# Laboratory test procedures for nonlethal small caliber projectiles

***MARIUS VALERIU CÎRMACI-MATEI[1], LAVINIU HALLER[1], ADRIAN ROTARIU[1], EUGEN TRANĂ[1], CLOE VANSIGHEN[21], LUCIAN BOGDAN[31]***

***Abstract:*** *The goals of our work are to analyse the impact between nonlethal ammunition and human body. Despite the fact that a weapon cannot really be called nonlethal (any weapon has a probability to kill), we have chosen to use this term because it is the most common in any publication. And the lethality level must be known, with respect to caliber, velocity and the material in which the ammo is manufactured. Also, the distance to target plays a major role. Usual damages when using nonlethal or less-lethal ammunition are rib fracture, pulmonary contusion and heart damage. Besides the Abbreviated Injury Severity Scale (AIS), there are more experimental methods for trauma analysis:Bowen curves and modified Bowen curves, Axelsson criterion (chest wall velocity predictor) or Back Face Signature (BFS). Some of them are more dedicated to describe the effects of shock waves transmitted through the body or even the effect of a lethal ammo against a body protected with a ballistic vest. Because of a lack in nonlethal systems standardization from the market, the effects against human tissue may differ on a large scale. That is why additional laboratory devices and procedures may be useful in addition to the widely accepted tests. Our experimental work is based on NIJ Standard 01.01.06, USA, 2008, HOSDB Body Armour Standards for UK Police, 2007, Ballistic Resistance and AEP 94, NATO. There are two types of ammunition to test, a 40 mm flour grenade and custom made pistol ammunition made in silicon, whose calibers are 8, 9, 10 and 12 mm. For the flour grenade we have to measure the surface evolution at the impact with respect to time and the impact force evolution. Their ratio must not exceed 10 MPa, which is generally assumed as a nonlethality limit. There are still discussions on this subject. Also, the cavity depth in a plastiline block without any protection may be taken as an modified BFS criterion. As a launching system we made an arrangement of the existent Hopkinson bar, transforming it into an air gun (Figure 1). This allows us to do a large number of shootings without spending too much ammunition cases, primers and time. Also, a ballistic pendullum was set to fit the Hopkinson bar stand. The pendullum is used to determine the grenade velocity at impact ( with the concurrent optoelectronic*

[1] Military Technical Academy, 39-49 George Coșbuc Blv., 050141, Bucharest, Romania
[2] Royal Military Academy, Brussels, Belgium
[3] Uzina Mecanică SADU S.A., Gorj, Romania

*device) and the generated impulse. Another adjustement is dedicated for the silicon projectiles. The system uses compressed air produced by a piston in order to have a rapid increase of the pressure behind the projectile. We are interested in skin penetration capabilities and the experiment is based on AEP 94, using ballistic gelatin as tissue simulator. Hydrostatic shock looks as a water filled can explodes or a gelatin block expands. Live tissue may behave the same and a body is affected by a projectile in a fashion similar to water. We have tried to model the ballistic gelatin using Autodyn code (Figure 2) and to compare the experimental results with the simulation outcomes. There are few tissue models and the kinematic viscosity has a great importance. The primarily cohesive material (the bones) is united by the same adhesion that resist breaking apart; oposition to penetration is constant, the depth of penetration is proportional to the square of the energy. The primarily viscous material (fat tissue) has a molecular attraction that resists a tendency to flow; the opposition to penetration is directly proportional with the projectile velocity. The slower the bullet, the less resistance and the faster the bullet, the stronger resistance. Finally, the brain tissue is supposed to act primarily like water: opposition to penetration is proportional to the velocity squared. Low velocity, easy penetration. Doubling velocity will not double penetration.*

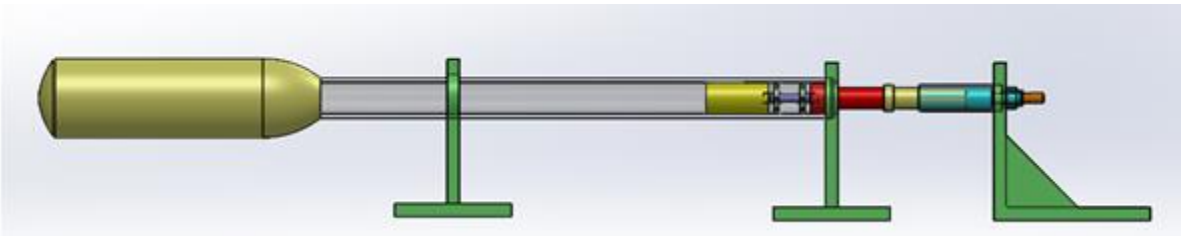
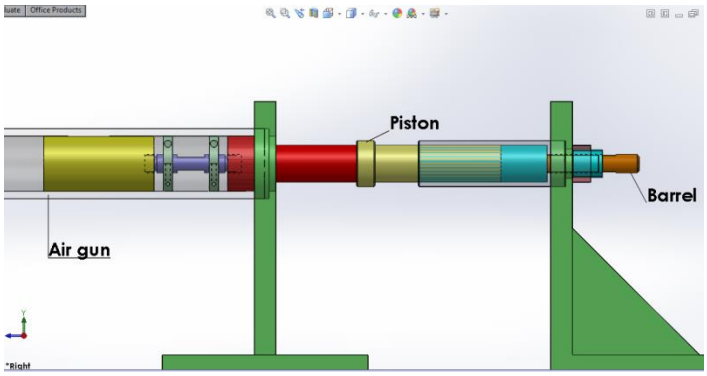


*Figure 1*

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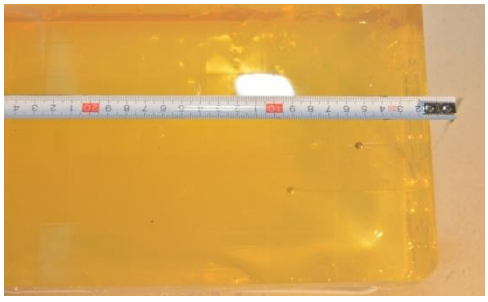

*Figure 2*