Test of shotgun ammunition with steel shot, in regard to safety for dynamic shotgun disciplines

David Karásek, Miloš Čermák

Abstract

Dynamic disciplines of sport shooting utilize shotguns to shoot steel targets at close range. We tested shotgun ammunition with steel and lead shot for ricochets (deflected pellets) in this situation. We found that steel pellets ricochet more often than lead pellets, and furthermore that lead pellets disintegrate upon impact into tiny splash, while steel pellets deflect in whole and can be deformed to have sharp edges.

Description of the problem

European Chemical Agency (ECHA) has published proposal to ban on use of lead shot on outdoor ranges.

Dynamic sport shooting disciplines are branches of sport shooting which utilize firearms, including shotguns, for target shooting. Shotguns are usually shot at steel targets which fall down upon strike, because as shotgun fires many pellets at once, each target is usually hit multiple times. With paper targets, this would result in need to change all shotgun targets for each shooter.

As the shotgun is short-range weapon, these steel targets usually stand in short distance from the shooter. There is always possibility of ricochet when using steel target, therefore rules of the discipline usually set minimal distance of the target from shooter and other persons. For example, IPSC discipline sets minimal distance to 5 meters[1], while western shooting rules set minimal distance to 8 yards[2]. Furthermore, only lead shot is allowed for shooting steel targets. This is also safety measure, as lead shot is soft and malleable, therefore not prone to ricocheting.

ECHA proposal claims that sufficient replacements for lead shot are readily available. These replacements should be either steel shot, or nonlead shot from other material than steel, namely tungsten/polymer composite, and bismuth metal.

Hardness of bismuth and tungsten/polymer composition is a bit higher that hardness of lead, but still comparable. We can therefore assume that danger of ricochets from shot made from these materials would not be significantly higher than with lead shot.
However, the cost of bismuth shot would be prohibitive for many shooters, given large amounts of ammunition used both in competitions and for training. This applies even more for tungsten/polymer shot, due to even higher price.

Cost of ammunition with steel shot is comparable to cost of ammunition with lead shot. However, hardness of steel used for manufacture of steel shot is significantly higher than hardness of lead. This fact often leads to safety concerns, as steel shot is expected to be more prone to ricochets dangerous to shooter and other persons. We therefore decided to put this hypothesis to test.

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[1] IPSC - SHOTGUN COMPETITION RULES - JANUARY 2019 EDITION, p.9 , https://www.ipsc.org/pdf/RulesShotgun.pdf

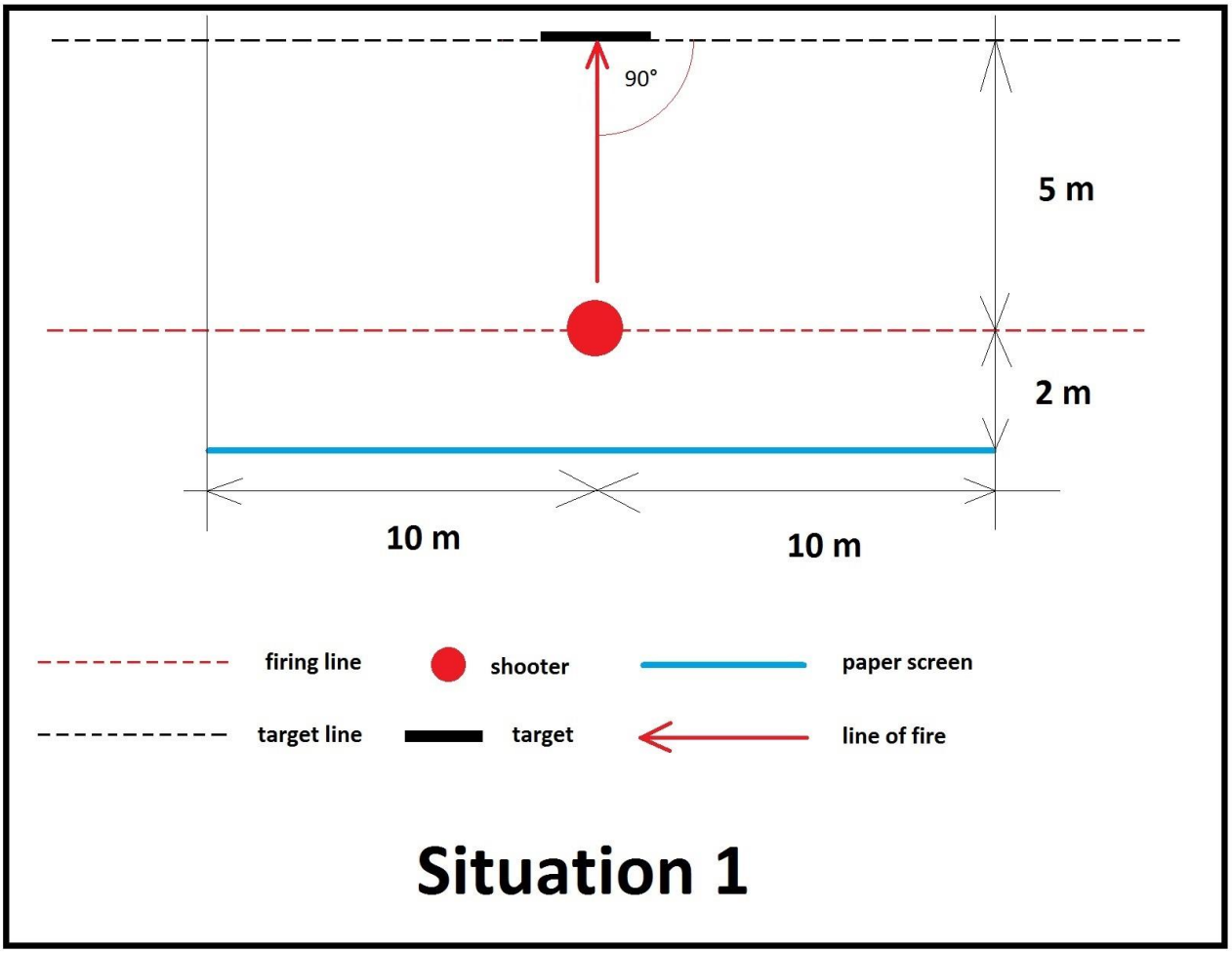
[2] COWBOY ACTION SHOOTING™ SHOOTER'S HANDBOOK, p.23, https://www.sassnet.com/Downloads/Shooters%20Handbook%20%20Vers%2025%20Jan%202021.pdf

Situation on the range

There are two types of persons who are endangered by deflected shot during shooting shotgun on steel targets.
First group is shooter himself and persons standing near him (usually referee). The shooter stands most close to the target, but he should be endangered only by ricochets from the target right in front of him (horizontal angle of impact close to 90°).
The other endangered group is audience, who stands somewhat further (usually by 2-3 m) but can be hit by ricochets from other angles. This can happen when the shooter shoots target which is not in front of him (in which case projectiles are deflected away from him).

Test situations

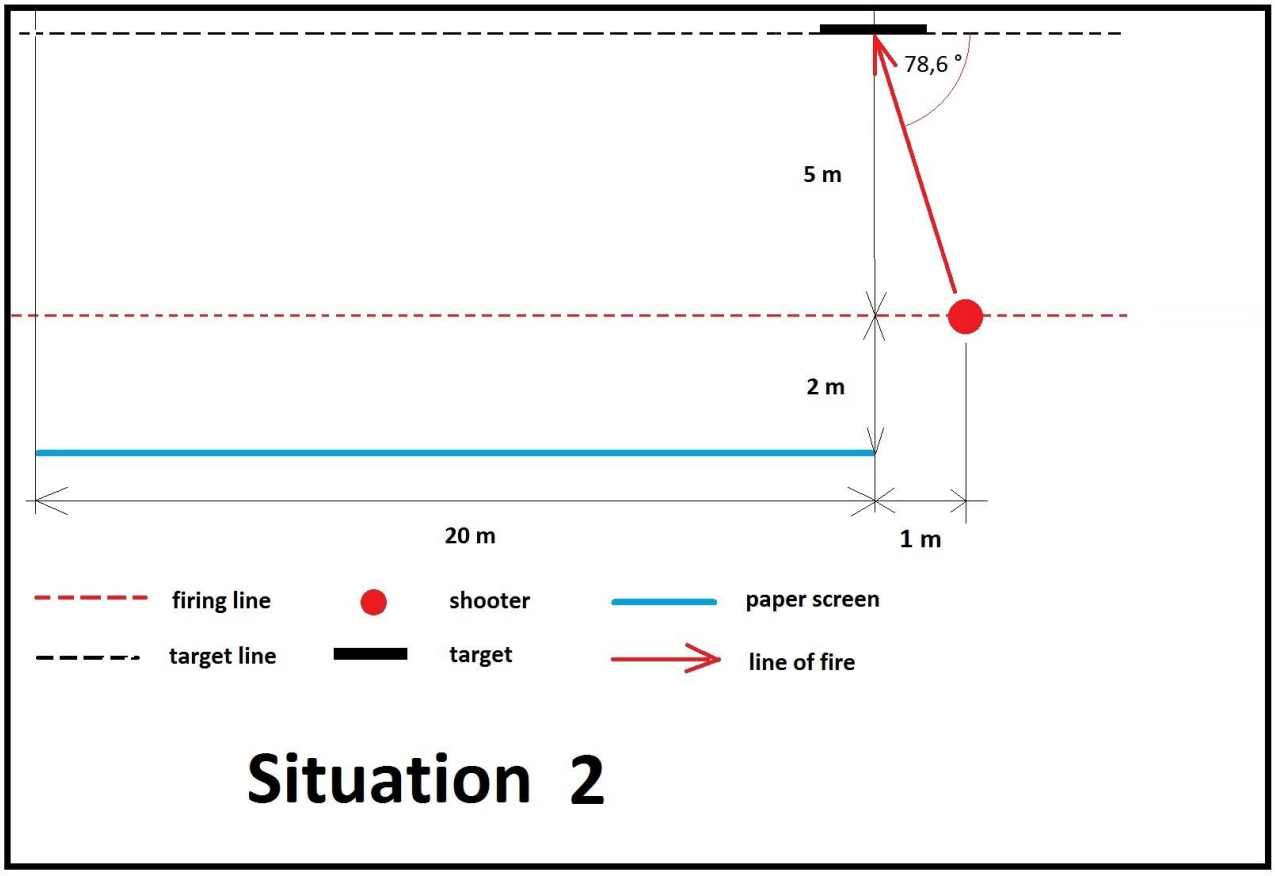
Reenacting of first situation was quite simple. One steel target was set 5 meters before shooting line, with striking face towards shooter (angle of impact 90°). Vertically, the target was tilted by about 10° away from shooter. This tilt is common, as can be seen on videos from actual competitions[3]. The target was not in exactly the same position before each shot, as it fell after each hit and had to be set again. Two meters behind the shooter, we did set cardboard paper screen 2 meters high, in order to detect ricochets which would be deflected but miss the shooter. We shot five rounds of lead shot and five rounds of steel shot.

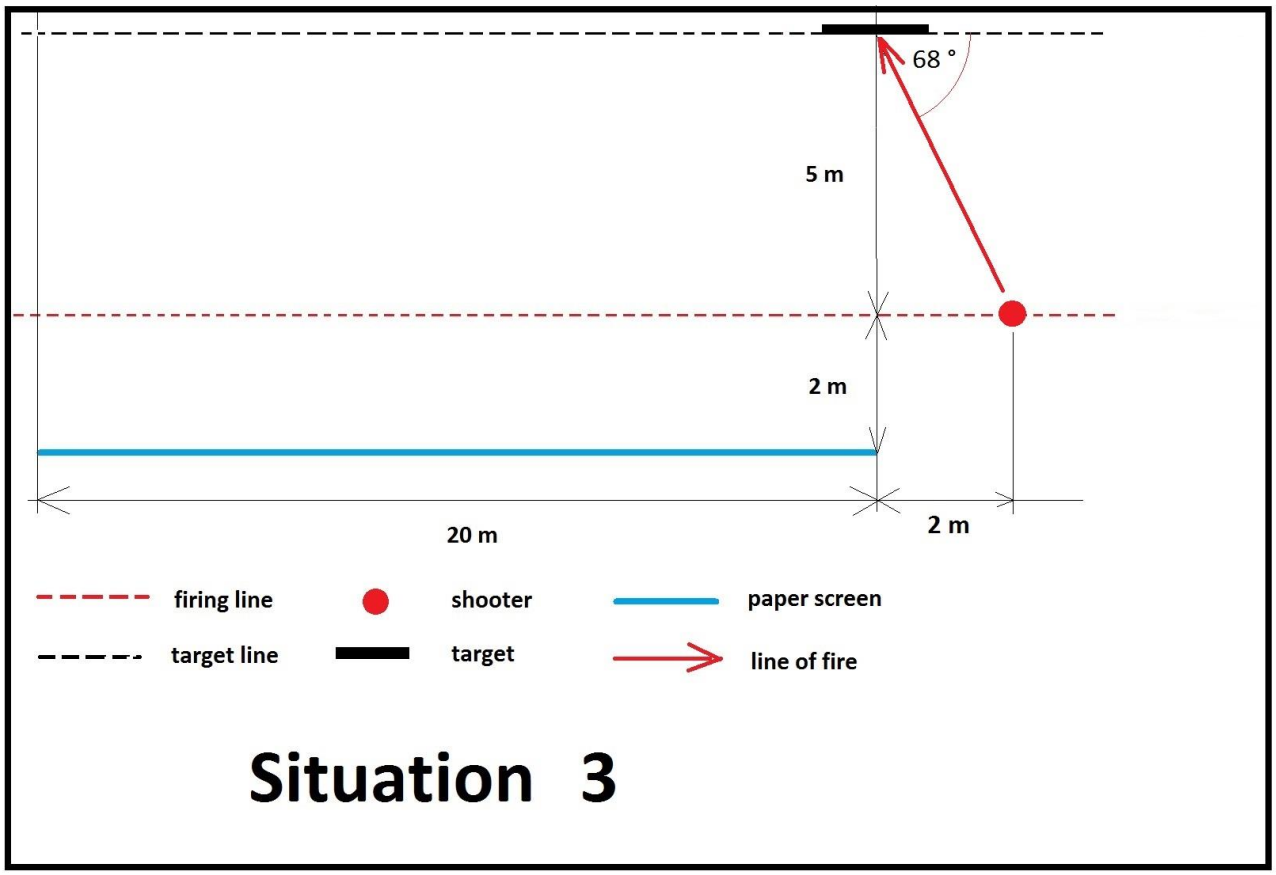


Setting up second type of situation was a bit more difficult, as the probability of ricochet depends

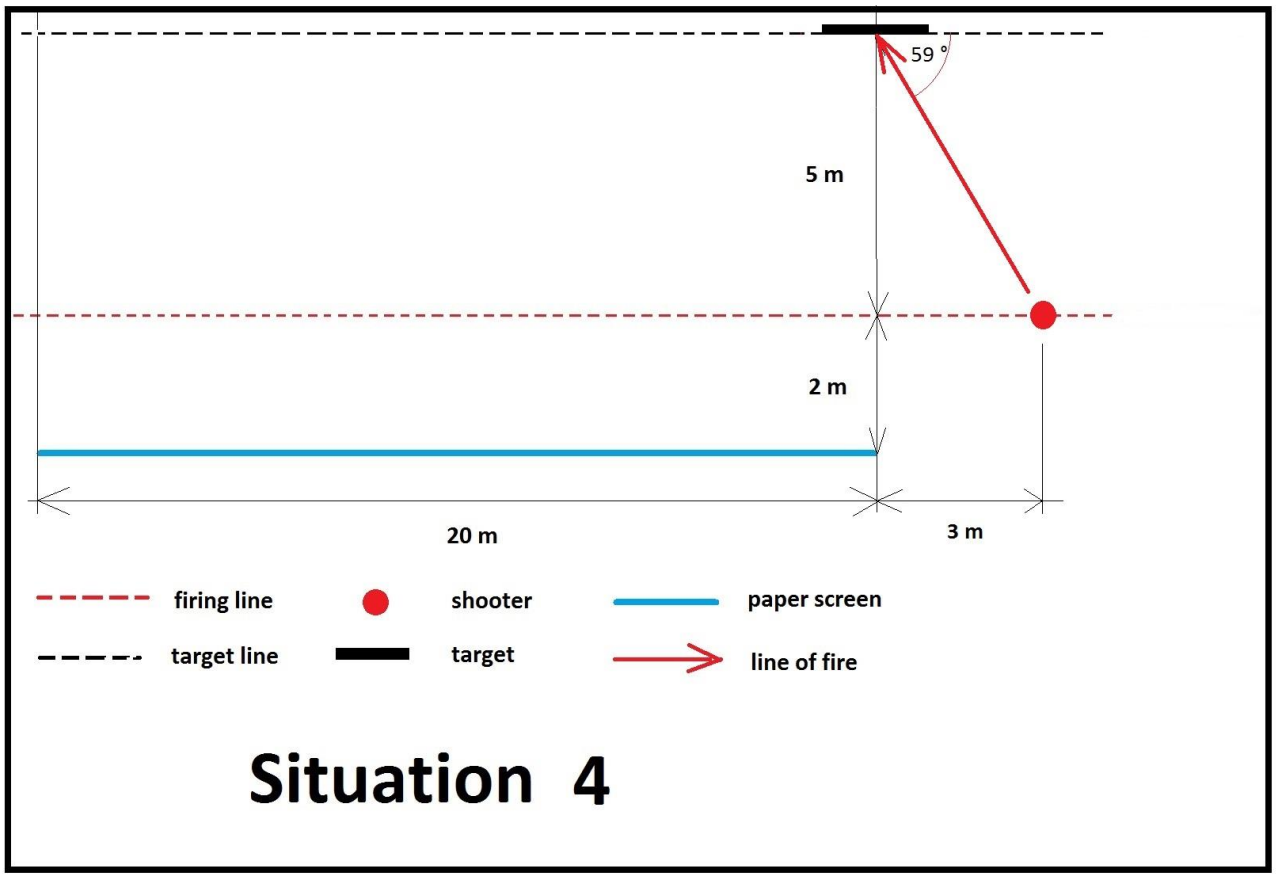
[3] for example at https://www.aws-czech.cz/video-dokument-dot-2018.html , at time 07:31

greatly on angle of impact – the lesser is the angle, the greater is risk of deflection. Rules of dynamic disciplines do not set any minimal angle of impact. As rules of western shooting allow deviation of barrel up to 85° and rules of IPSC allow deviation of the barrel of gun up to 90° (i.e., shooting parallel to firing line), it would be theoretically possible to set angle of impact close to 0°, where deflection is almost certain. However, shooting situations in competitions are never construed in this way. Common situation when target is struck from lesser angle than 90° is when there is line of targets in front of shooter. Our estimate is that in such a situation, angle of impact should be not lesser that 45°. We therefore set four situations, where target line was 5 meters away from firing line. First target was set 1 m aside (angle of impact 78,6°), second was set 2 m aside (angle of impact 68°), third was set 3 m aside (angle of impact 59°) and last one was set 5 m aside (angle of impact 45°). Two meters behind firing line (i.e., 7 m from targets) we set cardboard paper screen two meters high to detect ricochets which would be deflected into audience. We shot five rounds of lead shot and five rounds of steel shot on each target.

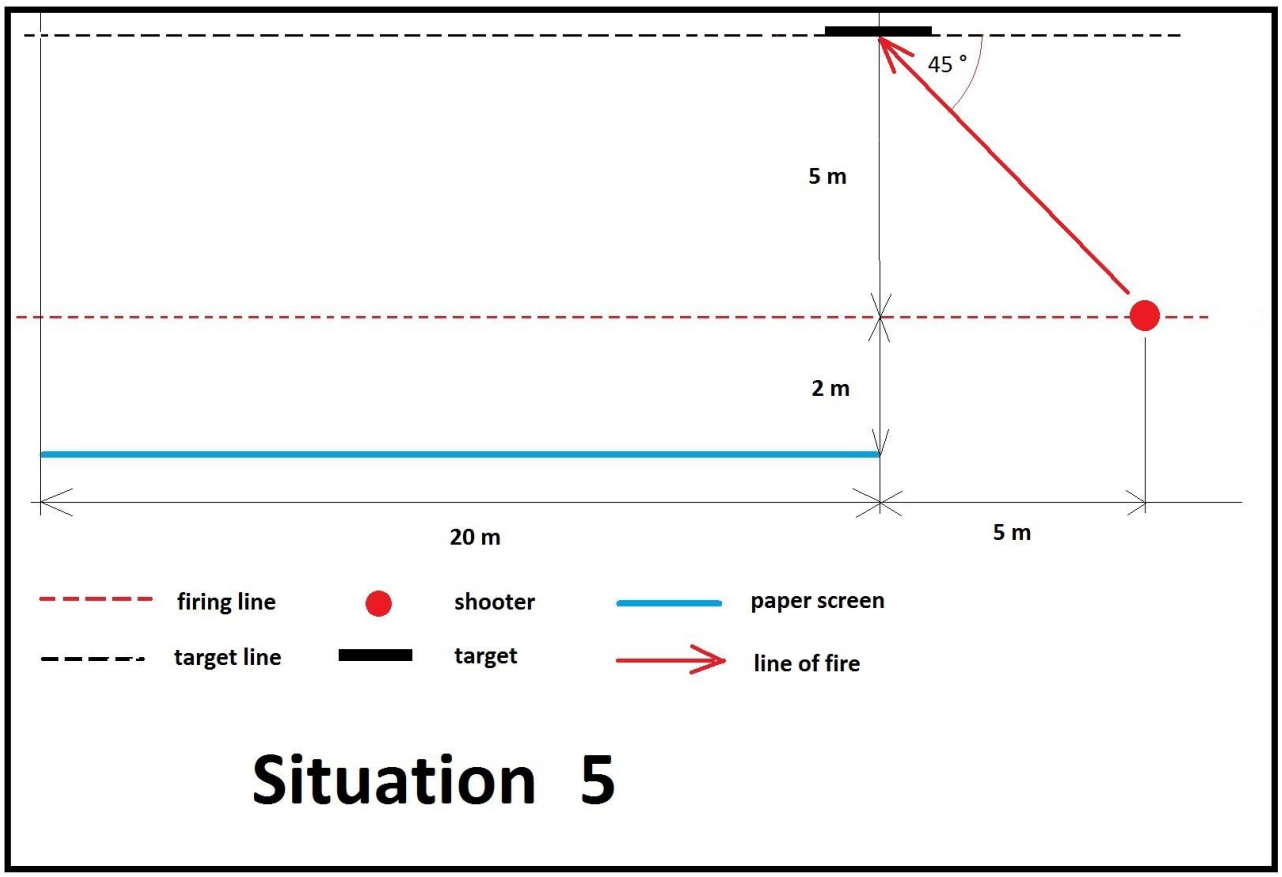




Situation 3



Situation 4



Equipment

We tested shotgun ammunition NSI Steel Caccia with 3.1 mm steel shot, and S&B Corona with 3.0 mm lead shot as testing group[4] [5]. Both types of ammunition were of common shotgun caliber 12/70 and were fired from repeating lever-action shotgun Norinco YL12 – IJ87 with cylindrical (no choke) barrel 560 mm long (including the chamber).
Steel targets were 83 cm tall, 31 cm wide and 1 cm thick. Front surface was rough due to extensive previous use.

[4] Maximum size of shot allowed for western shooting is size 4 (3.5 mm). IPSC rules do not limit size of shot.

[5] Tested shots are not of the same size, because they are not made of the same size – steel shot is manufactured a bit larger, to make up for worse ballistic properties.

Test results

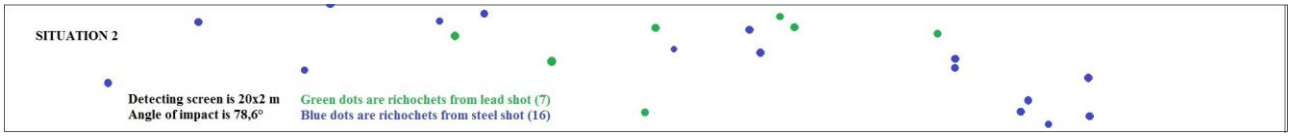
Deflection

In situation 5 (angle of impact 45°), we found no marks of ricochets from either type of shot on the screen. We presume that if there were any ricochets, they fell farther than 20 m. This should mean no problem for sport shooting disciplines, as these pellets would probably hit side berm, but it could mean safety concerns for hunting use (for example after accidental deflection from rock), as the line of hunting participants can be easily over 100 m long.

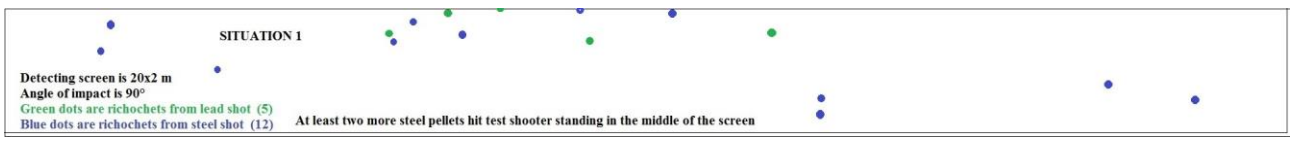
In situation 4 (angle of impact 59°), we found 1 ricochet from lead shot and 3 ricochets from steel shot. Pattern of disperse can be seen on the picture.

In situation 3 (angle of impact 68°), we found 2 ricochets from lead shot and 3 ricochets from steel shot. Pattern of disperse can be seen on the picture.

In situation 2 (angle of impact 78,6°), we found 7 ricochets from lead shot and 16 ricochets from steel shot. Pattern of disperse can be seen on the picture.



In situation 1 (angle of impact 90°), we found 5 ricochets from lead shot and 12 ricochets from steel shot. Pattern of disperse can be seen on the picture.



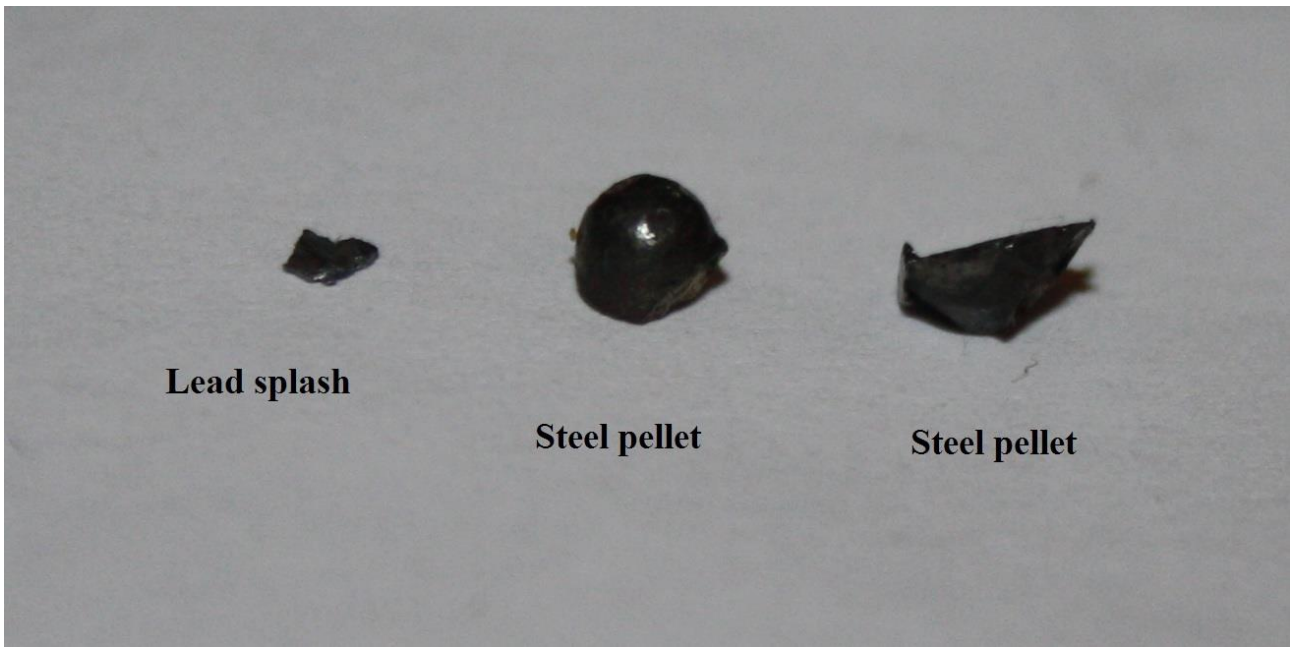
At least two more steel pellets in Situation 1 did hit test shooter – one was found on clothing on right shoulder, second did hit protective goggles where it left small mark (see photo). Also when shooting steel shot, we heard sound of many pellets which flew over the screen and fell into bushes behind it. This was not observed with lead shot.

In total, we found 15 ricochets from lead shot and 36 ricochets from steel shot.

Situation	Angle of impact	Lead ricochets	Steel ricochets
1	90°	5	14
2	78,6°	7	16
3	68°	2	3
4	59°	1	3
5	45°	0	0
Total	45° - 90°	15	36

Deformation of pellets

Some deflected projectiles were caught in the cardboard and retrieved. (The fact that some ricochets did not penetrate cardboard should not be construed into claims that these ricochets are not dangerous, as some pellets were caught but others went cleanly through, and at least one pellet retained enough energy to damage ballistic goggles.) All recovered residue from lead shot were tiny splinters (around 1 – 2 mm). All retrieved steel shots were deformed but whole, with deformation ranging from mildly damaged round pellet to almost flat with quite sharp rim (see photo).



Conclusion

In our test, we found that both lead and steel shot can ricochet when shot into hard target from close distance. In the matter of difference between lead and steel shot, we found two important findings. First, that steel pellets are significantly more prone to deflect upon such impact than lead pellets. Second, that steel pellets deflect in whole and can deform to sharp edges, while lead pellets fragment upon impact into splash.

Further consideration

Beside shotguns, dynamic disciplines also utilize pistols and rifles for shooting at steel targets. Since minimal distances are usually similar[6], we considered to perform this test for handgun and rifle ammunition as well. However we decided not to do it, because of safety reasons. We already submitted to ECHA results of tests where we tested nonlead rifle ammunition for hunting. These bullets are made from copper alloys and have front part cross-cut to ensure deformation. We tested those bullets in similar way (shooting from 100 m distance at steel target set at 45° angle) and found that upon such impact, front part of the bullet creates large splinters while back part deflects in whole. We presume that solid bullets without deformation zone would behave in latter manner (i.e. deflect in whole), and could be deformed to sharp edges like steel pellets were. Having in mind that 80 J is considered a threshold of potential lethality, and that most pistols/rifles muzzle energy is higher by order of magnitude, we decided not to perform ricochet tests of this ammunition on closer range, as the outcome could be actually fatal.

We also recommend for further consideration the implications of our finding in the scope of hunting use. Impact materials in hunting environment are usually softer than steel targets, but impact angle can be sharper than 45°. Therefore, use of steel shot could be cause of higher incidence of ricochets in this environment as well.

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6 Minimal distance of steel target in western shooting is 7 yards for pistol and 13 yards for rifle; IPSC prescribes at least 7 meters of distance for pistol (and 50 for rifle)