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METHODS PAPER

Design of non-lead rifle bullets to allow instant identification

Vernon G. Thomas[1]

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Abstract A design feature for non-lead bullets was proposed enabling visual distinction from lead-core bullets. The feature would allow rapid, non-invasive, examination of ammunition to ensure compliance with lead-free bullet regulations. The feature entails making symmetric flutes, or concentric rings, behind the bullet tip during manufacture. They are unlikely to affect bullets' ballistic performance. Should the design be adopted, agreement among governmental agencies and bullet makers is essential to incorporate this design protocol into regulations.

Keywords Lead-free rifle bullets · Hunting · Visual identification · Design · Regulation

Introduction

California will require in 2019 under Assembly Bill 711 that all rifle hunters use non-lead[1] bullets. This state-wide extension of the 2007 Ridley-Tree Condor Preservation Act was passed to reduce poisoning of California Condors (*Gymnogyps californianus*) and other scavengers from ingested lead fragments of spent bullets (Thomas 2009; Watson et al. 2009; Golden et al. 2016; California Department of Fish and Wildlife 2015). This concern has relevance to German hunting. The Federal German Ministry for Food and Agriculture has proposed amending the German Federal Hunting Act (CGerLI 2008) to require use of non-lead rifle ammunition to prevent lead bullet contamination of game meat and wildlife scavengers (Gremse and Rieger 2015).

Enforcing regulations under California Assembly Bill 711 and the German Federal Hunting Act requires verification that the bullets in a hunter's ammunition are non-lead. To date, there is no portable, effective, and low-cost electronic device that allows instant verification. Because California state enforcement officers and German regulatory bodies will have to verify hunters' ammunition, it is assumed that their agencies will devise such technology. This is analogous to the American enforcement agents verifying that cartridges used to hunt migratory birds contain non-lead shot, using electronic HotShot® meters. While the shot inside cartridges cannot be removed for testing, bullets are largely exposed, allowing direct, non-invasive, examination. Non-lead and lead-core bullets are of similar appearance, and their external surface may not reveal the chemical nature of the contents. A novel approach requires makers of non-lead bullets to incorporate a feature in the exposed bullet indicating its non-lead composition. Then, makers would provide the visual cue that the bullets were legal. This is the rationale for the proposed design of non-lead rifle bullets of all calibers and shapes.

Design assumptions

- Features should not diminish the bullet's ballistic properties, be instantly recognizable, and denote only non-lead bullets.
- Features apply to all bullet calibers, weights, and shapes. It is in the bullet tip and visible in loaded cartridges.
- Features would be made during normal manufacturing and not add substantial extra costs.

[1] Containing a maximum 1 % lead (California Department of Fish and Wildlife 2015).

✉ Vernon G. Thomas
vthomas@uoguelph.ca

[1] Department of Integrative Biology, College of Biological Science, University of Guelph, Guelph, Ontario N1G 2W1, Canada

- Features should endure normal handling and storage.
- Specific features would be agreed among different ammunition makers and used in their own bullet manufacturing according to regulations.
- International agreement among manufacturers would promote international trade.

Features incorporated into non-lead bullets

Two methods exist for making non-lead bullets from copper or gilding metal (90–95 % copper, 5–10 % zinc). One involves machining the desired caliber and bullet profile on CNC lathes. The other involves swaging, or die-pressing, the metal into the desired caliber and profile. Regardless of the method, the following features could be produced by a slight modification of existing processes.

Longitudinal flutes in the bullet tip

There could be 3–4 flutes, each 0.2 mm deep, pressed or cut symmetrically into the bullet's tip. Each would be "V" shaped and be 3–4 mm long, depending on bullet caliber and size (Fig. 1). The flutes would be visible and felt by finger nail. This cue would define bullets as legal and non-lead. The flutes would be made in the tip of the bullet when made in a swaging die. Ridges in the die would produce the "V-shaped" flutes, whose shape would not cause the bullet to stick in the shaping die. If bullets were made by CNC lathing, flutes would be cut as a last stage of production. The flutes would not likely affect the bullet's sectional density significantly or change the mass and length of the bullet. The flutes would not impede cartridge loading from the magazine of a bolt action rifle or other type of magazine-loading rifle. It is suggested that the symmetrical flutes would not interfere with the bullet's ballistic properties and its ability to expand. The flutes could, possibly, create the fault lines along which the bullet opens during its initial expansion. Prototypes of this design would have to be tested for accuracy, especially in bullets of smaller caliber and bullet mass.

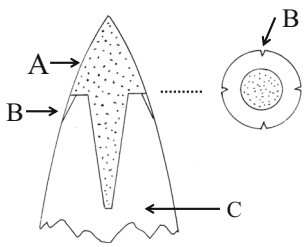

Fig. 1 Non-lead bullet in longitudinal and cross section. *A*, plastic tip; *B*, one of four flutes cut into bullet's surface; *C*, copper body of bullet

A commercial precedent exists for this design. The US company, Federal,[2] makes copper slugs in 12 and 20 gauge (Vital-Shok® Trophy® Copper Slug) with longitudinal flutes in the anterior region to facilitate expansion of the copper petals during penetration of the target animal. While these flutes are readily made in copper slugs, the same process could be applied to make similar identification flutes in non-lead hunting bullets.

Concentric rings in the bullet's tip

Two rings 0.5 mm apart and "V-shaped" could be pressed into the bullet during swaging, each 0.2 mm deep and behind the bullet tip or plastic tip (Fig. 2). This depth would permit visual, or a finger nail, confirmation of the bullet's being made of non-lead material. Two rings could be readily and precisely cut by CNC lathes during conventional machining of the stock material. Such rings would not, likely, affect the ballistic properties of the bullet and its ability to expand. This feature could be used for bullets of all calibers and lengths, and especially round-nosed bullets. A precedent exists for this modification. Cannalures pressed into the mid-section of bullets enable the cartridge case to grip the bullet: serration of the cannalure enhances the grip. Serrating the rings of a non-lead bullet could act, further, to identify it as non-lead and deter counterfeiting.

A similar feature is already incorporated into the anterior region of traditional German lead-core hunting bullets (RWS UNI Classic: RWS ID Classic: RWS DK: Brenneke TIG: Brenneke TUG, Brenneke TOG) without any detrimental ballistic effect. A sharp, raised, leading edge (German: Scharfrand) behind the bullet tip is designed to cut through hair and skin of animals on impact. This edge, if further serrated, could serve as the diagnostic indicator of a non-lead bullet.

Using plastic tips of specified color for non-lead bullets

Lead-core and non-lead bullets often include a plastic tip to promote bullet expansion during penetration. The colors have no special designation and appear in black, blue, red, and green, depending on manufacturer. A specific color (e.g., bright yellow) could be used and agreed among makers to represent a non-lead bullet and could complement use of flutes or rings. This would not cost more, given the existing use of plastic tips.

Manufacturing considerations

Assuming that shallow flutes or rings did not affect the ballistic properties of bullets, manufacturing considerations should

[2] URL: http://federalpremium.com

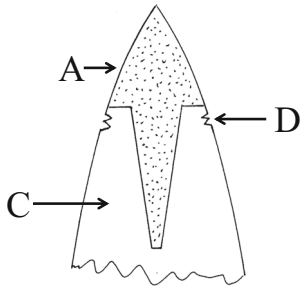

Fig. 2 Non-lead bullet in longitudinal section. *D*, two concentric rings cut into bullet posterior to plastic tip. *A*, plastic tip; *C*, copper body of bullet

be addressed. Swaging dies used to make non-lead bullets of all calibers, shapes, and weights would have to be modified, incurring costs and time within the factories. Cutting two extra rings on a CNC lathe-made bullet entails an extra step. The governments of the USA, California, and Germany (European Union) could compensate bullet makers because the makers would be certifying their product as non-lead, sparing governments the high costs of inventing, producing, and deploying field technology to do the same. The latter would be, likely, far more expensive and time consuming than producing an identity mark on each bullet. Furthermore, implementation of California Assembly Bill 711 requires that a bullet verification system be in place before 2019. It is reasonable to suggest that, as bullet makers increase production of non-lead bullets across all calibers, they also engineer the identification features into new production. A protocol that identifies the bullet, rather than the loaded cartridge, also means that hand-loaders of rifle ammunition would have their loaded cartridges comply with a lead-free bullet regulation.

Development of a non-lead identification feature on rifle bullets would benefit other US states and countries that might adopt them for hunting in future. It is reasonable to ask for US federal assistance to companies making non-lead bullets because the advantages extend across other states and their wildlife and not California alone. The same consideration applies to Germany, and other European makers of non-lead bullets, whose products are sold internationally.

At least 30 major US and 13 European companies make non-lead and lead-core rifle ammunition and sell to California hunters. Assuming that a flute or ring identification feature were adopted, all makers should adopt a commonly agreed upon identification system, applying to the both bullets and the cartridge containers. Forging this agreement among all makers would take time. Were US non-lead bullet makers to agree on a common identification feature, it would be advisable for other makers to adopt the same identification design. This would require an international agreement on this protocol, a precedent for which exists. All 20 gauge cartridge cases are colored yellow which identifies them as uniquely 20 gauge, regardless of their maker. This visual coding prevents their being loaded, accidently, into 12 gauge guns ahead of 12 gauge cartridges. A unique color protocol for the plastic tip of non-lead bullets could enhance the identification process.

One could mark the copper jacket of a lead-core bullet to appear to be non-lead, but it would be difficult to match the consistency of appearance of flutes and rings made by swaging or lathing. There is, also, no financial incentive, given the similar costs of equivalent non-lead and lead-core bullets (Thomas 2013).

Next steps

This design protocol has to be supported by the California Department of Fish and Wildlife, the US Fish and Wildlife Service, and the Federal German Government. With that support, the bullet makers in the USA, Europe, and other countries have to be approached for their opinion. If positive, prototype bullets of several selected common calibers and mass be made with either flutes and/or concentric rings, then tested ballistically under controlled bench-rest conditions at different target distances and across a range of bullet profiles. Costs of testing could be supported by the governments of California, the USA, Germany, and possibly the European Union. The costs include purchasing and modifying bullets with flutes or rings, testing the fired non-lead and control lead-core bullets, and statistical analysis of results. It is in the US government's interest to have non-lead bullets that can be used in the states across the entire California Condor range (i.e., California, Arizona, and Utah) to protect this endangered species. A possible source of state funding could be the Pitmann-Robertson Grant in Aid to wildlife conservation, with the US Department of Fish and Wildlife as the co-sponsor. European makers of non-lead bullets in Germany, Finland, France, Austria, and Sweden and their national governments could act as a consortium to partner with the US agencies in performing this testing.

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Compliance with ethical standards

Conflict of interest The author declares that he has no conflict of interest.

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