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- **Cover photograph:** Japie van Reenen
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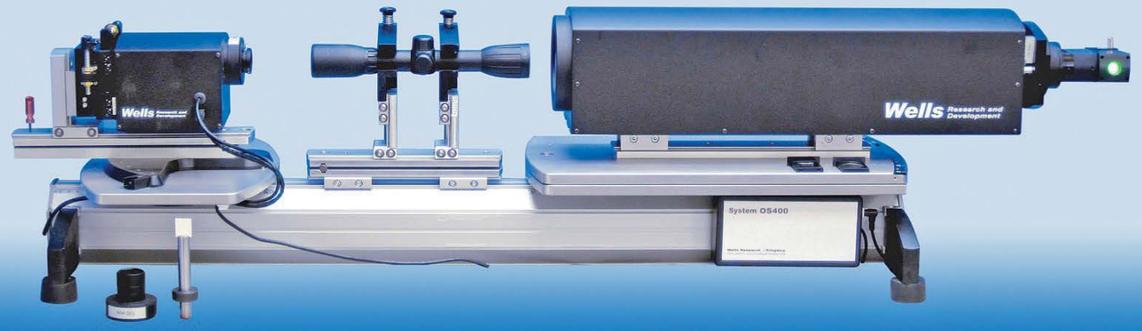
EVALUATION OF HUNTING SCOPES

A daunting task if left to gun writers without optic testing equipment

Part 1

Chris Bekker



Riflescope test bench for doing MTF analysis – Model OS400-50. Tests that it can perform: on- and off-axis MTF, 3-bar contrast, through-focus MTF, magnification and zoom magnification, distortion, field curvature in diopter, reticle parameters, astigmatism, parallax, field of view (FOV) (objective and subjective), and much more. The bench is connected to a big computer screen that displays the visuals of the results.

Introduction

During the last two years scope manufacturers have put their research and development departments to work, tasking them to produce new products and enhance current products by adding new features. Product differentiation is intended to bolster future sales and grow the company while at the same time making their products more attractive against the opposition. We have noticed a trend of scopes becoming bigger and heavier due to bigger eyepieces, bigger tubes and bigger objective bells. More brands are now offering higher magnification scopes for long-range hunters. It is all well and good, but there is also a downside to this, as one is compelled to mount scopes higher, causing the hunter to lose a firm cheek hold.

The goal of my optical performance evaluation

The focus of this article is therefore to look at scopes that can be mounted low. Most medium variable scopes come with 1" tubes and objective lenses vary from 40-44 mm. Some objective lenses are larger, but in most cases these larger lenses are not necessary for sunny South Africa. Most game can be taken well under 300 yds and therefore one does not really need magnification higher than 12x. When using more than 10x power, the situation becomes even more severe in terms of optic compromises, including image quality due to chromatic aberration if not countered by the use of extra-low dispersion (ED) lenses to reduce colour fringing, adding parallax adjustments and larger objective bells to prevent diminishing exit pupils. Smaller and lighter scopes do not affect the balance of a rifle in a major way and still look aesthetically pleasing. In part 1 of this article I am dealing with the significance of some key aspects that will relate to the evaluation criteria, which are discussed in part 2.

When optical designers attempt to compare the performance of optical systems, they use modulation transfer function (MTF) – MTF equipment being the most scientific method of describing lens performance. It measures how faithfully the lens reproduces (or transfers) detail from the object. The goal of my optical performance evaluation is NOT to attempt to establish a ranking system with a final score, as it is notoriously difficult to measure optics in an objective and quantifiable way. Tools, such as MTF plots, have been devised for that purpose primarily by the photography business. Since I have no access to such equipment, my optical performance evaluation is instead based on comparative observation to assist the reader with getting a sense of the character of a particular optic.

The significance of the "exit pupil"

A scope with a 42 mm objective lens, set at 10x power, provides an adequate exit pupil of 4.2 mm for light transmission. We know that the human eye can actually only dilate to 3.5 mm in daylight, and when the scope is set at 6x magnification it offers an exit pupil of 7 mm, which is the maximum the human eye can utilise at night-time. What more could a hunter ask for? Objective lenses larger than 42 mm tend to make for heavy and bulky scopes. A 3-18x50 mm scope would reduce the exit pupil to 2.8 mm at maximum magnification, making for a much more sensitive alignment of the human eye. This is the trade-off that the long-range shooter has to make.

USA study

A study was conducted in the USA where more than 700 hunters were surveyed. They thought that mechanical performance (referring to precisely calibrated clicks and internal adjustment range) was most important, and ranked it as 30% more important than optical performance (referring to resolution, contrast, field of view, and zoom ratio). Trailing those were factors like reticle options, locking turrets, zero stop, illumination, etc. And right behind those considerations were ergonomics, which relates to the size and weight of the scope, as well as how easy it was to use the scope.

For hunting purposes, the extra magnification is not nearly as much of a deal as people make it out to be. However, a wider FOV does make a difference in quick target acquisition. The FOV of a scope gets bigger as the magnification is zoomed down. Also, the way a scope is designed will influence the width of field that is visible to the shooter. **Here is a typical list of what a hunter may prefer:**

- A lifetime warranty backed by a good reputation for service
- A good eye box – comfortable getting quick target for the eye to be behind acquisition
- A good FOV to keep a slow-moving herd in view
- Durability – being able to take the punishment of recoil
- Bright optics with good resolution and contrast
- Accurate adjustments for dialling in and out
- Preference for a specific reticle style
- Avoiding a large and heavy scope that affects the balance of the rifle

Optical quality

Optical quality includes a **bright image, a good resolution and contrast**, which is assisted by a reduction of reflected light inside the scope. Some scopes do not offer clarity around the outer edges of the lens as some high-end scopes do. Image quality at maximum magnification is one of the areas where many scopes fall short. Resolution essentially means the sharpness of the image – a scope with good resolution can resolve fine details. Contrast means the ability to separate one thing from another. Together, they determine how clear things look through a scope. However, it is actually a bit more complex, as a multitude of factors come into play, such as good design, high-quality glass, good lens coatings, good internal flare suppression and precise assembly. Unfortunately, none of these things are coming cheap.

Image brightness depends on two factors: transmission and exit pupil. The transmission of most modern rifle scopes spans a relatively narrow range of about 85% to about 95%; over 90% is considered very good. The exit pupil factor can be a much stronger effect than the transmission factor, so experienced shooters will make an effort to maximise the exit pupil in low light conditions. In daytime conditions though, differences in transmission have very little effect on visual acuity, and a high image contrast is more important than transmission.

Chromatic aberration is the failure of a lens to focus all colours to the same point. It occurs because lenses have different refractive indexes for different wavelengths of light (the dispersion of the lens). The refractive index decreases with an increasing wavelength. Chromatic aberration is easy to test for in a scope; check if you can see "fringes" of colour along boundaries that separate dark and bright parts of the image. It typically occurs in poor-quality scopes because each colour in the optical spectrum cannot be focused at a single common point on the optical axis.

Internal glare: Image contrast is a very important characteristic in any visual optic. When blacks look gray and colours look faded rather than vivid, low image contrast is usually the problem. Optical aberrations can also degrade contrast, but the primary cause of low contrast is veiling glare, which happens when bright light outside the field of view bounces around inside the optic and lands on the image inside the field of view. Glare does not normally affect target shooting very much, because paper targets usually have high contrast features, and in addition, shooting ranges are set up so that the target faces the sun, rather than the shooter facing the sun. However, in game hunting, high image contrast is far more important since game animals have low-contrast features. In addition, hunters often find that their target is between them and the sun or at some angle. Since the best hunting times are often in the early morning and late afternoon, veiling glare can become a problem for hunters just when they need the optic to perform. Image contrast performance varies a lot from one manufacturer to another.

Low-light optimised scopes are tuned to do well in the **green-blue** side of the light spectrum. For example, high transmission in the **red part of the spectrum** (550-650 nanometres) improves discrimination of game animals in daytime, while high transmission in the **blue part of the spectrum** (450-550 nanometres) enables glassing in low light. So, for a balanced hunting application, the spectral transmission curve should be nearly flat between 450 and 650 nanometres. Also, a triplet lens is often installed in higher-priced scopes. A triplet lens makes the scope apochromatic (almost no optical aberrations), which means the resolution is good even at high magnification settings of more than 10 times. Most optical sights have **magnesium fluoride anti-reflection coatings** on their air-to-glass surfaces. These coatings assist with light transmission. They are what produce the blue, red or green reflections you see when you look into the front (objective) lens of a scope.

Tracking of turrets

The quality of turret mechanisms used in scopes will affect their accuracy and stability, especially if a shooter dials in a lot. For this reason quality scopes will feature positive steel-on-steel adjustments to ensure repeatable accuracy; heat-treated, high-tensile steel being preferred over untreated steel as these scopes are more wear-resistant. Most gun writers would do a "box shooting test", but it is not an absolute precision measure as done in lab testing with proper equipment.

When you see your groups open up without any reasonable explanation, the cause of the problem may well be your optics. You may notice some conditions such as:

- Large shot-to-shot variance in point of impact (POI) with known accurate loads.
- The change of POI does not correspond to click inputs.
- Inability to zero in reasonable number of shots.
- Visible shift in reticle from centre of view.
- Internal scope components rattle when the gun is moved.

Despite not being as precise as in a ballistic laboratory, the easiest way to check for reasonable accuracy of the adjustment turrets is to turn them up to maximum and back again to your zero position. Shoot three shots at your zero position to get a group at 100 yds; then turn the turret that adjusts the vertical setting (trajectory) all the way up and back again; then shoot another three shots. The same can be done with horizontal (windage) adjustments. The test is to see if you group in the same place as before. Another way, of course, is to shoot your first group at your zero position; then turn 40 clicks up and shoot; then turn 40 clicks down and shoot. Assess the distance between the two groups that should give you 10.47" (assuming quarter MOA clicks – 1 MOA = 1.047"), and see if you can get back to your zero position again – this will require nine shots.

Choice of turrets

Lately, most scope manufacturers have changed from slot-adjustable (coin-style) to finger-adjustable turrets for the hunter's convenience. We have also seen a trend in resettable zero turrets having no dust covers to enable quick adjustments. Low-profile target turrets, such as Swarovski's speed dial ballistic turret, is becoming increasingly popular – the colour-coded turret lets you set predetermined distances easily, allowing you to change later if you switch loads or rifles, something that you cannot do with the Leupold CDS system. Let us look at some pros and cons:

Benefits of ballistic turrets:

- They are very simple to use – you just dial in the distance
- More precise and finer accuracy
- Allows for multiple zeros
- Takes holdovers and bullet drop out of the equation
- Offers a zero-stop feature

Drawbacks of ballistic turrets:

- More costly than other turrets and holdover reticle types
- Custom-made makes such as the Leupold CDS are rendered useless when changing to another type of bullet with a different BC.

Reticles

Wire reticles are prone to damage, movement, and even misalignment during manufacturing, and also because of the "abuse" of heavy and repeated recoil. To avoid this, manufacturers typically opt for glass-etched reticles to replace the standard use of wire. Glass-etched reticles are laser-etched onto the lens for more precise ballistic measurements and ultimate protection from rust, recoil and potential damage. When hunting primarily in areas of low light conditions, reticles with thicker posts are preferred and the finer lines at the centre should not be too thin.

BDC-type reticles (bullet drop compensation) have become more popular over the last decade to prevent holdover when using a traditional "Plex" reticle when shots are taken further than the zero range. The latest craze is getting a speed dial ballistic turret that is again paired with a Plex or a 4A reticle, as there is no longer any need for the BDC reticle, because you are now dialling in to your selected range.

FFP reticles (first focal plane) have one drawback as they do change with the magnification setting. At the highest magnification, reticle lines can be too thick and so overlap small targets, while at the lowest magnification, the reticle becomes too small again and is hard to use over short distances. This is why some manufacturers offer an illuminated dot in the middle, thereby overcoming this shortcoming.

MOA adjustments

It is quite common that some brands of rifles have actions that are not perfectly level at the top and parallel with the bore of the barrel. To zero the scope you will therefore eat away some of the scope's vertical MOA adjustment. When a scope is being advertised with, say 50 MOA, and you are able to zero it in the centre, you only have 25 MOA of upward travel. If you need 26 MOA or more adjustment, you are in trouble. The most common fix to this problem is to make use of an angled or tapered scope rail that is taller at the back than at the front, so that when you mount your scope, the muzzle is slightly elevated in relation to the line of sight. This causes the scope to zero closer to the bottom of its range of elevation, which means you have more capacity to go up, meaning you can adjust for more drop at longer ranges. Do bear in mind that when you zero your rifle you will invariably use up some of your scope's vertical adjustment range, and it is not good practice to operate near the scope's adjustment end, as it does not work so well on the outer fringes of adjustment.

Scopes with less than 50 MOA are generally not intended for long-range shooting and are prone to running into the problem I alluded to. Just to give you some indication of what is needed out to 500 yds – assuming we shoot a 180 gr PMP load in a .308 Win (180 gr @ 2 543 fps), we will need 16 MOA of adjustment from a 100 yd zero to hit the bull at 500 yds. When a scope offers 50 MOA, for example, it affords us 25 MOA of vertical adjustment, and when we use say 9 MOA to zero the rifle at 100 yds, we are only left with 16 MOA that would put us at the outer limit of the scope. Since bullet drop is a much greater issue over extended ranges, a Palma competition shooter who competes at 1 000 yds with his .308 Win, will need about 39 MOA or 11 MIL of adjustment from a 100 yd zero, and so one typically needs a minimum of 80 MOA; typically these shooters also install 20 MOA **Picatinny rails**.

Durability/robustness

A durable leaf spring is one of the critical components in a riflescope to avoid a POI shift by maintaining pressure on the elevation and windage adjustments. Some scopes only have one leaf spring to dampen the recoil of the erector tube. However, double leaf springs have proven more reliable and longer-lasting than the conventional single-leaf spring arrays on most scopes. For example, Leupold stated that their dual leaf springs are made of beryllium-copper alloy, having 30% more holding force. Swarovski has now engineered a patented 4-point coil spring system in their high-end Z5 and Z6 series of scopes to steady the erector tube. These coil springs replace the standard single-leaf spring system that most major rifle scope manufacturers are using today, including their own Z3 series that retains the traditional leaf spring system.

Nightforce for example uses titanium adjustment springs instead, as this is the only known metal in the world that can be compressed and held in place repeatedly, even for years, without developing fatigue or "muzzle memory". This guarantees zero loss of repeatability. It is known for example that the Nightforce NXS scopes have to pass a test of punishing positive and negative forces of recoil at 1,250 Gs – that is 1 250 times the force of gravity! Their reticles are glass-etched as they are being used as tactical scopes. The durability of Nightforce scopes is definitely without equal.

Leupold, on the other hand, has a different view on torture-testing than many other companies. Leupold's test equipment is able to plot the entire recoil curve of a rifle/cartridge combination, showing the amplitude and duration with all the peaks. Leupold has proven that the duration is as important as amplitude. The longer the acceleration lasts, the harder it is for the scope to survive. Leopold also subjected rival brands to their test, and in one case they have broken a very expensive European scope. In another case a rival scope, which was advertised to withstand 1,300 G acceleration, was tested and failed. However, Leupold found that this particular scope could indeed withstand 1,000 Gs, but only as long as the acceleration was essentially instantaneous and not sustained. Thus, the longer a scope is being subjected to the forces of acceleration and deceleration, the more likely it is to fail.

All scopes are therefore not created equal when it comes to withstanding the force of recoil; some are made and tested to a higher standard. Clearly this is an area that is nebulous and ill-defined for us poor mortals, as testing methods used by scope manufacturers differ widely, and it is cryptically stated in advertising material, if at all. Since there is no universal best and common method used by all, the reader is left with a cloudy appreciation, making it very difficult to really compare the relative recoil thresholds of each type of scope.

Eye relief

Eye relief is the distance that your eye can be away from the ocular lens of the scope and still provide a full and clear picture of your target. Most European-made scopes generally have a shorter eye relief than American-made ones. The reason may well be that European deer hunting was traditionally done with medium recoiling rifles, such as a 7x64, the most popular hunting cartridge in Europe. Scopes that offer a very short eye relief, such as **75-80 mm**, generally are good enough for standard calibres up to .30-06 Spr level or 20 ft-lbs of recoil. However, glass wearers may prefer 85 mm for a slightly bigger safety margin. A longer eye relief, such as **90 mm**, is certainly preferred for more powerful cartridges such as the .300 Win Mag, as recoil starts to become a factor to reckon with from about 26 ft-lbs. Stepping the recoil up to .375 H&H level or 37 ft-lbs, I would strongly suggest picking a scope that offers **95 mm or more**. Be mindful that stock designs with a fair amount of drop at the comb and heel buck upward and are notorious for cutting eyes open when scoped. Needless to say that the real big bores from .416 calibre and up require a longer eye relief of **100 mm and more**.

Eye box

The "eye box" is the useable area of the light output from a scope, being the **movement away from the exit pupil** (EP = the aperture that lets the light through) along with **the useable forward and backward movement from the eye relief.** So there are two components that affect the eye box, one of which cannot be expressed in a number format. Thus it becomes somewhat of a subjective term as to how much "slop" in eye position a scope will tolerate before losing the target image, i.e. blacking out. This is for the most part directly related to exit pupil that the scope affords. It then follows that the eye box will be perceived as more "forgiving" at lower magnifications in a variable scope because of the larger exit pupil, as the scope's exit pupil will invariably be larger than the human eye pupil, and so the shooter can move his eye pupil inside the larger exit pupil of the scope. Scopes do differ in this regard as to their sensitivity in terms of eye positioning; the only way to tell is to compare them alongside one another. It stands to reason that scopes that offer a good eye box make for much quicker target acquisition, thereby assisting the hunter. We will therefore rate the various scopes on this aspect, which is largely overlooked at the time of buying a scope.

Let me give a practical example to demonstrate that the eye box becomes more critical beyond a 10x magnification. For illustrative purposes I will use a scope with a 42 mm objective, set at 10 magnification, giving us a **4.2 mm EP**. That is as far as we can push it and still have an EP that is large enough to be user-friendly, as the human eye can only dilate to a maximum of **3.5 mm**,

allowing the eye to move within the exit pupil of the scope. The same EP position of 4.2 mm is reached with a 12x magnification scope with a 50 mm objective. So, with any bigger magnification in both these objective lenses (42 mm and 50 mm), the EP will reduce, making the eye box more critical. On the other hand, we can improve the eye box by turning the magnification down, thereby increasing the light beam coming through the scope within which you can move your eye. The sensitivity of the positioning of the eye can best be illustrated when the EP becomes less than 3.5 mm, such as when the Leupold VX3 4.5-14x40 mm scope is set on maximum magnification, yielding an EP of only **2.8 mm** [40/14.4 actual magnification).

Ergonomics

Ergonomics deals with the general look and feel of the rifle and scope set-up, the focus/turrets being centrally placed in the middle, a rubber ring around the eyepiece, and a tube that is scratch-resistant with a high-quality finish – all looking aesthetically pleasing to the eye and being user-friendly. A scope looks odd and unbalanced when the turret control mechanism is placed too far forward for one, and for another that it could restrict the placement of the scope, forcing one to use extension rings. This position is further compounded when the tube is generally shorter than 5.4". A sleek eyepiece also helps not to obstruct the opening of the bolt handle.

Part 2

Introduction

As mentioned in part I, the purpose is to focus on scopes for the hunter who is seeking a low-mounting hunting scope of no more than 10x magnification or thereabouts. For ease of comparison, a comparative chart listing the features of the various scopes will be provided. Also, a second chart with some evaluation criteria and a score against each will be provided. The idea is to give a rating of excellence on each evaluation parameter. Four scope distributors, namely Lynx, Leupold, Meopta and Swarovski, chose not to partake in this exercise, which is rather a pity as all of them are offering 1" low-mounting scopes that I would have liked to compare as a more comprehensive exercise, as they are all well-known names in the industry. The line-up of scopes in this article differs quite a bit in price. Value for money is a fairly subjective thing and is mostly influenced by a buyer's budget, but could also be in the eye of the beholder, as preferences may vary from individual to individual. For example, those with weak eyes will invariably be prepared to spend more on a scope that offers better or brighter glass, whereas someone else can live with a lower-grade glass and coatings as long as the scope is not eye-sensitive – i.e. having a better "eye box". Each hunter has to decide which features are more important or desirable to him.

A typical list of important features may look like this (in order of importance):

- A rock-solid lifetime guarantee in case something goes wrong; protecting your investment.
- Durability to absorb the recoil of the cartridge in question – more important for heavy kickers.
- A good eye box for quick target acquisition.
- Matching the scope's eye relief in line with the recoil of the cartridge.
- Accurate and reliable turrets for those that are dialling a lot.
- Quality and brightness of the lenses.
- Easy mounting to fit Mauser, Winchester and CZ actions.
- Sufficient MOA elevation adjustment range for long-range shooting.

Another important aspect is that in a review of this nature, it is rather difficult to assess the robustness of a scope, even though it is very important for hard-kicking rifles. I am thus not able to express a view, as we have limited information from the manufacturers. Furthermore, it is something that needs to be stressed-tested, which was not one of the goals of this article. The other complicating factor is that torture tests applied by manufacturers are not uniform and differ from each other.

Evaluation method

While it is very easy to select criteria to rate a scope, it is much more difficult to assign weights to the various criteria, as it is not so easy to determine which aspects of optical performance, such as resolution, colour rendition, contrast, curvature of field, distortion, and chromatic aberration, should be considered of greater or lesser importance, and a host of other practical issues. For such analysis to have absolute value, a universally agreeable formula would have to be devised to quantitatively weigh the relative merits of each parameter, and then finally arrive at a weighted average score. Thus it would not be equitable to simply summate the individual scores. The point is that a given user may regard one criterion as being more meaningful than another, such as having a better eye box, or a better vision in a twilight situation, or more reliable turret adjustments for constant dialling in and out, or enough vertical MOA adjustment for long shots, etc. Since this is not possible, I have just opted to rate each criterion and the hunter can decide what he regards as more or less important. Needless to say, it could be argued that my score, being based on my very own observation, is subjective. To deal with this matter, I will engage at least one more individual to confirm my observations or to mitigate the potential bias.

Image quality is generally regarded as an important feature of a rifle scope, but it can also be a highly complex and technical discussion for those that work in optical laboratories. Companies that advertise, on the other hand, try to get our attention with a 92% light transmission rate, mesmerise us with their code names for the various coatings, the use of lead-free ED glass, or where the glass is made as indicators of image quality. This is what engineer and optics expert, ILya Koshkin, has to say about it in the book *Rifle Scope Fundamentals:*

"How do you sell good image quality? Every magazine ad for every scope company for a riflescope talks about how well you can see. You pretty much have to tout something: patented coating recipe, extra low-dispersion glass, 'high-definition' glass, etc. **None of these things by themselves are of any importance** and (by my estimate) nearly 100% of what you see in a typical advertisement is, at best, misleading and at worst, pure BS. However, all these tricks are necessary for attracting enough attention to a particular product to at least get you to consider it."

While coatings and glass specs do play a role in image quality, they are not what we as users really care about; at least not directly. All we can really do as laymen are worry about how much detail (resolution and contrast) we can see through the scope. I have therefore listed the following to guide us through this minefield:

- Brightness of image
- Resolution and contrast
- Low light visibility in twilight conditions
- Checking for tunnel vision at low magnification
- Reticle installed and visibility in low light
- Eye box for quick target acquisition
- Ample eye relief
- Comment on turrets and mechanics
- Ergonomics – ease of use and looks

This is the crux of designing a riflescope: Resolution is simply the ability of the scope to distinguish small details within the image and **contrast** is the ability of the scope to faithfully transmit the difference between light and dark (and by extension colour fidelity and saturation). For every optical system, the designer has to compromise between resolution and contrast in order to achieve a well-balanced image. Be aware that at above 10x magnification, we do find that **chromatic aberrations (CA)** begin to soften edges, because not all colours in the light spectrum can easily be focused back to the same point. The result is sort of a double image; one laid over the other that is slightly larger and causes a distortion. The fringe colour can be any colour of the rainbow, and this is why **extra-low dispersion (ED)** lenses are used to minimise this colour fringing in high-magnification scopes.

While most of the above is self-explanatory, just a word on ergonomics:

- **Weight and size** – I believe we should try to strike the right balance between optical performance and weight/size of the scope. All other things being equal, we would all prefer a scope that weighs less.
- **Mounting flexibility** – Does the scope have enough mounting length to provide some flexibility to slide it forward or backward to attain proper eye relief for your natural point of aim?
- **Turret design** – This has to do with the overall feel and usability of the turrets. Hunters that dial for elevation are using the elevation turret constantly, and so it does affect their experience behind the scope more, whereas for hunters who use hold-off reticles (BDC), it is less important.
- **General look and feel –** This may be in the eye of the

beholder, but most hunters prefer ease of operation and clean lines.

To see my detailed analysis, please go to the accompanying charts, listing scope specifications and ratings, all in a matrix form for easy comparison (see p 79, 80).

How to focus your optics

Before any test can be done with a scope, it needs to be set up for the individual eye. Allow me to explain how to focus your optic: Before you use any scope, adjust the ocular lens (the eyepiece) for your eyes – **in order to get the reticle into focus**. Point the scope towards something bright like a white wall or the sky, so you can get contrast between the black reticle and the bright background. Start from a blurry position and turn it up until the reticle appears crisp and clear. Then, if your scope has a parallax adjustment (adjustable objective or side focus), you need to get the **target at range** (from 50 yds to infinity) **and the reticle on the same focal plane**. Most hunting scopes without a parallax adjustment have been focused at 100 m or 100 yds by the factory.

The set-up for testing

The scopes were mounted on tripods for stability next to one another, allowing me to focus all the scopes on a single object and enabling me to move quickly from one scope to the next. All scopes were tested on the same power, be it 3x, 6x or 10x (the highest common power shared by all). Though power numbers are by no means precisely calibrated, a good enough approximation can be obtained. Each scope will have the dioptre individually adjusted by the tester.

An eye-testing chart and a life-size impala paper target were used. The impala target was set up in the shade to mimic a real-life hunting situation. An artificial white target with black letters was used to assess contrast and legibility. The same lighting conditions applied to all scopes. Resolution and contrast were tested by looking at the black-and-white optical chart. Low light performance, which is also part of optical quality, is not just applicable during twilight, but also on a cloudy day where an animal is standing in the shade of a tree or is blending in with thick brush or vegetation.

By selecting a 6x magnification setting to maximise the scope exit pupil while providing enough magnification, I looked at the impala paper target through each of the scopes at dusk. The later the impala target was "shootable" through a given scope, the higher the score I would award. I picked an impala as its reddish-brown colour is difficult to pick up. I used my Zeiss 6x42 mm Diatal fixed as a standard for judging for its excellent eye box, as it is one of the parameters that I particularly value in a hunting scope.

The following scopes were tested:

Docter Optic

The **Docter Classic Sport 3-10x40 mm** scope is fully multicoated and its reticle remains the same size as the magnification is changed, being a second-plane scope. Like other German/Austrian riflescopes, the Docter Optic's biggest selling point is its optical quality. The scope provided a sharp and clear image and could not pick up any glare. It offers 59 MOA, which is 10 MOA better than some of its rivals. Key components are brass or stainless steel, and it is evident that quality materials have been used. It is a 1" scope with a 40 mm objective bell and it weighs 18.8 oz. The magnification scale at the back of the zoom ring is sloped toward the shooter's eye for ease of use. Elevation and windage adjustments require the use of a coin. However, the clicks are not firm and audible as I had hoped for. Buyers should be aware that this scope only offers 75 mm of eye relief, which is rather short. This is a quality scope and it is being priced very competitively against the opposition. It comes with a 5-year parts-and-labour warranty and an additional 25-year warranty on materials.

Zeiss Conquest HD5

The HD5 is an update on the previous model, and continual product enhancements are becoming a regular thing amongst competitors in an attempt to leapfrog one another. The **2-10x42 mm Conquest HD5 scope** combines high-definition (HD) glass and Zeiss' fully multicoated optics with T* anti-reflection coatings (before it had lower-grade MC coatings) to provide enhanced brightness, contrast and colour fidelity. The LotuTec protective lens coatings repel water and dust particles from the surface. The design of the new Conquest HD5 comes with rubberised magnification rings with finer adjustments than previous versions. The scope comes in at 17.5 oz.

This scope offers a stunning 80 MOA in a 1" tube with finger-adjustable turrets. In fact, it offers more elevation adjustment range than the 30 mm tube Zeiss Duralyt that has only 43 MOA. I must admit, I do not understand the design logic of designing a scope with a thicker tube, but with less elevation range to adjust for. Be that as it may, the blame should actually be levelled against some rifles where the receiver is not 100% true, meaning that the scope does not lie parallel with the receiver, and consequently it now erodes the scope's adjustment range. To fix the problem, either the receiver requires some milling or special angled bases need to be installed. Zeiss offers a limited lifetime transferable warranty.

Sightron SIII

The Sightron SIII 3.5-10x44 mm scope is physically large, weighs in at 21.7 oz, is built on a 30 mm tube, and its fully multicoated lenses are bright and offer good contrast, being sharp from edge to edge. It offers an exceptional 120 MOA elevation adjustment range and the adjustment turrets are the large, tactical type. It incorporates a side focus with hash marks. I much prefer a side focus to be numbered in yards rather than just marked with hash marks, as it makes one slower in finding the sweet spot of focus. My major criticism is that the side focus turret is extremely stiff to turn.

In my opinion the lines of the reticle are too thin for a hunting scope and its field of view is also the poorest of all the scopes reviewed here. It has a sensitive eye box to boot. All in all, my assessment is that this scope may be put to better use as a target or sniping scope as opposed to a hunting scope. However, this is a well-made Japanese scope and the brand is renowned for its accurate tracking. Sightron does offer an excellent lifetime replacement warranty.

Minox ZX5

Minox recently released their ZX5 range of scopes, and I understand that it has been improved in terms of quality and reliability over the previous model. All glass components are multicoated to ensure image quality. **The 2-10x45 mm model** is assembled at its manufacturing facility in Germany. This product line comes with 30 mm tubes and a zoom of 5x. It is also available with an illuminated reticle, enhancing shootability in low light conditions. The turrets are of high quality, positive and hand-adjustable. The biggest shortcoming of this scope in my opinion is its very limited vertical adjustment range of only 38 MOA, given the fact that 30 mm tubes should provide a bigger adjustment range. It offers the smallest adjustment range of all 30 mm tube scopes that I have seen so far.

It has a smooth power adjustment and an easy-to-adjust rubber-armoured eyepiece for quick eye focusing. The extended eye relief of 100 mm is extremely beneficial to users wearing eyeglasses and when using larger calibres dishing out more recoil. The scopes come with a choice of reticles: German 4, ballistic drop compensating (BDC) and Plex, and they are positioned in the second focal plane. From the date of registration the scope will be protected against manufacturing defects and functional failures for the duration of 30 years.

Bushnell LRHS

The **Bushnell LRHS3-12x 44, G2H, FFP and zero stop scope** is a rather interesting scope that differs quite a bit from all the others being compared here, as it is a combination of a hunting and a tactical scope, as is evident from its G2H reticle. Its large target turret knobs are very easy to work with. It is the first Bushnell hunting scope to have its reticle in the first focal plane. What this means is that the reticle allows range estimation at any magnification setting, but the reticle size will change when the magnification is turned up, which some hunters may not prefer. I regard this as more of a long-range scope, as the inner part of the reticle is too fine at lower magnifications. The scope excels at higher magnifications from 8-12x power for shooting at longer ranges, as its very design is geared for that. That is why this scope has been fitted with a side-parallax adjustment, which is clearly marked (visible) and calibrated in yards, as I prefer it, and above all easy to work.

The click adjustments on the turrets are superb. It is a 30 mm tube scope but its 44 mm objective still allows for low mounting. While it is heavier than most hunting scopes in this review, it is actually lighter (24.4 oz) than most tactical scopes. It has a low profile elevation turret and a capped windage turret, offering the reliability of tracking of a tactical scope. The elevation turret is great in every respect with its zero stop, and I like it much better than the Nightforce turrets, for example. Its glass is superb. It offers a 95 mm eye relief, which is rather nice too. Another plus factor is that it has a good eye box. This scope has a unique combination of features built into a hunting scope. Bushnell offers a no-questions-asked lifetime warranty that is also transferable.

Leica Visus I LW

Leica Sport Optics, a German company, announced a new hunting riflescope, the **Visus I LW** at the IWA 2016 show. The design offers some high-tech features on a traditional-looking platform. The Visus I LW comes in two models: a 2.5-10x42 mm and 3-12x50 mm, both with a 4:1 magnification ratio. Eye relief is a constant 3.9". The lenses are fully multicoated and crafted from high-quality glass to produce a bright image, high contrast, and vivid colour, even in low light conditions. The lenses are also enhanced with a moisture-repellent coating. Leica states that it has

Specification chart

Brand:	Meopta	Leupold	Swarovski	Lynx	Docter	Zeiss	Shightron	Minox	Bushnell	Leica
Model:	Meopro	VX-3i	Z3	LX2	Optic	Conquest HD5	SIII	ZX5	LRHS	Visus
	R 8 500	R 10 200	R 16 500	R 5 750	R 10 500	R 15 250	R 15 500	R 11 600	R 17 500	R 23 000
Erector zoom	3x	3x	3x	3x	3x	5x	3x	5x	4x	4x
Magnification range	3.5-10x44	3.5-10x40	3-10x42	4-12x40	3-10x40	2-10x42	3.5-10x44	2-10x45	3.0-12x44	2.5-10x42
Exit pupil @ max magnification	4.4 mm	4.0 mm	4.2 mm	3.3 mm	4.0 mm	4.2 mm	4.4 mm	4.5 mm	3.7 mm	4.2 mm
Field of view @ 100 yds	33.8-11.8 ft	29.8-11.0 ft	33.0-11.7 ft	25.2-7.7 ft	37.4-12.5 ft	52.0-10.0 ft	27.8-9.7 ft	37.1-11.4 ft	34.8-8.96 ft	45.9-12.8 ft
Eye relief - inches	3.54"	4.4"-3.6"	3.54"	3.85"-.74"	3.0"	3.54"	3.8"-3.6"	4.0"	3.74"	3.9"
Max Int. Adj. - MOA	68 MOA	52 MOA	50 MOA	50 MOA	59 MOA	80/60 MOA	120 MOA	38 MOA	24 Mils	70 MOA
Focal plane	2nd	2nd	2nd	2nd	2nd	2nd	1st	2nd	1st	2nd
Parallax side focus	No	No	No	No	No	No	Yes	No	Yes	No
Tube diameter in mm	25 mm	25 mm	25 mm	25 mm	25 mm	25 mm	30 mm	30 mm	30 mm	30 mm
Tube mounting area	5.55"	6.0"	5.9"	6.0"	5.6"	5.6"	6.0"	6.0"	5.6"	6.1"
Reticle illumination	No	No	No	No	No	No	No	No	No	Yes
Length – inches	12.95"	12.6"	12.6"	13."	12.9'	13.2"	13.2"	13.2"	13.4"	12.76"
Weight – ounces	16.6 oz	12.6 oz	12.7 oz	17.6 oz	18.8 oz	17.5 oz	21.7 oz	19.5 oz	24.4 oz	18.3 oz

focused on delivering a product of impeccable optical and mechanical performance.

The 2.5-10x 42 model that has been evaluated here comes in at 18.3 oz, even though it has a bigger 30 mm tube offering 70 MOA vertical adjustment. The finish on this scope is top class and the turrets are superb, the clicks are firm and precise with a tactile feel. Leica has designed the scope with a short eyepiece in an attempt to not obstruct the free movement of the rifle's bolt handle, while its long tube offers ample mounting area. I also like the large field of view of this scope, as it makes for getting a good image of the scenery around one's target. The red-dot daylight illumination switch offers nine brightness settings with intelligent automatic switch-off. In particular, I like the illuminated 4a reticle that is located in the second focal plane, keeping the subtensions the same as one zooms up. It is heavier than average posts and the illuminated red centre dot is a great aid against dark targets in low light conditions. This reticle is a winner in my opinion. The only slight criticism that I have is that the power ring is rather stiff to turn, but it may glide more easily with frequent use. Leica offers a limited lifetime warranty.

Ratings chart

Evaluation criteria for hunting scopes Scores are awarded out of 10 (all scopes being low-mounting scopes)	Magnification setting for test	Docter Optic 3-10x40	Zeiss ConQuest HD5 2-10x42	Sightron SIII 3.5-10x44	Minox ZX5 2-10x45	Bushnell LRHS 3-12x44	Leica Visus 2.5-10x42	Zeiss Diatal 6x Fixed
Selling price - suggested retail		**R 10 500**	**R 15 250**	**R 15 500**	**R 11 600**	**R 17 500**	**R 23 000**	**N/A**
Brightness of image (daylight conditions)								
Quality of light throughput and absence of glare	10x	8,5	7,5	8	8	9	8,5	7,5
Clarity of lenses at the outer edges	10x	8,5	7,5	8	8	9	8,5	7,5
Resolution and contrast (daylight conditions)								
How resolute are the letters at 25 m	3x	8,5	8	7,5	7,5	9	8,5	N/A
Contrast of black and white stripes	6x	8,5	8	7,5	7,5	9	8,5	8
Low light visibility in twilight conditions								
Visibility of a warthog chart at 200 yds	6x	8	7,3	7	7,5	8,5	8,5	8
Reticle installed and visibility in low light		**9**	**8**	**6**	**8**	**7**	**9**	**9**
Type of reticle installed		4A	Plex	MOA	4A	G2H	L-4A	4A
Visibility of reticle: poor, fair or good	6x	Excellent	Good	Poor	Good	Fair	Good	Excellent
Illuminated reticle: Yes/No		No	No	Yes	No	No	Yes	No
Checking for tunnel vision at low magnification								
Can a black ring be seen at the outer edges - yes or no?	3x	No	No	No	No	No	No	No
Field of view @ 10 power in feet		**12.5 ft**	**10 ft**	**9.7 ft**	**11.4 ft**	**14. ft**	**12.8 ft**	**N/A**
Best [10], Very good [9], Good [8], Fair [7], Poor [6]	10x	9	7	6	8	10	9	N/A
Eye box for quick target acquisition								
Sensitivity of "eye line-up" makes one slow	6x	8	8	6,5	7,5	8	9	9
Eye relief for higher recoiling rifles	**N.A.**							
The longer the eye reliëf, the better		6,5	7,5	7,5	8,5	8	8,5	7
Turrets and mechanics	**N.A.**							
Type of turret - hunting [H], open tactical [T]		H	H	T	H	T	H	H
Hand [H] or coin [C] adjustable		C	H	H	H	H	H	H
Firm tactile and audible clicks		No	Yes	Yes	Yes	Yes	Yes	Yes
Ease of adjusting side-focus turret		N/A	N/A	Stiff	N/A	Smooth	N/A	N/A
Ergonomics – ease of use and looks	**N.A.**							
Ease of turning the power ring		Firm	Firm	Firm	Smooth	Smooth	Stiff	N/A
Ease of turning side-focus turret		N/A	N/A	Stiff	N/A	Smooth	N/A	N/A
Turrets balanced in the middle of the tube		Yes	Yes	Yes	No	Yes	Yes	Yes
Mounting flexibility		9	8	9	7,5	8	9	8
Weight and size		8,5	8,5	7	8	7	8	8,5
Finish and general aesthetic look		8	8,5	8,5	8,5	9	9	9

General comments and closing thoughts

I must confess that when I bought my first scope in 1977 as a young man, a 4x40 mm Tasco World Class scope, I did not go through any selection criteria at all, as that was all that was available in the shop at the time, and I did not know any better. Today we have a very different situation both in variety, quality and features that we can choose from. So we need to do better homework before we buy. In closing, just a few last observations that may be of some value:

Awarding points on a scale out of 10 or 100 is always subject to one's standard, and in this regard it becomes subjective if one does not have the very top-of-the-line scopes available as a reference point, such as the Swarovski Z6, Zeiss Victory V8 and some others. Thus it would not be equitable to rate mid-line scopes between 90% and 100%.

The reason I tested the scopes at a 6x power was **to gain ample exit pupil**, while still providing me with enough magnification, and then to test for **balance of resolution and contrast** for each scope. A lens may appear to be bright, but stray light causing glare can erode resolution and contrast, and as such I regard resolution and contrast as more important than brightness.

When most scope manufacturers quote a **percentage of light transmission (like 90% or 92%)** they usually mean at 550 nanometres, where the green wavelength is best for the human eye. In twilight conditions though, green light disappears and blue/violet light takes over and the image starts to fade away. In a daylight hunting scenario the human eye can scarcely detect a 2% difference in light transmission, and so it is not the be-all and end-all.

A **parallax adjustment** on a 10x hunting scope is not needed, just like it has never been required on military sniper scopes of 10x42 mm, such as the well-known Schmidt & Bender PM II scopes and others. It is just one more thing to fiddle with. However, if a scope is fitted with a parallax adjustment, you will be better off when it indicates the yardage markings rather than thin hash marks, so as to give a better indication of where the turret should be for a parallax-free view.

Limited elevation travel is something that some companies must give attention to in my humble opinion – just as a rough guide not less than 50 MOA. Long-range shooters need to be aware of this aspect before they buy a scope, as it could be a limiting factor.

As much as we like all things in a scope to be perfect, having the very best lenses and edge-to-edge clarity, the absence of a tunnelling effect and chromatic aberration (CA), it remains of secondary importance. Of primary importance is that the **centre of the lenses is sharp and clear, as that is where the aiming takes place, even though they might not be the brightest.**

Having a good eye box is more important because a small eye box can be aggravating and will slow you down when you can least afford it. I regard a good eye box and a good FOV as foremost in a hunting scope.

Smooth adjustments make the scope easier to use, whereas stiff adjustments are annoying and a distraction from the focus on the image in the scope.

Thin reticles in low light are a bad combination for a hunting rig. If you wish to do some hunting in low light or twilight conditions, and are allowed to do so, then by all means buy a scope with lenses that are optimised for dawn or dusk, because optimised lenses effectively separate a game animal from leafy or shadowy backgrounds. My recommendation, however, would be to combine it with an illuminated reticle for more precise aiming. Most hunting lodges in South Africa do not allow hunting near sunset due to difficult follow-ups that may result when an animal is wounded.

The "twilight window" is basically only 20 minutes long on a good day, and the visible light fades progressively to the point where one cannot see the target without an external light source, in which case an illuminated red- or green-dot reticle comes in very handy to place the shot more precisely.

I am sad to see that that 1" tube scopes are starting to fade more and more with most manufacturers, as the 30 mm tube scopes typically come with large objective bells, making the scopes much heavier. In addition, these **30 mm tubes with their 50-56 mm objective bells are forcing us to mount scopes higher on factory stocks** that are designed with a drop at the comb and heel, resulting in the comb losing its firm hold under one's cheekbone.

More and more scope manufacturers are **designing their eyepieces with a bigger diameter and even more length,** such as Schmidt & Bender and a few others.

I hope that my criticism will be seen as constructive by the various manufacturers, and I hope that they will attend to the shortcomings that I have pointed out to make their products even better. At the same time I hope that my critical evaluation will serve the best interest of prospective buyers.