

Improving the Reliability of the M16/M4 Weapon Systems: Advantages of the Magpul Enhanced Self-Leveling Follower

By Eric Nakayama, Mechanical Engineer & Brian Nakayama, Mechanical Engineer

1. Overview

The M16/M4 weapon series are combat proven systems that continue to evolve. Yet with the myriad of engineering improvements that have been implemented since its inception, there remain significant shortcomings. As with any system, the M16/M4 weapon system is only as reliable as its most faulty link. It is widely recognized and acknowledged that the detachable ammunition magazine is the most sensitive and unreliable component of this system. Thus increasing the reliability of the USGI M16 30-round magazine should increase systemic reliability which benefits the end-user.

2. Purpose and Anatomy of a Detachable Ammunition Magazine

The M16/M4 weapon system utilizes a detachable box magazine to feed ammunition into to the firing mechanism. The standard USGI magazine holds 30 rounds of 5.56x45mm NATO ammunition and provides the user with a more convenient method for handling, carrying and utilizing those rounds. Without a reliable magazine to feed the ammunition into the weapon, the M16/M4 system ceases to function properly. Operating the M16/M4 while having to diagnose problems and performing corrective action under the stress of combat, dramatically decreases user effectiveness and it will get operators killed. Since both the individual magazine components and how they work together affect reliability, each basic part that constitutes a complete magazine assembly will be introduced and its purpose discussed.



Fig 2.1: USGI M16 30-Round Magazine with 2nd Generation Green Follower

The M16 magazine is similar to most other magazines of its type and has four main components. The most visible exterior component is the *magazine body* (See *Figure 2.1* above). This part is made of aluminum alloy and constructed from two shell halves which are stamped, formed and then spot welded together. The magazine body contains, protects, and guides the individual rounds of ammunition while serving as a track for the interior mechanism. The other exterior part, the *magazine base-plate*, attaches to the bottom of the magazine body and serves to contain the interior components. (The magazine base-plate, located on the far end of the magazine pictured in *Figure 2.1* above, is not readily apparent). The magazine base-plate removes from the magazine body for disassembly. The only fully interior part, the *magazine spring*, provides the force to feed the individual rounds into the weapon. Due to the vertically upward direction of feed, the spring force must overcome the counteracting forces of gravity, friction and dynamic forces applied during firing. Lastly, the *magazine follower* (See *Figure 2.1* above for the lime-green colored magazine follower) serves as a link between the spring and the ammunition. It rides within and is guided by the magazine body so as to provide a stable platform for the spring to apply force to the ammunition stack. The follower shape is critical since it organizes the ammunition stack to be tight and properly aligned.

While malfunctions may occur for numerous reasons, the magazine follower is often cited as the root cause. Since the follower acts as a guide for applying the spring force to the ammunition, it forms a critical link. If a follower tilts and becomes misaligned then the ammunition may not feed properly into the weapon. When too severe, the misalignment in the follower can cause a jam inside the magazine resulting in complete magazine failure until the follower can be dislodged.

3. Outmoded Magazine Followers: Why They Fail

The original Vietnam-era M16 magazine was straight, with a 20-round capacity and utilized a relatively flat, metallic follower. One problem encountered during this time was the tendency for soldiers to attempt to load their magazines beyond the maximum 20-round capacity. While some individual 20-round magazines can be forced to hold more, this sometimes caused the spring to become over-compressed and then subsequently bind. Once a spring became bound to itself, the magazine would lose spring pressure and fail to feed rounds into the weapon. This is one of the largest failures of the original 20-round magazine design. To address this and many other issues, the current USGI 30-round curved magazine was developed.



Fig 3.1: USGI M16 30-Round Magazine Followers (2nd Generation Green and 1st Generation Black) from AR15.com

In the current USGI curved 30-round magazine, a plastic follower replaced the metallic follower. The first follower design for these magazines was black in color (See *Figure 3.1* above) and had a central post protruding from the bottom. This post was designed to prevent the spring from over-compression and was a great improvement over the original 20-round metallic follower in this regard. However, since a plastic follower flexes more than a metallic one, the *black follower* exhibited more tilting problems than had been previously observed. Detrimental follower tilting generally occurs along one rotational axis. Each rotational direction of displacement causes different problems. The first is when the rear of the follower dives down (backward tilt) causing the rounds to point up with the cartridge bases depressing into the magazine. This prevents the bolt from stripping the rounds and feeding them into the chamber during cycling. The second case occurs when the follower nose dives down (forward tilt) causing bullet tips to strike either the magazine body or to strike below the feed ramps on the upper receiver. If the follower is allowed to tilt too far in this second direction it can cause a complete magazine jam. Environmental hazards such as sand, dust or grime magnify this tilting problem since it can impede the natural travel of the follower.

In order to correct this, the 2nd generation of M16 follower design reduces this detrimental tilt. This version is commonly referred to as the *green follower* because of its characteristic lime green color (See *Figure 3.1* above). It has similar geometry to the black follower with the addition of a downward extension placed below the nose of the follower. This extension piece design reduces excessive tilting unlike the black follower which lacks this feature. Theoretically, this is a correct method for improving reliability but the method chosen to implement this theory proved less than optimal. The reason is because the green follower extension only reduces backwards tilt and does not mitigate forward tilting. Thus while the green follower shows an improvement over its black follower predecessor, it only addresses half of the problem and can still tilt enough to cause malfunctions.

From an engineering standpoint, the green follower appears to be more of an improvisation rather than purposely designed. This is evident from the almost identical geometry to the black follower with the addition of the extension in the front. This “quick-fix” for the tilting problem would be an easy feature to add into a pre-existing mold. In practice, the green follower reduces tilting compared to the black follower but leaves significant gaps between it and the magazine body which still allows for rotation. These observations suggest that its performance relies heavily on spring pressure and is not necessarily due to follower geometry.

4. Magpul Enhanced Self-Leveling Follower

The Magpul Enhanced Self-Leveling Follower is a patent-pending 3rd generation design which offers a variety of critical improvements over previous USGI M16 magazine followers. These benefits are reliability, operational compatibility, maintainability, and verifiability.

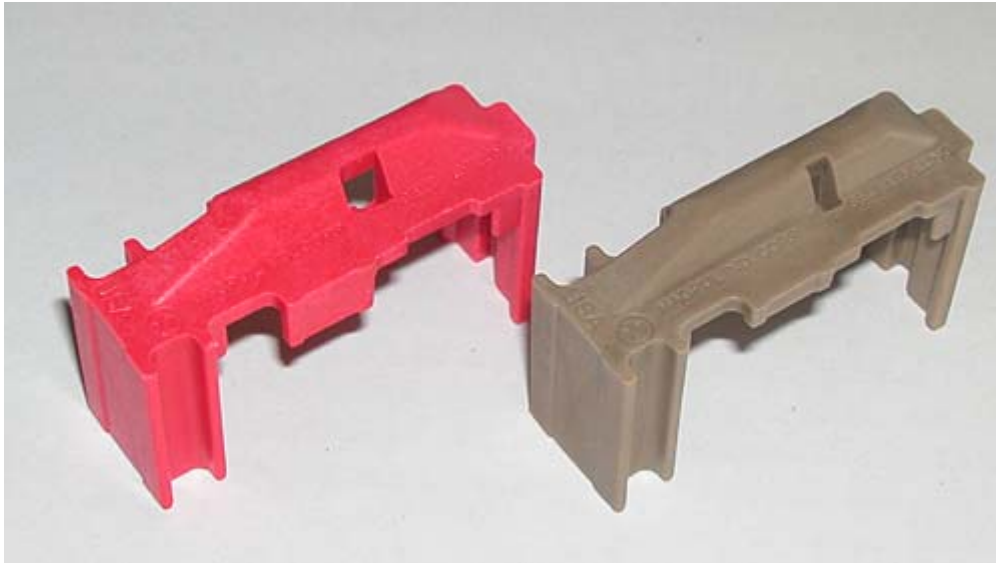


Fig 4.1: Magpul M16 Enhanced Self-Leveling Follower (Red Prototype and Coyote Brown Production Units)

4.1 Reliability

The Magpul Enhanced Self-Leveling Follower design increases the mean time between magazine related failures. When analyzing the most reliable rifle magazines from around the world such as the Steyr AUG, HK G36 and most recently the HK SA80A2 magazines, they have one common feature amongst them; the quad anti-tilt follower. All of these magazines have a much higher Mean Time Between Failure (MTBF) when observed over a statistically significant sample.

Out of the box, the HK SA80A2 magazine, probably the most reliable M16-compatible magazine currently made, has twice the mean time between failure rate of a USGI 30-round magazine. However, this reliability increase comes at a price both in dollar cost and compatibility. The HK SA80A2 magazine does not accept all standard USGI magazine parts, is noticeably heavier and is more susceptible to corrosion due to its steel body construction.

The design goal of the Magpul Enhanced Self-Leveling Follower was to achieve an 80% reliability increase over a USGI 30-round magazine with a simple retrofit of the follower. This maintains the lightness of the USGI aluminum magazine body in addition to the ability to accept all standard magazine parts such as the spring and base-plate. This compatibility allows the magazine to utilize other enhanced parts designed for the USGI magazine such as the Magpul Ranger Plate.

The Magpul Enhanced Self-Leveling Follower was purpose-built to address the problem of follower tilt. By interfacing with multiple points on the magazine body interior, this design constrains undesirable rotation in each direction on all three rotational axes. This is accomplished by the rectangular extensions protruding on the bottom of the enhanced follower on the front and back (See *Figure 4.1* above). These extensions more fully engage the magazine body therefore allowing the follower to be guided more effectively. The end result is a follower with only one semi-linear translational degree of freedom along length of the magazine body which is independent of spring pressure. This basically means the follower only goes up or down and does not tilt in any direction.

Empirically this can be demonstrated by pushing down on the nose of the follower and trying to induce a forward tilt malfunction. This is easily done on nearly all black and green follower equipped magazines as the follower will stay in the nose-down condition when depressed sufficiently in this manner. In stark contrast, the Magpul Enhanced Self-Leveling Follower will only translate along the magazine body length maintaining its level position.

The lack of rotational displacement increases orientation consistency of the follower allowing less variation in the way the individual rounds of ammunition stack within the magazine body. This consistency becomes especially critical when loaded magazines are dropped or otherwise subjected to impact loading and the ammunition packing is disturbed. This ammunition column stacking consistency ultimately improves reliability since the rounds do not tip up or dive down as much as with the older followers.

To prevent user induced failures, the rectangular extensions on the Magpul Enhanced Self-Leveling Follower also prevent over-compression of the magazine spring similarly to the black and green followers. However, it provides more stability and protects the spring better than either of these previous 30-round follower designs by capturing the spring in both the front and back. Additionally, the top of the follower retains a *rounds forward directional indicator* to assist in preventing rounds from being loaded backward into the magazine.

Lastly, to improve operation in various environmental conditions, the follower is designed to be self-lubricating through the addition of Teflon which has a very low coefficient of friction. The Teflon fill decreases the drag between the magazine body and the follower allowing for smoother operation and decreasing the chance of the follower binding within the magazine in the presence of sand or debris. Since the Teflon is distributed throughout the base material, this self-lubricating effect should not decrease with follower wear.

When these various considerations are taken into effect, the Magpul Enhanced Self-Leveling Follower not only meets current standards but should also demonstrate significantly higher reliability rates than either black or green follower equipped magazines.

4.2 Maintainability

The Magpul Enhanced Self-Leveling Follower incorporates a drop-in replacement design for the existing USGI 30-round magazine follower. It replaces either the black or green follower on a one-for-one basis without modification. To prevent improper assembly, the follower can only be inserted into magazine in the correct orientation and the magazine spring can only attach to the follower in the correct manner. As an added benefit for the user, it actually does “drop-in” and does not require coaxing to place inside the magazine body unlike previous followers.

The follower should not require any more maintenance than the black or green followers and is user-level maintainable using standard USGI weapon cleaning equipment including CLP.

4.3 Operational Compatibility

The Magpul Enhanced Self-Leveling Follower should be compatible with all common operational environments and should not pose any special concerns above that of the black or green followers. In fact, due to the subdued Coyote Brown coloration, it offers a reduced visual signature. Also, the improved consistency of the ammunition stack has the possibility for reducing the audible signature of a loaded magazine. When shaken, a loosely-packed loaded magazine emits a clicking sound as the loose rounds impact against the magazine body. Any weight differences between the various followers should be negligible.

4.4 Verifiability

The Magpul Enhanced Self-Leveling Follower is easily identifiable by its Coyote Brown coloration. This allows for rapid verification of each magazine that incorporates the follower. Additionally, each follower is stamped with the following information: "USA MAGPUL IND. CORP SELF LEVELING." In addition to its uniquely identifiable features, this printed information further guarantees that the follower is indeed a genuine Magpul product. Black and green followers have no such identifying information and, with only visually inspection, there is no way to verify that they indeed meet military specifications. Because of the ubiquity of the USGI magazine, some manufactures make green followers which may not meet the dimensional or material specifications that the United States Government requires. This fact makes the lack of identifiable markings on green followers more problematic.

5. Magpul as a Company

Magpul Industries Corporation is a domestic company located in Boulder, Colorado. The Magpul Enhanced Self-Leveling Follower is manufactured locally and different colors can be made available to match the remaining product line or other specifications. Manufacturing capacity is scalable to meet quantity requirements. Any warranties or guarantees can be negotiated directly with Richard Fitzpatrick who can be contacted via the information below:

Magpul Industries Corporation
PO Box 17697
Boulder, Colorado 80308-0697
Phone: 1-877-462-4785 (1-877-4MAGPUL)
E-mail: richfitz@magpul.com

6. Conclusion

When examining the features of the Magpul Enhanced Self-Leveling Follower, not only does it meets current standards but should also demonstrate significantly higher reliably rates than either black or green follower equipped magazines. This purpose-built design emphasizes reliability, operational compatibility, maintainability, and verifiability.

7. Disclaimer

The information provided is the professional opinion of the authors. These opinions are based on a variety of sources including, but not limited to, professional and personal experience, established engineering theory, practice and testing, and open source material. Nothing contained in this brief should be construed as a substitute or replacement for extensive laboratory, field and operational testing to determine the true performance of any product.

About the Authors

Brian Nakayama

Brian Nakayama, a former Sergeant in the United States Marine Corps, graduated from the Colorado School of Mines with a B.S. in Engineering, Mechanical. He served for over five years as an M1A1 Tank Crewman (MOS 1812) and has received the following commendations:

- Rifle Expert, 5th award
- Pistol Expert
- Distinguished Qualification on tank gunnery
- 5 Letters of Commendation
- Good Conduct Medal, 2nd award
- Navy/ Marine Corps Achievement Medal.

While attending the Colorado School of Mines, he was the Project Manager of the Formula SAE racing team. This Society of Automotive Engineers sponsored project involves the year-long design and fabrication of a formula car which is subsequently raced in competition.

In addition to his military service and engineering education, Mr. Nakayama has 2 years of experience working at a part fabrication company that specializes in various machining technologies including traditional, computer numeric control (CNC), and electrical discharge (EDM) amongst others. He is currently employed as a Design/Manufacturing Engineer by Magpul Industries Corporation.

Eric Nakayama

Eric Nakayama graduated from the University of Colorado at Boulder with a B.S. in Mechanical Engineering. Mr. Nakayama is defined by a lifelong passion for military firearms and technology and has experimented with modifications to numerous weapon systems including the M4A1 SOPMOD I Carbine, M203A1 Grenade Launcher, Beretta M9 Pistol, Colt M1911A1 Pistol, Mossberg M590 Shotgun, Benelli M1 Super 90 (Similar to M1014 Shotgun), and Ruger 10/22 Carbine.

While working for The Boeing Co., Mr. Nakayama was successful in utilizing thermal imaging technology to resolve a critical safety issue on the 737 NG aircraft. This technology was theretofore unused for that application. Additionally, he was crucial in resolving a critical safety issue which had the potential to ground all in-service Boeing/McDonnell-Douglas cargo aircraft. He is currently attending school at his alma mater and is pursuing an M.S. in Mechanical Engineering while performing Design Engineer duties for Magpul Industries Corporation.