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THE FACTS ON PROTECTION NEEDS IN HUMANITARIAN DEMINING

by Andy Smith, Consultant



When assessing protection needs, my approach has been to determine what the risks are, what injuries result and then decide how to minimize these risks and protect against any residual danger. I also bear in mind that there is no point in prescribing an action or a garment that will not be used.

Though this method may be practical, it is not an approach endorsed by the protective equipment industry, which seems to prefer to base their assessment of risk on experimental data and a scale of injury used in the automobile industry. If the injuries they commonly predicted were accurate, all of the deminer victims I know would be dead. Most of them are at work.

Anyone considering this matter objectively should bear in mind that deminers do not want to wear any equipment that is uncomfortable, heavy, restrictive of movement or thought to be unnecessary. Demining program managers do not want to buy equipment that will not be used or is expensive to purchase and replace. They also are aware that demining incidents are extremely rare. I believe that severe incidents occur at the rate of one per 25-30 years of actual demining experience for each deminer. This statement ignores the fact that some groups have more incidents or work in more dangerous areas than others, but it does explain why most deminers have never seen an incident.

The following paper draws on information derived from five years of field research and from an intimate knowledge of the incident data in the Database of Demining Incident Victims (DDIV). The DDIV stems from my work during 1998 and 1999 for the U.S. Army CECOM NVESD Humanitarian Demining research initiative. It covers all recorded explosive incidents that have occurred while demining in Angola, Mozambique, Cambodia, Bosnia-Herzegovina, Laos and Zimbabwe. It also covers all the usefully recorded incidents that occurred in Afghanistan (1997-99) and those made available from Kosovo. It does not include details of civilian incidents and injuries. Often with considerable detail about the circumstances surrounding an incident, the records provide a reference for an informed analysis.

The DDIV has been accepted as an authoritative resource by GICHD in its work advising the revision of UN standards for HD. The DDIV is available on CD.

Eye injury is common and easy to avoid.

Photo c/o Andy Smith

Threat activities

There are many opinions of what constitutes the greatest threat in demining. Using the DDIV as a data resource, it is possible to reduce the perceived threats to those that have a real manifestation. The "threats" are listed in terms of incident types and frequency.

Type of incident	Number of victims
Excavation	119
Missed-mine	85
Handling	32
Victim inattention	25
Detection/tripwire	18
Survey	16
Vegetation removal	12
Other	10
Demolition	7
Detection	6

One can see that "excavation" is the most frequent incident to occur. The second most likely type is a "missed-mine"; it involves a deminer stepping on a device missed during clearance. The essential difference is that the first is deliberate (the detector reading must be exposed by excavation) while the second is accidental (no one intended to miss the mine). In the first case, the victim is doing what must be done; in the second, he is the victim of someone else's mistakes.

Injuries Sustained

In the DDIV, injuries likely to be life-threatening to require surgery or result in permanent disability are rated as severe. All others are rated as minor.

For the whole database² the following injuries are recorded:

Face/head/neck

Severe eye 60, minor 37
 Severe face 19, minor 100
 Severe head 17, minor 16
 Severe neck 5, minor 23
Total: 101 severe injuries

Hand/arm

Severe hand 34, minor 84
 Amputation of hand 8
 Amputation of finger 26
 Severe arm 25, minor 66
 Amputation of arm 13
Total: 106 severe injuries

Leg/foot

Severe leg 40, minor 94
 Severe foot 17, minor 10
 Amputation of leg 63
 Amputation of foot 9
 Amputation of toes 1
Total: 130 severe injuries

Body/trunk

Severe body 13, minor 36
 Severe chest 18, minor 37
 Severe genital 11, minor 5
Total: 42 severe injuries

The table reveals that there are more severe lower limb injuries than any other. What is not immediately obvious is that the most common type of incident, "excavation," rarely involves any lower limb injury. This fact is explained because lower limb injuries tend to be disproportionately severe.

Devices Involved

I am defining the threat as the mine(s)/device(s) most commonly occurring in recorded incidents in any one theater and omitting the AT mine threat. The DDIV includes records of two incidents involving an AT mine, both were fatal. Such cases being rare and seemingly impossible to protect against, I have left them out of this analysis.

The Blast Mine Threat

Afghanistan – PMN (240g TNT) mine featured in 62 injuries.

Angola – PPM-2 (110g TNT) mine featured in 12 injuries (PMN in six).

Bosnia-Herzegovina – PMA-3 (35g Teteryl) mine featured in seven injuries; the PMA-2 (100g TNT) mine featured in five injuries.

Cambodia – PMN-2 mine featured in at least 21; the "minimum metal" mines Type 72 (a or b) (51g TNT) featured in 13; and the M14 and MD82B (27/28g) featured in eight (total of 21 minimum metal mines).

Iraq – the PMN (240g TNT) mine featured in five injuries.

Laos – none recorded.

Kosovo – the PMA-two mines featured in four injuries.

Mozambique – PMN (240g TNT) mine featured in 14 injuries.

Zimbabwe – R2M2 (58g RDX/WAX) mine featured in 10 injuries.

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In half of the countries, the PMN and/or PMN-2 represent the largest AP blast threats.

The Fragmentation Mine Threat

Afghanistan – POMZ (75g TNT) mine featured in 10 fragmentation injuries.

Angola – POMZ (75g TNT) mine featured in one fragmentation injury.

Bosnia-Herzegovina – PROM-1 (425g TNT) mine featured in 17 (all) fragmentation injuries.

Cambodia – POMZ (75g TNT) mine featured in one fragmentation injury.

Iraq – Valmara-69 (450g Comp B) featured in three injuries (PROM-1 also featured in two of these).

Kosovo – no fragmentation injuries are recorded (still waiting for data).

Laos – a mortar featured in the only recorded injury.

Mozambique – OZM-4 (170g TNT) mine featured in seven or eight fragmentation injuries.

Zimbabwe – none recorded.

The PROM-1, OZM-4 and POMZ represent the greatest threat (in that order), but the PROM-1 does not feature in the data for Cambodia, Afghanistan, Laos, Kosovo, Zimbabwe, Angola or Mozambique. Of those countries, it is known to be common in Kosovo.

The Ordnance Threat³

Afghanistan – a fuse featured in nine (of 12) ordnance related injuries.

Angola – no ordnance related injuries are recorded.

Bosnia-Herzegovina – a grenade featured in the only ordnance related injury recorded.

Cambodia – a fuse featured in four (of four) ordnance related injuries.

Iraq – no ordnance related injuries are recorded.

Kosovo – no ordnance injuries are recorded (still waiting for data).

Laos – phosphorous from an inadequately destroyed mortar featured in the only recorded injury.

Mozambique – a fuse featured in the only ordnance related injury.

Zimbabwe – no ordnance related injuries are recorded, but AP mine fuses featured in two recorded injuries.

Fuses are the most common cause of UXO injury with grenades being the next most common.

Reducing Risk

Most practical people accept that there are two ways to reduce the risk of severe injury in an incident. The first is to avoid the incident. The second is to provide effective protective equipment to limit any injury that occurs.

Avoiding risk can be achieved by revising the techniques used or by enforcing the application of operating procedures known to be safe. The DDIV recorded 82 incidents where a primary cause was “management inadequacy”—usually the failure to provide appropriate equipment or training. A further 190 incidents have “field control inadequacy,” recorded as their primary cause. In these cases, deminers were not working as directed by management, and their errors were not corrected by management. Often they *were* obeying their field supervisors! These listings show that more than 82 percent of incidents may have been avoidable if appropriate controls were in place. Even allowing for revision downwards, this point illustrates that attention paid to improved management at all levels could be an effective way to reduce severe injury.

When everything has been done to avoid an incident, provision must be made to protect against any residual risk. The initial problem with this method is that it is impossible to protect against the worst mines. Bounding fragmentation mines are reported to spread fragments at velocities up to 1,200 m/s; a speed more than twice the size most body armors are capable of withstanding and four times the size the best visors are capable of withstanding. Deminers who trigger a mine at close quarters invariably die whether or not they were wearing protection. The answer is to try harder to avoid that risk. Strategies for this approach exist, such as cutting undergrowth with protected machines, avoiding render-safe procedures using makeshift clips (a risk revealed by the DDIV) and generally keeping the deminer away from the threat.

The most common activity at the time of an incident is “excavation” of a detector reading. This activity must be carried out, and explosions have occurred when no “mistake” was attributed to the victim. The “duty of care” of an employer requires that the deminer be protected appropriately when he is working as directed on a required task such as this one.

The second most common incident involves stepping on a “missed-mine.” Missed-mine incidents indicate that clearance has not been effective. These types of incidents should never occur. Some time-served groups have not had any missed-mine incidents; others have had many. This fact implies that it

is possible to work in a way that avoids them. Incidentally, there is no evidence of a greater risk of missing a mine when demining in areas with minimum metal mines. In the vast majority of missed-mine incidents, the mine was a PMN, PMN-2 or PPM-2, all of which have a large metal content. Even in Cambodia where minimum metal mines are relatively common, as many deminers have stepped on PMN-2 mines as on all minimum metal mines combined (T72, M14 and MD82Bs). The evidence in the DDIV suggests that the best defense against the missed-mine risk is to avoid them by using better working methods and adequate supervision.

The next most common incident occurs when handling a device, sometimes one believed to be safe. Better training could alleviate ignorance, and some groups could avoid the risk altogether by not allowing devices to be handled. Practical protection is impossible without introducing a barrier so thick that the device becomes too remote for tactile feedback. Avoidance is the only open strategy.

The next most common incident is recorded as “victim inattention.” This type covers times when deminers accidentally fall over a mine, walk into an uncleared area or otherwise behave in a thoughtless manner. While in some cases close supervision and rigorous training might have prevented the incident, it has to be accepted that moments of inattention will occur. It is impossible to predict what an incident like this will involve. The only practical protection seems to be that which is used for other incidents.

The next most common incident is recorded as “detection/tripwire.” This type covers incidents where a tripwire was pulled or a deminer trod on a device while clearing land (the area was not declared “clear” at the time; so, the mine was not technically missed). Failure of equipment and careless use of the detector were the causes for these incidents. I believe that this type is another case where protecting the deminer would be best achieved by ensuring that the incident did not occur.

The next most common incident is recorded as “survey,” which occurs when a survey is being made or when a mine is initiated in an area declared “free from mines” or “reduced” during a survey. Most accidents involve mines that were missed during the survey; so, improving the quality of survey would have prevented most of them. No practical way of protecting against the remaining risk is apparent.

The next most common incident is classified as “vegetation removal.” These incidents involve pull-

ing a tripwire while cutting vegetation or stepping out of the safe area while doing so. Both could be avoided by enforcing existing operating procedures or by using, where possible, mechanical means to cut the vegetation prior to manual demining. Given that the risk includes the fragmentation mine threat, no practical protection against it is possible.

The next most common incident classification is “other.” This type covers a range of isolated incidents with little in common. Several of the incidents involve the apparent sickness of the victim, which may be something spotted by the field management.

The next most common incident classification is “demolition.” This type is rare and happens when an explosive injury occurs while charges are being prepared or laid for the demolition of a device(s) already located. These incidents have included fragmentation mines. No effective protection could have been made available for some of these incidents, and at least some were caused by the victim breaching operating procedures. It seems likely that improved training is the only practical way to reduce the number of these incidents and the severity of damage to the victims.

Of all the classifications mentioned above, the only incident that occurs even when a deminer adheres to his training and instructions is “excavation.” This type is also the most common incident. For these two reasons, I believe it should provide the benchmark for protection needs.

Protection While Excavating

To protect a deminer against incidents that occur when excavating, we must be aware of the position he is in and the areas of his body most at risk. Despite the claims of some ill-informed managers in the industry, the data in the DDIV clearly illustrates that almost all deminers work in a kneeling or squatting position while excavating. This news is good for the deminer because he avoids the whiplash acceleration injuries that have been associated with deminers in a stationary position with their heads only a few centimeters from the blast origin. The exploding device is almost invariably directly in front of and below his body and head. Often, his hand is above or alongside the device.



“What can often happen while a deminer is working as directed with the tool he is issued.” —Andy Smith, describing the cause of the above scene.

Photo © Andy Smith

Severe (disabling) Injuries Recorded While Excavating

Face & neck = 54 severe injuries
 Upper limb = 51 severe injuries
 Lower limb = 7 severe injuries
 Trunk/Body = 10 severe injuries

The difference in size between the injuries to the upper limbs and head (51-54) is statistically insignificant in a sample of this size. The drop to seven for lower limb injuries is significant, as it illustrates the way that a fragment cone rises from a seat of initiation and the core of it often misses the legs (minor leg injuries were more common - 36). The drop to 10 for trunk/body injury is also significant, illustrating clearly that the main torso is not at the same degree of risk as the upper limbs and the head. Several of the severe body injuries resulted from the tool, or part of it, hitting the body.

Face and Neck Protection

Despite the fact that some form of eye protection was issued, it was not worn in almost half of the recorded blast mine incidents. Eye injury accounted for 97 of the 236 blast mine victims in the database (more than one in three).

Eye protection issued varies from industrial safety spectacles to 5mm polycarbonate visors. Safety spectacles were issued to 25 percent of the victims in the DDIV. In 33 percent of the cases, 3mm visors were issued, and these visors sometimes shattered (there were 19 severe eye injuries in excavation incidents over two years in that theater alone).

Visors made of 5mm thick untreated polycarbonate sheet that cover the face have been used by most professional groups (MAG, HALO Trust, NPA Mozambique & Angola, MgM, Koch MineSafe, MineTech, INAROOE, etc.) for some years, and their use is spreading. Some of the visors are short and attach to helmets, all too often leaving the wearer's throat exposed (especially from below when kneeling). Others are long and worn without helmets. When worn properly, these offer some protection to the throat when kneeling and looking down.

I have tested 5mm untreated polycarbonate visors in over 40 blast tests using AP mines. They have not failed catastrophically, but a 5mm visor did break in two in one recorded incident. In one test, the material was penetrated by a steel fragment placed in the earth covering the mine. In several further tests against POMZ fragmentation mines, the visor was

not penetrated at all, illustrating the unpredictability of mines but also showing that 5mm polycarbonate does not guarantee protection to a deminer excavating an AP blast mine. A full-face visor made of polycarbonate is light enough for sustained wear (thousands of deminers use them) and is probably the best that can be provided until a lighter, stronger material is developed. This evidence suggests that 5mm polycarbonate full-face visors fixed in the "down" position should be the standard for facial protection while excavating AP blast mines.

Upper Limb Protection

It is unconventional to put hands and arms among the areas needing protection. However, the DDIV recorded 51 severe upper-limb injuries from blast mine detonations, including 14 amputations of fingers and hands and 10 of arms. These injuries are worse when the tool is short and used vertically. When the tool breaks into its component parts, deminers have been struck in the chest, upper arm and face with severe consequences. At least five deminers died after their hand-tool failed and fragmented in a blast.

There is also evidence in the DDIV that hand and arm safety can be enhanced by using hand-shields and sensible manufacturing constraints that keep a tool in one piece. For example, in at least eight prodigious incidents with a simple tool made in Africa, the tool blade curved and the handle and blade stayed together. In none of these incidents was the deminer injured by his tool.

The evidence from the DDIV supports my belief that

- To prevent hand injury when excavating, tools should be designed so that they are easiest to use at a low angle to the ground; and
- To reduce hand and arm injury, tools should be designed to stay in one piece, should be long enough to keep the deminer's hand at least 30cm from the blast and should incorporate a flexible blast shield whenever possible without reducing utility.

Examples of such tools exist and are available commercially.

Body Protection Against Fragmentation

Protection designed to reach a STANAG V50 of 450m/s (current U.N. standard) has proved less than adequate against bounding fragmentation mines. Fortunately, fragmentation mine incidents are rare outside Europe, and there are no records of a bounding

fragmentation mine incident occurring while excavating.

Body Protection Against Blast

The DDIV recorded 14 deminers dead as a result of blast mine detonations. Five of these victims were wearing frag-jackets of some kind, but all five were not wearing head protection (or not wearing it properly). Additionally, four of these involved severe head-injury; the fifth deminer was squatting and stepped on a mine so he suffered severe lower body injury. The frag-jacket did not appear to have "failed" in any of these cases. In excavation incidents where armor was worn, it did not fail; thus, the DDIV provides evidence that the STANAG 450m/s current standard of body protection is sufficient against the largest blast-mine threat (240g TNT) at a distance of 30cm.

However, a STANAG V50 of 450m/s is no measure of blast protection. A blast mine detonation is a significantly different kind of threat, and the materials used to protect against it may not have the same fragmentation resistance despite being more effective against a blast mine detonation. An example of this situation is the low cost, flexible ballistic Aramid; it retains its integrity in a blast better than Kevlar, but it has a much lower V50, weight for weight.

As the data in the DDIV shows, the armor currently issued is not always worn. Deminers tell me that because it is heavy and uncomfortable, they feel that the bulkiness of the gear may increase their chances of making a mistake. This assertion explains why there has been a general move away from flak-jackets toward frontal "aprons." Some of the aprons hang loose while others are strapped firmly to the body. Some aprons have a V50 as low as 380m/s; others exceed 450m/s. The only type to fail in my tests had the higher V50, but it was made up of discrete panels that the blast separated. Conversely, the one-piece apron with a lower V50 performed well in seven tests and in at least 15 real incidents.

The evidence shows that the need for body protection may not be a high priority, but it is desirable. It is even more desirable if it is comfortable enough for a deminer to wear. Simple blast resistant frontal aprons have proved adequate to protect an excavating deminer in real incidents and comfortable enough to be worn without protest. Thus, the evidence suggests that deminers should be issued frontal body and genital blast protection aprons (240g TNT at 30cm) when excavating.

No Protection Because of No Real Risk

There are a number of products available that offer protection against questionable risks. Facts suggest that these risks are so rare that deminers feel that protection against them is unnecessary.

There is no evidence among the data for over-pressure internal injuries ("thoracic disruption") resulting from an AP mine. The evidence in the DDIV proves beyond reasonable doubt that this "threat" is more commercially convenient than real. Presently, there is no evidence to suggest that blast-proof boots have reduced injury. Current evidence suggests that wearing blast-boots when stepping on a blast mine containing significantly more than 50g HE may actually worsen the level of severe injury. Also, the only

"No protective equipment I have seen used in humanitarian demining can guarantee protection against a bounding fragmentation mine."
 —Andy Smith

Photo c/o Andy Smith



FACTS

boots with some effectiveness against the smallest mines include a stand-off of at least 10 linear cm in their design. These boots would be impractical in the mined environments I know. There is no evidence in the DDIV that wearing a helmet or a back-panel to body armor has ever significantly reduced the severity of an injury.

Protection against hearing loss is sometimes suggested. While there have been many claims of hearing damage from single blasts in Afghanistan, this case has not appeared in other theaters. The compensation system in Afghanistan claims for low level and unverifiable ear damage (deminers could still return to work). Excluding Afghanistan, the DDIV lists only one claim of severe hearing damage resulting from a single blast (close proximity to a large device).

Practical Approaches to Meeting Deminer Protection Needs:

- Reducing the number of incidents that occur, and
- Reducing the severity of injury when an incident occurs.

The first can be pursued via changes to working methods and improved supervision and management. This approach is likely to be the most effective. The second can be pursued via the provision of Personal Protective Equipment (PPE) appropriate for use at times when risk cannot be avoided.

Practical PPE That Could Reduce the Severity of Incidents:

- Eye protection with a STANAG V50 equal to that offered by untreated 5mm polycarbonate (about 280m/s). This equipment must be in good condition and not reduce clarity of vision by more than 10 percent;
- Hand-tools that are fit for a purpose and are designed to minimize the risk of adding to injury; and
- Comfortable frontal blast protection (against 240g TNT at 30cm) for use when excavating. The inclusion of a collar that overlaps the visor and closes any access to the throat in a blast is desirable.

Some groups already do most of the above. A few of the organizations have done so for many years. This report provides evidence that my suggestions are practical, and the DDIV provides evidence that they are needed. ■

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¹ These activities are defined in detail in the DDIV.

² Statistics are based on the April 2000 release of the DDIV.

³ Submunitions with Anti-Disturbance fuses, frag-jackets and shaped-charges are a separate risk that requires a distanced approach and specialized SOPs. They have not been featured in recorded incidents.

One Last Appeal

Please, let us not spend mine-clearance money on unnecessary expensive equipment. Let us not load down a deminer with equipment that he will discard as soon as our backs are turned. Please, let us not ignore the facts just because they disturb our quest for profit.