Test Report

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Ram-Shell Durability Test

Solveering LLC

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Objective:

Determine if new version of Ram-Shell aluminum hull withstands higher impact forces consistently for Level 4 Ramsets with solid plastic and rubber projectiles.

Measurements to include: base and nose OD, approximate projectile velocity, seating force and notable events.

Summary of Results

- 30 discharges of #4 Ramsets: 25 hard plastic ball projectiles, 5 rubber projectiles.
- 50 lbf projectile seating force
- No observed failures, minimal deformation using rubber projectiles only
- Aluminum hull performance is suitable for extended use with high impact combinations.

Test Setup

One shell with MMC (Minimum Material Condition) tolerance range from latest version of machining program (-04).
Using a spring-loaded OD gauge, the shell is inspected at two critical points prior to starting the testing. The locations are marked with a Sharpie in Figure 1:

Figure 1: Shell before starting test. X marks the approximate location of dimensional tests.

Figure 2 shows the digital OD gauge being used which has a precision of 0.01mm:

Figure 2: Digital OD Gauge.

This gauge was chosen rather than a standard caliper or micrometer as it exerts a consistent force and does not compress the sleeve material by as much as a micrometer would. It also allows for quicker inspection and to slightly rotate the shell to observe changes in diameter and roundness.

In general, there are small variations introduced due to the sleeve material being a Polyolefin (Heat-Shrink) material that is not perfectly uniform. However, these variations were found to be minimally intrusive on the objective of the test and generally around 0.02-0.03mm [.0008”-.0012”].

Insertion force for the solid projectiles for this test was intended to be significantly higher than for the previous polymer hull design as that was often exceeded. While a “light” finger insertion force was found to be on the order of 5-10lbf, use of a cylindrical tool and exerting a “determined” amount of force was quantified as 50lbf, so 5-10x compared to the original – while still allowing a lower level of force to be used and achieve satisfactory results.

For the purpose of this test, a consistent (+/-5%) value of 50lbf was sought. This was achieved by using a digital force gauge, set to display the maximum force exerted. The tool is shown in Figure 3:

Figure 3: Digital Force Gauge used.

The flat, extended attachment made it easy to apply the desired force once the projectile was partially inserted into the hull.

Process

The object was considered met if the shell would withstand 30 cycles using a Level 4 Ramset and insertion force of 50lbf while showing minimal deformation and no failure. The following are the steps that were repeated over the course of these 30 discharges:

1) Set a new projectile using 50-52lb of force
2) Insert a Level 4 Ramset and either manually seat it or fully seat it by using the shotgun action.
3) Discharge into a capture container[1] and capture approximate velocity.
4) Eject spent Ramset charge and, if necessary, prepare pocket for next charge.

No cleaning of the main body was performed during these steps. It was observed that after about 5-10 discharges, the pocket holding the Ramset charge would start to accumulate paint or similar debris released from the perimeter and nose of the charge. Removal of this was done using a 5.7mm drill (by hand, just using light force and giving it a few turns).

During the first 10 discharges, the hull was measured to determine any initial deformation and after that only after every additional 10 discharges was the base and nose measured again. Internal Pictures of the hull and pocket were taken at regular intervals as well as of the shotgun barrel to observe any buildup of unburned propellant.

[1] A large diameter shipping tube partially filled with cardboard and backstopped with a wood board.

Results

Table 1 shows the dimensions measured as well as approximate velocities[2] and insertion force.

Table 1: Test Results

Test #	OD Base [mm]	OD Nose [mm]	Velocity [m/s]	Set Force [lb]	Comment
1	20.00	19.98	145	51.1	
2	20.05	20.01	121	50.1	
3	20.05	20.01	128	51.0	
4	20.02	20.01	157	51.2	
5	20.00	20.07	157	50.1	
6	20.07	20.07	149	50.1	
7	20.02	20.07	169	51.0	
8	20.01	20.08	158	50.8	Sleeve Slipped
9	20.03	20.07	153	51.4	
10	20.04	20.10	174	50.3	
11			161	50.2	
12			167	51.2	
13			170	52.0	
14			156	50.6	Pocket Cleaned
15			159	51.4	
16			183	53.9	
17			176	51.1	
18			185	50.0	
19			180	50.1	
20	20.08	20.20	170	52.2	
21			182	50.3	
22			188	51.3	
23			182	50.0	Pocket Cleaned
24			178	51.2	
25	20.02	20.19	173	50.9	
26			144	51.2	Rubber Projectile
27			186	50.9	Rubber Projectile
28			199	51.2	Rubber Projectile
29			220	52.6	Rubber Projectile
30	20.36	20.29	114	52.5	Rubber Projectile

[2] A clamp-on chronograph was used for the first test discharge and compared to a ProChrono DLX and found to differ by <5%. All measurements shown are using the clamp style unit.

Visual Results

Prior to starting the series of test discharges, the barrel of the shotgun was cleaned using a light oil and rag only. Figure 4 shows a view from the breech side into the barrel, showing little in terms of buildup or other debris:

Figure 4: View into barrel at start of process.

Once the process was started, no cleaning to the outside of the shell or inside was performed though, as listed in the results table, occasionally the pocket holding the charge had to be manually cleaned out using an appropriately sized drill bit.

During the course of the test, a number of photographs were taken of the shell with the first showing the overall condition after 10 cycles, including the internal view and view into the bore of the shotgun barrel - shown in Figure 5:

Figure 5: Shell after 10 discharges.

A second set of images was taken after 20 discharges:

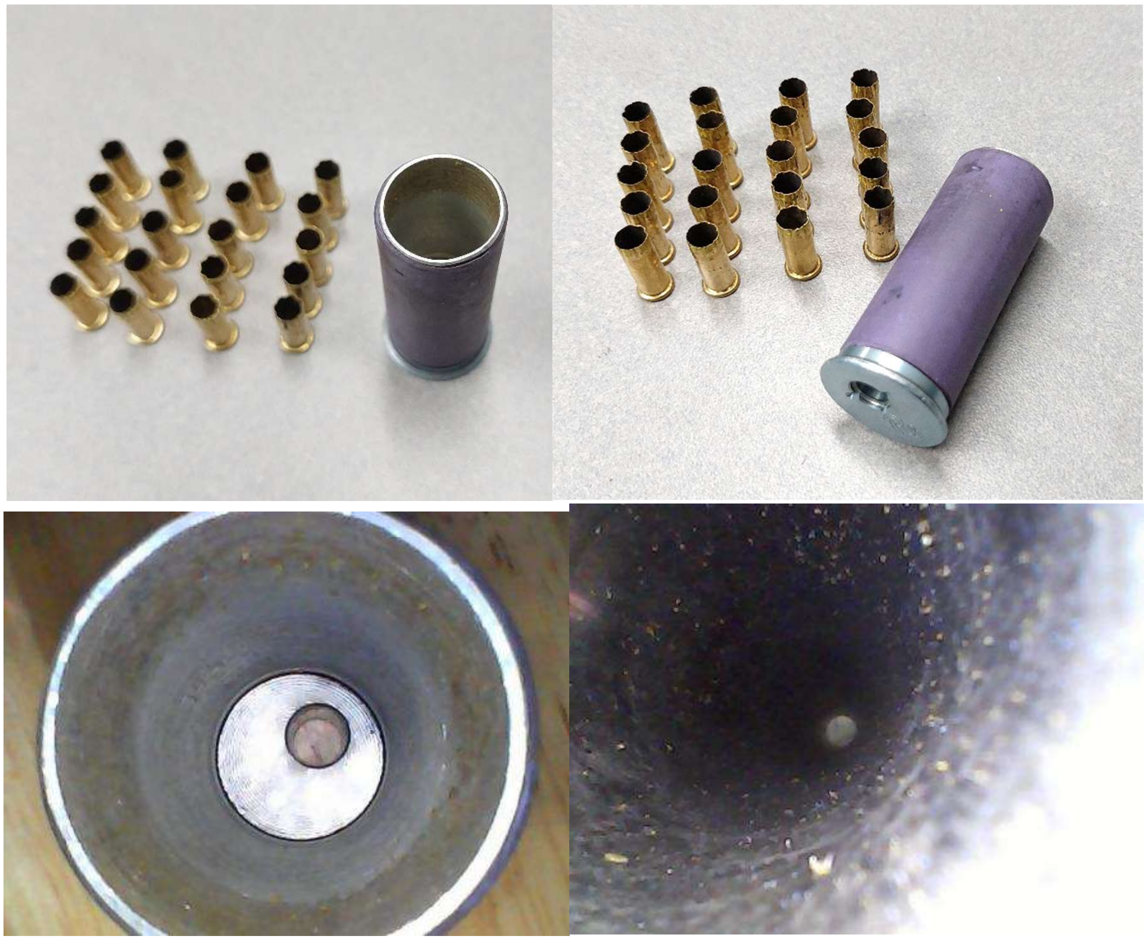

Figure 6: View of shell, interior of shell and barrel after 20 discharges.

In this set of images, the borescope was moved to the side of the barrel, near the breech section, so as to better observe a small amount of debris buildup. A similar buildup was noticed near the nose end of the shell at the approximate depth where the projectile was seated.

At the conclusion of the test discharges, after 30 of the Level 4 Ramsets were discharged from the same shell, more images were taken for closer examination. Figure 7 and Figure 8 show the shell exterior:

Figure 7: Exterior view of shell after 30 discharges.

In this image, it is noticeable that the interior rim has some discoloration and the base shows a slight bulge, matching measured change in diameter. It should be noted that this change only occurred once the rubber projectiles were used (for the last 5 discharges) as they sit at the base of the shell when inserted with the listed amount of force.

Figure 8: Exterior view of shell after 30 discharges.

Figure 9: Interior view of Shell.

Figure 10: View onto base of shell.

No noticeable deformation of the base material, both on interior or exterior was observed. Only residue from the discharged Ramset charges was left. Minimal deformations to hull near base as noted but without indications of excess strain.

Figure 11: View into barrel at conclusion of process.

The barrel, as shown in Figure 11 from the view of the breech, was mostly free from dirt or debris. Only a few small specs remained from the discharge of the Ramset charges.

Conclusions

The objective, to determine whether the aluminum hull was a long-term replacement option for use with the Ram-Shell cartridge, was determined to be met by this set of test procedures.

During the first discharge, the hull experienced very minor changes, likely the result of expanding by a small amount to make contact with the barrel's bore. Due to the flexible nature of tempered aluminum alloy, this expansion does not seem to have progressed sufficiently to experience plastic deformation but rather only enough to correct for any out-of-round or similar condition introduced during manufacturing. The small amount of measured change could also be the result of the polyolefin sleeve material experiencing thermal or stress induced motion and thus measurements may be affected by local non-uniformity in material thickness.

Little change was observed over the subsequent 10-25 discharges in terms of expansion. The only items that were determined to be noteworthy was that the sleeve material, though of a "shrink-fit" nature, was able to be moved when the spent charges were ejected. Also, the pocket holding the Ramset charges experiences increased levels of fouling - likely due to the higher pressures experienced, leading to paint and surface materials to be deposited – which in turn prompted the use of a slightly undersized drill bit (5.7mm or #2) to gently clean out the pocket.

After several discharges, it was noticed that the depth that the projectile was seated started to increase slightly (from barely flush to slightly below level). Though this wasn't a trend that continued, it is likely that it was caused by the force of the insertion rather than the forces generated during discharge.

At the conclusion of the first 25 discharges, the projectile was switched from a solid plastic (nylon) projectile to a hard rubber (Shore 80D) projectile. With the introduction of this rubber ball, a physical change to the outer hull was noticed. It is likely that the rubber material, being of a more compliant nature and thus able to be pushed to the very bottom of the shell, generated a higher-pressure spike during discharge which in turn was sufficient to cause minor plastic deformation of the aluminum hull in the immediate proximity to where the projectile was positioned. This deformation was observed immediately following the change to the rubber projectile but does not seem to noticeably increase over time.

Based on the presented data, it is the conclusion of this report that the updated design of the aluminum hull of the Ram-Shell is sufficient to withstand continued use, even with higher level Ramset charges and higher seating forces.