

Chris Bekker

# MONO-METAL BULLETS AND BARREL LIFE

*Some interesting  
and little-known facts*

It is generally believed that solid bullets, like copper and brass bullets, are harder on barrels than lead-core bullets. With mono-metal bullets becoming more and more popular, it is perhaps high time that we look into the properties of copper and brass as they are the two prime metals being used in the manufacture of bullets. Barnes was the pioneer to introduce its solid, non-expanding bullet in 1979 and its expanding Barnes X copper bullet in 1985, and since then many others have followed. The Barnes X bullet with its smooth shank has been replaced with the Barnes TSX, now featuring a grooved shank to reduce the bearing surface of the bullet in the barrel and so reduce the engraving resistance, and also allow space for the copper to flow into, thereby reducing copper fouling. Named the Triple-Shock X bullet (TSX), it can be identified from the original X bullet by having three or more grooves cut into its all-copper body. On the other hand, the Barnes Banded Solid has multiple “driving bands” rather than “grooves” to reduce pressure. It is made from “free-machining brass” instead, as it is less costly and easier to machine than copper.

**T**he Barnes TSX bullet is mimicked in South Africa by the Frontier Spartan bullet made from copper, as it is an expanding bullet. Solid bullets are made from brass by South African manufacturers such as PMP, Rhino, Dzombo, Impala, Du Plessis-werke and Peregrine, who all compete with the copper-made GS-FN bullet. Each one is quite unique in its own way, bringing a different nuance to the table – different in geometry and shape, varying length of bearing surface, varying size of meplat, different spacing and thickness of grooves or driving bands, the number of grooves or driving bands, and lastly, the choice of metal. The hunter has never had it so good in terms of selection or availability. Our focus here is not which bullet is superior, but to address the misconception that it is bad or hard on a barrel to fire mono-metal bullets.

## *Barrel life in general*

It might come as a surprise to you that the effective barrel life is actually very short – somewhere between two and five seconds, depending on the overbore situation of the cartridge and the rapidity of fire that is practised. It is not the bullet eroding the bore so much through friction, but the hot gasses behind the bullet that are act-

ing like a cutting torch, wearing the throat and the lands just in front of the throat that eventually degrades the accuracy of your rifle. Here is a typical scenario for a .308 Winchester, if we were to do the math with the assumption that a 150-grain bullet is propelled at 2,750 feet per second (fps) – it has a flight time to 100 yards of 0.1141 seconds, adjusted to .000761 seconds for a 24-inch barrel; one would get 5,916 shots for a barrel life of a mere 4.5 seconds. Typically we can expect no more than about 2,500 shots from a .243 Win that uses essentially the same cartridge case, but the hot gases need to go through a smaller bore diameter. Most long-range competition shooters change their barrels on a 6.5-284 at around the 1,250 shots mark, as they are engaged in a more extreme accuracy discipline.

Throats begin to erode more quickly when we have “overbore” conditions such as in the .220 Swift, or other calibres that use a large quantity of powder relative to their bore size. This is generally not the case with bigger bore calibres like in a .458 Win, for example. There are a number of factors that play into barrel erosion, and these have traditionally been broken down into three categories. However, these factors do not function independently of each other, but are tightly coupled and act in concert together in an interdependent fashion.



**Thermal** – Include bore surface phase changes (i.e. transitioning between solid, liquid, gas phases), softening and melting, as well as cracking due to expansion and contraction associated with the barrel heating and cooling.

**Chemical** – Include carburising or oxidising reactions, which are chemical processes that occur at the bore surface under extreme heat. These cause the barrel to change at a molecular level.

**Mechanical** – Includes erosion caused by direct impingement of gas and solid particles travelling across the bore surface.

Although controversial in shooting sports, many competition shooters claim to get almost double the barrel life when coating bullets with molybdenum disulphide (“moly” for short). Norma has done an interesting study with moly-coated bullets and they claim the following: “Testing showed barrels retained accuracy more than twice as long when Norma moly bullets were used from the outset. This is because Norma Diamond Line is coated with molybdenum disulphide and a protective layer of wax. Friction is reduced which means that the bullet travels further along the barrel before peak pressure is reached. The result is lower wear and improved accuracy.” The results of their tests can be seen on the internet at: [www.6mibr.com/normamoly.html](http://www.6mibr.com/normamoly.html) from which I quote: “Briefly we have found that moly-coated bullets do:

- ▶ decrease pressure by 3–5% depending on cartridge, bullet and powder
- ▶ decrease velocity with 0,5–1,5%
- ▶ reduce metal fouling
- ▶ increase accuracy under certain circumstances
- ▶ very likely increase barrel life

Moly is a superb friction reducer and its bearing capacity is beyond the yield point of known metals. When a moly-coated bullet enters the throat and travels down the barrel it has less friction than an ordinary bullet. So it is not surprising to see a lower pressure. We have not done any huge tests with many calibres, but the 3–5% pressure decrease has been there every time.”

### *Fouling and accuracy*

Metal fouling or deposits happens by the mechanism of friction – thus the more bullet friction, the more the barrel will foul. If you look through a borescope, copper builds up

most heavily right where the bullet is when the pressure is at its peak; normally one or two inches forward of the throat. When the pressure peaks, the bullet obturates to its maximum that it is capable of (the bullet becomes fatter), the friction between the bullet and the steel of the barrel will be at its highest, and with more friction more metal rubs off. It is fouling that destroys accuracy together with propellant residue that accumulates, and this happens over a number of repeated shots. This is not a major issue in most hunting conditions or for dangerous-game hunters, as the hunt is over within a few shots and then the rifle gets cleaned. Another culprit is barrels that are not lapped (polished), as the roughness of the barrel scrapes the bullet metal off. Where present, grooves in the bullet shank provide room for the copper to flow into instead of a build-up onto the lands of the barrel.

Loss of permanent accuracy though always results **solely from erosion and corrosion in the bore throat** and at the beginning of the rifling.

This is then why we need to bring the peak pressure down as it has the effect to increase flame temperatures that does the cutting. By reducing the bearing surface of the bullet we reduce the amount of friction and so lower the pressure. Here is a fine example of an Impala Spitzer Solid showing a bearing surface of only 62% with which I obtained 11 mm cloverleaf groups in my 9,3 x 62mm Mauser despite the fact that some manufacturers are claiming that their “bore-riding” designs are more accurate.



A 200 gr .375 Impala Spitzer Solid – ex gemsbok

### *Copper vs free-machining brass*

As the choice of metal needs some further clarification, I did some probing into the various compositions. C36000 **Free-cutting brass** is an alloy that is ideally suited for high-speed machining operations with *superior machinability*, thread rolling and knurling characteristics. Its machinability rating of 100 is the standard against which all other copper and other metallic alloys are rated. **C38500 Architectural brass** is technically a brass alloy (copper plus zinc) commonly known as architectural bronze, and also possesses excellent machinability.

The improvement in machinability of brass is brought about by the inclusion of 2.5–3% lead content, which is responsible for the magic. Relative to copper, brass is more brittle due to its zinc content. In this

regard I can mention that long brass bullets in .375 calibre that are weakened by the crimping groove in the shank are prone to bending and breaking in half on elephant bone. However, this is highly unlikely in the thicker .458 calibre due to its better ratio of diameter to length. Copper solids though may deform but are less likely to break than brass.



|                              |    | C360<br>Free-cutting<br>brass | C385<br>Architectural<br>brass |
|------------------------------|----|-------------------------------|--------------------------------|
| The chemical<br>composition: | Cu | 60.0 to 63.0                  | 55.0 to 59.0                   |
|                              | Fe | 0.35                          | .35                            |
|                              | Pb | 2.5 to 3.0                    | 2.5 to 3.5                     |
|                              | Zn | 35.4                          | 40.0                           |
| Machinability rating:        |    | 100%                          | 90%                            |

**C101 OFHC** Copper is composed of 99.99% pure copper content and mostly used for bullets made from copper. **C145 Tellurium copper** is classified as a free-machining copper. The copper telluride precipitations in the microstructure result in producing shorter cutting chips while turning, thus enabling a much higher machining speed versus pure copper. C145 Tellurium copper has a machinability rating scale of **85%**, compared to **20%** for pure copper, thus affording longer tool life. Pure copper C101 is very gummy and plates a barrel much more than C145 or free-machining brass (C360 & C385). One way to help reduce barrel fouling is to have grooves or driving bands to give the copper a place to flow into during the engraving process. You can also treat the bullet with "moly" to reduce friction even further. It stands to reason that C145 is thus the preferred choice when it comes to making competition bullets.

The machinability rating relates to a standard of how

long tool tips will last. So if we superimpose this rating on the life of the rifling of a barrel, we can clearly see that free-cutting brass is actually much easier on a barrel than pure copper (C101) – **100% vs 20%**. This should rid the misconception that many people have about free-cutting brass bullets. C210 Gilding metal has a machinability of **50%** of which some bullet jacket material is made – typically 90% copper and 10% zinc. Generally, smooth bullets made from brass or gilding metal jackets foul less than smooth bullets made from pure copper, hence the need to reduce the bullet's bearing surface when made from copper or brass. However, a brass bullet will always cause more hoop stress (radial stress) on the barrel as it is harder than copper, and that is why some manufacturers make their solids ever so slightly just under groove diameter. As far as fouling is concerned, pure copper does foul extensively when the copper that is being displaced by the rifling has no place to go.

The study of friction and the relationship between friction and wear depends on many factors such as load, geometry, sliding velocity, surface roughness of the rubbing surfaces, type of material, grain structure and lubrication. In tests that were done on friction, the results reveal that the friction coefficient increases with an increase in normal load and sliding velocity.

### *"Labyrinth seal" effect*

It has been suggested to me by an engineer, there is another aspect to grooves cut into bullets called the

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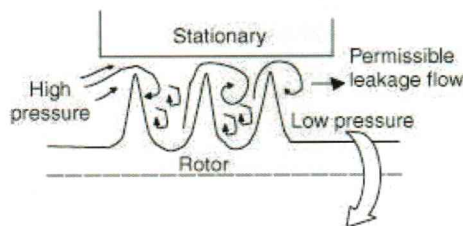


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“Labyrinth seal” effect, which may be of interest to us. A gas seal between fixed and moving parts that compose a series of chambers, even though their sides do not quite touch, reduces the escape of gas to near zero.



Significant leakage of high-pressure propellant gas past the projectile during firing can create jetting, thereby exacerbating **erosive flow effects** that could also be considered as mechanical erosion.

### Throat erosion/corrosion

The damage to the throat of a barrel is due in small part to mechanical wear and in large part to the effects of heat occurring during the very brief period of very high flame temperatures during the peak pressure phase. Heating and cooling are brief but intense, causing damage to the surface of the bore through corrosion, also called “fire-cracking”. Through a bore scope, it looks like a dried-out mud puddle. Whilst there are more technically advanced explanations, such as those suggested by ML McPherson regarding the process of wear, I believe that wear on a barrel is determined simply by the following factors working in tandem:

1. the amount of powder burned (how many BTUs of heat are produced)
2. the diameter of the bore (what area in square inches is being exposed to the heat)
3. the pressure of the load (higher pressure increases heat transfer)
4. heat build-up (a match firing of 20 rounds in 20 minutes makes a barrel hot)

### How did Woodleigh relieve pressure from their FMJ solid?

Woodleigh’s FMJ has been the most-used solid bullet in double rifles up to now. The problem (or potential problem) with a double rifle is that the barrels are joined by soldered ribs and it is claimed that the bulge of the passing monolithic bullet is enough to pop the solder joint. As steel-jacketed FMJs are bound to generate more pressure than soft-nose bullets for any given load, so Woodleigh made their FMJs **0.0005" to 0.001" under nominal diameter** to reduce engraving forces and pressure during firing. In addition they have also copper-plated their FMJs to facilitate engraving into the lands as the copper plating is softer than the underlying steel jacket. I am not sure how thick the copper plating is, but suspect it to be around **3-thou to 4-thou**, which is the depth of the grooves or near enough to it. So we see that they have adopted a two-tier design approach to lower the pressure.

### Tests done by the Barnes bullet company

Barnes conducted a pressure test to confirm that their mono-metal Banded Solids do in fact yield lower pressures than Woodleigh’s copper-clad steel-jacketed FMJ bullets, making them safe for use in doubles. The following is a quote from their findings: “The Barnes Banded Solid is slightly undersized. We do this to accommodate the great variety of tolerances found in double rifles. It is a fact that some double rifle barrels are out of spec on bore and groove diameters. In a perfect world we would build bullets to fit each individual throat and barrel, but this is simply not feasible. So we try to build bullets that will work safely for the majority. SAAMI requires that diameters on all sporting rifles do not exceed +.002”, but as we know double rifles were being built long before SAAMI came into existence.

The material used to manufacture Barnes Banded Solids will not obturate at less than 45,000 psi. So how is it that a turned bullet, slightly undersized in diameter, held to precision tolerances on a CNC machine that will not obturate, creates excessive pressure or damages a barrel that is even close to within spec? I submit that a full metal jacket consisting of a .003" thick copper-plated steel core engraving into the lands and grooves is going to be much harder on a barrel. To further reduce bearing surface and pressure, Barnes has cut a series of grooves in the shank of the mono-metal solid that provides any material displaced by the lands someplace to go. Full metal jackets do not have this feature. Steel on steel is not the desired scenario for a rifle barrel, especially if what people are saying is true about the older barrels being made from softer material. Is the steel in the jacket material softer or harder than the barrel steel? In general, we do not know the answer to this as the metal used for double rifle barrels has varied to such a great extent over the years. However, we know for a fact that the brass in Barnes Banded Solids is indeed softer than barrel steel. We also know that the grooves cut in the shank provide an area for the softer material to displace.

Still sceptical? Of course you are. You want proof and we figured you would, so we performed pressure tests. Hopefully, the results will put this myth and your mind to rest. While we were at it, we shot some penetration tests to compare Barnes bullets with one of our leading competitors on the African market. I believe the ‘high pressure with all mono-metal solids’ propaganda was spread via the old ‘someone heard something from someone’ and so on, and so on. If someone out there is aware of an actual case involving pressure issues with Barnes mono-metal solids, I would ask that these people contact Barnes personally. We would like the opportunity to investigate any such claim. Based on our tests and experi-



**Barnes Banded Solid**



ence, I'm comfortable stating that Barnes Banded Solids are better for antique barrels than the competition.

For our test, we fired **500-grain bullets in a .470 Nitro test barrel** with 85.0 grains of RL15, Norma brass and Federal 215M primers."

| Type of bullet      | Group   | Pressure in psi | Velocity in fps |
|---------------------|---------|-----------------|-----------------|
| Barnes Banded Solid | 1       | 34,100          | 2,146           |
| Barnes Banded Solid | 2       | 33,600          | 2,140           |
|                     | Average | 33,850          | 2,143           |
| Woodleigh FMJ       | 1       | 36,300          | 2,132           |
| Woodleigh FMJ       | 2       | 34,900          | 2,124           |
|                     | Average | 35,600          | 2,128           |
| Barnes TSX          | 1       | 39,600          | 2,153           |
| Barnes TSX          | 2       | 38,100          | 2,139           |
|                     | Average | 38,850          | 2,146           |
| Woodleigh RNSP      | 1       | 36,500          | 2,146           |
| Woodleigh RNSP      | 2       | 34,800          | 2,095           |
|                     | Average | 35,650          | 2,121           |

Note: The above results were based on a 10-shot string.

### Some observations

It is interesting to note that the Barnes Banded Solid (33,850 psi) is yielding on average **4.9% lower pressure** than Woodleigh's FMJ (35,600 psi). Also the pressure of the TSX bullet in comparison with the Barnes Banded Solid is **higher by 14.8%** (33,850 vs 38,850 psi) as it is firstly made from copper and secondly the TSX features only three grooves, whereas the Banded Solid has much less bearing surface in comparison. The Barnes Banded Solid is a "bore-rider" design with less material that must engrave the rifling, whereas the TSX is not, and this explains the differential pressures between the two bullets.

We also know that Barnes stated that the TSX yields somewhat less pressure than the previous X-bullet, but I cannot say by what percentage. Another observation from the Barnes pressure test is that the TSX still yields **9% more** (38,850 vs 35,650 psi) pressure than Woodleigh's lead-core RNSP bullet that has a 1.6 mm gilding metal jacket. It seems that Woodleigh has engineered to achieve very similar pressures from their soft-nosed bullet and FMJ solids.

### Barnes Banded Solid has been banned

The Barnes Banded FN Solid is unfortunately no longer produced as **BATFE (ATF)** has deemed it as an armour-piercing bullet. Needless to say that no hunter understands this silly move, as we are hunters that use bullets



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in a hunting application and not in a military sense where much smaller assault cartridges are generally in use. Two other custom bullet makers in the USA, namely **Cutting Edge Bullets (CEB)** and **North Fork** have filled the void left by Barnes, and they are producing banded FN Solids. The North Fork bullet is made from pure copper, whereas the CEB is made from free-machining brass. Both bullet brands are now being imported into South Africa directly by Dawid du Toit (tel: 073 081 9635) and Wim Lamprechts (tel: 082 748 8808) respectively and sold exclusively by themselves and not through any other gun shops.

### North Fork technology

**North Fork** bullets have a design which utilises pure copper in their solid bullets as well as pure copper and pure lead in their soft expanding bullets with a solid shank. Despite higher costs, tougher machining and shorter tool life, North Fork maintains that their use of pure copper results in a tougher bullet that is less brittle and far less likely to break, or shear off part of a mushroom in their soft expanding bullets. The fact that pure copper strongly resists tearing results in a tougher bullet than a similar product produced from a gilding metal or a copper alloy. North Fork is also of the opinion that any harder copper alloy is more brittle than pure copper and will cause greater radial stresses when passing through a barrel, especially when shooting a double rifle.

North Fork also believes that their "micro" size of the Smart Bands™ results in a greater pressure reduction than a bullet design with broader (thicker) bands, even when bearing surfaces are similar, as broader bands still require a degree of compression of the shank or band and the proof is that North Fork bullets are very accurate over a long string of shots. North Fork offers solids in a flat-nose design as well as a cup-point design, and then also a soft, all made from the same material. They claim that their entire line of bullets allows for the same point of impact within a certain calibre, which affords the reloader a reduction in load development time.

### Cutting Edge Bullets

**Michael McCourry** has done some extensive tests with a Pressure Trace System to design a banded FN Solid bullet for Cutting Edge Bullets (CEB) that could safely be used in double rifles – it features only four driving bands spaced fairly wide apart, with one at the very bottom.

CEB states that all their bullets are **under groove diameter by .0002"**, so they can be loaded just like normal cup and core bullets, and none of their bullets are moly-coated. CEB, like all the other bore-riding bullet manufacturers, states that the "bands" do make a bullet more accurate on their brass designs whilst banding does have an effect to reduce the BC of a bullet. However, this is of little consequence on large-bore solid or expanding bullets used on heavy, dangerous game at close range. Banding definitely reduces the BC on long-range bullets, so Cutting Edge Bullets employs a smooth body design on all of its MTH (Match-Tactical-Hunting) or MTAC (Match-Tactical) solid

copper bullets with their patented SealTite Band™, providing a custom fit when fired through any barrel. You can see this in an extreme long-range test performed by Greg of Terminator Products, posted on Long Range Hunting.com (go to: [www.youtube.com/watch?v=4XVNWrtQo4](http://www.youtube.com/watch?v=4XVNWrtQo4)).

Daniel J Smitchko of CEB says, "We have shot thousands of our brass bullet designs, and I can tell you without a doubt, they foul much less than every 30–50 rounds when we first began testing the banded brass bullets, but realised pretty quick there was no need for that. We now will shoot well over 100 rounds between cleanings, and never clean because of accuracy degradation."

Here you can see a Cutting Edge Bullets Safari SOLID™ retrieved from an elephant shot by **Aaron Neilson** from his .600 Nitro Express. Note that the bullet's shank is not engraved, but only the bands and there is no deformation at the bullet's tip. Aaron states that two bullets fully exited – this was the only one retrieved and I quote:

"My 3rd shot on the tuskless elephant was in the right-rear hip, at roughly 50–60 yards. The bullet broke the right hip, penetrated all the way to the opposite left shoulder, through the left shoulder, and was protruding just inside the skin on the opposite side – left shoulder. Ian

was amazed, and so was I. The bullet easily penetrated 7 feet of elephant, through heavy bone, etc. It was truly amazing, and further proof for me that I am using the best bullet made."



**A CEB 900 gr .600 Nitro Safari SOLID™ retrieved after passing through 7 ft of elephant alongside a loaded cartridge. Note that only the bands, and not the shank of the bullet, were engraved.**

### Local manufacturers

Locally, FN Solids that are made from free-machining brass with grooves cut into the shanks are made by Rhino, Dzombo, Impala and Du Plessis-werke, whereas GS Custom is the only FN Banded Solid that is made from copper. Lubrication with moly reduces the friction, especially with copper bullets, but Rhino Bullets moly-coat both their copper and brass bullets. For more information on the comprehensive range of Peregrine bullets (copper & brass), I refer you to the test report that Koos Barnard published in the March 2013 issue of *Man Magnum*. Since various articles have already been published on local bullet manufacturers, I am not discussing it in depth in this article.



## Closing thoughts

In closing I wish to mention that I have consulted most of the custom bullet makers as to their opinions on this article, so as to portray a collective agreement of the subject at hand. In addition, I have also requested Johnny Rech, who holds two MSc degrees (Engineering and Metallurgy) to vet my article, as I am not a metallurgist and various opinions abound in the lay press.

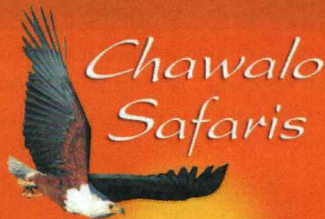
Having examined various factors that could play a role in reducing the engraving resistance, I wish to state that I am not presenting the above results on barrel wear and friction as absolute and definitive, but merely as indicative as to what one could expect. Since I have only quoted one test result that was done by Barnes, we need to allow for the possibility that there may be differences in respect of other cartridge and bullet load combinations that were not tested. Since there is interplay of many factors as discussed above, one should recognise that the coefficient of friction will differ from bullet brand to bullet brand as their designs differ, and more lab testing may be required to be more specific and precise in such comparisons. Also bear in mind that work hardening and annealing also do play a role as to whether a bullet is more ductile or more brittle as opposed to its virgin condition.

At least I have satisfied myself that I would not lose any sleep over the use of copper or free-machining brass bullets, as I see the main culprit as throat erosion by the flame-cutting effect of the hot gases rather than bullet abrasion. Let me put the matter into perspective: a .458



A .458 cal 550 and 500 gr North Fork FN Solid

Win will last you for at least 5 000 shots, and even if we concede that monolithic bullets will curtail the useful life of a barrel by 10%, then make your first 4 500 shots count with the best bullet that is available to you. You need not worry about the last 500 shots as this will invariably put you in the company of John "Pondoro" Taylor and other legendary elephant hunters of yesteryear, even if you use three bullets per elephant every time, as that would make you the proud owner of a "modest" 1 500 trophies. 🐾



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