Developing protective clothing poses permanent challenges

Protective clothing in the form of body armour has been constantly modified and improved since time immemorial. The two world wars of the 20th century ensured that further developments to protective clothing were continuously pursued. Today, protective clothing is mainly worn by the armed forces and the police and is subject to standardised test procedures applicable throughout the world.

Protective clothing was being developed in Greek and Roman times. In those days it was made of leather, bronze and iron and weighed around 10 kg. Later on, in the Middle Ages, plate armour was made of iron. Although this armour protected knights from head to foot, it weighed between 20 and 30 kg and restricted movement. Engaging in combat while wearing protective clothing of this nature was extremely tiring. In summer, the temperature inside the armour could rise to levels which caused warriors to faint. The first principle which history teaches us is that protective clothing is always a compromise between the area to be protected, the degree of protection to be afforded, weight and mobility.

New threats demand step-by-step adjustment

In the 16th century, suits of plate armour experienced rapid development to the extent that they became genuine works of art. Nonetheless, shortly afterwards they disappeared from the battlefield. Why was this? Close-quarter weapons such as battleaxes were soon replaced by firearms and plate armour was no longer capable of withstanding this new threat. Since adequate protection against firearms was not possible using the materials available at that time, the 17th century saw greater emphasis being placed on mobility. A second principle which history teaches us is that a new threat can quite quickly make the best protective elements appear outmoded.

Two world wars as the catalyst for textile innovation?

In the First World War, steel breastplates were mainly worn for static duties and provided protection against fragments. Trench armour typically weighed 10 kg. In the United States, trials were carried out with protective elements made of chromium-nickel steel. At a weight of 18 kg, this armour offered protection against machine gun fire. But it was never produced because it was too heavy for operational use. In contrast, textiles such as silk had been used as protection very early on by the Samurai in Japan. In Europe, silk was first used in the 20th century for undergarment protective vests. These vests were effective against the weak revolver ammunition at that time. In the Second World War, with the exception of helmets, most soldiers wore no protective clothing of any kind. It was only at the end of the war that textiles (nylon) reinforced with steel plates were again used as protection against fragments. A particular favourite was the *flak jacket* for bomber crews. The development of aramid fibres in 1965 made it possible to manufacture textile vests which were both lightweight and comfortable. Undergarment protective vests made of aramid or similar fibres for protection against hand guns currently weigh approx. 2 kg. Ceramic plates need to be added for overgarment vests for protection against small arms. This increases the weight of the vest to approx. 10 kg. History teaches us that any new technology in the field of protection opens up new perspectives for how clothing performs and how comfortable it is to wear.

Global standardised guidelines for protective clothing

Global standards for protective clothing began to be introduced with the development of the new aramid technology. Today, the performance profiles, characteristics and test procedures for protective vests and helmets are set out in several standards. One may wonder whether this excessive number of directives is really necessary. However, widely differing requirements make it essential. In the past there was a clear distinction between the protection needs of the police and the armed forces. The main threat faced by soldiers in conventional conflicts was fragments. Fragments cause approx. 62% of injuries while bullets cause approx. 23%. The rest are attributable to burns and the effects of blast. Consequently, NATO's STANAG 2920 (Standardization Agreement) directive concentrates on this particular area. In contrast, the threat for police came mainly from knives and handguns. Since the distribution of these weapons varies greatly throughout the world depending on local laws, culture and availability, the requirements also varied. This meant that different standards had to be drawn up. Today, the distinction between the police and the armed forces is no longer so clear-cut. As their anti-terror tasks have grown, the police need protection against small arms. In several countries, police forces are supported by the armed forces in combating terror, so soldiers and police officers have, to some extent, similar requirements. In the 3rd version of STANAG 2920, which has now been published, NATO has included handguns and small arms as threats.

Optimum protection thanks to laboratory tests

The appropriate infrastructure needs to be in place to be able to test ballistic protective clothing in accordance with the directives. The Science and Technology (S+T) division at armasuisse has the relevant infrastructure at its test centre for bullet-resistant materials and structures. This test centre is a member of VPAM (the Association of Centers for Certification of Bullet-Resistant Materials and Constructions) and has been accredited to STS 0118 (ISO 17025) standards since 1995. Accreditation is a confidence-building measure and formal recognition of the centre's professional and organizational expertise, transparency, trustworthiness and comparability. The scope of the test centre's work covers firing trials against body protection elements and protective materials. On behalf of the armed forces procurement system, the centre tests all items of protective clothing, either during the evaluation phase and the selection process or as part of acceptance inspections. Random testing only is carried out during acceptance inspections. As regards the testing of protective vests and helmets, it should be noted that the conditions (firing distance, impact angle, test rounds, test velocity, etc.) are specified by the directives. This guarantees reproducibility and comparisons with other test centres. The directives are aimed at achieving maximum protection by ensuring that the tests cover every parameter (various impact angles) and environmental factor affecting the test item (cold, heat and humidity). It should not be forgotten that the actual conditions experienced under operational use will vary from the laboratory conditions. Some residual risk will always remain.

Further weight reductions are almost impossible

Although wearers of protective vests are convinced by the performance of these products, they are not impressed by their weight. Lighter vests and helmets have improved their ergonomics and made them more comfortable to wear. But without further advanced technologies, the wall thickness of the protective materials cannot be made any thinner, otherwise they would not meet the current criteria. For this reason, it is necessary to refine the criteria. This is the direction in which research is trending throughout the world, and there are indications that possible solutions may be found. This is a challenge with the vital objective of ensuring that the protective clothing overcomes the threat (bullet, fragment or knife). The problem has not yet been completely solved. Detailed investigation is still required into what happens at the inner side of the clothing. Even if it is not fully penetrated, injuries may still occur (e.g. bruising, broken ribs or injuries to internal organs.). The new methods use very realistic diaphragms, known as biofidelic diaphragms, which simulate the dynamic deformations suffered by a human body when it is wounded by gunfire.

The devil is in the detail

Throughout the entire process of developing protective equipment, manufacturers have had to adjust their production methods and the materials employed to meet the constant increase in the threat. Protective clothing has become highly reliable now that test methods, threat classes and assessment criteria are standardised. One aspect still to be overcome is material ageing. For various reasons, the ability of textiles to withstand attack diminishes over time. Consequently, protective equipment should be monitored and replaced after a certain period. In addition, there is a demand for modularity; i.e. there are many opportunities for adding small parts (throat and neck protection, etc.). Testing these small parts is a challenge because the standardised minimum distances between impact point and the edge of the protective equipment cannot always be adhered to. S+T is committed to supporting the armed forces by carrying out ballistic testing as part of the procurement process for materials offering a high level of protection.

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