



40 mm Impact Munitions

by TR Staff

Impact munitions have been around since the 1960s. During the last decade of increased use, these munitions have steadily improved in design as shortcomings have been identified. They have also become more effective on the subjects while at the same time less likely to cause unintended injuries. They have also steadily widened the ranges of usefulness, i.e., the minimum safe recommended range has become shorter while the maximum effective range has become longer.

In 1999, impact munitions for police hit its peak with the release of the Def-Tec 40 mm Sponge round, the eXact iMpact. Among all impact munitions at the time (beanbag, single baton, multiple projectiles), the eXact iMpact proved to be the ultimate option.

The 40 mm eXact iMpact comes directly from the XM1006 developed by the U.S. Army Research Laboratory. In 1999, Def-Tec licensed the munition from the Dept. of Defense to both produce the load and distribute it to law enforcement. This began the major transition from 37 mm smoothbore tear gas guns to 40 mm rifled launchers.

Human Effects Testing

No single, clear and definitive test protocol exists for any less-lethal munition. However, two different and somewhat well accepted protocols exist. The first, a rather technical one, is the 3-Rib Chest Structure (3-RCS) impact developed by General Motors Research Laboratory. The second, a rather

practical test, is an adaptation of the NIJ body armor test to less-lethal munitions. As the XM1006, the eXact iMpat has been tested against a wide variety of impact media including ballistic clay, ordnance gelatin and the 3-Rib Chest Structure.

The most complicated and sophisticated test involved GM's 3-RCS model. Much of what we know about injuries from less-lethal munitions comes from the field of sports medicine and automotive injuries. GM developed the 3-RCS to predict the varying degrees of injury from a driver impacting the steering wheel, including outright chest compressions and broken ribs. The 3-RCS test, in turn, is based on testing with human cadavers. This sort of human effects testing results in the safest and yet most effective rate of energy transfer and depth of energy transfer.

The 3-RCS measures a VCmax, which is a prediction on the probability of injury. A VCmax of 1.0 indicates a great risk of injury while a VCmax of 0.0 indicates a very low risk of injury. The XM1006, now Def-Tec eXact iMpat, had a VCmax of 0.21 with a near-muzzle impact to the rib cage.

One of the more easily understood tests is the amount of backface deformation based on the NIJ's body armor testing protocol, i.e., Standard 0101.03 using Roma Plastilina No. 1 Modeling clay, aka ballistic clay or ductseal. In T-shirt covered clay, at closely controlled temperature and humidity, the depth of the backface indentation cannot exceed 44 mm.

Ordnance gelatin testing involved the same 10% ordnance type 250A gelatin used by the FBI for their bullet testing. Significantly, the XM1006 did not produce any penetration at all in a substance that a BB penetrates 3 inches. The XM1006 did not even lacerate the surface of the gelatin.

Def-Tec eXact iMpat

The 40 mm eXact iMpat was originally labeled as a Sponge Round...and the name stuck. The eXact iMpat uses a one-piece projectile made of a soft (sponge) nose and a hard plastic body. The eXact iMpat weighs 1.1 ounces (30 grams) and has a muzzle velocity of 325 fps. That equates to a muzzle energy of 115 ft-lbs.

Def-Tec indicates the 40 mm eXact iMpat has an optimal energy range of 10 feet to 75 feet, and a useable engagement range of 5 feet to 120 feet. In some scenarios, the less-lethal operator used to have to back up to be far enough away. In these scenarios, the eXact iMpat's 5-foot engagement range was a clear tactical solution.

At the nearly same time the original 40 mm Sponge was released, Def-Tec also released a 40 mm round with a marking compound. This was called the XMarker. The current Direct Impact Marking projectile has replaced this.

Def-Tec Direct Impact

Def-Tec recently added three 40 mm impact munitions to its eXact iMPact product line under the name Direct Impact. Like the eXact iMPact, these are intended to be fired directly at aggressive, non-compliant subjects. Their new loads include Direct Impact OC, Direct Impact Inert and Direct Impact Marking.

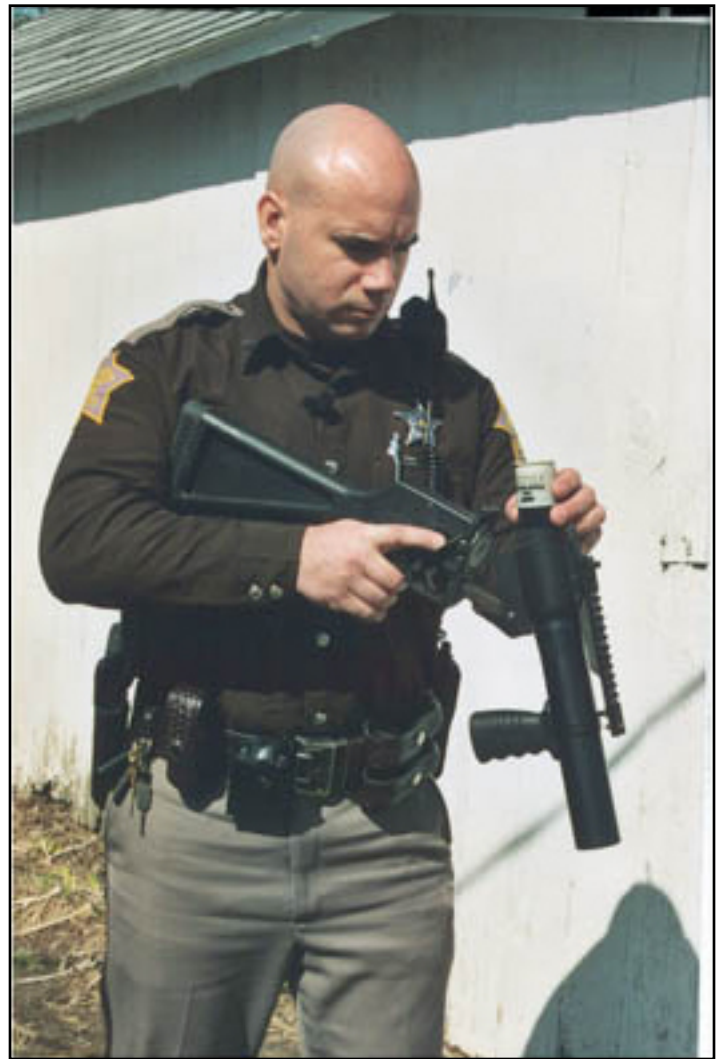
These projectiles are, of course, very different from the solid foam eXact iMPact. These loads have a harder, but crushable, foam nose containing a powder payload. Like the eXact iMPact, the deployment range for Direct Impact projectiles is between 5 feet to 120 feet.

The various Def-Tec 40 mm loads are color-coded. The eXact iMPact is blue, a color that has come to mean less-lethal. The marking is green. Think of marking Greenpeace protesters. The color of the marking compound is, of course, fluorescent green. The Inert is black, a neutral color. The OC, consistent with all OC munitions and sprays, is color-coded orange.

Color aside, in the somewhat tense scenarios where these munitions are deployed, there is also a tactile (touch) difference between the payload-bearing Direct Impact munitions, and all of the other foam or rubber 40 mm projectiles. The tip of the direct impact loads feel hard and solid. All the other impact munitions are soft and yielding.

The Direct Impact projectiles weigh approximately 1.4 ounces (between 36 and 38 grams) and have a muzzle velocity of 295 to 300 fps. The Direct Impact loads have between 113 and 118 ft-lbs of energy.

These Direct Impact munitions carry 3.8 to 5 grams of powder. That is about the equivalent of two PepperBall® projectiles. The rigid, crushable foam nose, about 3/16-inch thick, covers a hollow internal cavity. On impact, the nose deforms and crushes. This increases the surface area of the impact. This action also ejects the payload laterally. The result is a 2-foot diameter cloud of irritant or marking



The Penn Arms GL-1 was used to test these 40 mm rounds.

compound.

Since the Direct Impact has a harder outer shell, special testing was done to determine the risk of cuts or lacerations from the crushed foam. This included both simulated and real animal skin over both soft (ballistic clay) and hard surfaces. No skin laceration occurred in any of the tests. The Direct Impact rounds also passed rough handling and 6-foot drop tests to be sure the outer shell would not accidentally crack and disperse the powder.

On the topic of rough handling, the Def-Tec 40 mm eXact iMpacT projectile is crimped in place by the cartridge case. The CTS 40 mm Foam Baton has the projectile held in the case with a silicone-type sealant.



Each munition has a different point of impact, even at 30 feet.

CTS Foam Baton

Since the introduction of the Def-Tec 40 mm Sponge, and based on its street reputation, Combined Tactical Systems and ALS Technologies have also introduced similar but not identical 40 mm rounds. The CTS round is their 40 mm Foam Baton. At 2.1 ounces (60 grams), the CTS Foam Baton is the heaviest of the three kinds of 40mm projectiles. While it has the slowest muzzle velocity at 260 fps, it has the highest muzzle energy at 139 ft-lbs.

The CTS Foam Baton has a minimum recommended range of 5 feet and a maximum recommended range of 60 feet. It performs best, or most optimal, between these two ranges, but CTS does not specifically limit the 40 mm Foam Baton to these ranges. The California Department of Corrections successfully uses both the CTS Foam Baton and the Def-Tec eXact iMpacT out to ranges of 105 feet.

CTS indicates at longer ranges the shooter's ability under the situation at hand becomes an issue, and that the closest recommended close range is more important than the longest recommended long range. Indeed, most tactical operators are interested in the shortest possible engagement distance. At 5 feet, even with the most energy, the CTS 40 mm Foam Baton “passes” the 3-RCS test protocol.

ALS REACT Impact



The Direct Impact OC round leaves a cloud.



The Direct Impact marking round uses green dust.

The ALS 40 mm round is their REACT Impact. The ALS 40 mm REACT uses a soft, low density rubber tip permanently attached to a plastic rifling band. The projectile weighs 1.2 ounces (33 grams), has a velocity of 325 fps, and energy at the muzzle of 119 ft-lbs. The recommended deployment range for the ALS 40 mm REACT is 30 feet minimum to 120 feet maximum. This is the longest of the minimum engagement distances.

ALS uses a modified version of the NIJ 0101.03 body armor standard to establish both the shortest and longest engagement range. Specifically, ALS uses the amount of backface deformation in Roma Plastilina (clay) and follows the NIJ guidelines of 44 mm maximum

indentation for the shortest range. This is the same maximum indentation allowed for bullets that do not penetrate body armor.

ALS is currently working to reduce their minimum engagement range to 15 feet. As it is now, their 40 mm REACT can be fired as close as 21 feet and still not produce too much backface deformation. However, for liability reasons they are sticking with a 30-foot minimum.

ALS has two different tests to determine their maximum engagement distance. First, the REACT projectile must indent the clay by at least 10 mm. This indicates it has enough retained energy to be effective. Second, the REACT projectile has to be accurate enough to impact within 18 inches of the point of aim, i.e., a 36-inch center to center spread, maximum. This 18-inch radius generally represents the distance from the belly button to the neck. The ALS 40 mm REACT achieves both these requirements at a maximum of 120 feet.

According to ALS, the REACT tip expands to 1.5 times its initial diameter on impact. The result is a doubling of the surface area. The tip is so soft that the tip even expands to fill the rifling grooves during

the force of ignition. As such the rubber tip has been coated with a lubricant to prevent bore fouling and to increase muzzle velocity.

Sponge, Foam and Rubber

The material in the sponge tip of the Def-Tec eXact iMpacT is a thermoplastic polyolefin (TPO). These elastomers are a combination of polyethylene and polypropylene (plastics) as opposed to rubber. These have properties very similar to rubber.

The material in the foam tip of the CTS Foam Baton is neoprene (chloroprene rubber, CR), which is the very first synthesized rubber. This is also an elastomer, and technically, a thermoplastic rubber (TPR). It is virtually impossible to tell the “sponge” plastic tip of the eXact iMpacT from the “foam” neoprene tip of the Foam Baton. Both have the same look and feel, and both have the same durometer, or initial compressibility.

The term “sponge” is just another word for “foam,” of course. Both are closed cell foams, as opposed to open cell foams. In a closed cell foam, the material is full of individual air bubbles that are not connecting. In an open cell foam, all the air bubbles do connect. All else equal, the closed cell foam holds its shape better, which is important for stability and accuracy.

The tip of the ALS 40 mm REACT is a thermoplastic rubber (TPR), which is different from other two foam tips. The ALS projectile tip is actually a combination of a 25 durometer rubber and a 65 durometer rubber. These are infused with air during the injection molding process, which explains the acronym REACT, Radiated Energy Air Cushioned Trajectory.

Plastic and rubber hardness is expressed as a number on the Shore Hardness Scale. The A scale is used for anything softer than the sole of a shoe, while the D scale is used for very hard rubber and plastics. The instrument used is a durometer, therefore the hardness is commonly called durometer, and the A scale is simply assumed for softer rubbers and foams.

The ALS 40 mm REACT has a durometer of 45. Both the Def-Tec 40 mm eXact iMpacT and CTS 40 mm Foam Baton have a durometer of 30. The foam or rubber in all these projectile tips is a little stiffer than the foam in a wrestling mat.



The Def-Tec round produced the best accuracy at 100 feet.

Shortest Recommended Range

The recommended range of less-lethal munitions is at the same time both critical and controversial. The primary targets for these 40 mm impact munitions are the large muscle groups of the thigh, buttocks and even the knees of the subject. However, the size, weight, velocity and especially impacting diameter make these the safest of all impact munitions for engaging the abdomen or upper torso of the subject.

These 40 mm foam, sponge and rubber rounds have about the same energy as a 12-gauge beanbag, i.e., the feel of a baseball impact or perhaps a fist. Of course, the .75-inch diameter beanbag transfers energy very differently from a baseball or a fist. The 40 mm rounds, however, spread their energy across 4.5 times the surface area. That means the 40 mm rounds impact 4.5 times the skin...and pain receptors are in the skin.



The goal is not to cause deep organ disruption. In fact, just the opposite. For example, in the lower left abdomen, we want to cause pain on impact, not rupture a spleen. The larger, 40 mm projectiles also make it impossible to penetrate in between two ribs, or to penetrate an eye socket. The round is just too big. That is why these 40 mm (1.6-inch) diameter loads are so clearly safer...and more effective.

The effectiveness of less-lethal munitions is all about impact energy and the dwell time of that impact. That said, there are too many variables for this to be as exacting and certain and predictable as, for

example, bullet effectiveness. The variables include skin tension, health, age, layers of clothes, fat layer and muscle depth...all for exactly the same point of impact.

Impact munitions are a balance of risk and performance, a balance of safety and effectiveness. The manufacturers cannot increase the long-range effectiveness without increasing the short-range risk. In fact, most tactical operators want the closest allowable engagement range.

The amount of energy transferred to the subject is what determines the shortest recommended range. The velocity of the projectile, the weight of the projectile, and how much the projectile tip deforms on impact will affect both this impact energy, and the dwell time. In all cases, the goal is to have the shortest possible recommended range. Muzzle contact would be perfect.

Accuracy Limits Range

The goal is also to have the longest possible recommended range. We want to have an effect on individuals as far away as possible. We want the projectile to retain as much energy as possible. Most of all, we want it to be accurate at longer ranges.

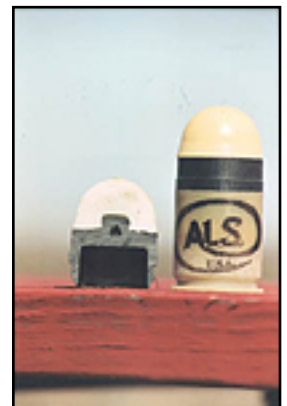
Accuracy, as it turns out, is the limiting factor for most less-lethal munitions, including these 40 mm loads. This is also why the 40 mm munitions are vastly superior to 37 mm loads. The 40 mm launcher uses a rifled barrel and spin-stabilizes the projectile for maximum accuracy. Fired from a smoothbore, the 37 mm projectile is not spin-stabilized.

While the accuracy standards vary slightly, the idea is that the munitions will not strike the subject in the neck or head if a belly button aim is used. This makes about a 36-inch extreme spread, or 18 inches maximum from the point of aim.

Some companies further limit their longest recommended range based on the reality that the tactical operator is not firing from a bench rest! This partially explains the difference between the maximum recommended range and the slightly longer maximum effective range (or similar language, i.e., optimal energy range).

Accuracy Testing

All these 40 mm projectiles are spin-stabilized by a rifling collar on the body. We tested the three 40 mm loads using a Penn Arms GL-1 Single Shot 40 mm Launcher provided by ALS Technologies. We fired these loads at two distances. The close range was 30 feet, since this is the longest minimum



range of the three different munitions.

	<i>Def-Tec</i>	<i>CTS</i>	<i>ALS</i>
The long range was 100 feet, a compromise among the various recommended and effective ranges. We fired five-shot groups and measured both the extreme spread, and the difference between point of aim and the center of the group. At both 30 feet and 100 feet, we bench rested the Penn Arms launcher to eliminate shooter error.	<i>eXact iMpacT</i>	<i>Foam Baton</i>	<i>REACT Impact</i>

The zero, and thus point of aim versus point of impact, was totally arbitrary. We simply used the factory sight adjustment from Penn Arms. These 40 mm impact munitions are NOT interchangeable without rezeroing the launcher! Even at 30 feet, the point of aim, point of impact is greatly different.

The CTS round just happened to impact at point of aim at 30 feet, while the ALS round was 2 inches low and the Def-Tec round was 4 inches low. Of course, zeroed for the Def-Tec round, the CTS round would have impacted 4 inches high. The lesson is the launcher should be sighted in for the specific load in use.

At 30 feet, all three loads produced a 2-inch, center to center, group. Essentially, the five shots made one big hole. With this sort of precision, a thigh shot is relatively easy, and a belly button shot will, indeed, hit the belly button. At 30 feet, the CTS and ALS rounds experienced one flier in each five-shot group widening the group to 7 inches. The Def-Tec round did not produce any fliers.

The overall accuracy results from 100 feet were much different. The Def-Tec 40 mm eXact iMpacT grouped into 8 inches, while the CTS 40-mm Foam Baton printed 13 inches and the ALS 40 mm REACT shot 21-inch groups. These differences in longer range accuracy have tactical implications.

Interestingly, the more accurate rounds also happened to be the flattest shooting. Corrected for zero, the Def-Tec projectile dropped just 13 inches in 100 feet. The CTS baton hit 17 inches lower at 100 feet. The trajectory of the ALS projectile put it 25 inches low at 100 feet. These differences in longer range trajectory also have tactical implications.

An obvious question with the Def-Tec Direct Impact munitions is how their point of aim versus point of impact compares to the Def-Tec eXact iMpacT munitions. Tested at the same time as the other loads and from the same launcher, from 100 feet both the Def-Tec Marking round and the Def-Tec OC round had exactly the same accuracy (8-inch group) and trajectory (13-inch drop) as the eXact iMpacT round. All these Def-Tec loads are truly interchangeable.

The bottom line? Put the 37-mm smoothbore gas guns in the department's museum. For deploying impact munitions, the 40 mm rifled launchers are much more effective over a wider range of deployment...and much safer to use for direct fire.

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