Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland

Test b908

Levante Labs Test Report b908
Pages 50 (including this one)

Authorized Signature
Test Approved for Release

Note: Hard copy available from Levante Labs. Send self addressed envelope to address above.

Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland Test b908

AIRSOFT BB AMMUNITION BALLISTIC TEST

1. INTRODUCTION

We have been commissioned by our client to execute a study of 6mm ammunition used in the sport/game of airsoft (henceforth bbs). We have been further commissioned to execute supplementary studies on new ammunition as soon as it is made available to the market. Our client has asked us to limit the technical terms in this study so as to allow a person with no prior experience in ballistics to understand the significance of the results. We have also been asked to add our comments, observations and conclusions.

2. AIM

The aim of this study is to execute an accurate and comparative assessment of the performance and safety of the bb ammunition when used in the game/sport of airsoft. To this end we have selected and acquired a wide array of ammunition by both manufacturer and weight class **(FIG 1 in Annex).**

3. SCOPE

3.1 This study was carried out under controlled environmental conditions in an indoor testing range and laboratory. All results are expressed in SI units. Conversion to British Imperial Units or American Units is to be executed using legally accepted conversion tables.

3.2 Ballistic Clay - This study adopts the National Institute of Justice Standard for the Ballistic Resistance of Body Armour (NIJ Standard - 0101.06) method of measuring back face signature: a homogenous block of non hardening, oil-based modelling clay henceforth referred to as ballistic clay.

3.3 Gun Assembly - This study adopts the compressed gas gun method for obtaining consistent and repeatable muzzle velocities and impact velocities (henceforth gas gun). In this configuration peek performance was attained with a 6.01mm diameter cold hammer forged steel barrel, 50cm in length and coated with Teflon on the inside. This surface treatment on the inside of the barrel is designed to drastically reduce the friction produced by the bb hitting the walls of the barrel as it travels under the hop up and down to the muzzle. Gas pressure and temperature was accurately monitored and maintained with each shot fired.

3.4 Methodology - The bbs were fired from a compressed gas gun, with controlled air pressure and temperatures, into ballistic clay, at impact targets and through speed traps. Each bb was measured at muzzle velocity (V0) and impact velocities at a distance of 10m (V10), 20m (V20) and 30m (V30). Individual bb weight, bb diameter, depth of bb penetration into ballistic clay, diameter of entry canal and velocity at impact were measured. A thinner sample of ballistic clay was used to document the diameter of the exit canal and the effects of bb dynamics as they traveled through the ballistic clay.

3.5 Human Target - The bbs were fired at human volunteer targets and human bone simulators for visual recording and measurement of injury. The distance between the muzzle of the gas gun and the human target and bone simulator was 5m (V5). A survey of the volunteers was taken to decide the location of impact and the front thigh muscle was elected. The muzzle was aimed at the front thigh muscle mass with a BDU placed tight against the skin over the impact zone. A medical technician was called upon to supervise the test and to make periodic visual inspections and observations of the individual wounds over a period of 4 days.

3.6 Cordura on Ballistic Clay - The bbs were fired at cordura material that was placed against a block of ballistic clay. The distance between the muzzle and this target was V10. The purpose of this test was to document the damage to the cordura and depth of the indentation in the ballistic clay (Back Face Signature - BFS) measured by calculating the total area of the indentation.

3.7 Cordura on Aluminum - The bbs were fired at cordura material that was placed against an aluminum plate (type 6061 3mm thick). The distance between the muzzle and this target was V10. The purpose of this test is to simulate and document the damage to cordura material when a bb strikes a pouch loaded with standard airsoft rifle magazines.

3.8 BDU on Ballistic Clay - The bbs were fired at BDU material taken from the rear area of Tru Spec BDU jacket made of poly-cotton (65%, 35%) rip-stop placed tight against a block of ballistic clay. The purpose of this test is to document the effects of the impacts on the BDU and the extent of the indentations (BFS) caused by the impacts on the ballistic clay.

3.9 Induced Expansion - The bbs were fired at a target with a 0.058mm sheet of cardboard placed against a block of ballistic clay. A thin block of clay was used to allow the bbs to completely traverse it and cause an exit hole on the reverse side. The purpose of this test is to examine the dynamics of the impacts involved.

3.10 Face Mask - The bbs were fired at a JT style mask. This system provides full face protection, a 280° optical visor fitted to a goggle support that affords a complete seal around the eye area. This system provides protection against bbs fired from all directions and angles and was deemed safe for the scope of this study.

3.11 Accuracy - Accurately quantifying V0, V10, V20, V30 is crucial to determine the effects of the bbs on humans and on property. Ballistic clay was used in various instances as a velocimeter. Calibration was achieved by correlating each bb's V0, V10, V20, V30 generated by the compressed gas gun and measured with ballistic sensors, to the bb's depth of penetration into the ballistic clay (BFS). Excellent repeatability was achieved. Calibration test was executed by loading the bb into the gas gun, pressurizing the accumulator and firing the gun. This method allows accurate measurements and provides physical evidence which can be photographed and compared for later study or for reference purposes **(FIG A, B in Annex).**

3.12 Talyrond and Mitutoyo metrology systems are used to measure the size, sphericity and density of the bbs. Ballistic data measured with Oehler Research Inc instruments and in house impact target systems.

Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland

4. PRELIMINARY OBSERVATIONS

Density

4.1 During the initial testing of the bbs it was confirmed that a very high percentage presented considerable inconsistencies in material density within each of the bbs themselves. This was documented and recorded into a chart shown in **FIG 2 in Annex**.

4.2 By measuring and analyzing different areas of the same bb a different density result was recorded. This data indicates that most of the bbs tested are therefore to be considered inhomogeneous spherical objects with asymmetric densities. This conclusion has profound negative consequences on the ballistic performance of this type of ammunition.

4.3 The most common problem of plastic and bio degradable bbs is the presence of small to very large air bubbles and the extent to which the ingredients are properly mixed. These inconsistencies were amplified within each of the manufacturer's bb weight class and within each specific lot so that no 2 bbs were found with similar densities.

4.4 The root cause of inconsistent density in injection moulded plastics and bio-resins are as follows:

> **4.4.1** manufacturing process, quality control, quality of plastic resin, quality of biodegradable resin, the mixing of ingredients;
>
> **4.4.2** The limitations imposed by the plastic or bio-plastic materials themselves. Perfectly uniform densities are difficult to achieve with plastics or biodegradable resins relative to other materials. It is for this reason that good results are possible only if great effort is placed in the manufacturing process and in the choice and use of the ingredients involved.

4.5 In order to achieve good ballistic performance, a bb projectile with an imparted back spin depends heavily on the uniform distribution of weight within its structure. This weight in turn depends upon the density of the material measured at any point within the spherical structure of the bb itself. Even a slight difference in density from one point of the bb to another will cause its trajectory to deviate from the point of aim **(FIG 3 in Annex)**.

4.6 Uniform density is a difficult quality to achieve in plastic bbs. The manufacturing process may cause inconsistencies within each bb, from bb to bb, from lot to lot of the same brand and from brand to brand. Consistent performance and good ballistics require high quality manufacturing procedures and ingredients.

4.7 Our test data concludes that the BBBMAX is noticeably different in terms of performance and density from other bbs in the test since most probably this bb is not moulded (the manufacturer has not furnished any details in this regard).

4.8 Our tests and observations concluded that the Digicon 0.43g bbs, the Bioval bio bbs and some of the bbs of Japanese manufacture have better results in measured densities and performance when compared to other bbs in the test. This is due to a better manufacturing process, a higher quality control and to a higher quality of the materials used.

Magnus Effect

4.9 The back spin or rotational torque, known as the magnus effect, causes bbs to respond in potentially negative ways while in flight. Bbs have elastic properties that will cause them to deform when force is applied to their structure. This deformation is a function of the applied force and the material that they are made of. Once this force is removed the bb should return to its original form. In this study, the difference between the original form and that measured after the force is removed is the degree to which the bb is actually elastic (or not). The magnus effect imparts centripetal and centrifugal forces on the bb that together cause it to deform inward along its spin axis (from pole to pole) and outward along the circumference of its equator. This deformation is proportional to its rpm and its elasticity and when taken together with the actual distribution of weight within the bb itself may have negative effects on the ballistics of the bb as it travels along the barrel and as it travels along its intended trajectory to the target **(FIG 4, 5 in Annex)**.

Sphericity and Diameter

4.10 The next issue confronting the initial testing process was the inconsistency in measured sphericity and diameter of the bb samples. These data are based on the comparison of a near perfect axis of rotation with the unknown quality of the bbs. Each bb was repeatedly measured along a different axis. A total of 1000 bbs were measured from each manufacturer and each weight class.

4.11 Spherical and diameter inconsistencies (within each bb, from bb to bb, from lot to lot, from brand to brand) contribute to flawed mechanical performance within the gun as the bb moves from the magazine, to the hop up chamber and as it travels down the barrel. Also, the lack of elasticity (defined here as the capacity of the bb to return to its original spherical shape) common to softer bbs does not allow them to regain their original spherical shape as they undergo various types of forces within the magazine, in the hop chamber and finally below and around the hop up itself. Inconsistent sphericity and lack of elasticity helps explain some of the more common malfunctions associated with airsoft guns in general. On the other hand, bbs that are too hard will crack or break within these mechanisms causing damage to the airsoft gun. The correct compromise between hardness, softness and elasticity is only possible with high quality manufacturing, quality control and the choice of correct materials. Sphericity, as defined in this study, reflects all these issues taken together and is simplified in one diagram shown in **Fig 6 in Annex**.

4.12 Spherical and diameter inconsistencies degrade ballistic performance (with each bb, from bb to bb, from lot to lot, from brand to brand) since the aerodynamics of the bb is affected during flight. This difficulty is further magnified with the application of the hop up device since this setting must be placed at relative constant to get consistent data and to hit the targets.

4.13 Sphericity is a notoriously difficult quality to achieve in plastic and bioplastic materials. The process of removing mould marks, injection port sprues, injection port marks and other surface imperfections may cause inconsistencies in sphericity and diameter within each bb, from bb to bb, from lot to lot and from brand to brand.

4.14 Our tests and observations conclude that the BBBMAX is the most consistent bb tested. This supports our view that most probably this bb is not moulded and therefore the manufacturing process adopts a more accurate polishing system. The manufacturer has not provided details in this regard.

4.15 Our tests and observations concluded that the Digicon 0.43g bbs, the Bioval bio bbs and some bbs of Japanese manufacture are noticeably different from other bbs in the test. Again, this is propably due to better manufacturing process, higher quality control and higher quality of material used.

5. Velocity V0, V10, V20, V30

V0 (FIG.7,8,9)

5.1 The Velocity at V0 in m/s was measured using a precision speed trap placed at the muzzle of the gas gun and a block of ballistic clay placed behind the speed trap. This part of the study examines the dynamics of the bb as it is accelerated down the barrel and is known as interior ballistics. In this phase, the bb's acceleration is affected by 5 forces that are acting on its forward motion and ultimately affecting the measured muzzle velocity: (1) the gas pressure behind the bb; (2) the back spin or rotational torque (magnus effect) imparted on the bb by the hop up mechanism; (3) the rpm of the back spin. This spin may also deform the bb to some degree see 4.9 above; (4) the air resistance in front of the bb; (5) the friction of the bb against the barrel. This force is not uniform since it depends on the condition of the barrel and on the diameter, sphericity and smoothness of the bb.

5.2 The events that occur as the bb interfaces with the barrel and the forces described in 4.9 and 5.1 above are crucial to the trajectory of the bb when it leaves the barrel of the gun. An in depth study of the interior ballistics of each bb is beyond the scope of this study and for this reason we have chosen to set specific parameters by using the gas gun apparatus as described in 3.3 above. Suffice it to say that the forces interacting with the bb in the barrel will inevitably be dissimilar and inconsistent (from shot to shot) in a different set up from that described in this study. Our test apparatus forms an ideal neutral test basis necessary to record accurate measurements of the bb as it leaves the barrel. It is for this reason that gun tests and bb tests outside an ideal parameter are to be regarded as highly suspect and wholly inaccurate.

5.3 The results of V0 were recorded in FIG.7,8,9 and were executed at 3 different power settings of the gas gun. These settings are represented by the V0 of our control bbs in each of the tables. All other bbs within each table were tested at the power settings of the control bbs thus enabling an accurate comparison of each bb's performance relative to its competitor.

5.4 Interpreting the results of FIG 7,8,9. The higher the speed of the bb the more efficiently the bb is able to cope with the forces it is interacting with in the gas gun test barrel. The results represent the average V0 in m/s of 1000 bbs fired for each brand and weight **(FIG 7,8,9 in Annex).**

V10 (FIG 10,11,12)

5.5 As the bb leaves the barrel the situation changes drastically. The propellant pressure behind the bb drops violently to the local atmospheric pressure. The gas gun ceases to be an influencing factor in the bb's trajectory.

5.6 At this point Newton's laws of motion come into play and the science of external ballistics is applied to understand the dynamics of the forces that act on the bb.

5.7 In this phase, the bb's trajectory is affected by the following forces: (1) Drag force, or the force acting against the bb's forward motion. (2) the rpm of the back spin; (3) the elastic deformation of the bb (see 4.9 above); (4) the bb's gyroscopic motion; (5) the V0 of the bb. These forces taken together will slow the bb down (negative acceleration) and change its trajectory.

5.8 The results of V10 were recorded in FIG 10, 11, 12 . The initial V0 in m/s and the power settings recorded earlier form the basis of the results recorded in the V10 tables. As explained in 5.3 above, all the results help compare the performance of each bb against the control bbs and against their competitors.

5.9 Interpreting the results in FIG 10,11,12. The higher the speed of the bb the more efficiently the bb is able to cope with the forces it is interacting with as it travels along its trajectory. The results represent the average V10 in m/s of 1000 bbs fired for each brand and weight **(FIG 10,11,12 in Annex).**

V20 and V30 (FIG 13 to 17)

5.10 The counterintuitive nature of external ballistics becomes very apparent in the results of the bbs' performance out to V20 and V30.

5.11 Many of the bbs tested were unable to hit their intended targets in a consistent manner and therefore results were unattainable. This is reflected in the V20 and V30 tables by a lack of data. The main cause of this can be explained by the magnus and gyroscopic forces, influenced by the inconsistent sphericity and density within the bbs, changing the trajectory in a very noticeable manner **(FIG 3,4,5 in Annex).**

5.12 The results of V20/V30 were recorded in FIG 13 to 17. The initial V0 is m/s and the power settings recorded earlier form the basis of the results recorded in the V20/V30 tables. As explained in 5.3 above all the results help compare the performance of each bb against the control bbs and against their competitors.

5.13 Interpreting the results in FIG 13 to 17. The higher the speed of the bb the more efficiently the bb is able to cope with the forces it is interacting with as it travels along its trajectory. The results represent the average V20/V30 in m/s of 1000 bbs fired for each brand and weight **(FIG 13,14,15,16,17).**

6. Impact Tests

6.1 The result of any impact between two objects depends on the force and time during which the objects are in contact.

6.2 The time the two impacting objects remain in contact depends on the material properties of the two objects.

6.3 The softer the objects the more time they will remain in contact.

6.4 With sufficient force the objects will either break or deform.

Observations and Comments

6.5 This section of testing is based on the laws of physics (described in 6.1, 6.2, 6.3 and 6.4) above to determine bb impact results against various types of material and against airsoft players. As a preliminary test it was necessary to carry out impact tests of all the bbs involved to record their physical properties. In general, it was observed that the BBBMAX does not deform during impact and will not readily break while all other bbs will deform to some degree and some will easily break. Deformation was permanent at elevated speeds for some softer bbs. Harder plastic or bio bbs either regained much of their original form or shattered catastrophically.

6.6 Testing against masks and mask optics, involved firing bbs at the visor assembly and mask body. *NB This test was necessary in terms of the scope of this report but does not represent a homologation test of the masks involved. For more precise information please refer to the manufacturers safety warnings and their declared level of homologation.* Nevertheless, it was observed that all masks adopting a ***wire mesh visor assembly*** instead of a transparent plastic or polycarbonate optical visor assembly caused the bbs to shatter or were penetrated. This catastrophic failure can cause extreme and/or permanent eye injury. *The wire mesh masks were deemed too dangerous for further testing and removed from the test location.*

Cordura against hard surface at V0, V10, V20, V30 speed set 130/170

V0 130/170

6.7 The first test involved setting up a target with one layer of cordura denier 1000 tight against a hard aluminium 6061 plate 3mm thick. The purpose of this test is to document the extreme dynamics and resulting damage to cordura material when a bb strikes the target assembly.

6.8 The distance between the muzzle and this target was V0 (point blank) and the bbs were fired at the speed settings described in 5.3 above. This test simulates a pouch loaded with an airsoft rifle magazine on a load bearing vest of a type normally used by players. This test represents a worst case scenario since (1) most magazines have an irregular surface area therefore not all of the area would be exposed to this type of impact; (2) point blank impacts are rare. Nevertheless, an extreme case was necessary to form a database of control data against which future tests (below) could be compared to.

6.9 In general, due to their elastic properties, plastic and bio bbs tend to expand on impact and will cause a wider area of damage to the fibers than harder bbs. Harder bbs will not deform and expand and will cause a more focused and much smaller area of damage. The results of the test were photographically recorded and documented.

6.10 Plastic and bio bb impacts on the cordura material are characterized by individual cordura fiber breakage. Three types of damage were observed: (1) in some cases the heat produced by the impact will cause individual cordura fibers to melt and to bind with the surrounding fibers limiting further damage; (2) in other instances the cordura did not melt and may result in further damage as the individual damaged cordura fibers come unraveled from the weave. With time and heavy usage this result may cause the damaged area to expand since the mechanical resistance of the cordura fabric is compromised. (3) in many instances a combination of melted fibers and broken fibers were observed. In this case, the structure of the cordura fabric may be compromised and cause further damage with time and heavy usage.

6.11 Harder bbs, such as the BBBMAX, tend to cause much smaller damage areas since they will not deform and expand on impact. The heat produced by the impact will cause individual cordura fibers to melt and to bind with the surrounding fibers. The small nature of this damage and the fact that the damaged fibers are fastened (melted) to the surrounding structure will severely limit further damage with time and heavy usage.

V10 at 130/170

6.12 The second test involved setting up a target with one layer of cordura denier 1000 tight against a hard aluminium 6061 plate 3mm thick. The purpose of this test is to document the extreme dynamics and resulting damage to cordura material when a bb strikes the target assembly.

6.13 The distance between the muzzle and this target was V10 (10m) and the bbs were fired at the speed settings described in 5.3 above. This test simulates a pouch loaded with an airsoft rifle magazine on a load bearing vest of a type normally used by players. As in 6.8 above, this test represents a worst case scenario since most magazines have an irregular surface area therefore not all of the area would be exposed to this type of impact. Nevertheless, impacts at this distance are more likely to occur.

6.14 Plastic and bio bbs generally tend to deform and expand on impact to a lesser degree than described in 6.9 above since the force of impact is reduced. Nevertheless, they will cause a wider area of damage to the fibers relative to harder bbs. Harder bbs will not deform and expand and will cause a more focused and much smaller area of damage. The results of the test were photographically recorded and documented.

6.15 At this greater distance it was observed that Plastic and bio bb impacts on the cordura material are characterized by individual cordura fiber breakage but too a lesser degree. A repetition of the three types of damage observed in 6.10 above were recorded.

6.16 At this greater distance the damage caused by harder bbs, such as the BBBMAX, tend to cause an even smaller damage area and to a lesser degree than those described in 6.10, 6.11, 6.14 above. The is due mainly to the fact that hard bbs will not deform and expand on impact **(FIG C, D).**

V20/V30 at 130/170

6.17 At these medium and extreme distances exactly the same target assembly as described in 6.7 and 6.12 was used though with roughly double the size since it was difficult for many bbs to actually hit the target.

6.18 This test represents the most likely distance of engagement in most airsoft games. Due to the irregular surface area of most airsoft magazines not all of the area would be exposed to this type of impact.

6.19 At these extreme distances the results were a repetition of those recorded in the sections 6.7 to 6.18 above though to a degree proportional to the greater distance and therefore much smaller forces were involved.

6.20 At these distances recorded damage was fundamentally different than that of previous tests. Statistically, the force transferred to the cordura was not enough to cause any damage to the cordura structure. Nevertheless some damage was recorded with the following characteristics: Plastic and bio bbs will still deform and expand but due to the reduced force any resulting damage was limited to broken fibers with no melting; heavy bbs still caused melting and breakage of fibers.

Cordura against soft surface at V0, V10, V20, V30 speed set 170

6.21 This test involved setting up a target with one layer of cordura denier 1000 placed tight against a block of ballistic clay. The purpose of this test is to document the effects of the impacts on the cordura and the extent of the indentations caused by the impacts on the clay.

6.22 The target was placed at various distances (V0, V10, V20, V30) and the bbs were fired at the 170 speed settings described in 5.3 above. This test simulates the impact of a bb on a soft back drop such as human skin.

V0 at 170

6.23 No penetrations of the cordura material were observed by any bb.

6.24 Damage to the cordura was very limited with some very limited fiber damage but absolutely no holes.

6.25 By examining and measuring the bbs after the impacts it was observed that all plastic and bio bbs and the digicon expanded and deformed on impact as they decelerated into the ballistic clay. Hard bbs (bbbmax) did not deform or expand as they decelerated into the clay. No bb breakage was recorded during testing.

6.26 By observing the indentations caused by the bbs impacting into the ballistic clay we were able to estimate the total energy transfer of the impacting bbs. The remaining energy was expended by the bbs rebounding off the targets.

6.27 Digicon 0.43g - the measured impact area caused by the digicon bbs was 12 times larger than the measured area of the bb. This result is a function of the bbs weight, the amount of deformation and expansion upon impact.

6.28 Plastic & bio 0.28g/0.30g – the average measured impact area caused by these heavy bbs was 11 times larger than the measured area of the bb. This result is a function of the bbs weight, the amount of deformation and expansion upon on impact.

6.29 Plastic & Bio 0.23g/0.25g – the average measured impact area caused by these medium bbs was 10.5 times larger than the measured area of the bb. This result is a function of the bbs weight, the amount of deformation and expansion upon impact.

6.30 BBBMAX – the average measured impact area caused by the BBBMAX was 7 times larger than the measured area of the bb.

6.31 Plastic & bio 0.20g – the average measured impact area caused by the light bbs was 6 times larger than the measured area of the bb. This result is a function of the bbs weight, the amount of deformation and expansion upon on impact.

6.32 Conclusion – in proportion to their weight and size, the energy transferred from the bb to the target ballistic clay via the cordura is much greater with all plastic, bio and digicon bbs than with the BBBMAX.

V10 at 170

6.33 No penetrations of the cordura material were observed by any bb.

6.34 Damage to the cordura was very limited with some very limited fiber damage but absolutely no holes.

6.35 By observing and measuring the bbs after the impacts it was observed that all plastic, bio and the digicon expanded and deformed on impact as they decelerated into the ballistic clay. Hard bbs (bbbmax) did not deform or expand as they decelerated into the clay. No bb breakage was recorded during testing.

6.36 By observing the indentations caused by the bbs impacting into the ballistic clay we were able to estimate the total energy transfer of the impacting bbs. The remaining energy was expended by the bbs rebounding off the targets.

6.37 Digicon 0.43g - the measured impact area caused by the digicon bbs was 8 times larger than the measured area of the bb. This result is a function of the bbs weight, the amount of deformation and expansion upon on impact.

6.38 Plastic & bio 0.28g/0.30g – the average measured impact area caused by the heavy bbs was 7 times larger than the measured area of the bb. This result is a function of the bbs weight, the amount of deformation and expansion upon on impact.

6.39 Plastic & bio 0.23g/0.25g – the average measured impact area caused by the medium bbs was 6.5 times larger than the measured area of the bb. This result is a function of the bbs weight, the amount of deformation and expansion upon on impact.

6.40 BBBMAX – the average measured impact area caused by the BBBMAX was 4 times larger than the measured area of the bb.

6.41 Plastic & bio 0.20g – the average measured impact area caused by the light bbs was 3 times larger than the measured area of the bb. This result is a function of the bbs weight, the amount of deformation and expansion upon on impact.

6.42 Conclusion – in proportion to their weight and size, the energy transferred from the bb to the target clay via the cordura is much greater with all plastic, bio and digicon bbs than with the BBBMAX **(FIG E).**

V20/V30 at 170

6.43 No damage or penetrations of the cordura material were observed.

6.44 Due to the small amount of energy retained in the bbs at V20 and V30 small and very small indentations were observed in the ballistic clay relative to the results recorded in 6.21 to 6.42 above.

6.45 Digicon - At V20 the digicons still retained enough energy to cause indentations that were larger than their size. At V30 indentations were either the same size or smaller than the size of the bb.

6.46 Plastic & bio 0.28g/0.30g - At V20 the heavy bbs still retained enough energy to cause indentations that were larger than their size. At V30 indentations were either the same size or smaller than the size of the bb.

6.47 BBBMAX – At V20 the BBBMAX still retained enough energy to cause indentations that were larger than their size. At V30 indentations were either the same size or smaller than the size of the bb.

6.48 Plastic & bio 0.20g – At V20 not all the light bbs were able to hit the target. Those that did caused indentations that were smaller than their size. Tests at V30 were suspended since no bb was able to hit the target.

6.49 Conclusion – in proportion to their weight and size, the energy transferred from the bb to the target clay via the cordura is much greater with all plastic, bio and digicon bbs than with the BBBMAX.

BDU against soft surface at V10, V20, V30 speed set 170

6.50 This test involved setting up a target with one layer of olive drab material taken from the rear area of Tru Spec BDU jacket made of poly-cotton (65%, 35%) rip-stop placed tight against a block of ballistic clay. The purpose of this test is to document the effects of the impacts on the BDU and the extent of the indentations caused by the impacts on the ballistic clay.

6.51 The target was placed at various distances (V10, V20, V30) and the bbs were fired at the 170 speed settings described in 5.3 above. This test simulates a worst case scenario of the impact of a bb on a soft back drop.

V10 at 170

6.52 The Digicon 0.43g bb penetrated the BDU. Non of the other bbs penetrated the BDU.

6.53 The Digicon 0.43g bb caused a hole in the BDU seriously damaging the fabric. Non of the other bbs caused any damage to the BDU material except small indentations that were fixed by placing some warm water on the material and flattening them out.

6.54 By observing and measuring the bbs after the impacts it was observed that all plastic, bio and the digicon bbs expanded and deformed on impact as they decelerated into the ballistic clay. Hard bbs (bbbmax) did not deform or expand as they decelerated into the clay. No bb breakage was recorded during testing.

6.55 By observing the indentations caused by the bbs impacting into the ballistic clay we were able to estimate the total energy transfer of the impacting bbs. The remaining energy was expended by the bbs rebounding off the targets. The Digicon 0.43g bb transferred all its energy into the BDU material and into the ballistic clay.

6.56 Digicon 0.43g – this bb penetrated the BDU material and was found lodged 25mm into the ballistic clay. The total measured impact area of the entry channel was 21 times the size of the bb. This result is a function of the bbs weight, the amount of deformation and expansion upon impact.

6.58 Plastic & bio 0.28g/0.30g – the average measured impact area caused by the heavy bbs was 13 times larger than the measured area of the bb. This is result is a function of the bbs weight, the amount of deformation and expansion upon impact.

6.58 Plastic & bio 0.23g/0.25g – the average measured impact area caused by the medium bbs was 11 times larger than the measured area of the bb. This is result is a function of the bbs weight, the amount of deformation and expansion upon impact.

6.59 BBBMAX – the average measured impact area caused by the BBBMAX was 7 times larger than the measured area of the bb.

6.60 Plastic & bio 0.20g – the average measured impact area caused by the light bbs was 8 times larger than the measured area of the bb. This is result is a function of the bbs weight, the amount of deformation and expansion upon impact.

6.61 Conclusion – the impact caused by the bbs in the cordura are a little smaller when compared to the results above. All conditions being equal, the only difference between the cordura soft target tests (6.21 to 6.49) and the results above (6.50 to 6.60) is the nature of the material placed between the bbs and the ballistic clay. Cordura is able to cause the bbs to expand more than poly-cotton but cordura is also able to dissipate the bb's impact more efficiently along its fibers than the poly-cotton in the BDU. In proportion to their weight and size, the energy transferred from the bb to the target clay via the BDU is much greater with all plastic, bio and digicon bbs than with the BBBMAX **(PLACE FIG F, G, H).**

V20/V30 at 170

6.62 No penetrations were observed.

6.63 No damage of any nature was observed.

6.64 The impacts observed at V20 caused by the plastic and the digicon bbs into the ballistic clay were smaller than at V10. Hard bbs (bbbmax) did not deform or expand as they decelerated into the clay and caused even smaller indentations at V20 and V30. No bb breakage was recorded during testing.

6.65 By observing the indentations caused by the bbs impacting into the ballistic clay we were able to estimate the total energy transfer of the impacting bbs. The remaining energy was expended by the bbs rebounding off the targets.

6.66 Digicon 0.43g – the average measured impact area caused by the heavy plastic bbs was slightly larger than the measured area of the bb.

6.67 Plastic & bio 0.28g/0.30g – the average measured impact area caused by the heavy plastic bbs was slightly larger than the measured area of the bb.

6.68 Plastic & bio 0.23g/0.25g – the average measured impact area caused by the medium plastic bbs was smaller than the measured area of the bb.

6.69 BBBMAX – the average measured impact area caused by the BBBMAX was smaller than the measured area of the bb.

6.70 Plastic & bio 0.20g – At V20 not all the light bbs were able to hit the target. Those that did caused indentations that were smaller than their size. Tests at V30 were suspended since no bb was able to hit the target.

6.71 Conclusion – at V20 and V30 the recorded indentations were negligible but slightly larger than those recorded in the cordura tests above (6.21 to 6.49). This is due to the characteristics of the cordura material that is able to better dissipate the impact energy along its fibers at the V20 and V30 distances. As in previous test, and in proportion to their weight and size, the energy transferred from the bb to the target clay via the BDU is much greater with all plastic, Bio and digicon bbs than with the BBBMAX.

Full Face Protective Systems

6.72 *NB This test was necessary in terms of the scope of this report but does not represent a homologation test of the face and eye protective systems involved. For more precise information please refer to the manufacturers safety warnings and their declared level of homologation. Furthermore, we do not recommend or condemn the use of any type of face and eye protective systems. The purpose of this test is to study the possible types of damage bb ammunition can cause on face and eye protection and to understand the dynamics of bb ammunition against face and eye protective systems.*

6.73 High velocity projectiles such as all bbs of any manufacturer used in the sport/game of airsoft are potentially very dangerous and may cause severe eye and face injury and damage to teeth. In many instances damage and injury may be permanent. Always wear full face protection with fully sealed goggles using homologated optics (henceforth Mask) on the game field and during preparation before a game. Never use any Masks until you have read, understood and followed all instructions and safety precautions/warnings provided by the manufacturer. Never remove the Mask while on the game field or during preparation.

6.74 The producers of Masks typically state the following precautions must be followed closely (this is not an exhaustive list and other precautions may be stated by some manufacturers): Any impact on the Mask optics may damage its structure. Always inspect the protective Mask for small cracks each time before you play and replace it immediately if any cracks are found. Always replace the optics every time they are shot even if you cannot see any cracks or evidence of damage. This is because the structure of the optics may be compromised and fail catastrophically with future impacts. Always replace the optics at least once per year, beginning with the date of purchase. Atmospheric conditions will degrade the structure of the optics with time. Always inspect the entire Mask that you are borrowing or renting using the above criteria.

6.75 Chemicals, heat, sunlight, fumes and other products and atmospheric conditions may degrade the structure of the Mask and optics and cause the system to fail when impacted by a projectile. Read the owners manual and follow the instructions regarding storage and cleaning very carefully.

6.76 In order to remain within the scope of this study, masks must provide a complete seal around the eyes to prevent bb penetration when fired from multiple angles and directions. All other systems were removed from the test area.

6.77 SPECIFICALLY: it was observed that all masks adopting a wire mesh visor assembly instead of a transparent plastic or polycarbonate optical goggle visor assembly caused the bbs to shatter or were penetrated. This catastrophic failure can cause extreme and/or permanent eye injury. The wire mesh masks were deemed too dangerous for further testing and removed from the test location.

6.78 SPECIFICALLY: It was observed that sunglass style ballistic protection was unable to prevent bbs from penetrating into the area behind the lenses when fired from multiple angles and directions. Wrap around styles also failed. Many bbs impacting around this type of system rebounded off the test supports and were found lodged behind the optics. The sunglass style ballistic protection were deemed too dangerous and removed from the test area.

6.79 For the purposes of this test a JT style mask was used. This system provides full face protection, a 280° optical visor fitted to a goggle support that affords a complete seal around the eye area. This system provides protection against bbs fired from all directions and angles and was deemed sufficiently safe for the scope of this study. Please see 6.72 to 6.78 above.

6.80 For the purposes of this study two possible types of full face protective system failures are possible on the tested Mask (WARNING: other types of failure may be possible. Please read the manufacturers full face protection level of homologation for more precise information and see 6.72 to 6.78 above): (1) penetration of the mask and/or the optics and (2) spalling.

6.81 Penetration of the mask occurs when the bb impacts with sufficient force to travel through the protective material or protective optics. The bb will then continue to travel and strike the wearer in the eyes or face. Collateral damage occurs when the bb causes shattering of the protective Mask material or optics thereby increasing the degree of injury to the wearer. This type of injury may cause permanent eye damage.

6.82 Spall may occur when a bb strikes the Mask or optical protection on the mask. Upon impact, flakes of material are broken off a Mask or optical body. When a projectile impacts a hard surface but does not have enough energy to penetrate the surface, it will create a shock wave that travels through the material and will break the material on the inside of the Mask or optics. This broken material is known as spall and may have sufficient energy to travel across the space between the Mask/optics and eyes/face and may cause injury to the eyes/face on the inside of the Mask/optics.

6.83 The purpose of this test is to document the effects of the expansion and deformation of the bbs caused by the impact against a full face mask protective system and against the optics of the Mask. By observing the damage and the effects of the impacts more accurate evidence can be recorded of the dynamics involved. This test represents a real world worst case scenario.

6.84 This test involved setting up a JT nForcer full face mask fixed to a support as the target. The type of supports used prevented the Mask and optics to flex or bend as a result of the bb impacts. A block of ballistic clay was placed behind the target set up to record any penetrations or spall resulting from the impact.

6.85 All the bbs tested at V0 speed setting 170 (see 5.53 above) caused surface damage to the protective optics. No damage was observed on the rest of the mask body. The goggle frame holding the optics did not fail and was not penetrated. At V10, V20 and V30 speed setting 170 (see 5.53 above) damage was observed on the optics with all bbs that were able to hit the target. The goggle frame holding the optics did not fail and was not penetrated.

6.86 The damage observed on the Mask optics was characterised by a visible impact point and with extremely small stress lines in the optical material radiating away from this point. No mask/optics spalling was observed (see 6.82 above).

6.87 Digicon 0.43g – at V0 the average measured impact area caused by these bbs was slightly larger than the immediate frontal strike area of the bb itself. The stress lines radiating away from the impact point were multiple times longer than the diameter of the impact point. This result suggests that the digicon bb was severely deformed and expanded upon impact causing massive damage to the optics. This was confirmed by examining the bb itself. The digicon was severely flattened and presented large cracks in its structure. At V10 the bb flattened and cracked upon impact. The damage and stress lines to the mask optics was smaller but still multiple times larger than the diameter of the impact point. At V20 and V30 the impact point and stress lines were smaller than those recorded at V10. The bb was deformed but did not crack. No spalling was observed at V10, V20, and V30. The Mask structure itself was dented at V0, V10 but stress marks could not be recorded because this material is not transparent. At V20 and V30 the goggle frame material did not fail and damage was very limited.

6.88 Plastic & Bio 0.28g/0.30g – the damage recorder by these bbs was very similar compared to that recorded in 6.87 above. Bbs expanded and some shattered violently at V0. Impact points and stress lines were observed though to a smaller degree than those recorded for the digicon above. Damage assessment confirmed that bbs expanded and deformed upon impact dramatically increasing stress marks and impact points.

6.89 Plastic & Bio 0.23g/0.25g – the damage recorder by these bbs was very similar compared to that recorded in 6.85 and 6.86 above. Bbs expanded and some shattered violently at V0. Impact points and stress lines were observed though to a smaller degree than those recorded for the heavier bbs above. Damage assessment confirmed that bbs expanded and deformed upon impact dramatically increasing stress marks and impact points.

6.90 BBBMAX – Damage assessment of the impacts caused by the BBBMAX suggests that this bb does not expand or deform upon impact. None of the bbs tested fractured or shattered upon impact and subsequent measurements of the recovered bbs confirmed that they did not expand or deform. The degree of stress marks and the size of the impact point was smaller in proportion when compared to all other bbs.

6.91 Plastic & Bio 0.20g – Results of the impacts of these bbs are comparable to the those of the bbs tested in 6.87 to 6.89 above. At V0 and V10 these bbs expanded and deformed and some shattered violently. At V20 not all the light bbs were able to hit the target. Those that did caused indentations that were smaller than their size or no indentations at all. Tests at V30 were suspended since no bb was able to hit the target.

6.92 Conclusions – Plastic, Bio and the digicon bbs expand and deform on impact causing damage areas multiple time larger than their size. Impact points and stress marks taken together form massive damage to the optics. The BBBMAX does not expand upon impact and the impact point and stress marks were measured to be much smaller when compared to other bbs.

7. Induced expansion

7.1 This test involved setting up a target with a 0.058mm sheet of cardboard against a block of ballistic clay. A thinner block of ballistic clay was used to allow the bbs to completely penetrate it and cause an exit hole on the reverse side.

7.2 The purpose of this test is to document the effects of the expansion and deformation of the bbs caused by the impact against a relatively hard cardboard surface and as they completely travel through the ballistic clay. By observing the exit hole and the effects of the impacts on the bbs themselves more accurate evidence can be recorded of the dynamics involved.

7.3 The target was placed at V10 and the bbs were fired at the 170 speed setting described in 5.3 above. This test does not simulate any particular real world situation and is only intended to create a data base of empirical evidence that will be used to confirm the observations and conclusions in previous tests and from which to make further observations regarding testing on human targets below.

7.4 By measuring the exit hole we were able to confirm the results of previous tests. The BBBMAX exit hole was 6mm wide. This is proof positive that this bb does not expand upon impact and is able retain its original form, sphericity and diameter. All the plastic, Bio and the digicon bbs had measured exit holes that were between 8mm and 10mm wide. This indicates that these bbs undergo deformation and expansion upon impact with the cardboard and do not regain their original spherical shape as they pass through the ballistic clay.

7.5 To further confirm this result the same test was carried out against the ballistic clay without the cardboard placed in front. The objective of this second test is to compare the exit holes of the bbs without the induced expansion and deformation caused by the cardboard. The resulting exit hole was the same for the BBBMAX; 6mm. The plastic bbs and the digicon formed exit holes that were smaller than those recorder in 7.4 above; in the order of between 6.5 to 8mm.

7.6 By examining the penetration channels of both tests 7.4 and 7.5 above to record any further evidence of expansion and deformation, small plastic flakes were discovered along the inside walls of the channels and at the mouth of exit holes. By subsequently recovering the fired bbs and examining their surface area it was discovered that the flakes originated from some of the plastic bbs. This flaking is caused by the violent deceleration of the bbs and their subsequent deformation and expansion. A violent stoppage of the magnus effect from very high rpm to near zero in an extremely short period of time and the subsequent deformation/expansion does not afford all of the plastic or bio material within the bbs themselves enough time to move from one state to the other in a uniform fashion. This effect creates a shock wave that travels through the bbs causing surface material to break off. This result was observed for plastic and bio degradable bbs of Chinese manufacture and not in the bbs of Japanese manufacture, nor in the digicons, G&G, Bioval or BBBMAX. This empirical data further supports those outlined in section 4 above.

7.7 Conclusion - The plastic and bio bbs expand and deform on impact and therefore are able to transfer more of their energy to the target than the BBBMAX. See section 6.1 to 6.4 above. Furthermore, empirical evidence confirms that most bbs are not made with the same high quality standards and materials than bbs of Japanese manufacture, nor of the digicons, G&G, Bioval or BBBMAX **(FIG I, J).**

8. Human Target

This test does not in any way represent a homologation test of the bb ammunition involved. This test is dangerous and must not be repeated by the reader. This test was conducted under the supervision of a qualified medical technician in a controlled environment against volunteers and simulators. We also strongly advise all airsoft players to wear homologated protective full face gear, gloves with plastic inserts and heavy clothing over the arms and legs.

8.1 Plastic and bio degradable bbs are softer than other harder types of bbs (ex. Some metal alloy and BBBMAX) and our tests show that they may cause greater damage to human skin and bone tissue than hard bb projectiles. Most airsoft bb injuries are caused by impacts on skin tissue in the legs/arms and to the cortical bone tissue in the hands. The degree of these injuries depends upon the bb mass, velocity and the material that it is made of. The physiological limitations (in this case, the resistance to impacts) of human skin, subcutaneous tissue and bone depends strongly on many factors such as for example, age group, skin type and bone type. There is a great amount of literature on this subject and it has been found that the impact energy threshold will vary considerably from person to person and from age group to age group and may be significantly lower for many players. A very good database of high energy impact injuries has been formed over the years in the sport of paintball. For example, there have been recorded instances of fractured collar bones caused by impacting paintballs at low energies. Paintball impact forces are many times more powerful than those of airsoft bb impacts and can cause very serious injuries. Due to the very low bb velocities in airsoft, serious injuries caused by bbs occur less often and are mainly caused by the negligent behavior of the players themselves. The main areas of serious bb impact injury are the eyes and teeth. Other more common impact injuries occur to the skin surface of the face, the hands and on the legs/arms. Simple and inexpensive protective gear can be adopted to virtually eliminate the risk of injuries caused by bb impacts: full face protection (excluding wire mesh masks), gloves with plastic inserts and thicker clothing.

8.2 - Human Surface and Subcutaneous Tissue (HSST) – Human skin (specific weight of 1.09) is considered very resistant to ballistic injury and has required a lot of research over many decades to establish a sound database of ballistic evidence. It must be noted that this study does not deal with penetration of the skin but only with surface injury. Generally, as the bb projectile begins to impact skin, the retarding force of the skin itself causes it to decelerate and lose kinetic energy. This rapid deceleration causes the bb to deform as it expands against the skin surface thus (a) increasing its cross-sectional area towards the impact axis and (b) transferring more of its kinetic energy into the HSST. Softer bbs will deform more readily and will therefore transfer more energy to the HSST and over a greater/deeper area than will harder bbs. An impacting bb causes crushing, laceration, stretching and contusion of the tissue in front and around it. There are many models used to represent the size of the wound, one of the simplest to understand is expressed as follows:

$$Ed = Cv * V$$

Where:
Ed - is dissipated energy
Cv – is a constant depending on the properties of the target material, in this case skin
V – wound size or total inflicted area

Therefore the size of the inflicted area is directly proportional to the dissipated energy *Ed*. The dissipated energy depends upon the time the bb remains in contact with the skin. We know from the laws of physics that (1) the result of any impact between two objects depends on the force and time during which the objects are in contact; (2) the time the two impacting objects remain in contact depends on the material properties of the two objects; (3) the softer the objects the more time they will remain in contact. Soft bbs impacting on HSST will remain on the impact zone for a longer period of time therefore dissipating more energy into the HSST and causing bigger and deeper wounds **(FIG K, L).**

8.2.1 - Human Bone Tissue (HBT) – Bone has greater density (specific weight of 1.11) and strength than the surrounding tissue. It is also non-elastic. It goes without saying that volunteers for this test were not forthcoming and, therefore, a suitable simulator was sought. There are a number of sources that manufacture simulated bones used for medical training applications and ballistic tests. These are manufactured from specially formulated polyurethane foam forming a cancellous inner core and a harder outer shell simulating cortical bone. During ballistics testing these products have been shown to fracture in a manner very similar to natural bone providing an excellent reproducible simulation. Simulating a bone impact injury for the sport of airsoft is very difficult since (a) the bb velocities involved are very low; (b) an accurate simulation requires that a substance simulating skin be placed over the simulated bone target area; (c) the most exposed part of the player are the bones is in the hands. To the best of our knowledge, a suitable substance simulating skin has yet to be found. Therefore, any test results would need to take this into account. Nevertheless, since it is our opinion that the great majority of injuries would be restricted to the cortical bone structures in the knuckles and fingers we can assume that the amount of skin and muscle protecting these areas is minimal when compared to other areas of the body. *In any case, tests show that all bbs will cause some damage to cortical bone structures and there is ample evidence from the field of broken teeth caused by bbs of all weight classes and types (though teeth are not considered bones)*. The observed difference in the degree of injury will decrease as (a) the simulated target is placed further away from the muzzle of the gas gun; (b) the velocity of the bbs fired is lowered; (c) a combination of distance and speed thereof. It is beyond the scope of this study to present detailed damage assessment since it is not our intention to mislead the reader into believing that some bbs are more or less safe in this regard. Any damage to bones and teeth is serious and therefore adequate protection must be adopted in order to avoid the risk of injury. Many low cost solutions are readily available. Nevertheless, our evidence points to the same conclusions reached in other areas of this study: soft bbs may cause the same if not greater damage due to their tendency to deform and expand on impact **(FIG M).**

8.2.2 Injuries to the muscle mass in the legs and arms are also avoidable but will necessarily be more common since habitually players will wear a simple BDU over these areas. *Again it is within the scope of this study to present detailed information regarding this specific test but it is not our intention to mislead the reader into believing that some bbs are more or less safe. Preventing injuries of this type is easily achieved with the adoption of adequate protective equipment.* We have chosen, therefore, to present this evidence in more detail. In the following test the bbs were fired at human volunteer targets for visual recording and measurement of surface injury. The distance between the muzzle of the gas gun and the human target was 5 meters (V5). A survey of the volunteers was taken to decide the location of impact and the front thigh muscle was elected. The muzzle was aimed at the front thigh muscle mass with a BDU placed tight against the skin over the impact zone. A medical technician was called upon to supervise the test and to make periodic visual inspections and observations of the individual wounds over a period of 4 days.

8.3 A cross section of plastic, bio, hard and heavy bbs was selected and used for this test: a 0.20g, 0.25g, 0.28, BBBMAX and the 0.43g Digicon. The test gun was set at speed rating 130 and 170 (see 5.3 above) and were fired into the target area selected by the volunteers.

8.4 Two types of damage were noted. The first was in the immediate impact area of the bb and the second was in the tissue surrounding the impact point.

8.5 Digicon 0.43g – the unlucky volunteer that was struck at V5 with this bb at speed rating 130 and 170 presented massive surface wounding and broken skin. The BDU held tight over the skin caused the bb to expand and deform permanently at both 130 and 170. At 170 the bb caused a wound that was 10mm in diameter with an impact area 8mm in diameter. The wound also caused hardening of tissue in depth and radiating out from the impact area suggesting sub surface damage. The wound was a uneven combination of broken skin and subcutaneous hematoma radiating out from the impact point. At both speed ratings the wound was still evident and actually expanded on the second day after the test. Only on day three was the wound noted to diminish in size. On day 4 the impact zone and the subcutaneous hematoma were still visible. The volunteer complained of pain even on day four.

8.6 0.28g – Same damage as observed in 8.5 above. At 170 the damage area was larger than that of the digicon suggesting much more expansion of the bb due to the faster speed and force of impact. On day 4 the observations were the same as in 8.5 above.

8.7 0.25g – Due to the faster speed of the bb and therefore of the impact force the wound caused by the impact of this bb was larger than that of the Digicon and that of the 0.28g bb. The wound can be described in the same terms as in 8.5 above and diminished in size only on day 3 and 4.

8.8 BBBMAX – The wound caused by the BBBMAX fired at 170 was fundamentally different from that of the other bbs tested. Immediately no impact point was identified suggesting that it was very small. The total measured size of the wound was 13mm in diameter and can be described as a subcutaneous hematoma. After only 5 hours the wound changed dramatically as the hematoma began to be absorbed and a small impact point 3mm in diameter became apparent. After 24 hours the impact point completely disappeared and only slight bruising was apparent. Day 4 the size of the wound was smaller with obvious signs of healing. This difference can be attributed to the fact that the BBBMAX does not expand on impact and therefore is unable to transfer energy to the target as efficiently as the other bbs tested. This also explains the very focused and small impact point identified after 5 hours from impact.

8.9 0.20g – The most interesting results were observed from the impact of the 0.20g bb fired at the same volunteer that was struck with the BBBMAX (opposite leg). This wound was a massive 15mm in diameter with a very large impact point measuring 7mm in diameter. The image taken immediately after impact shows a barely visible subcutaneous hematoma around the lower part of the open wound suggesting a very deep injury. On day 4 the wound was still 10mm in diameter with an impact point 4mm in diameter. This compelling evidence further supports the results from previous tests: plastic and bio plastic bbs expand and deform on impact causing damage that is in proportion much larger than their diameter and much larger than their immediate frontal impact areas.

8.10 Conclusion: Impacts on human skin and subcutaneous tissue. The evidence shows that the BBBMAX causes less damage to human targets since the structure of the bb itself does not allow for an efficient transfer of energy upon impact. This test leads us to believe that plastic and bio bbs can potentially cause more damage to skin tissue than harder bbs. Moreover, our evidence allows us to conclude that the softer the bb the more damage it causes to skin tissue.

9. Conclusions

The aim of this study was to determine the performance and safety of the bb ammunition tested. We believe that the tested number, weight, brand and country of manufacture represents an accurate cross-section of the market in general.

9.1 The empirical evidence accumulated allows us to conclude that all the tested bb ammunition is safe for use in the sport/game of airsoft. We suggest the use of certified full face and hand protection (in the form of gloves with plastic inserts) and minimum engagement distances to be adopted.

9.2 Bbs in general can be divided into 2 very broad categories:

SOFT - Bbs made of plastic, of bio degradable materials, and of some low grade metal alloys are defined as soft and will cause more damage (on human skin and materials) when compared to hard bbs. We stress this point throughout this study since it is a commonly overlooked factor when assessing damage and the potential for damage. This is due to the elastic properties of the materials used to make these bbs. Upon impact these bbs will deform and expand causing the bb to (a) remain in contact with the impact area for a much longer period of time than harder bbs; (b) produce damage on a much larger area in the impact zone. Soft bbs transfer energy more efficiently to the impact area when compared to the harder bbs.

HARD - Bbs such as the BBBMAX are defined as hard. These bbs will not deform on impact. This characteristic drastically reduces the time they remain in contact with the impact point relative to their softer competitors described in 9.2 above. This means that a lower amount of energy is transferred from the bb to the impact area. A large proportion of the energy is dissipated by the bb as it rebounds off the impacted area.

9.4 Good ballistic performance depends entirely on consistent density and consistent sphericity within a bb, from bb to bb and within the same lot of a particular manufacturer. In this regard, the BBBMAX markedly stands out from the rest of the bbs tested and represents as near an ideal spherical projectile as we have ever tested. The material used to manufacture BBBMAX obviously allows this projectile to better cope with the forces it is interacting with both in the barrel of the gun and as it travels along its intended trajectory. Of the more traditional bbs, those of Japanese manufacture, the bioval bio bbs and the digicons outperformed their competitors by a wide margin.

Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland

Test b908

ANNEX

TESTED BRANDS & WEIGHTS	BIODEGRADABLE						PLASTIC										
	0,20	0,23	0,25	0,27	0,30	0,32	0,20	0,22	0,23	0,25	0,28	0,29	0,30	0,33	0,35	0,36	0,43
1st Target Rough	•	•	•				•		•	•	•			•			
1st Target Smooth							•						•				
Airsoft Elite	•		•				•		•	•							
Airsplat	•		•														
BCB							•		•	•	•						
Bioval BBB	•	•	•		•	•											
Bioval BBBMAX				•													
Blaster							•										
Digicom	•						•						•			•	•
Excel	•	•	•				•		•	•							
Extreme Precision	•						•		•	•	•		•				
G&G	•		•				•			•	•						
Green Devil	•																
HFC							•			•							
ICS							•			•							
KSC							•			•			•				
Kurata							•			•							
LH Super Grade			•				•			•	•			•			
Marui	•						•			•			•				
Marushin							•			•							
Maruzen							•			•		•	•				
Matrix							•										
PHX	•						•			•							
Sansei																	
SIIS							•			•	•		•	•			
Stinger							•										
Super King	•		•				•		•	•							
Systema							•										
TFC							•		•	•	•		•				
Toy-Jet							•			•	•		•				
TSD tactical	•						•		•	•	•						
WA								•									

Fig.1

Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland

Test b908

DENSITY CONSISTENCY	BIODEGRADABLE						PLASTIC										
	0,20	0,23	0,25	0,27	0,30	0,32	0,20	0,22	0,23	0,25	0,28	0,29	0,30	0,33	0,35	0,36	0,43
1st Target Rough	xx	xx	xx				xx		xx	xx	xx			xx			
1st Target Smooth							xx						xx				
Airsoft Elite	x		x				x		x	x							
Airsplat	xx		xx														
BCB							x		x	x	x						
Bioval BBB	••	••	••		••	••											
Bioval BBBMAX				•••													
Blaster							xx										
Digicom	=						=						••			••	••
Excel	=	=	=				=		=	•							
Extreme Precision	xx						xx		xx	xx	xx		xx				
G&G	x		=				x			=	•						
Green Devil	x																
HFC							xx			xx							
ICS							xx			xx							
KSC							xx			xx			xx				
Kurata							x			x							
LH Super Grade			=				x			x	x			=			
Marui	•						••			••			••				
Marushin							••			••							
Maruzen							••			••		••	••				
Matrix							xx										
PHX	xx						xx			xx							
Sansei							xx			xx							
SIIS							=			=	=		=	=			
Stinger							xx										
Super King	xx		xx				x		xx	=							
Systema							•										
TFC							xx		xx	xx	xx		xx				
Toy-Jet							•			•	•		•				
TSD tactical	xx						xx		xx	xx	xx						
WA								•									

Density Consistency

- ••• Excellent
- •• Very Good
- • Good
- = Fair
- x Poor
- xx Very Poor

Fig.2

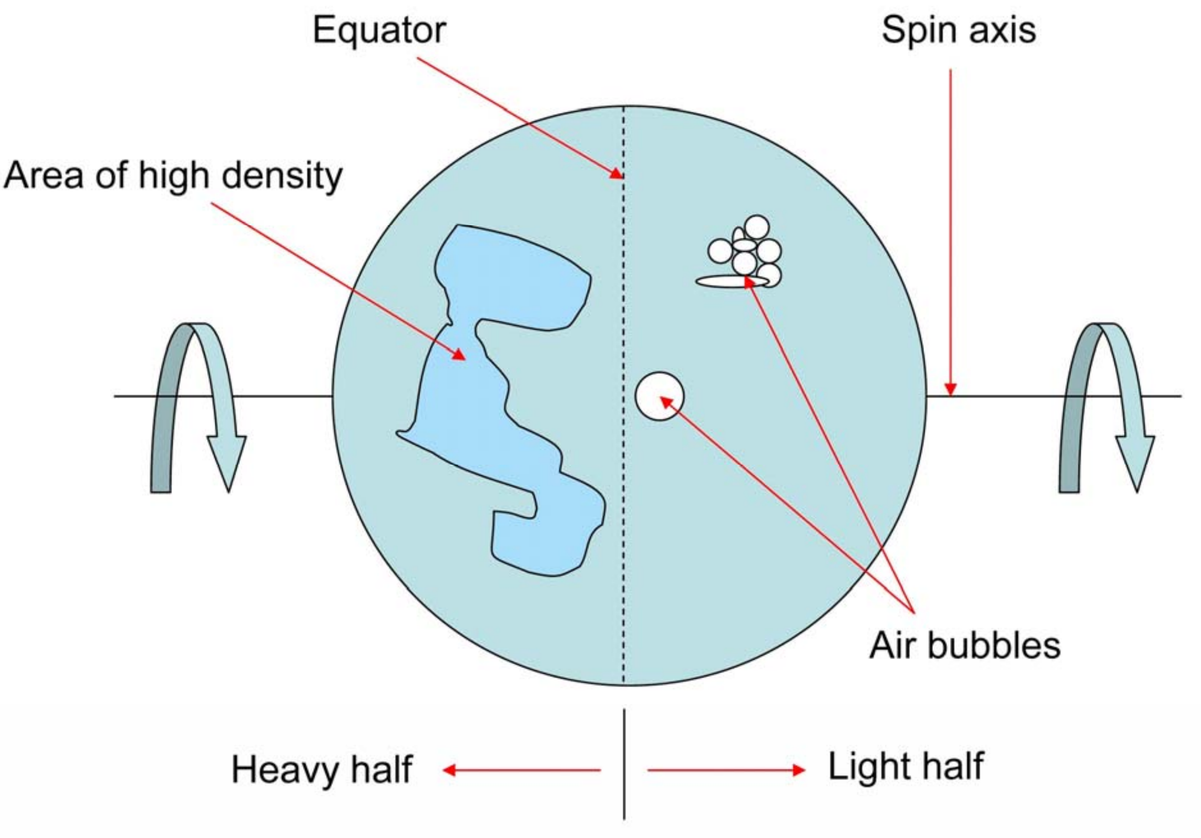

Equator
Spin axis
Area of high density
Air bubbles
Heavy half
Light half

Fig.3

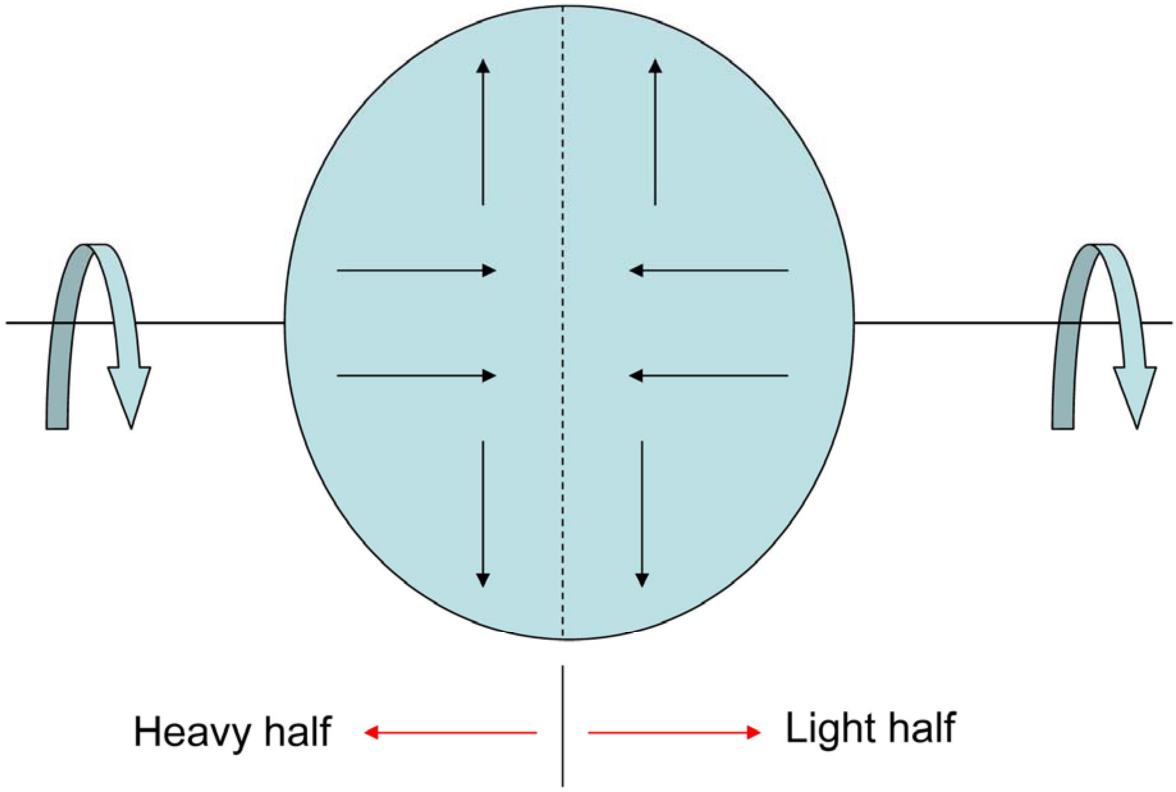


Fig.4

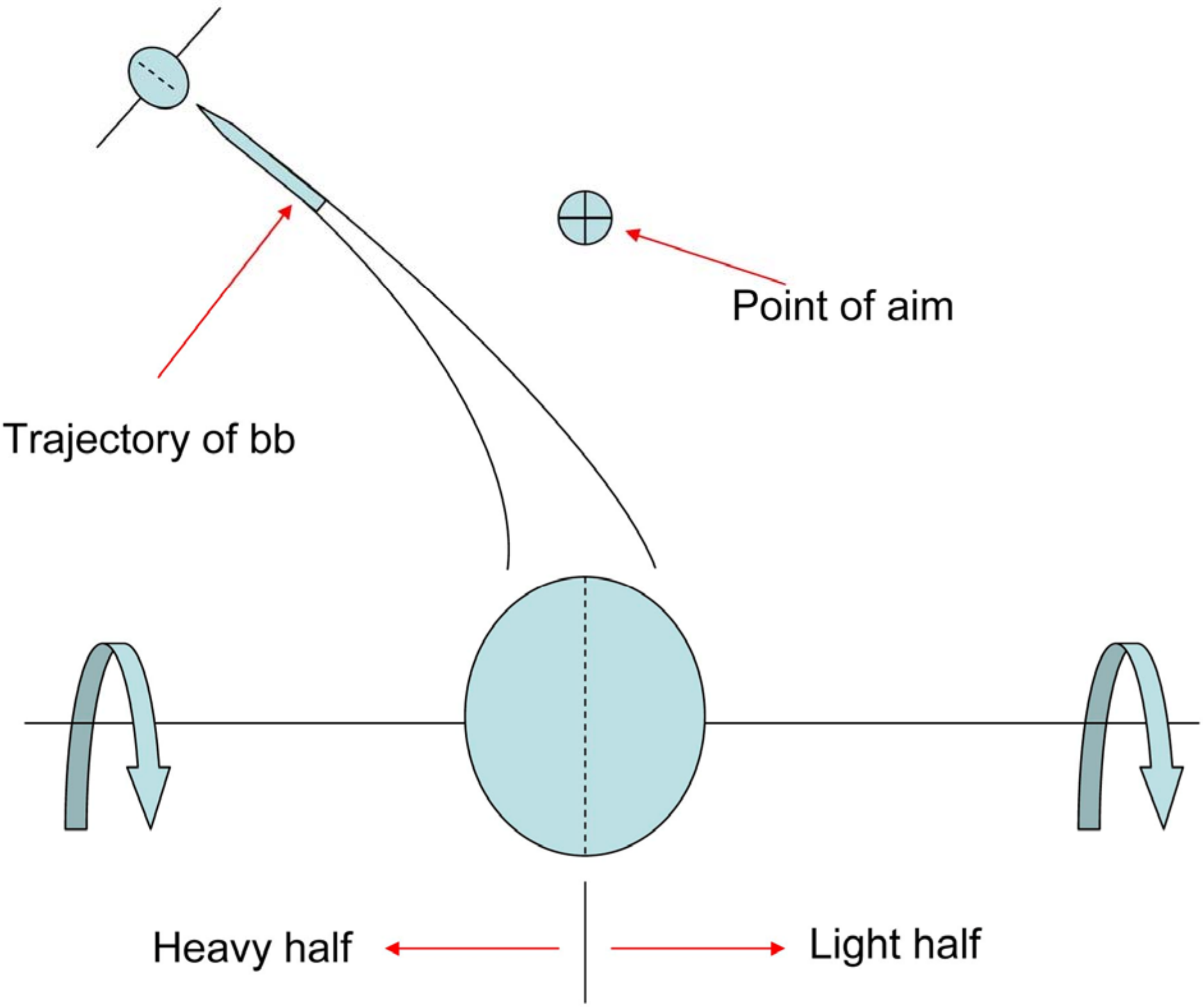


Fig.5

Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland

Test b908

SPHERICAL CONSISTENCY	BIODEGRADABLE						PLASTIC										
	0,20	0,23	0,25	0,27	0,30	0,32	0,20	0,22	0,23	0,25	0,28	0,29	0,30	0,33	0,35	0,36	0,43
1st Target Rough	xx	xx	xx				xx		xx	xx	xx			xx			
1st Target Smooth							xx						xx				
Airsoft Elite	x		x				x		x	x							
Airsplat	x		x														
BCB							x		x	x	x						
Bioval BBB	•	•	•		•	•											
Bioval BBBMAX				••													
Blaster							xx										
Digicom	=						=						•			•	•
Excel	=	=	=				=		=	=							
Extreme Precision	x						x		x	x	x		x				
G&G	x		=				x			=	=						
Green Devil	x																
HFC							xx			xx							
ICS							xx			xx							
KSC							xx			xx			xx				
Kurata							x			x							
LH Super Grade			=				x			x	x			=			
Marui	•						•			•			•				
Marushin							•			•							
Maruzen							•			•		•	•				
Matrix							xx										
PHX	xx						xx			xx							
Sansei							xx			xx							
SIIS							=			=	=		=	=			
Stinger							=										
Super King	x		x				x		x	=							
Systema							=										
TFC							xx		xx	xx	xx		xx				
Toy-Jet							=			=	=		=				
TSD tactical	xx						xx		xx	xx	xx						
WA								=									

Spherical Consistency

•••	Excellent
••	Very Good
•	Good
=	Fair
x	Poor
xx	Very Poor

Fig.6

V0 100	BIODEGRADABLE						PLASTIC										
	0,20	0,23	0,25	0,27	0,30	0,32	0,20	0,22	0,23	0,25	0,28	0,29	0,30	0,33	0,35	0,36	0,43
Control bb 020							100,0										
Control bb 025										90,0							
Control bb 030													80,0				
1st Target Rough	97,5	93,2	92,2				96,9		93,0	92,0	77,2			75,2			
1st Target Smooth							98,4						79,5				
Airsoft Elite	98,3		92,5				98,6		92,1	92,4							
Airsplat	98,4		93,1				98,9										
BCB							98,5		91,0	90,0	77,5						
Bioval BBB	103,1	95,0	94,3		83,5	81,5											
Bioval BBBMAX				101,3													
Blaster							97,1										
Digicom	98,2						99,8						83,2			76,8	64,3
Excel	99,3	94,0	93,0				100,0		94,2	93,1							
Extreme Precision	98,5						97,8		93,3	92,1	78,2		79,8				
G&G	101,3		93,5				100,1			93,4	84,2						
Green Devil	98,3																
HFC							97,5			90,1							
ICS							97,1			91,0							
KSC							96,9			91,7			79,6				
Kurata							99,8			93,8							
LH Super Grade			92,5				96,9			92,8	78,9			76,1			
Marui	101,5						100,2			94,0			82,5				
Marushin							100,4			93,9							
Maruzen							100,1			94,2		83,0	82,9				
Matrix							94,5										
PHX	99,2						97,5			92,7							
Sansei							97,3			92,6							
SIIS							99,8			93,9	80,0		82,4	78,2			
Stinger							99,0										
Super King	97,4		90,5				97,5		91,5	90,2							
Systema							103,7										
TFC							97,4		92,5	91,7	77,2		78,5				
Toy-Jet							100,0			93,9	83,0		82,0				
TSD tactical	96,2						97,5		91,0	90,2	77,2						
WA								96,2									

Fig.7

Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland
Test b908

V0 130	BIODEGRADABLE						PLASTIC										
	0,20	0,23	0,25	0,27	0,30	0,32	0,20	0,22	0,23	0,25	0,28	0,29	0,30	0,33	0,35	0,36	0,43
Control bb 020							130,0										
Control bb 025										118,0							
Control bb 030													108,0				
1st Target Rough	126,5	117,0	114,8				126,7		117,1	114,5	104,2			98,6			
1st Target Smooth							127,6						101,7				
Airsoft Elite	127,8		115,8				127,7		116,0	115,2							
Airsplat	126,3		115,2				126,2										
BCB							125,2		114,7	113,2	103,7						
Bioval BBB	133,0	121,6	120,1		107,0	103,8											
Bioval BBBMAX				121,1													
Blaster							125,7										
Digicom	127,5						129,4						107,1			97,2	88,2
Excel	128,0	118,2	116,7				128,4		118,5	117,0							
Extreme Precision	124,7						125,2		113,2	113,0	102,4		101,2				
G&G	129,8		119,6				100,1			119,5	110,0						
Green Devil	127,9																
HFC							125,4			114,0							
ICS							126,2			114,2							
KSC							125,8			115,7			102,3				
Kurata							129,9			119,2							
LH Super Grade			92,5				126,1			115,1	103,4			76,1			
Marui	130,0						130,0			120,2			107,1				
Marushin							131,8			120,0							
Maruzen							133,1			120,1		109,1	107,2				
Matrix							126,2										
PHX	125,0						125,0			92,7							
Sansei							125,7			92,6							
SIIS							129,6			93,9	109,8		106,8	100,1			
Stinger							124,2										
Super King	125,8		116,0				125,7		114,7	116,0							
Systema							131,0										
TFC							124,8		114,9	116,0	104,2		102,4				
Toy-Jet							100,0			119,8	110,0		106,9				
TSD tactical	125,3						125,3		114,7	117,4	102,4						
WA								124,5									

Fig.8

V0 170	BIODEGRADABLE						PLASTIC										
	0,20	0,23	0,25	0,27	0,30	0,32	0,20	0,22	0,23	0,25	0,28	0,29	0,30	0,33	0,35	0,36	0,43
Control bb 020							160,0										
Control bb 025										170,0							
Control bb 030													160,0				
1st Target Rough	162,6	153,5	166,0				161,8		154,1	166,1	156,2			145,3			
1st Target Smooth							162,0						155,7				
Airsoft Elite	162,8		165,5				162,2		153,1	165,8							
Airsplat	161,2		164,9				161,5										
BCB							162,2		152,0	166,0	156,3						
Bioval BBB	166,8	157,5	170,1		156,0	151,4											
Bioval BBBMAX				164,0													
Blaster							161,2										
Digicom	167,9						167,8						156,2			144,0	143,5
Excel	160,2	155,4	166,4				160,2		155,3	167,0							
Extreme Precision	162,8						163,0		152,0	168,0	158,0		156,0				
G&G	163,0		167,0				163,2			170,2	160,7						
Green Devil	162,0																
HFC							162,7			165,9							
ICS							160,1			164,0							
KSC							162,0			165,2			155,7				
Kurata							160,0			166,0							
LH Super Grade			164,0				161,9			165,2	159,0			149,0			
Marui	165,5						165,2			167,0			156,0				
Marushin							164,3			167,3							
Maruzen							160,2			165,0		155,6	155,8				
Matrix							160,1										
PHX	161,5						160,4			164,0							
Sansei							161,0			165,0							
SIIS							162,1			167,3	159,7		155,6	149,2			
Stinger							161,3										
Super King	165,0		170,0				165,0		155,0	170,0							
Systema							167,8										
TFC							163,0		154,8	166,1	158,9		155,8				
Toy-Jet							165,0			167,2	160,1		156,0				
TSD tactical	161,0						163,2		154,7	165,7	160,0						
WA								154,2									

Fig.9

Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland

Test b908

V10 100	BIODEGRADABLE						PLASTIC										
	0,20	0,23	0,25	0,27	0,30	0,32	0,20	0,22	0,23	0,25	0,28	0,29	0,30	0,33	0,35	0,36	0,43
Control bb 020							58,00										
Control bb 025										59,1							
Control bb 030													56,56				
1st Target Rough	59,0	60,0	62,9				60,0		60,1	61,8	56,0			51,3			
1st Target Smooth							61,0						55,6				
Airsoft Elite	59,4		61,0				60,3		61,5	61,0							
Airsplat	58,1		59,0				60,1										
BCB							59,0		60,0	61,0	55,0						
Bioval BBB	62,2	63,3	63,4		57,9	57,9											
Bioval BBBMAX				70,0													
Blaster							59,4										
Digicom	57,6						62,0						58,0			52,0	50,4
Excel	60,0	61,6	62,4				61,0		61,3	62,2	56,0						
Extreme Precision	57,7						57,8		58,0	59,7	55,7		56,0				
G&G	61,8		62,5				61,7			62,7	58,2						
Green Devil	59,0																
HFC							59,5			60,0							
ICS							57,3			58,7							
KSC							57,9			58,5			55,8				
Kurata							60,2			62,0							
LH Super Grade			59,0				57,8			58,9	55,8			52,2			
Marui	58,8						60,3			63,2			58,1				
Marushin							61,0			63,2							
Maruzen							58,1			61,9		58,0	58,8				
Matrix							54,3										
PHX	58,2						57,3			59,0							
Sansei							56,2			58,5							
SIIS							58,0			59,4	58,9		57,7	53,6			
Stinger							58,2										
Super King	57,8		59,0				57,9		59,0	60,4							
Systema							60,8										
TFC							58,9		58,3	59,8	56,1		56,8				
Toy-Jet							60,7			62,7	58,6		58,2				
TSD tactical	55,0						56,0		58,2	59,7	56,0						
WA								61,0									

Fig.10

Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland

Test b908

V10 130	BIODEGRADABLE						PLASTIC										
	0,20	0,23	0,25	0,27	0,30	0,32	0,20	0,22	0,23	0,25	0,28	0,29	0,30	0,33	0,35	0,36	0,43
Control bb 020							74,6										
Control bb 025										76,5							
Control bb 030													76,9				
1st Target Rough	75,4	76,1	77,4				75,6		76,5	77,2	76,0			71,8			
1st Target Smooth							76,0						74,6				
Airsoft Elite	75,6		76,9				76,5		75,8	77,0							
Airsplat	75,2		76,8				76,3										
BCB							75,7		76,5	76,8	75,7						
Bioval BBB	80,6	81,7	81,1		78,5	78,8											
Bioval BBBMAX				83,9													
Blaster							75,7										
Digicom	74,3						76,3						76,0			72,0	69,6
Excel	76,4	77,0	77,4				76,1		76,4	77,0	76,5						
Extreme Precision	75,2						75,8		75,6	76,5	75,0		74,0				
G&G	76,7		77,9				76,2			77,0	77,3						
Green Devil	75,0																
HFC							75,0			76,1							
ICS							74,0			75,3							
KSC							74,1			75,6			74,0				
Kurata							75,8			76,1							
LH Super Grade			75,6				75,2			76,2	74,6			72,0			
Marui	77,0						77,2			78,0			76,0				
Marushin							76,0			77,0							
Maruzen							79,1			80,0		75,5	76,0				
Matrix							75,2										
PHX	75,1						75,0			76,0							
Sansei							75,1			76,0							
SIIS							77,2			78,0	77,4		76,0	73,3			
Stinger							75,4										
Super King	75,2		77,3				76,0		76,7	77,6							
Systema							77,7										
TFC							75,6		75,4	76,9	75,4		75,8				
Toy-Jet							77,5			78,3	77,3		77,0				
TSD tactical	75,0						75,7		75,5	76,4	75,4						
WA								76,0									

Fig.11

Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland

Test b908

V10 170	BIODEGRADABLE						PLASTIC										
	0,20	0,23	0,25	0,27	0,30	0,32	0,20	0,22	0,23	0,25	0,28	0,29	0,30	0,33	0,35	0,36	0,43
Control bb 020							96,10										
Control bb 025										107,5							
Control bb 030													111,4				
1st Target Rough	97,4	98,1	108,5				96,6		76,5	107,3	109,0			112,3			
1st Target Smooth							97,9						111,6				
Airsoft Elite	96,4		107,4				97,5		75,8	107,9							
Airsplat	95,3		108,3				97,4										
BCB							97,3		76,5	106,8	109,6						
Bioval BBB	100,7	105,8	109,8		112,5	114,1											
Bioval BBBMAX				110,6													
Blaster							98,4										
Digicom	96,4						100,0						112,5			114,0	113,5
Excel	98,9	103,5	108,5				99,7		103,0	108,7	109,5						
Extreme Precision	95,3						96,6		100,0	107,0	108,8		110,0				
G&G	98,9		108,7				100,0			109,0	109,0						
Green Devil	97,3																
HFC							97,4			106,6							
ICS							96,4			105,9							
KSC							98,9			106,8			109,8				
Kurata							99,0			108,2							
LH Super Grade			107,6				95,6			105,4	107,3			111,9			
Marui	101,0						101,0			110,0			112,9				
Marushin							102,0			110,3							
Maruzen							100,0			109,6		111,3	112,6				
Matrix							95,7										
PHX	96,3						96,2			106,8							
Sansei							95,5			106,4							
SIIS							99,0			108,7	108,4		111,1	112,5			
Stinger							96,6										
Super King	97,5		107,5				97,8		101,0	106,8							
Systema							98,3										
TFC							97,6		101,3	105,8	106,0		109,0				
Toy-Jet							99,0			108,3	109,2		110,2				
TSD tactical	96,5						96,9		101,9	106,0	106,9						
WA								104,0									

fig.12

Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland

Test b908

V20 100	BIODEGRADABLE						PLASTIC										
	0,20	0,23	0,25	0,27	0,30	0,32	0,20	0,22	0,23	0,25	0,28	0,29	0,30	0,33	0,35	0,36	0,43
Control bb 020							34,5										
Control bb 025										38,9							
Control bb 030													39,4				
1st Target Rough		37,2	39,0						37,6	39,0	41,0			40,2			
1st Target Smooth													39,2				
Airsoft Elite			38,4						37,2	38,9							
Airsplat			37,6														
BCB									36,0	38,1	41,2						
Bioval BBB	37,7	40,5	41,7		40,9	41,7											
Bioval BBBMAX				47,6													
Blaster																	
Digicom	36,9						36,8						39,4			40,1	39,9
Excel	35,0	37,4	39,0				35,3		37,1	39,4	40,0						
Extreme Precision									36,0	38,2	39,5		39,5				
G&G	36,5		40,0				36,8			40,9	41,0						
Green Devil																	
HFC										38,9							
ICS										38,0							
KSC										37,2			38,5				
Kurata							36,5			38,7							
LH Super Grade			39,1							38,0	39,0			40,0			
Marui	37,9						37,8			42,0			41,4				
Marushin							37,6			42,1							
Maruzen							34,8			41,9		39,3	41,0				
Matrix																	
PHX										35,6							
Sansei										36,0							
SIIS							34,2			40,0	41,0		38,7	40,0			
Stinger																	
Super King			39,9							39,5							
Systema							34,7										
TFC										38,9	40,3		38,9				
Toy-Jet							33,5			39,4	41,1		40,0				
TSD tactical										38,9	40,2						
WA								38,0									

Fig.13

Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland

Test b908

V20 130	BIODEGRADABLE						PLASTIC										
	0,20	0,23	0,25	0,27	0,30	0,32	0,20	0,22	0,23	0,25	0,28	0,29	0,30	0,33	0,35	0,36	0,43
Control bb 020							44,7										
Control bb 025										50,8							
Control bb 030													53,9				
1st Target Rough		50,3	50,9						50,3	50,9	51,6			56,8			
1st Target Smooth													54,0				
Airsoft Elite			49,5						50,2	50,8							
Airsplat			48,9														
BCB									50,4	50,9	51,4						
Bioval BBB	47,9	51,7	51,9		56,2	57,4											
Bioval BBBMAX				57,2													
Blaster																	
Digicom	46,6						47,0						53,8			56,4	55,1
Excel	46,9	50,0	50,6				46,8		50,2	50,8	51,4						
Extreme Precision									49,9	50,1	50,9		53,9				
G&G	46,0		50,2				47,1			50,3	50,8						
Green Devil																	
HFC										50,2							
ICS										50,5							
KSC										49,9			55,0				
Kurata							47,2			50,9							
LH Super Grade			50,3							49,7	50,1			56,0			
Marui	47,8						48,0			52,0			56,9				
Marushin							48,2			52,8							
Maruzen							48,2			52,9		55,0	56,8				
Matrix																	
PHX										50,8							
Sansei										49,9							
SIIS							47,2			50,8	51,2		53,2	54,0			
Stinger																	
Super King			49,2							50,4							
Systema							44,6										
TFC										50,5	51,3		53,4				
Toy-Jet							44,7			50,0	51,1		55,9				
TSD tactical										49,8	51,0						
WA								49,0									

Fig.14

Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland Test b908

V20 170	BIODEGRADABLE						PLASTIC										
	0,20	0,23	0,25	0,27	0,30	0,32	0,20	0,22	0,23	0,25	0,28	0,29	0,30	0,33	0,35	0,36	0,43
Control bb 020							54,8										
Control bb 025										72,9							
Control bb 030													78,6				
1st Target Rough		65,0	72,1						65,2	72,7	77,1			83,9			
1st Target Smooth													79,0				
Airsoft Elite			71,2						65,1	71,2							
Airsplat			72,3														
BCB									65,3	72,4	76,2						
Bioval BBB	59,5	68,0	73,9		81,9	84,3											
Bioval BBBMAX				78,7													
Blaster																	
Digicom	58,0						58,5						80,0			86,8	90,0
Excel	54,8	66,1	72,5				54,5		66,2	72,1	75,3						
Extreme Precision									65,1	69,0	72,5		78,4				
G&G	55,0		72,2				55,0			72,4	77,7						
Green Devil																	
HFC										71,3							
ICS										72,0							
KSC										71,5			78,3				
Kurata							55,3			72,8							
LH Super Grade			71,0							72,9	75,2			82,1			
Marui	58,1						59,5			74,0			83,2				
Marushin							59,9			73,9							
Maruzen							60,0			73,8		80,3	82,2				
Matrix																	
PHX										71,2							
Sansei										70,8							
SIIS							55,3			72,4	73,0		80,0	81,0			
Stinger																	
Super King			70,3							70,6							
Systema							57,0										
TFC										71,3	71,6		78,6				
Toy-Jet							57,8			72,4	73,0		79,0				
TSD tactical										71,7	72,2						
WA								67,6									

Fig.15

Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland

Test b908

V30 130	BIODEGRADABLE						PLASTIC										
	0,20	0,23	0,25	0,27	0,30	0,32	0,20	0,22	0,23	0,25	0,28	0,29	0,30	0,33	0,35	0,36	0,43
Control bb 020																	
Control bb 025										32,5							
Control bb 030													38,15				
1st Target Rough																	
1st Target Smooth																	
Airsoft Elite																	
Airsplat																	
BCB																	
Bioval BBB			34,7		39,6	41,4											
Bioval BBBMAX				39,4													
Blaster																	
Digicom													39,1			40,2	43,2
Excel																	
Extreme Precision																	
G&G										33,1	37,2						
Green Devil																	
HFC																	
ICS																	
KSC																	
Kurata																	
LH Super Grade																	
Marui										35,8			40,0				
Marushin										35,6							
Maruzen										35,7		39,1	39,5				
Matrix																	
PHX																	
Sansei																	
SIIS																	
Stinger																	
Super King																	
Systema																	
TFC																	
Toy-Jet																	
TSD tactical																	
WA																	

Fig 16

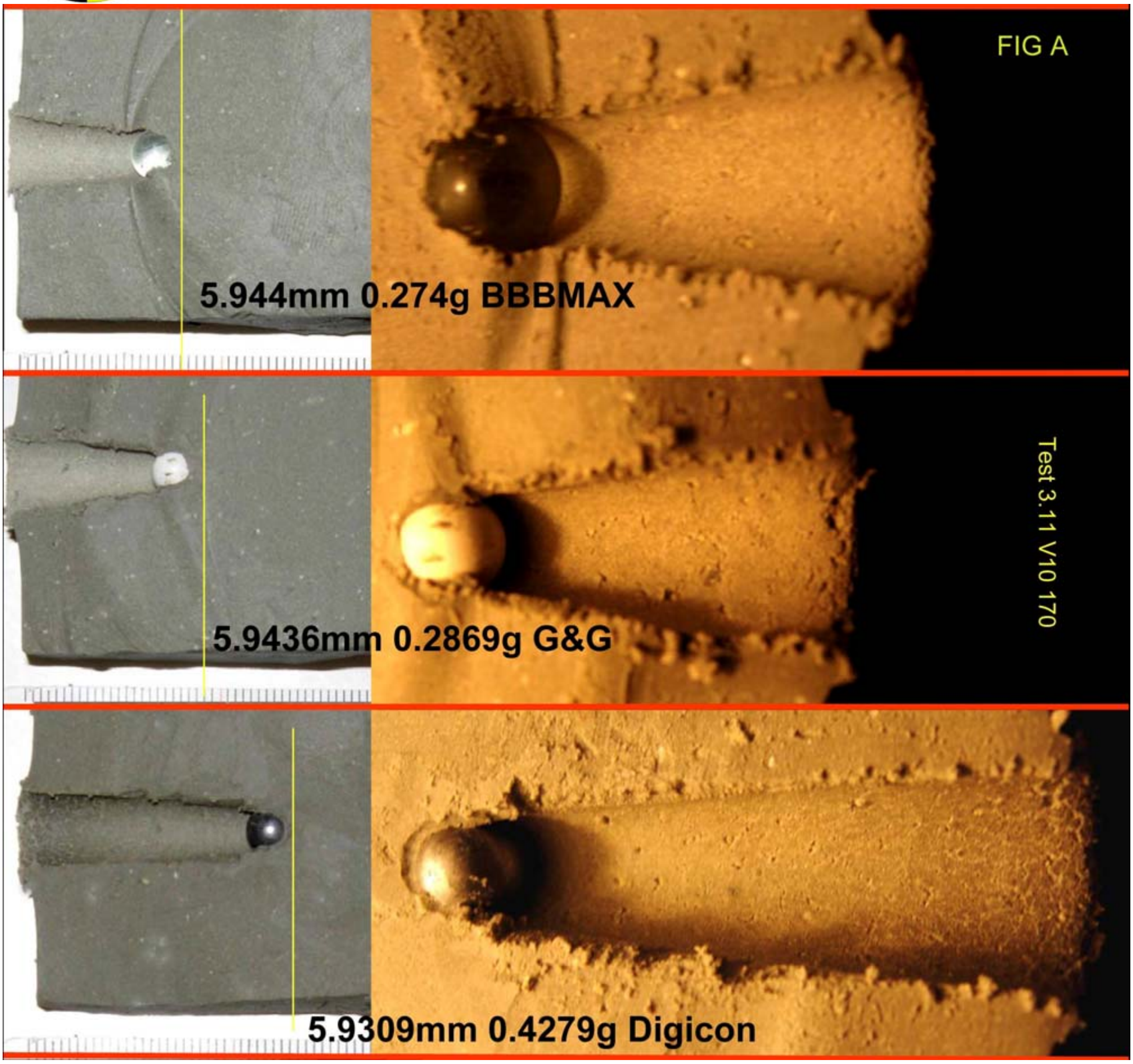
Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland

Test b908

V30 170	BIODEGRADABLE						PLASTIC										
	0,20	0,23	0,25	0,27	0,30	0,32	0,20	0,22	0,23	0,25	0,28	0,29	0,30	0,33	0,35	0,36	0,43
Control bb 020																	
Control bb 025										48,00							
Control bb 030													56,01				
1st Target Rough																	
1st Target Smooth																	
Airsoft Elite																	
Airsplat																	
BCB																	
Bioval BBB			49,8		57,9	61,4											
Bioval BBBMAX				53,5													
Blaster																	
Digicom													57,2			65,4	70,6
Excel																	
Extreme Precision																	
G&G										48,2	54,9						
Green Devil																	
HFC																	
ICS																	
KSC																	
Kurata																	
LH Super Grade																	
Marui										50,0			58,0				
Marushin										50,2							
Maruzen										49,9		57,5	57,7				
Matrix																	
PHX																	
Sansei																	
SIIS																	
Stinger																	
Super King																	
Systema																	
TFC																	
Toy-Jet																	
TSD tactical																	
WA																	

Fig.17

Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland Test b908



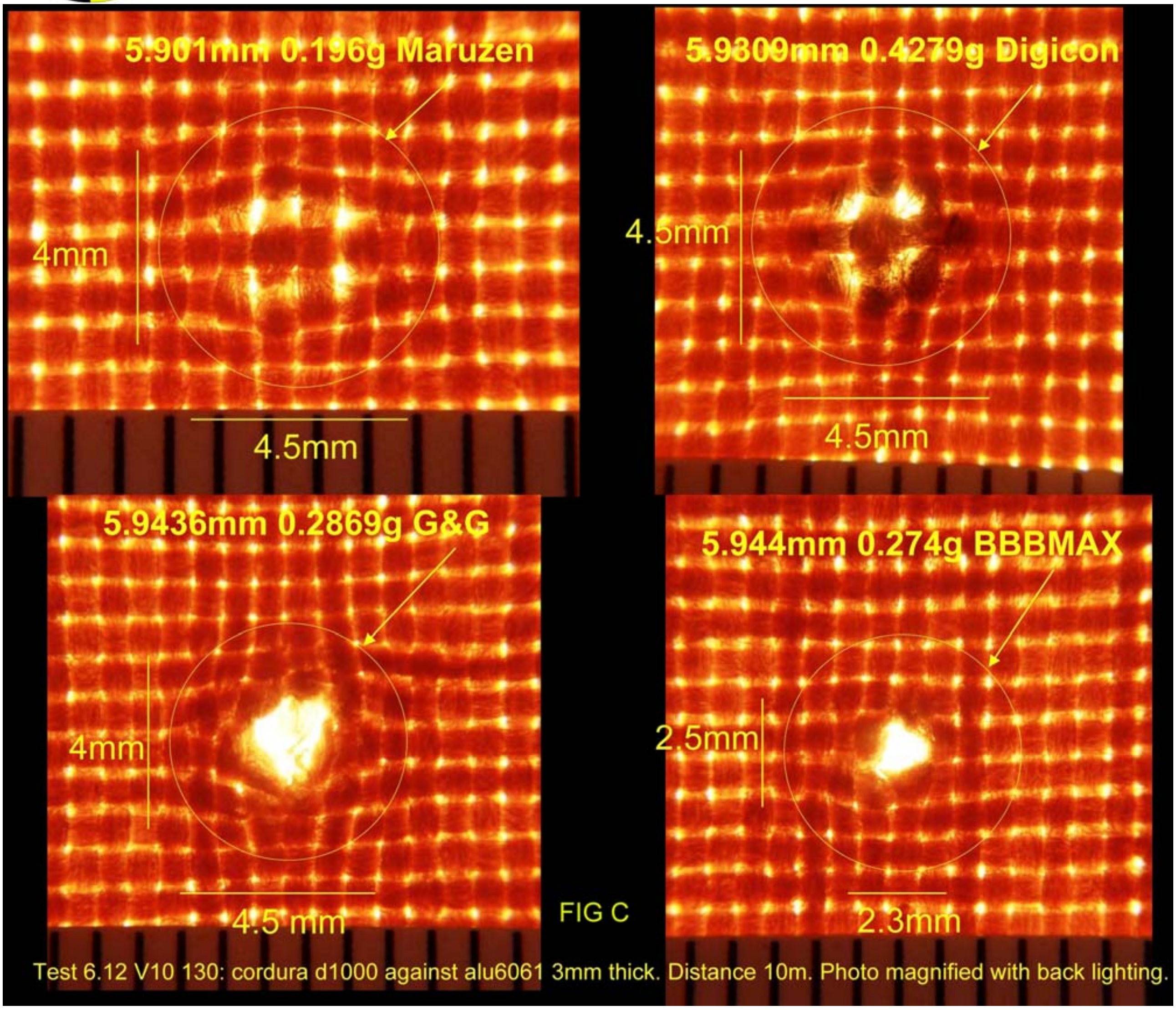
Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland Test b908

V0	100		130		170	
	Depth	Diameter	Depth	Diameter	Depth	Diameter
Maruzen 0.20g	10,01	7,47	15,95	8,97	24,10	12,72
Systema 0.20g	10,62	7,49	16,17	9,49	21,84	12,45
Bioval BBB 0.20g	11,01	7,48	15,94	9,01	24,16	12,51
Bioval BBB 0.25g	12,78	8,12	18,94	9,14	29,05	12,10
1st Target 0.25g	10,99	7,48	17,26	9,12	27,15	12,57
Super King Bio 0.25g	12,01	7,29	19,57	8,92	29,32	13,44
BBBMAX 0.27g	13,64	7,47	21,29	9,75	28,04	10,53
G&G 0.28g	13,69	7,72	20,47	9,62	23,10	10,67
Digicon 0.43g	13,64	5,99	19,91	8,05	32,44	10,08

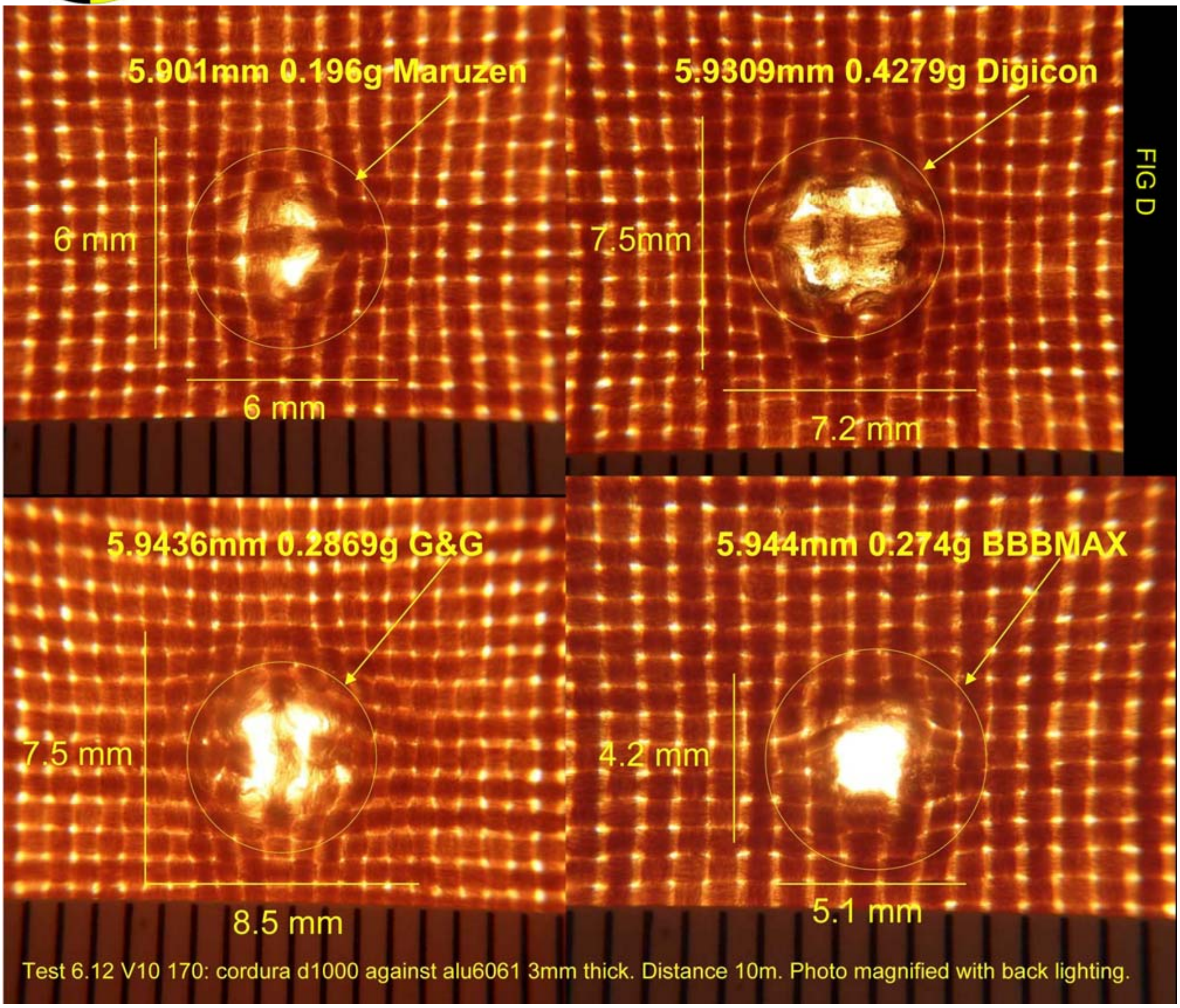
V10	100		130		170	
	Depth	Diameter	Depth	Diameter	Depth	Diameter
Maruzen 0.20g	6,62	5,70	10,37	7,12	15,39	9,47
Systema 0.20g	6,19	5,90	9,09	7,14	15,61	9,66
Bioval BBB 0.20g	8,53	6,02	10,52	7,47	14,73	8,70
Bioval BBB 0.25g	8,82	7,87	12,17	6,93	20,33	10,51
1st Target 0.25g	7,44	5,99	12,17	6,93	20,45	9,88
Super King Bio 0.25g	8,29	6,11	11,14	7,60	19,18	9,33
BBBMAX 0.27g	10,08	6,17	13,54	7,69	17,78	8,65
G&G 0.28g	8,31	6,08	14,38	8,31	21,38	13,51
Digicon 0.43g	10,08	5,99	16,89	5,94	41,12	9,07

Cross Section of bbs tested against ballistic clay at V0 and V10 with speed setting 100, 130, 170.
Values expressed in mm. See section 5.3 of text for explanation of seed settings.

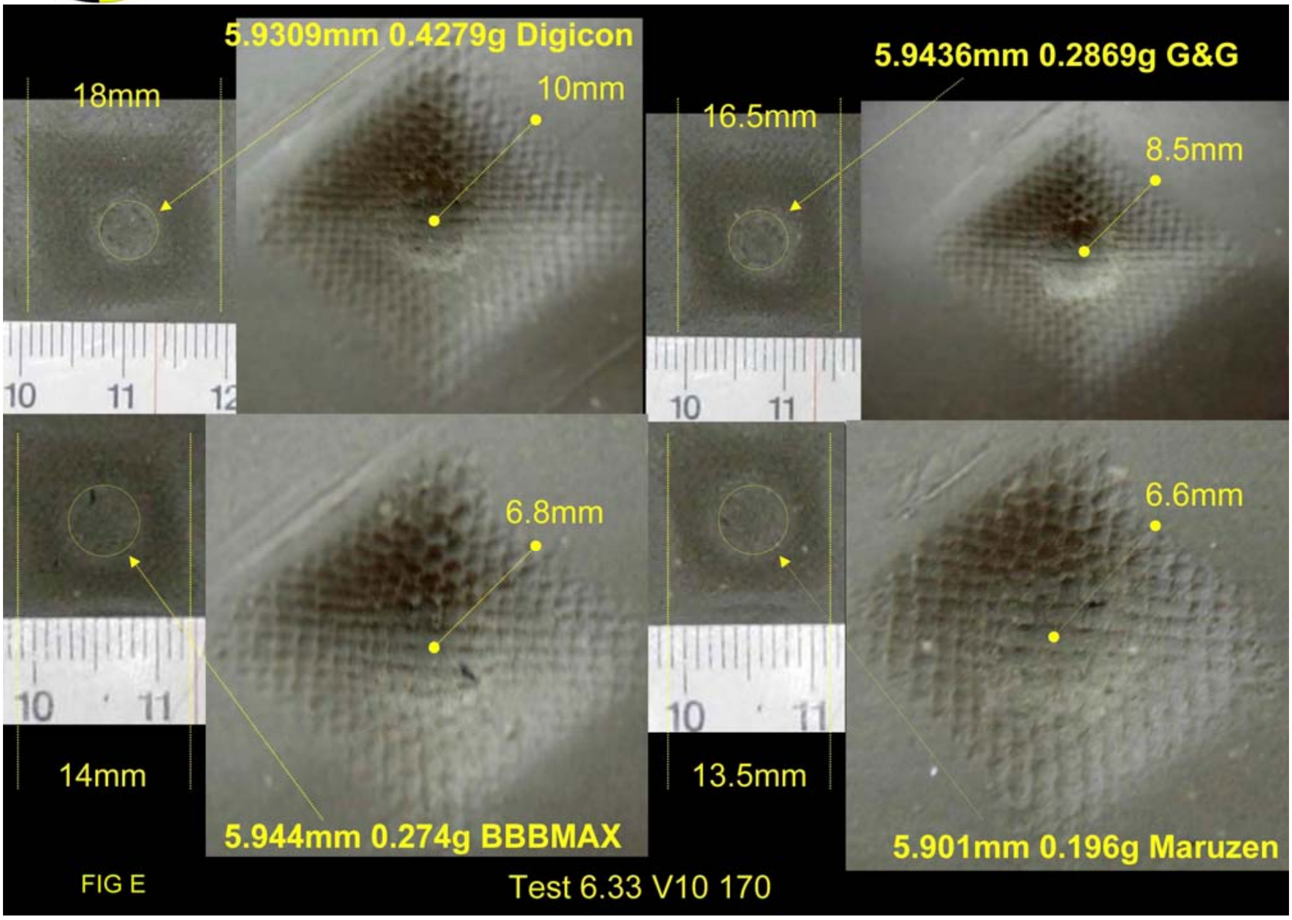
FIG B


5.901mm 0.196g Maruzen
4mm
4.5mm
5.9309mm 0.4279g Digicon
4.5mm
4.5mm
5.9436mm 0.2869g G&G
4mm
4.5 mm
5.944mm 0.274g BBBMAX
2.5mm
2.3mm
FIG C
Test 6.12 V10 130: cordura d1000 against alu6061 3mm thick. Distance 10m. Photo magnified with back lighting.

Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland Test b908

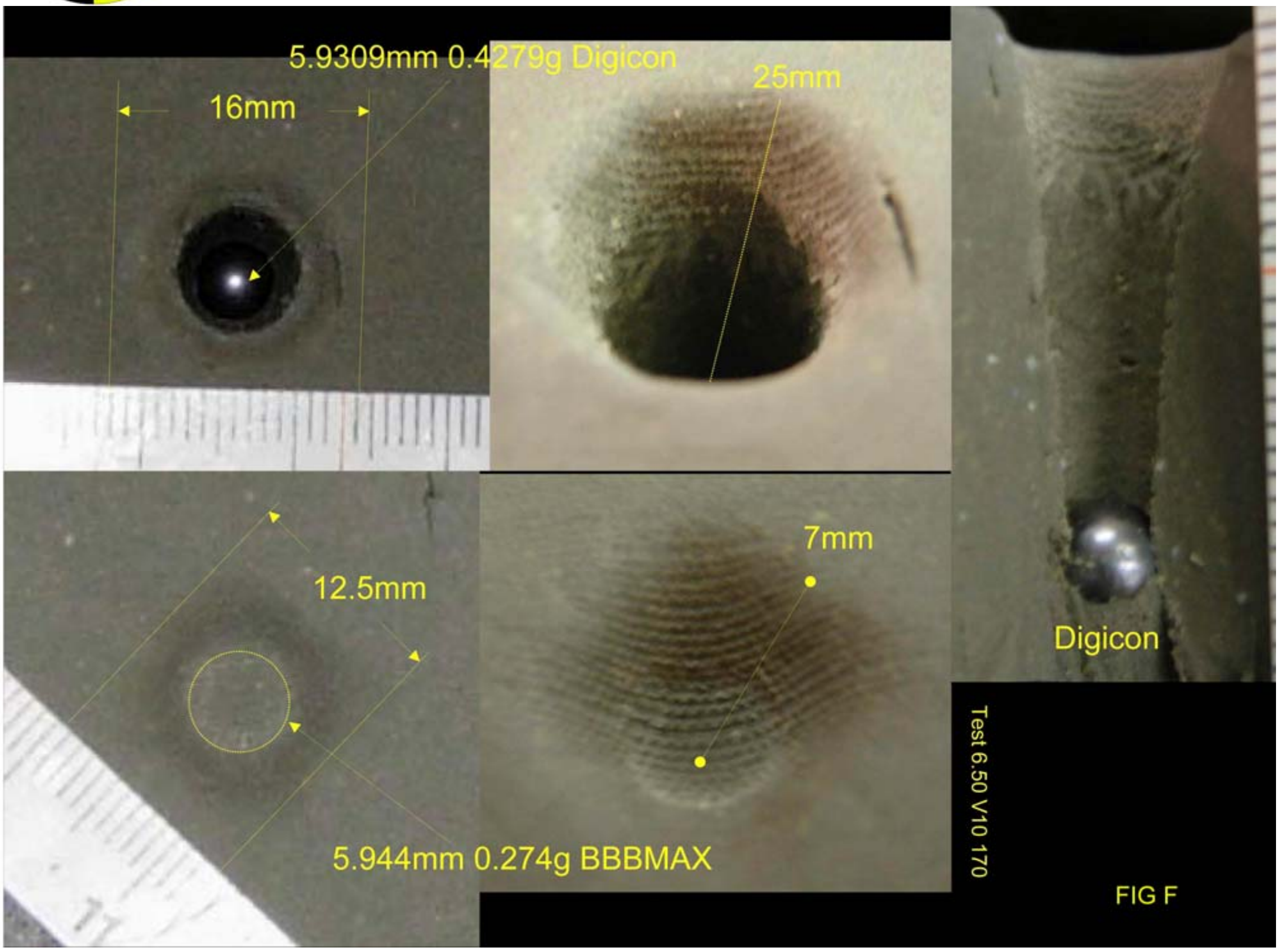


Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland

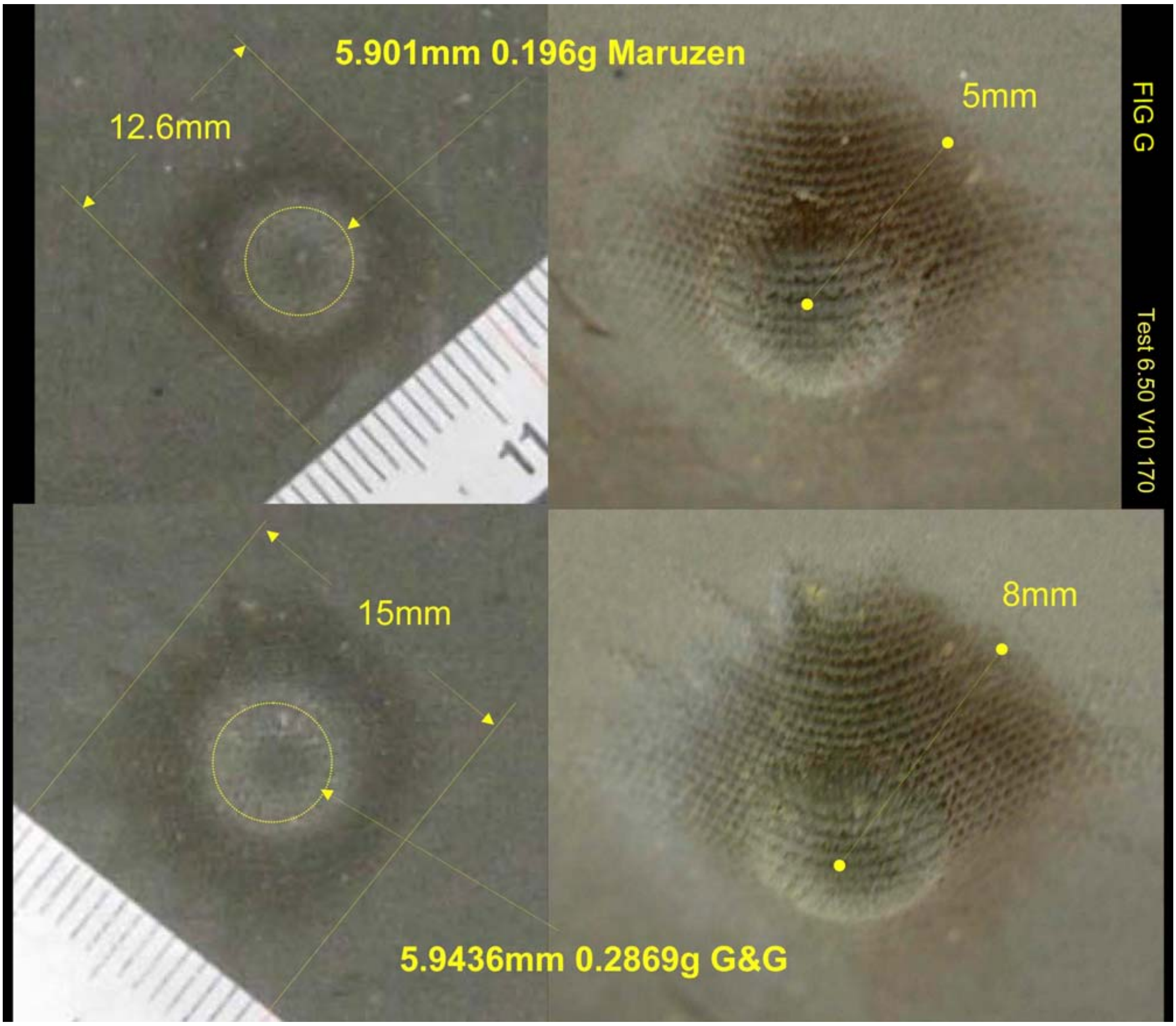


Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland

Test b908



Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland



Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland

Test b908

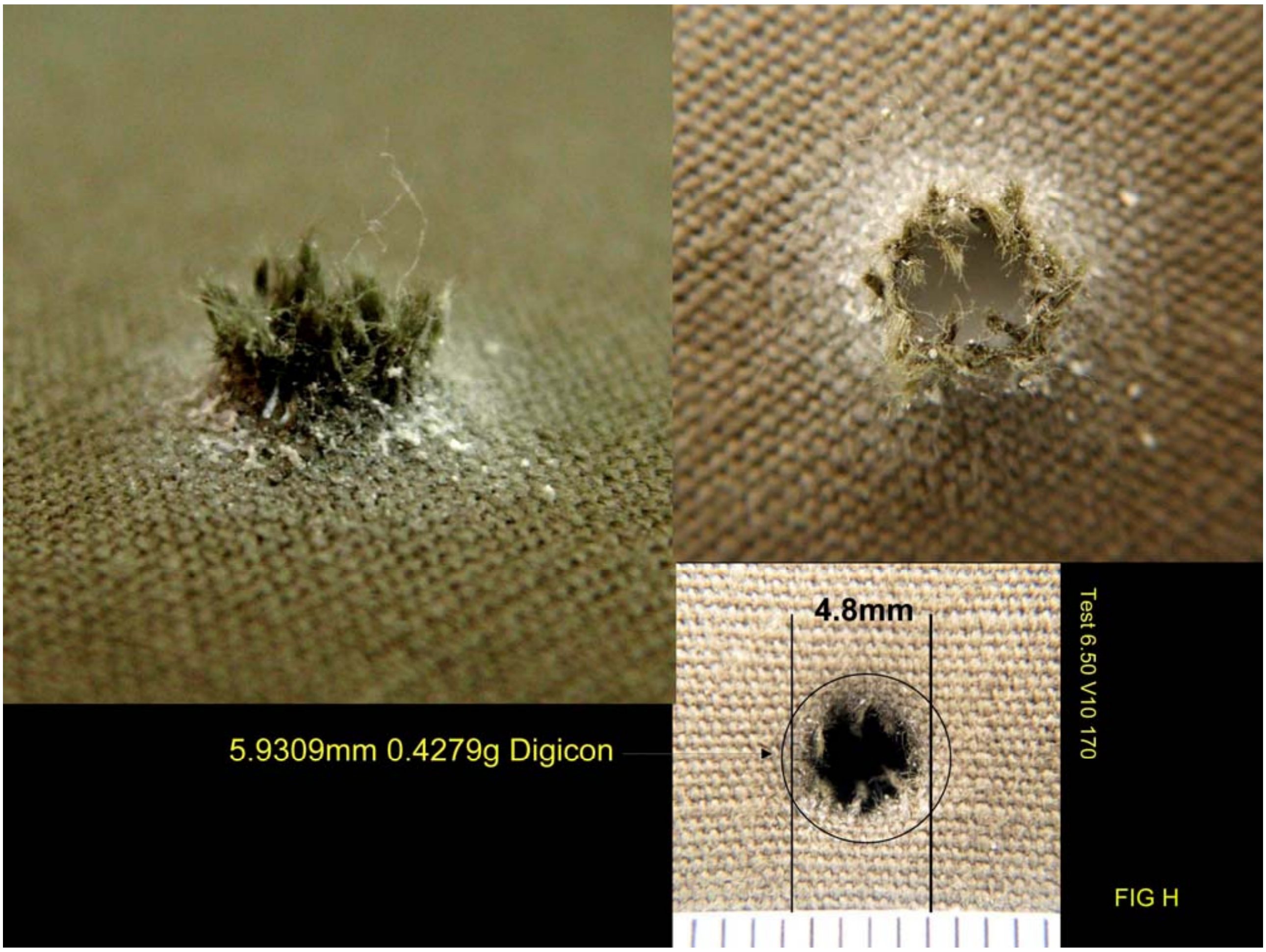
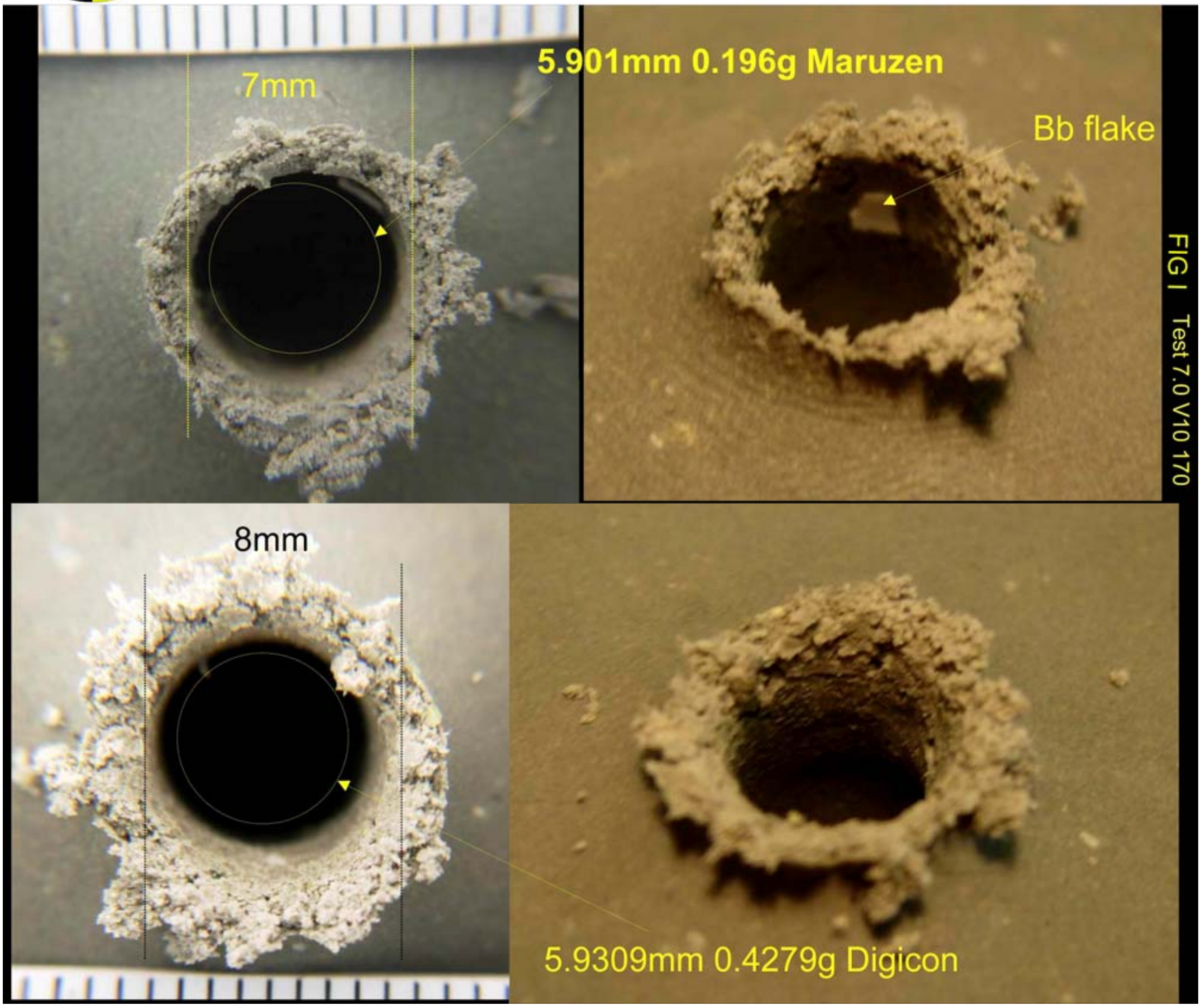


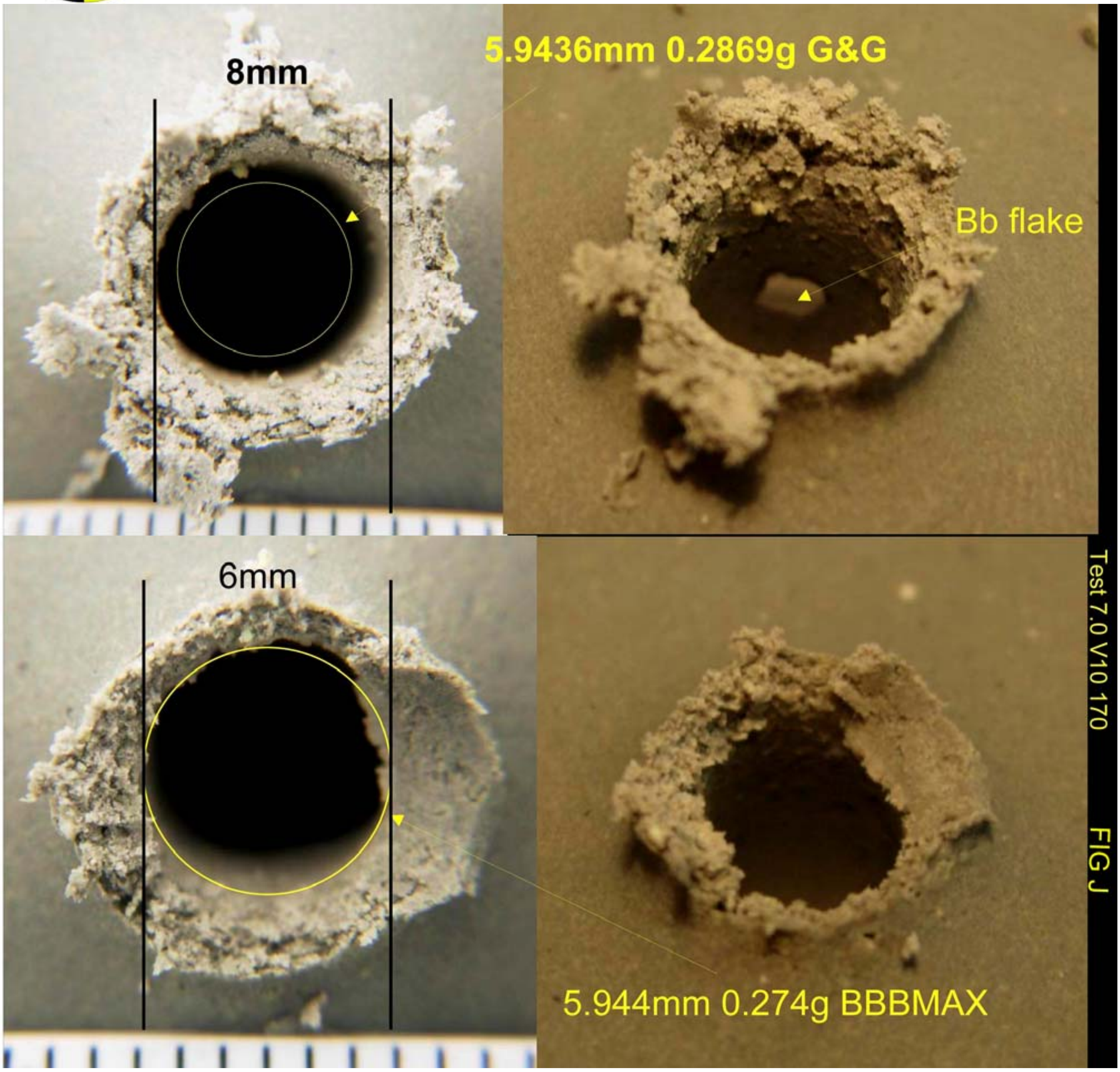
FIG H

Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland

Test b908



Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland



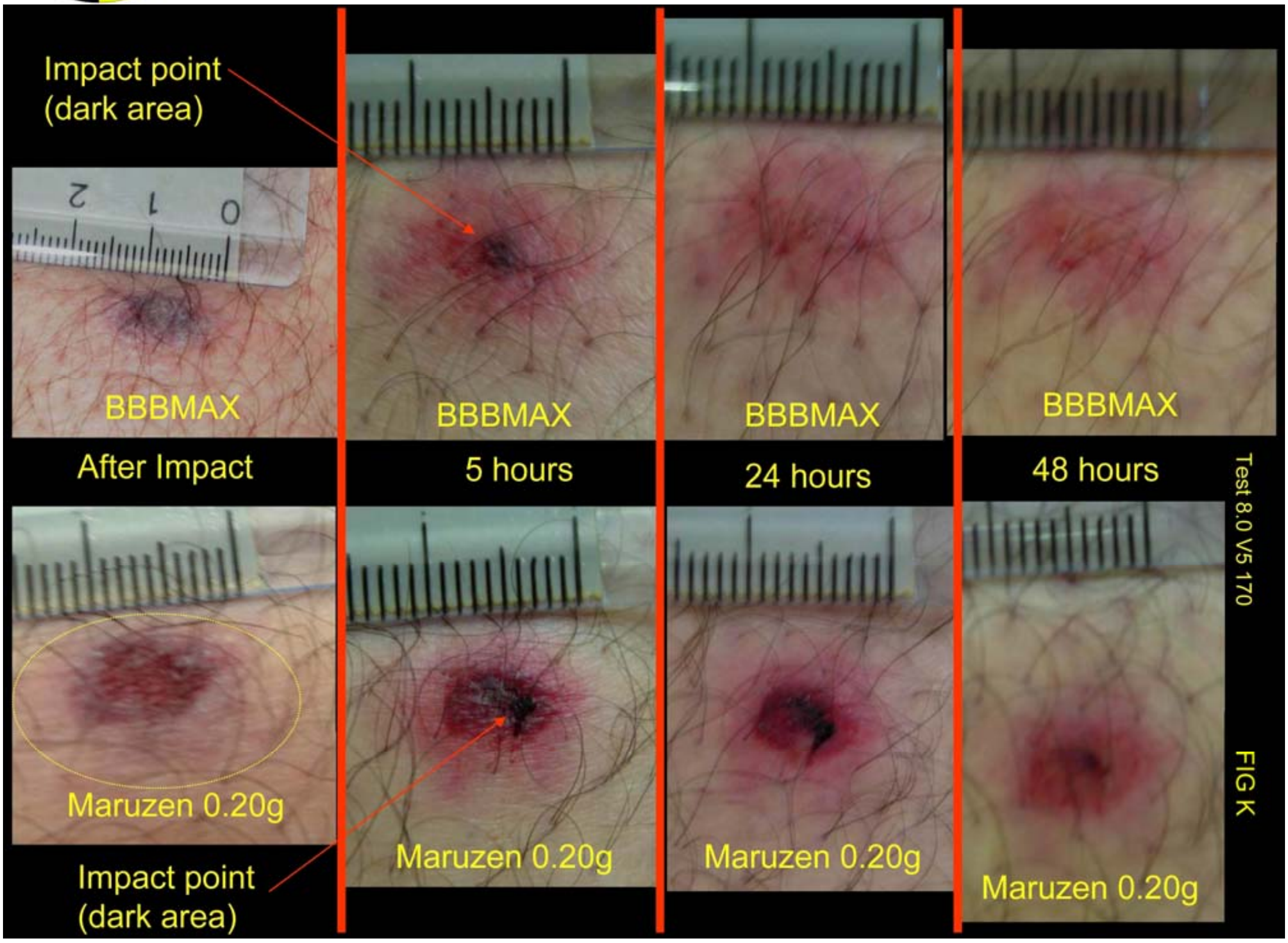

Impact point
(dark area)
BBBMAX
After Impact
BBBMAX
5 hours
BBBMAX
24 hours
BBBMAX
48 hours
Maruzen 0.20g
Impact point
(dark area)
Maruzen 0.20g
Maruzen 0.20g
Maruzen 0.20g
Test 8.0 V5 170

FIG K

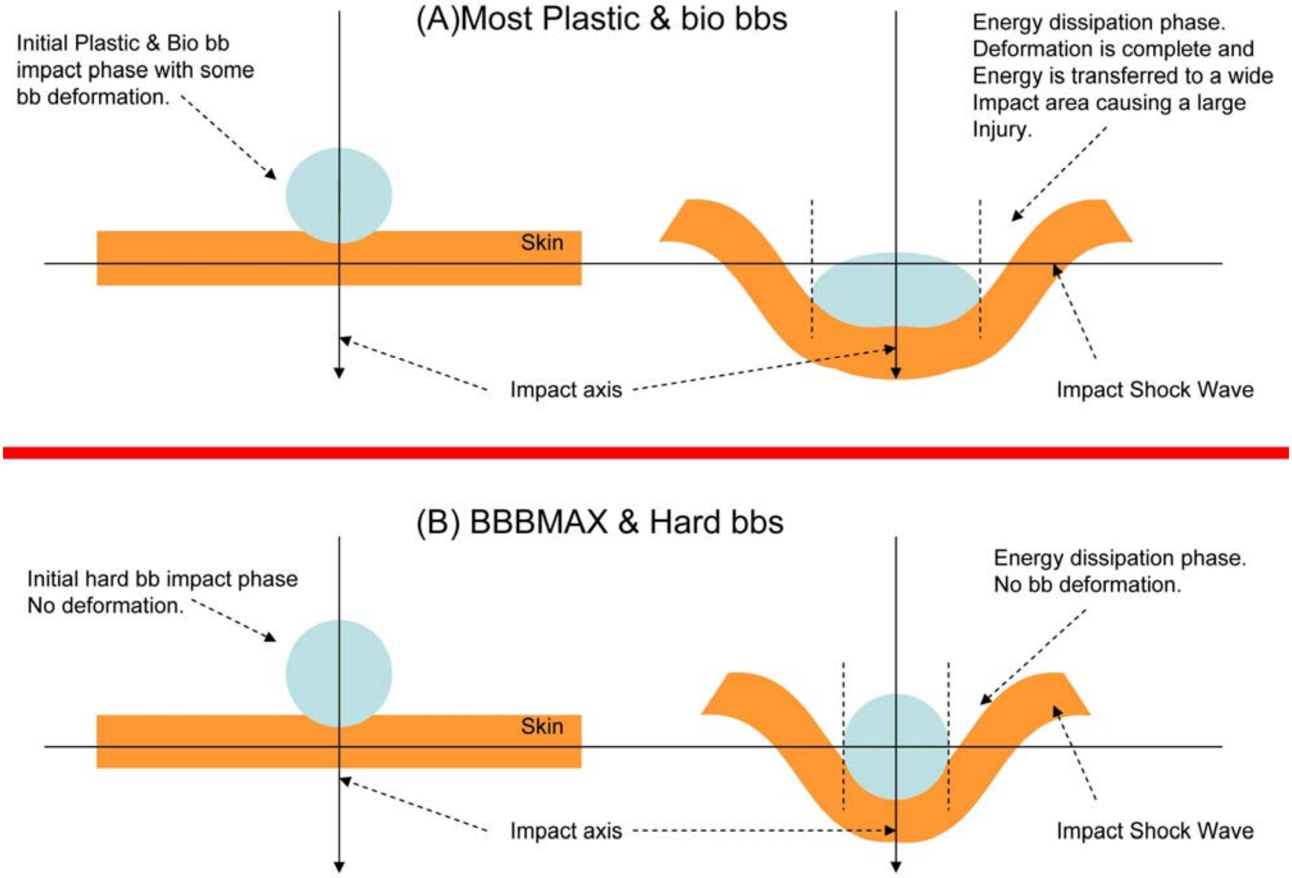
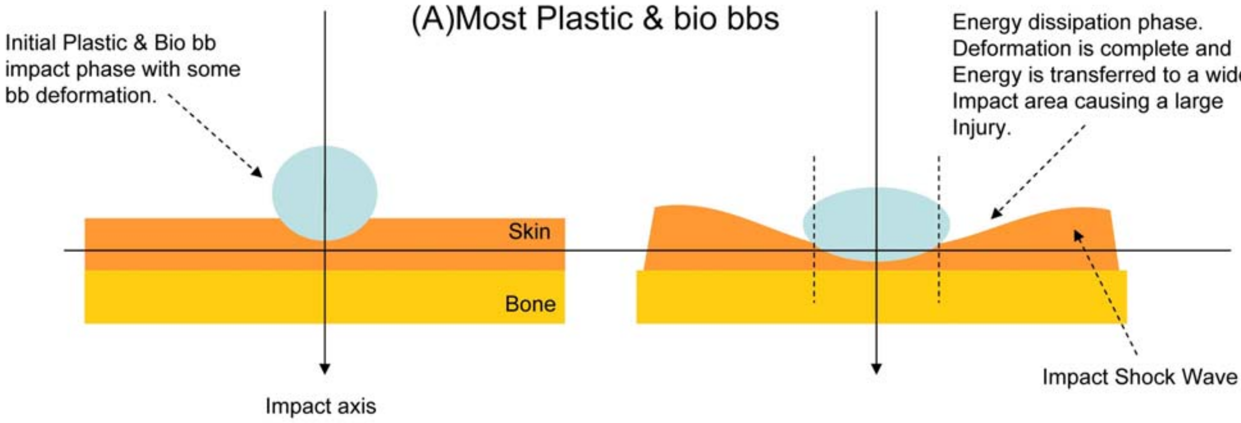

(A)Most Plastic & bio bbs
Initial Plastic & Bio bb impact phase with some bb deformation.
Energy dissipation phase. Deformation is complete and Energy is transferred to a wide Impact area causing a large Injury.
Skin
Impact axis
Impact Shock Wave
(B) BBBMAX & Hard bbs
Initial hard bb impact phase No deformation.
Energy dissipation phase. No bb deformation.
Skin
Impact axis
Impact Shock Wave

Fig L

Levante Labs
Std. Fd.U.W.
1 Centro Carvina
6807 Taverne
Switzerland Test b908



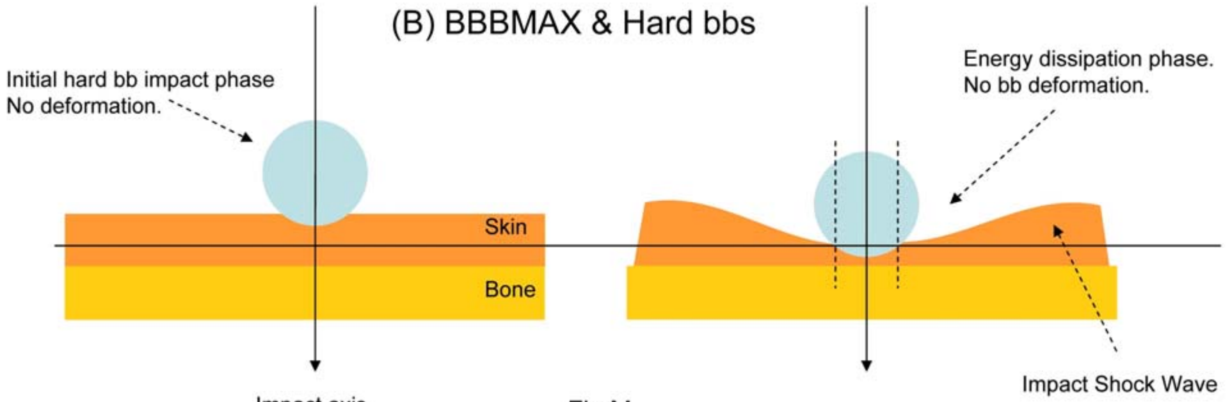


Fig M