KINETIC AND IMPACT PARAMETERS OF LESS-LETHAL MUNITIONS

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INTRODUCTION:

With increased scrutiny over law enforcement confrontations, several concerns have been raised. A majority of the concerns revolve around the issue of excessive force. But this is not a clear cut issue, rather a complex set of circumstances that give rise to the final outcome. Most often, it is not necessarily that the officer used poor judgment, because until recently, they have had only limited options available to them. The biggest concern is providing that officer with other viable methods of subduing an individual, or at least deterring that individual from an unwanted confrontation where the only alternative is lethal force. That alternative is the use of "less-lethal" munitions. These munitions, also referred to as kinetic energy rounds, can be fired from standard 12-gauge shotguns, 37/38mm gas guns or the M203A launcher.

While this is a desired alternative to the use of lethal force, it is important to properly understand the benefits and short falls of this alternative. First, these munitions are not intended to take the place of firearms, but rather offer an alternative prior to the use of lethal force. Secondly, it is necessary to understand the classification of difference between "less-lethal" and "non-lethal" Non-lethal implies that, when used, it will not yield a lethal outcome. Less-lethal leaves the possibility of a lethal outcome in rare or unexpected instances. It is imperative that these munitions be used properly to help ensure a less than lethal outcome.

BACKGROUND:

Less-lethal weapons have been researched intermittently over the past 30 years. Most of this research had been carried out by the Army and the information is somewhat difficult to obtain.

Because this application is relatively new, no uniform testing criteria has been established. In an effort to evaluate the safety of our products, we have borrowed the testing regime for body armor testing – the concept being that kinetic energy rounds should be similar in action to that of body armor protection when shot with a bullet. The kinetic energy rounds should not penetrate the body, but rather exert impact in the form of blunt trauma.

To test body armor, backing material (Roma Plastilina No. 1 Modeling Clay) is placed behind the armor, and a test round is fired into the vest. The bullet is not allowed to penetrate the vest, and the resultant deformation caused by the impact shall not be greater than 44mm. If either occurs, it constitutes a failure.

STUDY DESIGN:

Backing material was molded into a uniform block having the dimension 21 x 22 x 4.5 inches. A plywood box was constructed to hold the backing material in place during the testing. The test rounds were fired through a chronograph into the clay from a distance of 20 feet. All velocities were recorded along with the penetration depth and surface area displacement. Test procedures were adapted from the NIJ Standard 0101.03 Ballistic Resistance of Police Body Armor.

RESULTS:

ROUNDS	GRAIN	VELOCITY in ft/sec	FT*LB* ENERGY	DEFORMATION in mm	AVERAGE FORCE in lbs	AREA un mm^2	PRESSURE in lbs/in
23RS	88.9	467.8	43.4	22.4	600.3	1050.5	401.1
23RP	4.2	394.6	1.5	4.6	105.9	58.4	1242.6
23HV	6.7	921.8	12.7	16.4	247.2	335.7	481.3
23SB	53.9	928.7	104.3	39.5	829.2	1835.2	300.6
23BR	630.7	288.3	116.6	33.3	1073.6	2053.7	342.0
23WB	51.7	907.1	94.7	40.3	735.9	1907.4	255.1
23FS	87.7	508.2	50.5	30.6	501.6	1129.0	288.0
20W	355.6	212.4	35.8	28.0	390.0	1444.5	174.0
20F	287.7	285.7	53.5	12.2	1380.8	1773.8	506.6
27A	4.2	286.9	0,8	3.0	67.0	50.0	914.5
27B	4.2	259.4	0.6	3.0	63.5	36.0	1142.5
28A	35.0	294.5	6.8	5.5	373.5	257.0	944.5
28B	35.0	242.9	4.6	6.5	215.5	220.5	630.5
40A	4.2	286.9	0.8	3.0	67.0	50.0	914.5
40B	35.0	330.5	8.6	6.8	418.0	345.6	850.6
40BR	1617.20	227.0	185.5	35.0	1615.8	6120.0	170.3
40W	355.6	260.5	53.8	25.0	652.7	1720.7	246.3
40F	287.7	261.3	45.4	6.5	2202.8	1301.3	1458.5

NOTE: *The above numbers have been averaged from each test firing independently. Therefore, the averages may not yield the calucated averages shown.*

The following calculations were used to obtain the values listed:

Kinetic Energy: KE = $(^1/_2)(m/g)v^2$

where **m** is the weight of the projectile (converted to lbs.)
g is the acceleration due to gravity, 32.2 ft/sec^2 (so that mass is not a weight)
v is the velocity of the projectile in ft/sec.

Work: W = $\triangle$ KE(=KE-0), assuming the projectile is stopped at the deepest point in the clay.

Average Force: $\mathbf{F_{AVE}} = \mathbf{Wd}$

where $\mathbf{F_{AVE}}$ is the average force exerted by the projectile onto the target (measured in lbs.)
W is the work calculated above (measured in ft*lbs energy)
d is the distance required to stop the projectile (convened to feet).
Note: The peak force is probably higher than this value.

Average Pressure: $\mathbf{P_{AVE}} = \mathbf{F_{AVE}}/\mathbf{A}$

where $\mathbf{F_{AVE}}$ calculated above
A is the cross-sectional area of the clay surface displacement caused by the projectile (in in^2)
$\mathbf{P_{AVE}}$ is the average pressure exerted by the projectile on the target (measured in lbs/in^2).

CONCLUSION:

Kinetic energy measurements are widely accepted in the ballistics industry; however, these numbers can be misleading. For example, a 22-caliber bullet has roughly the same kinetic energy as a 23BR (12-gauge bean bag round). Obviously, the two act very differently when impacted on the body. This is due to the area of contact and the material of the projectile. A 22 strikes a very small surface area, so the force is concentrated on that area, resulting in penetration. The shot bag exerts the same amount of energy, but it is spread over a larger surface area. The result is blunt trauma with no penetration.

The determination of force was based upon the kinetic energy of the round divided by the penetration distance into the clay. However, this yields the average force exerted over that distance. Secondly, because the kinetic energy is divided by the penetration, the further the penetration, the smaller the force.

The pressure was calculated in an effort to find a more meaningful value. An object of small area will exert more pressure than an object of larger area. However, if the object is not rounded, this measurement is limited. For example, a blunt arrow will have the same impact as a sharp arrow, but with much different results. Also, the measurement of time is crucial. The time of impact of an object to a foreign body is required in order to properly understand the energy transfer between the two. The value presented assumes the round stuck into the clay upon impact and did not bounce off, which is not always the case. That is why the rubber balls and foam rounds show high values for force and pressure. Without knowing the time of contact, it implies all of the energy was transferred from the rubber ball or foam to the clay.

In actuality, the transfer of energy is more complex. When the rubber or foam rounds are shot into the clay, there is energy transferred from the round to the clay causing a deformation in the clay. However, there is also some amount of energy that is transferred from the clay to the round, plus stored energy from the compression of the foam or rubber. This combination causes the round to bounce off. Therefore, not all of the energy is transferred from the round to the clay.