Precision Shooter Aptitude Test (PSAT)
17 Questions and Answers

By James A. Boatright

Q1: Should we expect the boat-tails of our VLD (very low drag) match bullets occasionally to be re-swaged as blunt cylinders in firing with chamber pressures over 60,000 psi?

[No. The boat-tails of soft-lead-core, long-range VLD match bullets can "slump" under great acceleration just as can their long noses, but no amount of fluid pressure alone can cause the *shear stresses* that could directly upset the afterbody of our VLD bullets by force.]

Q2: What does the designation "R" stand for in the AISI Type 416R stainless steel often used for making our match barrels?

[Don Gentner once told me that the "R" in Type 416R stands for "Re-melted," a process used in manufacturing to improve the quality of the steel, and I believe that he should know. Before that, I used to think it stood for "Rifle quality."]

Q3: Does the recoil force on a rifle attachment, such as its scope, increase when we switch to firing heavier bullets at the same peak chamber pressure?

[No. By Newton's Third Law of Motion (equal and opposite forces), the amount of peak reaction force driving the entire free-recoiling rifle backwards is ***equal*** to the amount of peak force accelerating the bullet forward (peak pressure on the bullet base times the cross-sectional area of the bore). The peak recoil force on each rifle component, such as its scope, is the same proportion of this peak recoil force on the whole rifle as is that component's weight to the rifle's total weight. We are neglecting the relatively small force of the bullet's sliding friction in the bore. The larger force of engraving the bullet into the rifling is over and done before peak chamber pressure occurs, and effective external resistance to the recoiling of the stock has not yet materialized at the instant of peak recoil for a normally held rifle.]

Q4: Does the bore of a 6mm PPC-chambered, Light-Varmint profile barrel *increase, remain the same*, or *decrease* in diameter when the Type 416R stainless steel barrel material expands from the heat of repeated firing?

[Increase. All portions of the steel barrel material increase in length, in area, and in volume with increasing temperature. The empty bore expands just as if it were made of the barrel's stainless steel material and maintained at the barrel's core temperature. Think of heating an old-fashioned iron wagon tire for "heat shrinking" onto a wooden wheel for an obvious example in which the "hole diameter" enlarges with increasing temperature.]

Q5: Why is "hell-for-stout" tactical-style scope mounting more damaging to an expensive aluminum-bodied scope and more detrimental to the accuracy of the "tactical rifle" than the use of more conventional scope mounting systems would be?

[Aside from possibly being damaged by over-torquing its ring tensioning screws, the aluminum scope body needs to expand in length with increasing temperature at twice the rate of the chrome-moly steel receiver, and this expansion will bend the scope as the rifle warms up in use *if the scope is mounted too rigidly*. The receiver will also bend due to this differential thermal expansion, and this will affect where the barrel points. Weaker conventional scope mounting systems might allow the rings to flex, or the bases to slip, without causing so much damage either to the scope or to the accuracy of the rifle. The old "windage adjustable" rear scope-ring mounts were capable of easily slipping back and forth lengthwise to dissipate the forces of differential thermal expansion.]

Q6: Why do scope-base mounting screws always come loose on tubular rifle actions such as the Remington 700?

[Scope bases for attachment to plain tubular receivers require the working length of their mounting screws to be *much too short* to be able to maintain their preload force in use. Thread locking compound can only keep the screws from falling out after completely losing their preload.]

Q7: Is the individual *peak pressure* or the individual *headspace dimension* of each cartridge being fired the single most important variable factor affecting the peak rearward bolt thrust produced as that cartridge is fired in a target rifle?

[Headspace, assuming any reasonable peak chamber pressure. Cartridge cases with less than 0.001-inch headspace consistently transfer the full rearward thrust of firing to the bolt-face. Rimless bottlenecked cases with greater headspace "use up" much of the potential bolt thrust in stretching the walls of the brass cartridge cases in a narrow region about **0.280-inches** from the head. Both the impact of the firing pin and the resulting pressure inside the cup of the detonating primer will drive the cartridge case as far forward as it can go and hold it there while the powder combustion process gets started. The pressure-expanded case walls can then grip the inside walls of the chamber, while the **7,500 pounds**, or so, of internally generated rearward thrust begins to stretch the case-head of the cartridge back toward the bolt face. In extreme headspace and high-friction situations, the brass case does not even stretch back far enough to contact the bolt face at all—only the unseated primer cup does. This phenomenon can be observed even in extracted cartridge cases that were fired at normal peak chamber pressures for some low-pressure cartridges.]

Q8: Should we expect residual stress in a free-floating barrel to have any significant effect on the vibrations of that barrel in firing?

[Not a significant effect. Residual hoop stress does marginally increases the stiffness of the barrel. The stiffer barrel would resonate at slightly higher frequencies of transverse vibrations than would a similar barrel free of hoop stress. Leaving the barrel containing hoop stress about **0.25-inch** longer would probably just about offset that small frequency shift as far as barrel vibrations are concerned. In accordance with the well-accepted *superposition principle* of physics, other types of residual stresses should have *no measurable effect* on barrel vibrations.]

Q9: What part of the barrel steel surrounding a chamber would likely fail first from over-pressuring?

[The inside walls of the pressurized chamber undergo much greater strain than do other portions of the barrel steel surrounding the chamber. So, in a sense, the inside walls of the chamber are indeed the first parts of the chamber structure to "fail," but they are simply expanded a bit and then held in place by the remaining outer portions of the steel. As the stress levels in the steel immediately surrounding the chamber surpass the elastic limit for this material, a core of steel around the chamber gets plastically distorted by becoming permanently expanded in diameter, usually by less than **0.001-inch**. This expansion is resisted by "hoop stress" developing in the remaining steel around this expanded core. If the internal pressure in the chamber is allowed to increase a lot more, the diameter of the plasticized core progressively increases at the expense of the outer containment cylinder. The chamber finally "fails" only after the boundary of the plastic core has breached the outer contour of the barrel profile. For rifle barrels made of uniformly good steel, this final catastrophic failure would require about twice to three times the normal peak chamber pressure.]

Q10: About how much do the inside and outside diameters of a typical centerfire rifle's chamber expand during firing?

[The typical chamber expands by approximately one to two thousandths of an inch in *inside diameter* at normal peak chamber pressures. Its *outside diameter* expands by *considerably less*—about equal to the *ratio* of the inside to outside chamber diameters times the amount of inside expansion (or usually about **40 percent** as much).]

Q11: Would the chamber expand less in firing if the barrel were made of steel with a higher tensile strength rating?

[No. Chamber expansion with internal pressure depends on the *elasticity* of the barrel material—*not* on its *tensile strength rating*. Young's Modulus of Elasticity for a particular type of steel is not changed appreciably, for example, by heat-treatment to increase the tensile strength rating of the steel.]

Q12: Would slightly over-stressing the steel parts of a rifle, as in firing a single, significantly overpressure "proof load," for example, be more likely to *weaken* or to *strengthen* these rifle parts?

[Strengthen. Slightly exceeding the elastic limit a single time purposely to over-stress a steel part will strengthen it by the process of "work hardening" that steel part as it undergoes small permanent plastic deformations.]

Q13: What causes some barrels to "walk" their bullets across the target as they heat up?

[If the installed barrel contains some residual *bending stresses*, as would have been implanted during "barrel straightening," warming it above room temperature (as in firing) can begin to relax the *effects* of those built-in stresses—causing the barrel gradually to "re-bend," and walk its shots across the target as it continues warming with repeated firing.]

Q14: Why does merely touching the threads of an installed barrel with an over-length front action screw or front scope-base screw always seem to wreak havoc with rifle accuracy?

[Any side-loads on the installed barrel tenon will disrupt the *repeatable settling* of the free-floating barrel to its "natural point of aim" after the barrel tenon finishes moving around within the threaded joint during the commotion of firing.]

Q15: Is it a good idea to build a "pad" of bedding material to support the rear portion of the cylindrical chamber-swell of a heavy target or varmint barrel?

[No. The "pad" is not needed and it interferes with the barrel being completely "free-floating." See the answer immediately above, as well.]

Q16: When a benchrest competitor wishes to replace his centerfire rifle barrel at the range during a match, how much barrel installation torque should he use for best accuracy?

[The threaded barrel of a centerfire competition benchrest rifle needs only about **25 foot-pounds** of installation torque for best accuracy. The tenon of a competition benchrest barrel normally uses lubricated 60-degree V-threads for attaching the barrel into the glued-in receiver, and the front face of the competition benchrest receiver is certainly quite square to the axis of those threads in the front ring of the receiver. Even with this ultra-light barrel installation torque, the barrel shoulder is clamped to the face of the receiver with over **1000 pounds** of force. The miniscule torque reaction from spinning-up the bullet as it is fired in his right-hand-twist barrels works to *tighten* the right-hand-threaded barrel joint. Additional assembly torque would just unnecessarily increase the levels of stress and distortion in the receiver and in the chamber end of the barrel.]

Q17: Does a precision-made competition or varmint rifle benefit from having its chamber walls purposely "scratch roughened" in fitting a new barrel?

[No. The practice of providing "grip" on the chamber walls was probably developed long ago by gunsmiths who were re-barreling surplus military actions into hunting rifles. They found that roughing the chambers could ease the difficult extraction problems that would occur when these weaker or more poorly made actions were chambered for marginally too large and too powerful modern rimless, bottlenecked hunting cartridges. Such actions allowed too much bolt face setback when firing ammunition with minimum headspace, even at normal chamber pressures, and ended up jamming the expanded case back into the chamber as the pressure dropped again. By roughing-up the chamber walls, these old-time gunsmiths found that they could cause the brass cases to stretch a small amount in firing so that the same ammo generated enough less bolt thrust to ease the extraction problem. Today's gunsmiths mostly just continue the practice without considering its original purpose or its possible bad effects on case life in today's stronger target rifles. The chambers of our precision target rifles should be polished-out with crocus cloth, or something similar, to provide a more "brass friendly" firing chamber and to stop needlessly stretching our fully prepared and precision re-loaded brass cases.]