A Comparison of the Rebated Boattail Bullet Design with Flat Base and Conventional Boattail Bases...

Corbin Manufacturing & Supply, Inc.
600 Industrial Circle
White City, OR 97503 USA

D.R. Corbin, President
July 5, 1986

(Refer to Dr. A.B. Bailey, "An Aerodynamic Study of the Lapua Step Boat-tail Rifle Bullet and its Ballistics", 1981, Endrickvale, Fintry by Glasgow, Scotland, to R.H. Kent, "The Theory of the Motion of a Bullet About Its Center of Gravity in Dense Media, with Applications to Bullet Design", January 1957, Ballistic Research Laboratories, Aberdeen Proving Ground, Maryland, USA, and to D.L. Walters, "Cross-wind Weighting Functions for Direct-Fire Projectiles" (Report X-65), August 1975, Atmospheric Sciences Laboratory, US Army Electronics Command, White Sands Missile Range, New Mexico, USA, for background and mathematical support of the summary presented here.)

When a flat base bullet flys through the air at any velocity, it displaces an equal volume of air which then rushes in behind the passing bullet to fill the vaccuum. This happens at any velocity. But at speeds below Mach I (speed of sound), the drag caused by this turbulence is greater than most of the other forces slowing down the bullet. When the sound barrier is crossed, the air is compressed faster than it can move out of the way, and it compacts into a dense wave that is dragged along by the nose of the bullet. Moving this compressed shock wave adsorbs far more energy than the turbulent base drag. Thus, at super-sonic speeds, the nose shape has a greater effect than the base shape on the total retardation of the bullet (as a percentage of total drag).

If the base of the bullet were made more streamlined, then the air would be put back together more smoothly, with less turbulence, and would fill the space left by the passing bullet more quickly. This would eliminate much of the base drag. Putting a point on both ends of the bullet accomplishes this, but it generally makes the bullet too long, so that it takes up too much powder space or causes other physical problems in a practical size cartridge case or gun. There is no technical reason why a double-ended bullet should not be used to overcome drag, except for these physical considerations.

The next best idea is to use a truncated conical shape on the base, so that the bullet has some degree of streamlining to help reduce base turbulence. The conventional boattail does this reasonably well. By having a base that is made of an angled portion of the shank, the size of the flat base is reduced so that the turbulence works on a smaller area. A typical, practical size of boattail has from nine to fifteen degrees (measured from the center-line of the bullet) and is about a caliber long. There is no great difference in the performance of any specific angle or length within this general range.

The boattail reduces base drag at all velocities, but has the greatest percentage of effect when the bullet is flying at sub-sonic velocity. Thus, it is more important for slow bullets, or bullets fired at long ranges, than for bullets which will be moving at super-sonic speed over their entire path to the target. Ideally, pistol bullets should be boattails. However, due to the length and weight limitations imposed on most pistol bullets, this superior design is rarely used for handguns. It is often applied to rifle designs where it will have relatively little effect, but is primarily effective for promotional purposes.

The conventional boattail bullet does have three problems associated with it.

(1.) The angled boattail base tends to focus escaping muzzle gas like the nozzle of a hose, so that the gas flows in a laminar manner over the boattail, along the parallel shank, and partly attaches or follows the outline of the ogive until it separates at or near the tip, and breaks up into turbulence just ahead of the bullet. This can add as much as 15% to the total dispersion pattern of a given bullet design. The boattail bullet literally flys through its own muzzle blast because of the focusing effect of the streamlined base during the moment of exit from the barrel.

(2.) Since gas pressure acts normal to all surfaces (at 90-degrees), the compressive force of chamber and barrel pressure tends to compress the boattail section of the jacketed bullet inward, peeling it away from the bore and allowing gas to channel its way into the rifling grooves, causing gas cutting of the rifling edges and the edges of the rifling imposed on the bullet. Micro-droplets of melted jacket material can be observed on most boattail bullet jackets along the rifling edges, especially toward the rear of the bullet shank, some large enough to see without a magnifying aid. The flat based bullet tends to compress in length so that the shank is expanded into the rifling, for a superior seal.

(3.) The boattail bullet is sensitive to slight manufacturing variations in the position and concentric alignment of the boattail angle starting point. At the moment of exit from the bore, while the rifling is just losing contact with the shank diameter, any difference in position of the junction of the shank and the boattail gives a tremendous leverage to the escaping gas, which allows it to push the entire bullet in the direction of the higher starting point. That is, if the boattail is even slightly higher on one side of the bullet, the bullet will be deflected toward that side at the moment of exit by gas pressure escaping earlier from the opposite side.

All three of these objections are overcome by using the Rebated Boattail design.

(1.) Hyper-velocity gas escaping around the bullet base at the muzzle will impinge upon the rebate shoulder, which acts as a "spoiler" and deflects the gas from a laminar pattern. It causes a ring of gas to be blow off in a turbulent forward rolling expansion, but leaves a clear space directly in front of the bullet. This eliminates the buffetting of the bullet by its own muzzle gas, a source of up to 15% of the total dispersion factor.

(2.) Gas pressure acting normal to the surface of the Rebated Boattail will compress it inward, causing the lead to flow forward and outward. When the gas reaches the rebated area, it acts normal to this surface also, forcing the gas to act parallel to the bore rather than at a compressive angle, and holding the rebated edge rather than compressing it. Internal pressure from the compressed, angled base area then pushes the lead outward, against the inside of the jacket, which in turn seals against the bore more tightly. The peeling-away of the base from the bore is eliminated. An examination of fired RBT bullets at the same velocity and from the same guns as the BT design will show no micro-droplets of molten jacket along the rifling edges.

(3.) The Corbin method of producing the RBT design, using two dies and a finalizing punch during the point forming operation, greatly reduces or eliminates the chance of having the RBT angle start higher on one side than the other. In addition, if this should occur, the effect on dispersion is far less because of the vastly shorter transit time during which the gas can begin to escape around the emerging bullet base. The sudden drop in diameter releases the gas with smaller time/resistance factor than the slow increase as the BT angle passes the muzzle. Add to this the fact that the tooling lasts longer and is easier to produce in a precise manner, and you have every reason to abandon the BT in favor of the RBT.