I was present.

The picture on the left shows Hendrik Ehlers of MgM preparing a PPM-2 mine for a blast test. The picture below shows a 200g TNT charge prepared for fitting into a PMD-6 mine in Mozambique.

The picture below left shows John (Jabba) Kirby preparing a VS50 in Zimbabwe.

The picture below shows the PMD-6 mines used in Mozambique.

Below are the VS50s that were used in Zimbabwe.

Many people helped with the field testing. Special thanks to: Herman van der Vorm, John Kirby, Hendrik Ehlers, John Morrissey, Steve Priestley, Filipe Mazuma, Havard Bach and Gier Bjorsvik

User tests of hand-tools

The programme required us to produce a range of excavation/prodding tools that were safer to use than those commonly deployed to date.

The tools were tried by MgM and Koch MineSafe prior to blast testing. Some of the tools were bought immediately by these and other demining groups.

The pictures show Koch MineSafe deminers trying out the PPE and tools in an area near the Mozambique border during March 2000.

Koch MineSafe in Zimbabwe have agreed to field trial full tool sets but the current unstable political situation in the country has caused unavoidable delays. This commercial group ordered mine-grabs immediately after the successful blast tests and expressed interest in the range of excavation tools. They particularly liked the integral hand-guards on the range of prodders.

As a result of their good performance in the blast tests, the demining NGO MgM offered to long-term user-test six full AVS demining tool-sets and twenty MIT prodders in Mozambique and Angola from the end of April 2000.

Technical Advisors to the MAPA programme for Afghanistan have expressed a willingness to user trial all tools and equipment devised under this programme. MAPA is currently changing its leadership and it is anticipated that we will receive a request for samples when their situation settles down. The excavation tools were discussed with Afghan deminers and their field supervisors, who all expressed great interest in safer handtools.

Testing the AVS "Braveheart" excavator with a VS50

[This tool was nicknamed "the Braveheart" by Mark Buswell.]

The test was carried out on cleared land alongside a Zimbabwe minefield. The ground was hard and dry but fairly easy to dig in. (No soil hardness tester was available.) The mine used was an Italian VS50 with its original charge of 43g RDX supplemented by 10g of PE pushed into the detonator-well prior to inserting a detonator and fuse.

At the request of the demining group assisting with the test, the mine was positioned on its side in the ground with the pressure plate towards the tool. The tool was positioned so that the leading edge of the blade was in contact with the pressure plate of the mine. This simulated a deminer scraping across the pressure plate of a mine that had moved (or been laid) so that it faced the deminer, and so was felt to represent a "worst-case" blast scenario. The earth behind the mine was undisturbed. The earth in front of the mine was all loosened, so simulating the normal use of the tool.

The tool was held upright by being tied to a short stick.

The blast was recorded by a hand held video from a distance of 50 meters.

Post blast condition of the "Braveheart"

After the blast the tool had been thrown back three meters. The metal parts of the tool, its handle and arm-strap were intact. No welds or fixings had been broken or damaged. The blade of the tool had split in two places and the stainless steel curled away from the blast. The tool's hand-guard had been torn in two and some earth was caked against the front of the tool's handle. No metal had separated.

Conclusion

The metal parts of the "Braveheart" excavator performed as designed. The handle and arm-strap performed as designed. The hand-guard failed, broke away and allowed the handle to be struck by environmental fragmentation.

Consequence

It was decided to try attaching the hand-guard in a different way and to increase the number of layers of aramid present. Having performed adequately, the other parts of the tool were to remain unchanged for further blast tests.

Testing the commercial "grab" with a VS50

The test was carried out on cleared land alongside a Zimbabwe minefield. The ground was hard and dry but fairly easy to dig in. (No soil hardness tester was available.) The mine used was an Italian VS50 with its original charge of 43g RDX supplemented by 10g of PE pushed into the detonator-well prior to inserting a detonator and fuse.

At the request of the commercial company assisting with the test, the grab was positioned so that the mine was being gripped from above. This accurately reflected the way that the tool was currently used. A cardboard "body" was erected on cardboard tube legs. Rubber knee- shin-guards were strapped to the cardboard tubes in order to evaluate their usefulness in similar situations.

The blast was recorded by a hand held video from a distance of 50 meters.

Post blast condition of the Commercial "grab"
After the blast the tool had been thrown a meter to one side. The "jaws" of the tool had disintegrated. The aluminium "pole" had been damaged and the plastic handle had been broken by fragments of the "jaws". The cardboard "body" had been struck by more than 50 fragments.

Post blast condition of the knee- shin-pads
After the blast the shin-pads had been struck by environmental fragmentation but were undamaged. They wiped clean without sign of even superficial damage. Nothing had penetrated them.

Conclusion
The lightweight construction of the commercial grab include brittle materials that shattered in the test. This was anticipated. The damage to the pole may have been caused by parts of the "jaws" striking it in passing. Most of the aluminium distorted and did not break.

Consequence
The commercial company using the tool decided to seek a safer replacement.

Testing the AVS "mine-grab" with a VS50

The test was carried out on cleared land alongside a Zimbabwe minefield. The ground was hard and dry but fairly easy to dig in. (No soil hardness tester was available.) The mine used was an Italian VS50 with its original charge of 43g RDX supplemented by 10g of PE pushed into the detonator-well prior to inserting a detonator and fuse.

The mine-grab was positioned so that the mine was being gripped from the side. The "pole" of the tool is shaped to make this the easiest way to use it. A cardboard "body" was erected on cardboard tube legs. Rubber knee- shin-guards were strapped to the cardboard tubes in order to evaluate their usefulness in similar situations.

The blast was recorded by a hand held video from a distance of 50 meters.

Post blast condition of the AVS "mine-grab"
After the blast the tool had dropped to the ground. The "jaws" of the tool had disappeared. The stainless steel "pole" was undamaged and the handle was unmarked. The cardboard "body" had been knocked backwards but had not been struck by any fragments.

Post blast condition of the knee- shin-pads
After the blast the shin-pads had been struck by environmental fragmentation but were undamaged. They wiped clean. On examination, there was no sign of any penetrations.

Conclusion
The design and construction of the AVS "mine-grab" allowed the jaws to break up and be thrown sideways (small parts of torn polycarbonate were found). The distance between the user and the mine, the orientation of the tool and the selected materials from which it was constructed combined to make it far safer to use than the commercially available alternative.

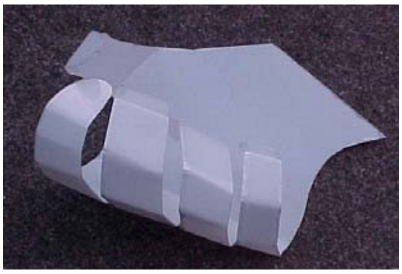
The rubber knee- shin-pads performed surprisingly well and appear to offer significant blast protection.

Consequence
The demining group assisting with the test asked for the tool to be fitted with a hand-guard and arm-padding, then asked for a dozen as soon as possible. The revised AVS "mine-grabs" are in use now.

Blast testing hand-tools in Angola

The testing of tools in March 2000 in Angola had to be completed in a limited time and with a limited number of mines. For this reason, several tools were tested simultaneously. MGM deminers and its director Hendrik Ehlers were present, along with several members of the local security forces.

In all these tests the handtools were held in a fabric-reinforced rubber glove with a 0.75mm polycarbonate "hand" inside. The hand slotted into a 5mm polycarbonate "forearm" that was held in position with a stainless steel spike as shown below.



The orientation of the tool was maintained at or below a measured 30º to the ground (the picture on the right includes the protractor).

The tools were arranged at approximately 90º to each other. Most tests involved three tools. A protected camera was positioned 4m away on the fourth side.

Each tool was placed so that its tip was in contact with the mine. No "interference" between the tools was observed and it is believed that the result would have been substantially the same if each tool had been tested separately.

In order to provide a "control", an ordinary demining/gardening tool was included in each test.

ANGOLA: hand-tool test 1

This test was against a PPM-2 AP blast mine casing refilled with 200g of PE. The ground was a hard, fibrous dark earth that required considerable effort to dig in. No soil tester was available but an MIT profile probe could not be pushed in further then 12cm (4.75”) with one hand (without twisting).

The following tools were tested:

- AVS MIT profile probe
- AVS Pick-prod
- Short gardening trowel

The picture shows the tools arranged with the mine still visible. A further covering of soil was added afterwards.

The blast was recorded by a protected video camera from a distance of 4 meters.

The sound of the detonation and its effects were less than anticipated.

Post blast condition of the hand-tools
After the blast the AVS tools had been thrown sideways 50cm. They had suffered little discernible damage. The “hands” holding the tools were unmarked.

The short trowel had separated from its handle and the parts had been thrown 12 and 9 meters away. The “hand” holding the trowel had been abraded and penetrated in the thumb.

Conclusion
The construction of the AVS MIT probe and pick-prod withstood the test well. The tools remained firmly in one piece with very light damage to their tips. The hand-guards had been struck by environmental fragmentation but their covers had not been penetrated. Their handles were unmarked and, in the opinion of the observers, they could have been used for demining again.

The “control” tool was an ordinary garden trowel. While the blast was not strong enough to deform the mild-steel blade, the tool separated and was thrown back a considerable distance (presumably with considerable force). This provides evidence of the need to extend the metal parts of the tool through a handle. The damage to the “hand” holding the tool provides evidence of a need for a hand-guard and some indication of the advantage of using longer tools.

ANGOLA: hand-tool test 2

This test was against a PPM-2 AP blast mine casing refilled with 200g of PE. The ground was a hard, fibrous dark earth that required considerable effort to dig in. No soil tester was available but an MIT profile probe could not be pushed in further then 12cm (4.75”) with one hand (without twisting).

The following tools were tested:

- AVS “Braveheart” excavator
- AVS brush
- Short gardening trowel

The picture shows the tools arranged with the mine still visible. A further covering of soil was added afterwards.

The blast was recorded by a protected video camera from a distance of 4 meters.

Post blast condition of the hand-tools
After the blast the AVS “Braveheart” was found five meters from the crater. The AVS brush was seven meters from the crater. The parts of the trowel were more than 10 meters from the crater.

The blade of the “Braveheart” had deformed dramatically but the tool was still in one piece. The attachment of the revised hand-guard had opened allowing some debris to mark the “hand” behind. The bristles of the brush had burned off and the stainless steel tubing had a 1cm split. The “hand” holding it was undamaged.

The short trowel had separated from its handle which had split. The “hand” holding the trowel had been abraded.

Conclusion
With the exception of the hand-guard, the AVS “Braveheart” and brush withstood the test well. Both tools performed as designed and remained in one piece (excluding the brush bristles). The hand-guard on the “Braveheart” had been struck by environmental fragmentation and its fastening opened.

The “control” tool was a wide bladed garden trowel. While the blast did not deform the mild-steel blade, the tool separated and was thrown back a considerable distance (presumably with considerable force). This provides evidence of the need to extend the metal parts of the tool through a handle. The damage to the “hand” holding the tool provides evidence of a need for a hand-guard and some indication of the advantage of using longer tools.

Consequences
It was decided to revise the hand-guard on the “Braveheart” once again.

ANGOLA: hand-tool test 3

This test was against a MAI-75 AP blast mine casing refilled with 200g of PE. The ground was a hard, fibrous dark earth that required considerable effort to dig in. No soil tester was available but an MIT profile probe could not be pushed in further then 12cm (4.75”) with one hand (without twisting).

The following tools were tested:

- AVS “Mini-spade”
- AVS root-cutter
- Standard cross-over secateurs

The picture shows the tools arranged with the mine still visible. A further covering of soil was added afterwards.

The blast was recorded by a protected video camera from a distance of about 4 meters.

Post blast condition of the hand-tools

After the blast the “mini-spade” had been blown back a metre. The “hand” was still “holding” it and was marked where it extended above the hand-guard. The hand-guard was marked but no fragments had penetrated the guard cover. The blade of the tool (which had been under the mine) was severely distorted but in one piece. The tool’s fixings and welds were undamaged.

The AVS root-cutter had been blown five meters away and separated from the “hand”. The polycarbonate “anvil” of the jaws had been separated and was not found. All the metal parts of the tool were in one piece although the hardened steel cutting blade was deformed. The “hand” holding it had been damaged but not penetrated.

The standard secateurs had separated and the two main parts were found seven meters away and five meters apart. The “hand” holding the short standard secateurs was severely damaged as shown above right.

Conclusion

The AVS “Mini-spade” performed as designed and remained in one piece with the blade deforming. The hand-guard performed well – as in normal use the hand does not appear above the guard.

The AVS secateurs were always a design compromise and performed better than anticipated. The separation of the polycarbonate “anvil” was anticipated. The small extra distance to the hand appears to have led to much less damage that with standard secateurs.

The “control” tool was a pair of standard cross-over secateurs. These distorted and snapped into two main parts. The hardened steel blade did not break, but the hinge mechanism distorted allowing the lower jaw to swing freely. The parts of the tool were thrown back a considerable distance (presumably with considerable force). The damage to the “hand” holding the tool provides evidence of a need for a hand-guard and some indication of the advantage of using longer, appropriately designed tools.

ANGOLA: hand-tool test 4

This test was against a PPM-2 AP blast mine casing refilled with 200g of PE. The ground was a hard, fibrous dark earth that required considerable effort to dig in. No soil tester was available but an MIT profile probe could not be pushed in further then 12cm (4.75”) with one hand (without twisting).

The following tools were tested:

- AVS demining shears
- Standard one-handed garden shears

One-handed garden shears were selected because some argue that their short blade length and the use of a single hand makes them safer than two-handed shears.

The picture shows the tools arranged with the mine still visible. A further covering of soil was added afterwards.

The blast was recorded by a protected video camera from a distance of about 4 meters.

Post blast condition of the hand-tools
After the blast the AVS shears had been blown back three meters leaving the “hands” almost unmoved. The standard one-handed shears had been blown back 80cm and were still held in the “hand”.

The AVS demining shears remained in one piece after the blast. They had been slightly bent (barely discernible) and still cut undergrowth after the blast. The “hands” holding the shears were undamaged.

The standard one-handed shears had been severely distorted in the blast – with one hardened blade bent back in a curve. They remained in one piece. The “hand” holding them was heavily abraded and punctured.

Conclusion
The AVS demining shears performed as designed and remained in one piece with a slight bend running throughout the length of both blades and handles after the blast.

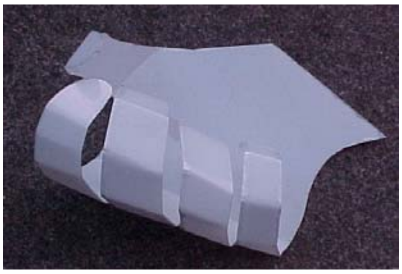
The standard one-handed gardening shears performed better than anticipated because the hardened steel blades did not break. This implies that they were not as hard as the manufacturer claimed. The hand holding the short shears was badly damaged. This illustrates the advantage of keeping the user’s hand a greater distance from any potential blast.

Consequences
Some basic work on the performance of various grades of hardened steels in blast situations would be appropriate.

Blast testing hand-tools in Mozambique

The testing of tools in March 2000 in Mozambique had to completed in a very limited time. For this reason, more than one tool was involved in each blast test. NPA deminers and the NGO's ex- country director Havard Bach were present.

In all these tests the handtools were held in a fabric-reinforced rubber glove with a 0.75mm polycarbonate "hand" inside. The hand slotted into a 5mm polycarbonate "forearm" that was held in position with a stainless steel spike as shown below.



The orientation of the tool was maintained at or below a measured 30º to the ground (the picture on the right includes the protractor).

The tools were arranged at approximately 90º to each other. All tests involved three tools.

A protected camera was positioned between 4-6m away on the fourth side.

Each tool was placed so that its tip was in contact with the mine. No "interference" between the tools was observed and it is believed that the result would have been substantially the same if each tool had been tested separately.

In order to provide a "control", an NPA demining scraper was provided for the test. The scraper provided is shown here alongside another example actually seen in use. The tool tested was significantly bigger than all those seen being used. The handle is made differently – using curved pipe rather than a welded join.

MOZAMBIQUE: hand-tool test 1

This test was against a PMD-6 AP blast mine complete with its original 200g TNT charge (the charge was in good condition having been taken from a store). The ground was a light sandy earth that was easy to dig into. No soil tester was available but an MIT profile probe could not be pushed in further then 16cm (6”) with one hand (without twisting).

The following tools were tested:

- AVS “Braveheart excavator”
- AVS pick-prod
- NPA excavating tool

The picture shows the tools arranged with the mine still visible with its lid open. The mine was closed and a further covering of soil added later.

The blast was recorded by a protected video camera from a distance of approximately 5 meters.

The blast created an unusually large amount of environmental fragmentation, dust and debris.

Post blast condition of the hand-tools

After the blast all the tools had been thrown backward between 6 and 10 meters. They landed in surrounding undergrowth and took some time to find. The AVS “Braveheart” was 6m away and was intact with the revised hand-guard in place and the hand protected. Its blade had been slightly bent but the fixings and welds were all undamaged.

The AVS pick-prod was 7 meters away with its “hand” close by. The tip of the prod was slightly bent but all welds and fixings were undamaged. The hand-guard had been marked by environmental fragmentation but the cover had not been penetrated.

The NPA excavator was thrown ten meters away and separated from the “hand”. The tool was slightly bent but intact. The hand holding has been marked over the thumb and fingers by environmental fragmentation and penetrated in one place. The short trowel had separated from the hand and the parts had been thrown 12 and 9 meters away. The “hand” holding the trowel had been abraded and penetrated in the thumb.

Conclusion

The construction of the AVS pick-prod and “Braveheart” excavator withstood the test well. The tools remained firmly in one piece with very light damage to their tips. The hand-guards had been struck by environmental fragmentation but their covers had not been penetrated. Their handles were unmarked. The “Braveheart’s lack of deforming damage was probably due to the fact that the explosive was positioned at some distance from it inside the mine as shown alongside (the “Braveheart” was on the left).

The NPA excavator tool held together well although the hand “holding” it was struck by a lot of debris. The “hand inside the glove was deeply scored and blackened. The damage to the “hand” provides evidence of a need for a hand-guard and further indication of the advantage of using longer tools.

MOZAMBIQUE: hand-tool test 2

This test was against a PMD-6 AP blast mine complete with its original 200g TNT charge (the charge was in good condition having been taken from a store). The ground was a light sandy earth that was easy to dig into. No soil tester was available but an MIT profile probe could not be pushed in further then 16cm (6”) with one hand (without twisting).

The following tools were tested:

- AVS “MIT profile” probe
- AVS “MIT profile” probe
- AVS pick-prod

The picture shows the tools arranged with the closed mine still visible. A further covering of soil was added later.

The blast was recorded by a protected video camera from a distance of approximately 5 meters.

The blast created an unusually large amount of environmental fragmentation, dust and debris.

Post blast condition of the hand-tools
After the blast one MIT probe had been blown backwards four meters with its “hand” 2m away to one side of it. The blade had been bent at the end and slightly curved along its length. The fixings and welds of the tool were undamaged. Its hand-guard was marked but no fragments had penetrated the cover of the guard.

The “hand” holding the second MIT probe was just in front of the crater. The probe itself was seven meters away with a long curve along the length of the blade. The fixings and welds of the tool were undamaged. Its hand-guard was marked but no fragments had penetrated the cover of the guard.

The pick-prod hand had been blown five meters back from the blast and the pick-prod was found about ten metres away. The blade was bent along its length. The fixings and welds of the tool were undamaged. Its hand-guard was marked but no fragments had penetrated the cover of the guard.

Conclusion
The construction of the AVS “MIT probes” and pick-prod withstood the test well. The tools remained in one piece and distorted along their lengths as designed. The hand-guards had all been struck by environmental fragmentation but their covers had not been penetrated. Their handles were unmarked. The orientation of the tips prior to the blast is shown on the right.

MOZAMBIQUE: hand-tool test 3

This test was against a PMD-6 AP blast mine complete with its original 200g TNT charge (the charge was in good condition having been taken from a store). The ground was a light sandy earth that was easy to dig into. No soil tester was available but an MIT profile probe could not be pushed in further then 16cm (6”) with one hand (without twisting).

The following tools were tested:

- AVS “Mini-spade”
- AVS “MIT profile” probe

The picture shows the tools arranged with the lid of the mine open. The explosive charge has been centred in the mine for this test. The mine was closed and a further covering of soil added later.

The blast was recorded by a protected video camera from a distance of approximately 5 meters.

The blast created an unusually large amount of environmental fragmentation, dust and debris.

Post blast condition of the hand-tools

After the blast the AVS mini-spade had been blown back four meters. Its blade was severely distorted and the handle had been bent back. The fixings and welds of the tool were undamaged. The hand-guard was heavily marked and blackened but no fragments had penetrated its outer cover. The hand “holding” it was marker on the top side where blast had gone above the extent of the shield.

The MIT probe had been blown backwards five meters with its “hand” 4m away to one side of it. The blade had been curved along its length. The fixings and welds of the tool were undamaged. Its hand-guard was marked but no fragments had penetrated the cover of the guard.

Conclusion

The construction of the AVS “MIT probe” and Mini-spade withstood the test well. The tools remained in one piece and distorted as designed. The hand-guards had all been struck by environmental fragmentation but their covers had not been penetrated. Their handles were unmarked. The damage to the “hand” holding the mini-spade was thought to have been caused by the tool angling forward when the blast pushed the blade down and back. A range of people were asked to grasp the tool and they did so low on the handle, leading us to believe that this would be the natural way to use the tool.

Consequences

There may be reason to consider the size of the hand-guard on the AVS “Mini-spade”.

Blast tests on hand-tools - conclusion

This testing was limited in number, and cannot be taken to prove anything comprehensively. However, if any of the main design features had failed to perform in any of the tests, that would have provided an indication that they were not able to achieve the design aims. In general, the tools performed to design and illustrate that the design and local manufacture of safer tools is possible. They also confirm that the AVS design rules are appropriate.

The AVS "Braveheart" excavator

Three "Braveheart" excavators were tested. While the blade was distorted as intended, the metal structure, welds and fixings survived without visible damage. The hand-guard of the first tore apart (although its cover was not penetrated by any fragments). The central fastening on the hand-guard on the middle example shown below, opened a little and allowed the "hand" behind to be marked. The hand-guard on the third had no openings or weak areas and so performed appropriately in its test. The third design of hand-guard has become the standard for this tool.

The AVS MIT profile probe

Four "MIT profile probes" were blast tested. The three that sustained visible distortion are shown alongside. While the blade was distorted as intended, the metal structure, welds and fixings of all the probes survived without visible damage. The hand-guards performed very well, with the washable outer cover not being penetrated in any of the blasts.

The basic probe design had been prototyped and revised before, so it is appropriate that it should have performed without any need for further revision.

The AVS "Pick-prod"

Three "Pick-prods" were blast tested and are shown alongside. While the blade was distorted as intended, the metal structure, welds and fixings of all the probes survived without visible damage. The hand-guards performed very well, with the washable outer cover not being penetrated in any of the blasts.

The basic prod design had been prototyped and revised before, so it is appropriate that it should have performed without any need for further revision.

The AVS "Mini-spade"

Two "Mini-spades were blast tested, both with the blade beneath a mine. The results are shown alongside.

While the spade-blades were heavily distorted as intended, the metal structure, welds and fixings survived very well. One blade started to split but no parts were torn away. Although in one case the guard was heavily blackened by blast, the hand-guards performed very well, with the washable outer cover not being penetrated in either blast.

The performance of the tool was adequate and we have no plans to revise it at this time.

The AVS demining brush

One AVS demining brush was tested with the bristles resting on a mine. The result is shown alongside.

The stainless steel pipe used as a handle was slightly split and distorted was no parts had broken away.

While the tool performed as designed, it would be possible to add a central disk as a hand-guard (providing protection whichever end was held) and this may be done if interest in the tool is shown.

The AVS root-cutters

One root-cutter was blast tested with the result shown alongside.

The tool stayed in one piece with the exception of the polycarbonate “anvil”. The loss of this part was anticipated and a material that did not shatter under impact selected, but this is still unsatisfactory.

While this tool is undoubtedly safer to use that standard gardening secateurs, it fails to keep the user’s hand 30cm from a blast and its polycarbonate “anvil” was torn away. More work is needed to make a one-handed tool with this function that is as safe in use as possible.

The AVS demining shears

One pair of shears was blast tested with the result shown alongside.

The tool stayed in one piece with no damage to the welds and fixings. The selected materials appear to be an appropriate compromise between hardness and malleability.

This tool is undoubtedly safer to use that standard gardening shears and should be a durable as many on the market. Some work on the properties of hardened steel blades in blast situations would be useful in order to allow the blade’s cutting properties to be optimised.