A sight should endure knocks on the hunt without changing zero—or raising fears that it might.

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Gremlins IN THE Glass

The best rifle scope doesn't always have the most features. You must know what not to buy.

Some things in rifle-scope design follow as logically as soap at a wash-basin. Holding tolerances to .0001 in lens manufacture, for example, helps ensure fine resolution in Zeiss lenses.

On the other hand, much of what you *can* buy in a scope has no place in one. Every feature affects utility; some don't improve it. A scope that costs you a killing hit won't please you.

Not long ago a fellow told me he was astonished that in my many years of hunting I'd had only one scope failure. "We've had several in our camp," he declared, looking for a rise. He got none. "We use hard-kicking rifles because we have to shoot elk close and going away." I couldn't tell then if he was asking for redemption or sympathy.

It may well be that scope failures plagued his group. I didn't ask what kind of failures, suspecting loss of zero would top the list. It crops up more often than any other fault—not because scopes are flawed, but because a shift in zero can cause a miss, and missing triggers the complaint. Weighing in on this issue by asking for proof

WHAT MAKES A SCOPE EXPENSIVE?

A Zeiss catalog in my file shows a 4x Zeilvier rifle scope at $45, a 6x Zeilsechs at $52. Variable Ix4x Zeilmulti and 1x-6x Zeilmultar scopes retailed for $66. Big money in 1926! Zeiss stressed that "the outer tube, together with the lens socket of our sighting telescopes, is drawn in one piece." The standard No. 1 "graticle" had one post and two horizontal bars, the gap between the bars subtending 25.2 inches at 100 yards. In other words, short of optical improvements, these scopes had the basic features of the best modern scopes. These days, most of the cost of a rifle scope remains in those features and in lens coatings. That's also where you'll find the utility and lasting value of a scope.

is senseless. If the scope is innocent, the shooter is probably guilty. Besides, proving a scope has suddenly lost its bearings is about as easy as proving that unemployment rising in the wake of $7 billion in economic stimulus would have climbed higher without it.

"My shop is a scope graveyard," says D'Arcy Echols, a Utah rifle-maker who insists on dime-size groups from his hardware. "Even top-name scopes can fail after a few bouts with a .458 Lott." He adds that mounts fail too, especially when customers insist on heavy scopes. "Increase inertia, and you hike the odds the tube will slip in the rings. Scopes would be much happier if people shot Cape buffalo with .223s."

Recoil does indeed test scope integrity—as it tests us. Not long ago at a rifle range I fired a rifle in .505 Gibbs. Its 600-grain bullet carries nearly three tons of truculence out the muzzle. A buffalo might equate the impact to that imparted by a speeding Land Rover. Recoil is a bit less violent, though not much. I fired offhand, and just thrice, to spare my clavicle.

"Hey, can I try that?" The range officer had never fired such a rifle.

He poked a cigar-size Norma round into the CZ's breech, then took aim. Boom! The rifle vaulted out of his forward hand, climbing skyward as he staggered back. It wrested itself from his right hand as he went to his knees. The rifle landed behind him in the grass. He did not ask for another cartridge.

Quite possibly we'd see more scope failures if we fired powerful rifles more often. I've had many problems with mounts on hard kickers. One, a .416 Rigby, pounded the rings loose during a range session. I didn't notice until the 1 1/2-pound scope flew by my ear. I'm less surprised by the occasional scope failure than I am that optical sights can be built to withstand such hammering.

It's unlikely you hunt with a .505 Gibbs or even a .416 Rigby. The 30 foot-pounds of recoil from a .300 Winchester shouldn't rattle your scope apart—especially if you keep things simple inside.

I suppose it's useless to hawk fixed-power scopes as sturdier than variables, albeit they *are* simpler and lighter. Like automatic transmissions, variable-power sights have improved a great deal since someone decided we needed them. CNC machining of the erector assembly to gnat's-wing tolerances has essentially eliminated zero shift. Lighted reticles don't induce changes in zero. An adjustable objective or focus knob doesn't affect zero; nor does a turret with indexing or resettable dials.

Still, complexity breeds malfunction. Even if a scope that rides out the rigors of many hunts with nary a hiccup can cause a miss. I recall watching an optics salesman

At modest magnification—say , to 6x—even slim scopes transmit plenty of light at dawn and dusk. When purchasing, look inside the tube from the front. A blackened interior limits internal reflection. That's good.

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How to inspect a scope

The optics counter in a sporting goods store is no place to evaluate scopes. But some differences between models *are* evident at first glance, if you know what to look for; and a walk outside can show you others. First, limit your shopping to sights with fully multi-coated lenses. They ensure the brightest images. Narrow your search to scopes with the lowest magnification or power range you can accept. Chances are, you'll seldom need magnification above 9x; you *will* appreciate a slim, lightweight scope. Stay with 32mm to 42mm front lenses. They allow you to mount the sight low on most rifles. Bigger lenses boost brightness only in dim light and at very high magnification. They add weight and cost, and impair rifle fit and balance.

- Check "free tube" to be sure the scope will mount easily on your rifle. Short scopes with big front bells, beefy turrets and long eyepiece assemblies are common now, limiting your options. Extension rings and bases can bail you out but may interfere with top loading or degrade the appearance of the rifle. I crawl with my stock so I install scopes well forward. Long ocular assemblies work against me, so I choose sights with compact eyepieces. I also like a modest bell overhang, front and rear, to protect the lenses.
- Don't be seduced by helical or quick-adjust oculars. Once you set an eyepiece, you shouldn't have to move it until your eyes change. It is *not* a device for focusing the scope at different distances!
- Stick with simple reticles. Decide first whether you want front-plane or rear-plane placement. The front-plane reticles popular in Europe stay the same size *relative to the target* throughout the power range, so are most useful as rangefinders. Because they change dimension with power changes, some hunters find them annoying—you get a fine aiming point at the low magnification you'll use for quick shots in thickets and a coarse reticle at high magnification for long shots at small targets. If in doubt about reticle placement, point the scope at a wall and turn the power up. A front-plane reticle will grow; a rear-plane reticle won't.
- Look inside the tube from the front. A blackened interior limits internal reflection. That's good.
- Remove the turret caps and move the windage and elevation dials. They should click crisply and yield evenly, yet not too easily to finger pressure. Less convenient coin-slotted dials are on the way out, though they function as well as finger dials. Target-style knobs don't make sense on hunting rifles subject to hard knocks and scabbard carry. Compact capless knobs, like Leupold's lift-and-turn dials, do.
- To check eye relief, clamp the scope in a tripod or set it on the counter and move your head back and forth to find the distance at which you get a full picture. Insist on three and a half inches of eye relief; four is better. To check for parallax error, set up the scope outside, with the reticle on a distant mark. Move your head side to side and up and down. The reticle should remain near the center of the mark. Most scopes are set for zero parallax at 100 or 150 yards, so you'll want to check for error at longer range. Adjustable objectives and turret-mounted focus knobs let you zero out parallax at any range.
- As you check for parallax, note color fringing and image curvature at field edges. You want a flat picture, with true colors to the rim. Check at top, middle, and bottom magnifications. At low power, you'll find field curvature more noticeable.
- Assess resolution by looking at finely detailed objects like leaves. Better yet: get an eye chart from an optometrist before you shop, and hang it at a distance outside the store. Comparisons will be easier!
- You can't truly test light transmission unless you shop at dusk, when looking into shadows outside can sift differences between scopes. Compare sight pictures on backlit targets too.
- To check for hydrophobic coatings, carry an eye-dropper or spray bottle of clean water. A drop on a water-repellent coating should bead and scoot off the glass. A shot of mist should not streak, but bead like shot. Scratch tests aren't as easy. Ask before you take a zipper tab to a lens!
- The real test of a scope comes in the field; but if you're diligent when shopping, you shouldn't be surprised on opening day.

The quick-focus—or European or helical—eyepiece is a convenience, not a necessity.

The 30mm tube on this superb Schmidt & Bender is becoming more popular; however, one-inch tubes suffice.

Even simple scopes require fine machining, careful assembly of many intricate parts.

frantically turning his scope's power dial up and down as he tried to find a mule deer on a Colorado ridge. I could see the buck plainly. My pal was looking for it not in the sage but in the scope. Sophisticated reticles have misled riflemen at the moment of truth. A bright reticle affords less precise aim, especially when the rheostat is turned too high (dim light calls for a low setting; dial up lumens only until the reticle becomes easily visible). A matrix of dots and bars requires thought. Which intersection to use? A crosswire or plex reticle, or a medium dot suits me. A reliable scope is not just one that does what it's supposed to; it helps *you* do what *you're* supposed to.

Slender, low-mounted scopes make sense if you travel in hunting country by horseback.

One huge advantage of a scope is its ability to brighten the target image. Those lenses that boost resolution and magnify the target, however, lose up to four percent of incident light to reflection and refraction *at each surface*. A series of lenses can thus leak an enormous amount of light. Look through a 19th-century scope, and you'll see a dim image indeed. But in the 1930s a Zeiss engineer found that a lens coating of magnesium fluoride reduced light loss dramatically. Later, other compounds and new ways to deposit them made multi-coating possible. Brightness became a criterion for judging rifle scopes that might be used to aim at game animals in dim light.

These days, even mid-priced scopes are fully multi-coated (all lens surfaces, in and out). It's hard to say one scope is brighter than another unless you test them in near-dark conditions. "Figure 80 percent light transmission through lenses with one coating, and 90 to 95 percent through a series of fully multi-coated lenses," says Walter Schwab, a Zeiss engineer. "Claims of near-100 percent light transmission through a scope aren't true." He adds that you can't tell if a scope is fully multi-coated by looking at it. The straw, purple and green colors on coated exterior glass tell you nothing about the lenses inside.

Coatings are applied electronically from a small circular pallet. Each coating is distributed as a film by an electron beam that excites the material and sprays it onto the lens. A final operation pounds the compounds onto the glass with volleys of ions. At least, that's how it's done at Zeiss. "T* (T-Star) coating is our best," says Walter Schwab. "But we have several T* formulas, each specific to a particular product."

Incidentally, while a big front lens transmits more light in dim conditions, your eye won't necessarily catch it all. You'll benefit only at high magnification. Oversize objectives burden you with extra weight and bulk and force high scope mounting. Neither is a 30mm tube a sound investment in brighter images. In fact, it has no appreciable effect on brightness. It may increase the latitude of windage and elevation adjustment; and it allows for a wider range of magnification than possible in one-inch tubes. Four-, five-, and six-times power ranges (3x to 18x instead of 3x to 9x) are more versatile; but magnification over 9x has limited application for hunting.

Fog-proofing scopes by sealing in nitrogen became standard practice during the 1960s. Now argon gas is used in lieu of nitrogen in some scopes. Both suffice. A scope should be fog-proof after submersion, and resist leakage in extreme temperatures. A scope that fogs can scuttle your shot. I recall on a deer hunt long ago having to periodically remove the ocular housing of my sight to let the sun suck moisture from its crevices. Of course, a scope with an eyepiece you can remove was never sealed.

Some hunters have told me their nitrogen-filled scopes fog. Unlikely. But the *lenses* may fog. At Bushnell, Bill Cross has been designing optics for as long as I've been writing about rifle sights. "Nitrogen gas prevents internal fogging," he says. "The glass

A FEATURE THAT KEEPS YOU OUT OF THE RECORDS BOOKS

Killing an animal that qualifies for Boone and Crockett listing would seem to have little to do with electronics. But the appearance of laser range-finding riflescopes and trajectory-compensating mechanisms raises questions, do they have a place in fair chase hunting and are they really necessary? Military applications and funding have spurred development of sights that are ill-suited to hunting rifles but are nonetheless marketed and sold to sportsmen. To ensure that animals in its records book have been hunted in traditional fair chase fashion, the Boone and Crockett Club does not accept entries taken with the use of sights with built-in electronic rangefinding capabilities.

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can fog outside too, from your breath and sudden changes in temperature. And when fogging doesn't occur, you can still lose a sight picture to rain or snow." So in the mid-1990s Bushnell began offering RainGuard, an exterior lens coating so slippery that water doesn't adhere. It beads up and runs off. "Look at a lens through a microscope," says Bill, "and you see tiny pits—even in the best glass. These enable water to cling. RainGuard fills the pits so water can't get traction. It forms a scratch-resistant surface too, because grit can't grip or imbed. It slides off." Now in its third generation, RainGuard is standard on Bushnell's best scopes. RainGuard HD is also oleophobic, meaning it sheds oils too.

LotuTec, offered by Zeiss on its Victory series optics, is another hydrophobic film. The name derives from "the lotus flower effect," which Walter Schwab describes as the beading of water on a surface. "LotuTec increases the contact angle of water droplets. They're small at the base. Instead of forming a dome on the lens, a droplet pearls up and skitters off. Actually, LotuTec is *three* coatings, to prevent mechanical damage as well as shed water and oils. It showed up on Zeiss sports optics in 2007 after a debut on eyeglasses.

Burris introduced its StormCoat for the same purpose. The company's Patrick Beckett says it not only sheds water but prevents damage "when we scrub off dust or rain stains with cloth that holds tiny particles of grit. StormCoat resists scratches but doesn't affect brightness." Best of all, it is less expensive than Q-Coat, an early Burris film that "cost more than twice as much as the lens itself!" Patrick adds that lens caps offer the best protection from the elements. "They also guarantee you all the resolution and brightness you pay for. Any dust or water on a lens reduces resolution and light transmission, especially if you must aim toward the sun! A cheap scope with a clean lens outperforms an expensive scope with clouded lenses."

Swarovski's lens coatings include an exterior film that resists insect repellent and tree resin *and* beads water. Rob Lancellotti at the Cranston, Rhode Island headquarters says this coating clears quickly if you fog it with your breath. Oddly enough, Swarovski applies it to binoculars and spotting scopes, but *not* to rifle scopes.

Neither does Nikon use a water-repellent coating. "We haven't found one that meets our standards for permanence and light transmission," explains Jon LaCort. Noted for their brilliance and high resolution, Nikon lenses can ill afford coatings that affect optical performance.

Leupold has backed off hydrophobic coating, after listing one for its Alumina lenses that thread onto a scope's objective bell. While the Alumina line remains, the water-repellent option has vanished. "We didn't get much call for it," shrugs Pat Mundy. "We never applied it to scope glass. We concluded that water-repellent coatings are like raincoats—sometimes useful but not often unnecessary." Pat says Leupold still applies a film to shield lenses from abrasion. "Our DiamondCoat has been replaced by DiamondCoat 2 on VX-7 and VX-3 scopes. The first surface was mil-spec hard, but DiamondCoat 2 has 10 times the scratch resistance."

Not all scratch-resistant surfaces are hydrophobic. Bill Cross points out that silicon dioxide protects glass against abrasion. "It's essentially quartz sand, extremely hard. But it won't shed fog or rain drops. Water-repellent coatings are both hard and *smooth*." There's really no down-side to these films, though they may be a bit more vulnerable to gun-cleaning solvents, which you'd best keep off lenses anyway.

The high cost of high-quality rifle scopes and the proliferation of features that add little to their price have nudged many hunters to buy more complicated sights than they need. Their complexity, weight and bulk work against the primary function of a scope; it is, after all a *sight*. What you *need* are high resolution in a flat field, bright, fog-proof images under hunting conditions and the reliability of a shop anvil. Add variable power, if you must, and hydrophobic lens coating, an adjustable objective and target knobs for long shooting. Simple is still good, however. The moment of truth is no time to squander attention on your scope! ■

Dave Emary levers in another round. Note hinged lens caps, a useful accessory in many places.

Gremlins IN THE Glass

FULLY MULTI-COATED LENSES BOOST LIGHT TRANSMISSION— IMPORTANT AT DUSK AND DAWN.