Developments in Bomb Suits Testing and Standardization

Dr. Aris MAKRIS, Ph.D.
Vice-President, RD&E and Chief Technology Officer,
Med-Eng, Canada

Dr. Makris is VP of Research, Development & Engineering and Chief Technology Officer at Med-Eng. He holds Masters and Ph.D. degrees in Mechanical Engineering, specializing in explosions and protection against blast effects, with over 30 years of related experience.
Dr. Makris has been an active member of several equipment performance standards, including the NIJ Bomb Suit standard, NATO & UN working groups and a member of the IABTI Advisory Board.

The recently released NIJ 0117.01 bomb suit standard is an essential tool to ensure that bomb suits are properly evaluated and certified by an officially accredited standards organization which oversees comprehensive testing of the suit carried out in approved third party laboratories. The NIJ bomb suit standard outlines in detail a significant list of minimum performance and capability to be expected in a bomb suit along with associated testing methods. In addition to selecting a certified suit, end-users must also consider additional features, which may not be currently outlined within NIJ 0117.01. Further developments in standardized tests are being considered for blast overpressure mitigation, through ASTM. The end-user community, government authorities and industry must continue to improve the standard and test methods, as protective materials and other technologies advance, or threat conditions evolve. The introduction of standard performance requirements and test methods permits for bomb suits to be officially certified, providing a "seal of approval" that the particular product can be trusted to perform according to the standard.

Introduction

Historically, bomb suit manufacturers relied on a number of performance standards inspired from adjacent technical fields, sometimes customized for EOD applications. Test methods were inconsistent between laboratories and many results could not be consistently reproduced, or trusted. On occasion, bomb suits suppliers made unsubstantiated claims of their product's performance, or provided questionable test data from laboratories which may not have adhered strictly to approved test methods. End-users were not sufficiently qualified to evaluate the diverse test reports for suitability, adequacy, or accuracy. The release of the US NIJ 0117.01 standard for public safety bomb suits [1] in 2016 bridged this gap in standardized EOD PPE evaluation and is intended to provide objective evidence and confidence in performance of EOD suits, once they are officially certified by the accredited authority. NIJ certification can only be achieved through a third party NIJ-approved certification organization. This organization overviews the entire certification process, including initial and annual testing, as well as audits of the manufacturing facilities where the suits are built. This third-party overview instills confidence in performance claims for certified bomb suits.

While a critical step forward for the EOD community, the NIJ 0117.01 remains a "minimum standard", as its requirements do not address all the possible protection and functional requirements end-users may require. For instance, the current NIJ standard revision does not include quantitative blast overpressure reduction requirements, CBRN compatibility, personal cooling, communications, electromagnetic compliance, power, remote controls, lighting, etc.

This paper emphasizes how the NIJ standard can help government agencies in the selection and procurement of EOD PPE, without needing wide ranging technical expertise to assess, evaluate and qualify a bomb suit from all engineering disciplines, i.e., protection against all blast threats, human factors, optics, field of view, electronics, manufacturing quality, labelling, etc.

The NIJ 0117.01 standard for Public Safety Bomb Suits

In 2016, the US National Institute of Justice released the NIJ 0117.01 standard for public safety bomb suits, which covers a wide range of requirements of direct relevance to EOD threats and operations, such as:

- *V50 Fragmentation protection (inspired from MIL-STD-662 [2])*: Pass/fail requirements are based on three different fragment simulating projectiles (17, 44, 207-grain, Figure 1). The large 207-grain (13.4 grams) fragment permits reliable V50 rating determinations for highly protective areas of the suit. This eliminates the need for questionable V0 ratings, impossible to obtain based on STANAG 2920 [3], given the requirement to fire fragments at 1.5 times the estimated V0 velocity (no known laboratory can perform this).

- *Spine Protection:* The NIJ standard includes a spine protector test methodology developed specifically for bomb suits with appropriate pass/fail thresholds, addressing the critical need for blunt impact protection when a technician is propelled by the force of a blast.

- *Head Impact Protection:* The NIJ standard includes a very extensive helmet impact attenuation test (72 drop tower impacts on 9 different helmets, Figure 2) The impact energies and pass/fail thresholds are customized for EOD operations, recognizing the importance of head impact protection to mitigate the risk of traumatic brain injury. The tests are conducted at three temperatures (20°C, -10°C and +55°C), as EOD helmets must provide protection in all harsh environments bomb technicians are potentially exposed to.

- *Flame Resistance:* The standard includes flame resistance tests for the suit outer shell materials and the helmet shell, based on ASTM D6413-99. The pass/fail requirements are customized for EOD applications, ensuring protection against the fire threat from IEDs.

- *Blast Overpressure*: The standard includes the qualitative evaluation of bomb suits against a 0.567 kg C4 charge at a standoff of 0.6 m, with a Hybrid III mannequin in a kneeling position (Figure 3). Many

qualitative requirements are included (protection to remain in place, no mannequin parts exposed after a blast, etc.) As the NIJ standard does not currently address quantitative blast overpressure protection requirements, ASTM Working Group WG22759 is currently defining a standardized test method for bomb suit quantitative overpressure evaluation, complementing the NIJ suit blast integrity test.

Figure 1: *NIJ 0117.01 Fragment Simulating Projectiles (17, 44 and 207-grain). The large 207-grain one eliminates the need for Vo tests*

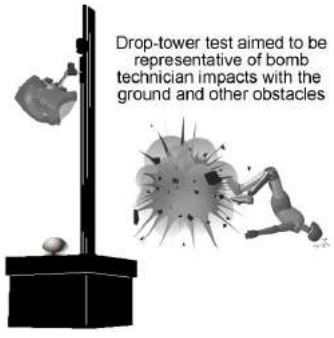

Figure 2: *Helmet drop tower testing relevant to traumatic brain injury. 72 drops conducted at 3 temperatures*

Figure 3: *High speed video images of the NU 0117.01 blast overpressure test (0.567 kg C4 explosive, standoff 0.6 m - kneeling position). Two mannequins used for more data.*

- *Static and Dynamic Field of View (FOV):* While the bomb suits' primary objective is to protect from the main blast threats, EOD ensembles designs must also minimize hindrance to bomb disposal operations. As such, the NIJ standard includes stringent field of view requirements. The static field of view test (Figure 4) is conducted with a headform and a laser system, ensuring objective measurements with thresholds determined based on actual bomb technician requirements (e.g. downward field of view when manipulating devices, horizontal field of view for peripheral vision). The dynamic field of view tests (Figure 5) evaluate the appropriate integration of the helmet with the suit and protective plates. This test ensures that the visual field is not blocked by suit components, such as the collar or frontal plates. Visor optics and visor fogging evaluations are also included in NIJ 0117.01.

Figure 4: *NIJ Static FOV apparatus - helmet fitte on headform and tested at various angles*

Figure 5: *NIJ Dynamic FOV test - Head and Body motion with volunteer*

The NIJ 0117.01 includes additional requirements related to ergonomics, the number of sizes, maximum weight, label legibility, etc. Certification to the NIJ standard thus provides a clear independent bomb suit model evaluation against test methods relevant to EOD. All tests are conducted only by NIJ approved test laboratories, thereby saving procurement agencies from having to rely on supplier credibility, or being forced to assess diverse test reports and data.

Beyond the NIJ Standard: Other relevant Requirements

The NIJ 0117.01 for bomb suit being a "minimum" standard, procurement agencies must also take other requirements into account when selecting bomb suits. In addition to quantitative blast overpressure (discussed above), which should be based on sufficient data points and involve head acceleration, ear and chest overpressure, other suit features, not necessarily directly related to protection, should be mandated. For instance, bomb technicians need to communicate remotely in a safe manner. All electronics within the suit and helmet must meet highly stringent military standards for electromagnetic compliance (emissions and susceptibility), as opposed to the less stringent industrial standards. EOD ensembles must provide proper lighting to work in dark areas, and they must fit a wide range of body sizes and shapes (recommended 5th percentile female to 95th percentile male). In addition, there is a need for personal cooling or ventilation, when operating in harsh environments. Ergonomics must also be evaluated beyond the NIJ requirements, which only ensure basic functionality in simulated scenarios. Purchasing agencies must also ensure that bomb suit manufacturers provide long-lasting, high quality and reliable products, with strong customer support. The NIJ manufacturing facility audit plays an important role for this aspect. Other accreditations of the product, such as CE markings, RoHS compliance and some regional standards may also apply for bomb suits to be procured and used in certain countries.

Discussion

The release of the NIJ 0117.01 standard for public safety bomb suits in 2016 empowered government agencies and EOD end-users to have confidence in the suitability of bomb suits they may select. Certified bomb suits according to the standard should meet all minimum relevant protection and performance requirements for EOD. Prior to the release of this standard, one had to rely on reports provided by manufacturers based on how they tested their products. Legacy test methods were not standardized and oftentimes not applicable to EOD scenarios. On occasion, some manufacturers often misrepresented the performance of

their suit or even manipulated the test data to make favorable performance claims.

While NIJ 0117.01 addresses the main blast threats (overpressure, fragmentation, impact and heat), historical focus has been on overpressure and fragmentation, with minimal emphasis on impact, especially for the head. Field experience in recent conflicts has highlighted the need for helmet impact protection to mitigate the very common occurrence of traumatic brain injury (arising from either blast or direct impact). The NIJ 0117.01 standard mandates a stringent set of helmet testing to ensure that EOD helmets provide high impact protection.

Purchasing agencies also have to take into account a number of other requirements beyond NIJ 0117.01, as the NIJ is a "minimum" standard, such as, quantitative blast overpressure, CBRN, electromagnetic compliance, personal cooling, communications, lighting, etc.

Conclusion

Bomb suit certification to the NIJ 0117.01 standard is the only way to ensure fully independent, comprehensive and reliable testing/validation of bomb suit performance against the most relevant EOD threats, built as per documented manufacturing processes and audited independently on a regular basis by an officially appointed and accredited organization.

References

[1] *U.S. National Institute of Justice (NIJ), Public Safety Bomb Suit Standard, NIJ-0117.01, 2016*

[2] *V50 Ballistic Test for Armor, Department of Defense Test Standards MIL-STD-662F, Dec. 1997*

[3] *NATO Stanag 2920, Edition 2: Ballistic Test Method for Personal Armour Materials and Combat Clothing, July 31, 2003*