Journal of Conventional Weapons Destruction

Volume 22
Issue 1 *The Journal of Conventional Weapons Destruction Issue 22.1*

Article 2

April 2018

PPE Development and Needs in HMA

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EDITORIAL

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Left to right, the image shows flechettes from a munition, pre-chopped fragments from a bounding fragmentation mine, and pre-scored diamond fragmentation from a submunition.
Image courtesy of the author.

As written in the International Mine Action Standards (IMAS) 10.30 on personal protective equipment (PPE), "the primary means of preventing explosive injury in the workplace is by the supervised use of demining tools and processes that reduce the likelihood of an unintended detonation." The IMAS goes on to state that PPE "should be the final protective measure after all planning, training and procedural efforts to reduce risk have been taken." To date the "final protective measure" has been to provide PPE that is **practical** but that does not provide full protection.

The threat posed by the blast wave(s) associated with the detonation of high or low explosive is highly dependent on the quantity of explosive involved. With small blast mines, the speed of the blast front (as the volume of gas expands) rapidly declines and many deminers wearing no protection on their bodies have suffered no body injury despite being very close during accidents. The evidence from the Database of Demining Accidents (DDAS) is that body armor serves little proven purpose when the accident involves a small blast mine unless the deminer's hand-tool breaks up and becomes part of the hazard. In any close-quarter blast involving kilograms of explosive, the disruptive blast forces can pass through body armor and pulverize the cells of the wearer almost as effectively as if the armor were not there. Polycarbonate blast visors are also of no proven use in a large blast but are useful against small blasts. As long as the material is not deliberately hardened, polycarbonate can flex in a way that has often prevented the blast front and associated tiny pieces of mine casing and unburned explosive from blinding the wearers.

It is fragmentation that causes most fatal injuries during demining. Fragmentation may come from the munition, from the soil and stones surrounding it, or tiny pieces of the explosive charge itself. Unsurprisingly, the most damaging kind of fragmentation is deliberately built into the munition either by designing a casing that fragments or by surrounding the explosive charge with fragments of metal, some of which may be shaped to be self-orientating and especially penetrating.

There are several reasons why the fragmentation threat to deminers has not been addressed despite the fact that even small fragmentation devices have regularly killed deminers wearing PPE.

1. To provide reliable protection against fragments by increasing the layers of flexible armor or by adding hard armor panels would increase weight dramatically. This would make the wearer uncomfortable and restrict mobility in a way that could increase the risk of an accident occurring. Experience indicates that it would also increase the risk of the PPE not being worn at all.
2. Effective fragmentation armor would have to be extended to protect the arms and legs because the spray of fragments is not confined to the torso. The improved armor would also have to cover the face and head, but

The images show combat body armor with a V50 of 450 m/s and a helmet after being struck by fragments from a PROM-1 bounding fragmentation mine. The deminer suffered multiple penetrations to torso, arms, and head and bled out rapidly.
Images courtesy of the author.

effective transparent visor material that could match the protection of body armor is not available, so this is not possible.

3. The much increased costs would mean that demining organizations could not afford to do as much actual demining—and controlling the risks faced by deminers has to be balanced against the risks being faced by the population who are waiting for them to arrive.

Reasons one and two are based on the premise that any protection is only as good as its weakest point. To provide torso protection able to stop the fragments while leaving the wearer's arms or face unprotected is inconsistent and illogical. This is true, but it is not a good reason not to increase protection where we can because the PPE we provide is already inconsistent. The current IMAS requirement for body armor is a NATO STANAG V50 of 450 m/s while the face and eye protection is 5 mm polycarbonate, which has a NATO STANAG V50 of less than half of that.[1,2] The V50 is the speed at which half of the fragments (50 percent) compromise the protection. So how can we justify requiring torso protection that is far greater than for the face? The answer is that it is not logical, but it was the best we could do when this part of the IMAS was written.

There is always a balance to be drawn between what is practical and what is ideal. In humanitarian mine action (HMA), we have rarely pursued the ideal because whatever we do must be practical. This is seen as being realistic because many of the hazards we confront simply cannot be protected against with any PPE currently available.

For example, this KB1 submunition contains only 30 g of high explosive that produces an expanding blast front that is relatively easy to protect against at 30 cm. It also has a fragmentation body with steel ball bearings encased in a nylon body that most body armor used in HMA could stop at a distance of a meter, even if the visor could not. However, it also has a shaped charge designed to penetrate armored steel, which nothing short of well-spaced layers of armored steel or reactive armor panels can stop close-up.

Whatever PPE is issued, the informed deminer knows that it cannot provide real protection against a worst case scenario, but that does not mean that we should not be trying to improve PPE so that it can provide effective protection more often.

The third reason for not improving PPE—increased cost—is unsound because failure to do "all that is reasonable" to protect the workers could end up costing the employer far more than the cost of better PPE. In the author's experience, most donors of HMA are open to requests for support to provide better PPE for those doing the work they fund.

Why Have There Been No Significant Improvements?

There have been improvements to demining PPE over the past twenty years, but most have been incremental. One example is

KB1 submission.
Image courtesy of the author.

The images show the lighter blast visor and the ROFI face mask.[5,6]
Images courtesy of the author.

the availability of lighter body armor materials with a tighter weave that allows higher levels of protection to be achieved in a garment of the same weight, or more of the wearer to be covered without a weight increase. The design of a lighter visor and some improved hand tools have also been incremental improvements.[3] The ROFI demining face mask is the only truly novel advance because it makes use of a very lightweight laminate named PURE, but its design has been criticized and it is not widely used.[4]

Changes to demining PPE over the last twenty years have been largely minor for three reasons.

1. **Lack of demand.** There is a general absence of an expressed wish for better PPE from the end users or their managers.
2. **The current risk is thought tolerable.** A generally low level of accidents has led many involved in demining to consider the current level of risk to be tolerable.
3. **There are more immediate ways to manage risk.** Managing risk by making improvements to procedures is known to be effective at preventing injury, so efforts in that direction are more likely to yield immediate benefits.

Lack of Demand

Although deminers rarely ask for better PPE, that may be because they often believe that the PPE they have provides greater protection than it does or that nothing better is available. The industry needs a PPE testing regime that provides a relevant means of comparing one PPE product with another. The only test we currently have is the NATO STANAG 2920 test, which was designed to provide a comparable measure of the protection offered against bullets and fragments in a combat scenario. To this end, the STANAG testing regime involves firing single, carefully shaped and weighed fragments of a very hard metal directly down a barrel toward the material at precisely measured speeds. The test is repeated at least six times with each strike well separated from the others. The result is calculated as a V50 in meters or feet per second.

Almost every part of the STANAG test is inappropriate to use when appraising demining PPE. When an explosive hazard detonates in front of a deminer, the PPE is struck by a blast front, which the test does nothing to replicate. It is also struck by fragments of the ground and parts of the munition's casing and/or deliberate fragments inside it. It may be struck by multiple fragments that are bunched closely together or following one after another. The fragments are not of a strictly controlled hardness, shape, and weight and have not been fired from a barrel. Even the pre-shaped fragments in fragmentation munitions tumble in the air, which usually makes them much easier to stop than a directed projectile moving at the same velocity. However, the explosions that launch these fragments can generate a brief heat of over 4,000 degrees Celsius (e.g., TNT) and some heat is transferred to the fragments, which can become hot enough to damage the material

There are large holes penetrating this body armor material, which has burned and shrunk away from hot fragments from a bounding mine. The material had a NATO STANAG 2920 V50 in excess of 450 m/s.
Image courtesy of DDAS.

they strike by melting or burning it. It is true that much of the kinetic energy in any projectile is converted to heat when it is obliged to stop rapidly, but some fragments generated by mines and explosive ordnance start off hot, a fact that makes some PPE materials shrink away from them.

In 2007, a European Workshop Agreement resulted in the publication of a test protocol for demining PPE that was referenced in IMAS 10.30 in 2008 but was quickly found to be unfit for purpose and quietly removed in 2010.[7,8] An attempt to create a better European agreement was started by the Royal Military Academy (RMA) in Belgium as part of the TIRAMISU project in 2016 but was not completed.[9] One feature of the planned test was the use of a triple-barrel fragment launcher so that the effect of near simultaneous fragment strikes could be measured. There would still be no way of recording the heat of the fragment during flight, but this would be an advance because some armor materials cannot withstand multiple simultaneous impacts as well as others.

The Current Risk is Thought Tolerable

The definition of **tolerable risk** in the IMAS is "risk which is accepted in a given context based on current values of society."[10] This is taken directly from the definition used by the International Standards Organization (ISO) and was designed to apply across all industries, not specifically those dealing with explosive hazards in countries that lack the means to clear the hazards themselves. Every industry is intended to interpret that definition appropriately in their own working context.

The level of risk that people live with during conflict is usually higher than it would be during peacetime, and this is a level of risk that is unavoidable and "accepted in a given context."[10] When conflict is over, people often become accustomed to living with a higher level of risk than would be tolerated elsewhere. It is inappropriate for any humanitarian demining organization to adopt the high-risk mindset that may prevail in an insecure post-conflict context because it is the current humanitarian values in peaceful and secure societies that should apply. These are the values that those paying for humanitarian mine action want to promote as part of supporting a sustainable peace.

Throughout the history of HMA, the high level of risk that is tolerated where we work has been used to justify using lower levels of PPE than is acceptable during such activities as range clearance and explosive ordnance disposal (EOD) tasks in Europe and America. Early demining PPE was inadequate and ranged from industrial safety spectacles to combat armor and purpose-designed albeit minimal protection.

The requirements of the IMAS published in 2001 went some way to level that playing field but did not bring standards up to those used in civil EOD work in Europe and the United States, because those drafting the IMAS, including the author, deemed that impractical. However, if we could reduce the number of deminer injuries and/or the severity of their injuries, it is an obligation for any **humanitarian** organization to do so because we must do "everything reasonable" to manage and reduce risk of injury to our employees. So the current risk is only tolerable if we can show that we have done everything reasonable to manage and mitigate risk and show that we have done this in a way that would satisfy a court of law. Some international demining insurance

The image shows the RMA's triple fragment launcher for testing PPE with near-simultaneous strikes.
Image courtesy of Georgios Kechagiadakis and Marc Pirlot.



Left to right, the images show demining PPE used in Mozambique and Cambodia in 1997.[11]
Images courtesy of the author.

providers insist that the minimum level of PPE required in the IMAS is used, which implies that the IMAS level of PPE is broadly accepted as being **reasonable**, but PPE is only the final protective measure after all other reasonable means of managing risk have been taken.

The definition of tolerable risk in the current edition of the National Mine Action Standards in Lebanon includes examples that may be useful to others:[13]

"…The 'tolerable risk' remaining after an area has been searched, cleared and released is the risk of explosive hazards being beneath the required search depth in that task area. The 'tolerable risk' to demining staff is the risk remaining after all reasonable efforts have been made to train, equip and supervise staff in the conduct of inherently safe demining procedures. All reasonable effort includes the production of a formal task risk assessment designed to ensure that appropriate measures to mitigate risk are taken. All formal risk assessments must be updated as work progresses and new information becomes known. The Lebanon Mine Action Centre determines the level of risk that is tolerable at any task. In the event of disagreement, the final arbiters of what is 'all reasonable effort' shall be the Government and Courts of Justice in Lebanon."[14]

There Are More Immediate Ways to Manage Risk

Dramatic progress has been made in risk avoidance over the past twenty years. One breakthrough came because of advances in metal detector technology, which meant that many hazards with a minimum-metal content could be reliably located. Another was the use of small radio-controlled machines to process areas with fragmentation mines before the deminers deployed.[15] Then came the use of long-handled rakes for excavation that used distance to avoid injury when there was an anti-personnel blast mine detonation. Today, there is the increasing use of unmanned aerial vehicles (UAV) with high-resolution cameras that are able to hover and allow the remote inspection of potential hazards before anyone approaches.



The images show the PPE currently being used by a demining organization clearing improvised explosive devices (IED) in Syria. In the author's opinion, they are doing everything reasonable to protect their workers both with PPE and with specialist IED training.
Images courtesy of MAT Kosovo.[12]

Images from a small unmanned aircraft (SUA) show the extent of structural damage, then close-up views of visible suspicious items.
Images courtesy of field operatives in Syria.

In the example above in Raqqah, Syria, in February 2018, a preliminary camera overview helped to identify access routes and make informed decisions about approaches that minimized risk to the workers. The skilled pilot then used the camera to look through doorways and windows and could identify a passive infrared (PIR) triggered IED (in the cardboard box with the sensor protruding) before anyone approached. The small unmanned aircraft (SUA) gave the organization an up-to-date overview of the extent of structural damage (a common cause of non-explosive injury), then a close-up view of visible suspicious items. They used this information to make an informed search plan that minimized risk to their staff.

Those conducting any kind of risk management must first have had appropriate training and/or experience so that they can identify and mitigate risks. Thereafter, managing risk effectively in HMA relies on having as much information about each unique task as possible so that an evidence-based risk assessment can be made. The use of SUA in Syria provides a good example of extending the knowledge available, improving identification and better mitigating risks in that context. Of course the process does not eliminate risk, but it does show an organization making "all reasonable effort" to identify risks as they plan to avoid casualties.

Needs

The accident record in the DDAS shows that PPE has been worth wearing because it has often reduced the number or the severity of the wearer's injuries. Although we have never had PPE that could reliably protect against all common fragmentation hazards in HMA, we still do not have a way to assess the relative effectiveness of existing or new PPE products, which might do better.

The hierarchy of common disabling injuries resulting from demining accidents over the past twenty years has only changed because stepping on a mine has become much less frequent. As a result, catastrophic damage to hands and eyes are now by far the most common severe injuries. Meanwhile, fragmentation injuries still cause the most deaths.

Although there have been no significant advances in demining PPE over the past twenty years, there has been a reduction in the IMAS PPE requirement.[16] The original 2001 IMAS 10.30 PPE requirements included the provision of frontal throat protection and the wearing of a full-face visor. In 2008, these former requirements were downgraded to recommendations.[17] The author asked for one of these changes because the accident record showed that visors were not being worn (or worn correctly) when accidents occurred whereas goggles were already being used to good effect.[18] The requirement was reduced to allow the wearing of goggles but recommended the continued use of visors. The downgrading of the requirement for throat protection appears to have gone unnoticed because almost all demining body armor still has a collar that folds back in a blast and protects the wearer's throat. Nonetheless, after the passage of ten years, it is perhaps time that the PPE requirements in IMAS 10.30 were revisited.

There are at least four other needs related to PPE that should be addressed:

1. To reduce the severity of blast injuries, further improvements in the design of blast resistant hand-tools would be beneficial, as would their adoption by organizations who have not yet done so (the IMAS recommend their use but do not require it).
2. To reduce eye loss, the invention of a lighter and stronger blast visor material could encourage the correct use of visors. This is rumored to have already happened; however, the material's manufacture and use have yet to filter down to readily available and affordable demining PPE.
3. To increase body protection, the development of flexible ceramic armor (e.g., modified Dragon Skin armor) or the use of PURE (i.e., the light material used in the

Smith (front) wearing the most commonly used demining PPE in Tajikistan in 2016 – the deminers behind are wearing the ROFI mask.
Images courtesy of Major Firuz Asadbekov, Humanitarian Demining unit, Army of Tajikistan.

ROFI demining face mask) would be worthwhile. This armor need not be able to protect against rifle fire (often approaching 1,000 m/s), but any increase to comfort and affordability in deminer protection would be an improvement.

4. To allow end users to compare products, the ability to compare one PPE product's performance against another in a low-cost test that replicated an agreed, typical demining accident event would encourage manufacturers to make further incremental improvements.

Finally, while the PPE provision has remained fairly static, the refinement and development of procedures and equipment that keep people at a distance from the hazards has reduced risk to the deminers in many organizations over the past 20 years. Alongside the formal conduct of disciplined risk assessments, the author believes that the avoidance approach of responsible field operatives often demonstrates doing "all that is reasonable" to make risk tolerable in spite of the inadequacy of the available PPE.[19]

See endnotes page 61

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A.V.Smith (AVS, Andy Smith) served as a PPE specialist on the International Mine Action Standards (IMAS) Review Board for 11 years and was the founder and keeper of the DDAS.[20] He has worked in humanitarian mine action (HMA) over more than 20 years at all levels from surveyor/deminer to Chief Technical Advisor to UNDP country programs. Having drafted the original IMAS Technical Note for Mine Action on Field Risk Assessment (TNMA), he was contracted by the Geneva International Centre for Humanitarian Demining (GICHD) to produce current field risk assessment training materials in 2016.[21]

PPE Development and Needs in HMA by Smith [from page 5]

1. NATO Standardization Agency (STANAG) 2920 PPS (edition 2) Ballistic test method for Personal Armor Materials and Combat Clothing, NSA/0723-PPS/2920, 2003.
2. The author has tested 5mm untreated polycarbonate using NATO STANAG 2920 and found a V50 ranging from 250 m/s to 280 m/s. The uncertain result is probably caused by variations in the ambient temperature or in the temperature of the fragments (which were fired using blanks or by compressed air).
3. Hand-tools are included in IMAS 10.30 PPE because the accident record shows that the use of well designed tools can protect the deminer by distance and by avoiding parts of the tool separating and causing injury.
4. PURE is a polypropylene self-reinforced composite material: see http://www.ditweaving.com/
5. This visor was designed by the author and given freely to the manufacturer: See: Security Devices. “SD Platinum Visor.” Accessed 12 April 2018. https://bit.ly/2vghH7B.
6. The author was invited to advise during a workshop in Norway at the start of the design process for this mask, but does not like the result. For information about the mask, see: Rofi: Protecting People. Accessed 12 April 2018. https://bit.ly/2vghUrp.
7. European Committee for Standardization (CEN) Workshop Agreement 15756, now defunct.
8. IMAS 10.30, 2nd Edition, amendment 2, “References to CWA for T&E of PPE were removed from Clause1 and Annex A” at the start of 2011.
9. The author was an advisor to the project.
10. From IMAS 04.10, Glossary, 2014. This definition is drawn from the International Standards Organization (ISO) Guide 51:1999(E).
11. Left to right, the pictures show a UNADP deminer in Mozambique a HALO Trust and a MAG deminer in Cambodia.
12. Pictures taken in 2017 during specialist IED clearance training conducted in Syria by PCM ERW Risk Management & MAT Kosovo. www.pcm-erw.com, email: info@pcm-erw.com.
13. Lebanon NMAS 04.10 Glossary, February, 2018.
14. Drafted by the LMAC with the author’s input, 2018.
15. The most successful of which in terms of sales is the DOK-ING MV4 made in Croatia (which has also supplied U.S. forces in Afghanistan).
16. IMAS 10.30 PPE, Edition 1, 2001. “The frontal protection ensemble provided to employees, whether required to kneel, sit or squat shall be designed to cover the eyes, throat (frontal neck), chest, abdomen and genitals”.
17. IMAS 10.30 2nd Edition, 2008.
18. As a member of the IMAS Review Board, the author argued for this change because of the lack of injuries sustained while wearing goggles while excavating with rakes. The wearing of blast goggles during EOD and IED tasks has since become common, which was not anticipated but the author respects the principle of wearer’s choice as long as blast visors are available at the task if they choose to wear them.
19. For a formal HMA Field Risk Assessment training course, the author recommends the one that he provided some materials for at GICHD. Contact: r.evans@gichd.org
20. Database of Demining Accidents, which is an informative reference in IMAS 10.30, (Annex A) and online at www.ddasonline.com.
21. International Mine Action Standards Technical Note for Mine Action (IMAS TNMA) TN 10.20 20 2009.

References

The author has written extensively on PPE in mine action over the past 20 year and has had several relevant papers published in the Journal over that period:

1. Smith, Andy (1998) "Current Situation and Perceived Needs for Head and Face Protection in Humanitarian Demining," The Journal of Humanitarian Demining: Vol. 2: Iss. 1, Article 4. Accessed 12 April 2018. https://bit.ly/2HvvwBh.
2. Smith, Andy (2000) "The Facts on Protection Needs in Humanitarian Demining," Journal of Mine Action: Vol. 4: Iss. 2, Article 11. Accessed 12 April 2018. https://bit.ly/2qrgDb7.
3. Smith, Andy (2002) "What Use is a Database of Demining Accidents?" Journal of Mine Action: Vol. 6 : Iss. 2, Article 21. Accessed 12 April 2018. https://bit.ly/2JGzCY6.
4. Smith, Andy (2002) "Developing Safer Demining Handtools in Zimbabwe," Journal of Mine Action: Vol. 6: Iss. 2, Article 7. Accessed 12 April 2018. https://bit.ly/2JEEBZh.
5. Smith, Andy (2003) "IMAS and PPE Requirements," Journal of Mine Action: Vol. 7: Iss. 1, Article. 12. Accessed 12 April 2018. https://bit.ly/2GTyG4Z.
6. Smith, Andy (2011) "The Database of Demining Accidents: A Driving Force in HMA," The Journal of ERW and Mine Action: Vol. 15: Iss. 2, Article 18. Accessed 12 April 2018. https://bit.ly/2qpmheS.
7. Smith, Andy (2014) "Understanding the Use of Prodders in Mine Detection," The Journal of ERW and Mine Action: Vol. 18: Iss. 1, Article 14. Accessed 12 April 2018. https://bit.ly/2JF1qfr.