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About scopes for hunting

SALES MANUAL

About scopes

For distributors and dealers

Interaims Sweden

Manufacturer of

Reitz Lux Scopes

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CONTENT

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INTRODUCTION

A good scope with good optics feels comfortable to look through. No optical distortion, no color spectra, no prismatic. A clear view through the scope without discomfort to the eye.

In a good scope there is no parallax. When aiming, the reticle remains on the target. Even when you slightly move your head.

A good scope is manufactured with precision.

With a good variable scope, the point of aiming does not change when increasing or decreasing the magnification.

A good scope has a wide field of view without distortion at the rim of the lenses.

With a good scope you can see the target in twilight bet-ter than you can see with your naked eye.

A good scope allows for a long enough eye relief for the recoil not to endanger your aiming eye.

A good scope is sturdy and robust; it is waterproof and moisture proof.

A good scope results in a high hit probability.

Most of us agree with these criteria for a good scope. However, like in most technical solutions there will be compromises as to the price we are willing to pay, and the weight we are will-ing to carry.

By this manual we would like to share our knowledge about scopes with you. We trust it will help you to get a better un-derstanding about hunting scopes. We also trust that you will think when reading “this is new to me”

As you will see in the following text, we have made references to Zeiss, which is the one and only outstanding manufacturer in this trade. Excuse us Swarowski.

If you have questions or a point to make you can find us at our e-mail address info@interaims.se or at our snail mail address Interaims, Lorensborgsgatan 4 a, SE-21761 Malmo.

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THE BRIGHNESS OF A SCOPE

Looking through your scope from the objective side about one inch from your eye, you’ll see a small lighter or darker circle in the scope. This circle is referred to as the exit pupil of the scope. Through this point the light beams pass the narrowest passage on their way through the scope. The size of the exit pupil determines to some extent the brightness of the scope.

One other, and equally important factor for the brightness of the scope, is the transparency of the lens system, i.e. how much light is passing through from one end to the other. Most scopes have 7 to 14 lenses, some of them glued together and some of them single lenses. The reason for using more lenses is to reduce the dis-tortion of the target area when looking through the scope. If you put a number of window glass pieces together it is hardly possible to see through them. The more lenses in the scope the lower the transmission, but the smaller the distortion.

The most important factor for determining the transparen-cy of a scope is the type and the quality of the glass or plastics used for the lenses. Modern plastics lenses have the same quality as glass lenses. Each type of glass has a transparency for each light wave-length. In the high quality or the so-called bright glass, the light ab-sorbed by the glass is only 0,1 % over the whole range of visible light from 770 Nm to 400 Nm meaning from red to purple. Zeiss is using this kind of glass. Most of the scope manufacturers are using glass with an inadequate transparency for blue light. Measured at 404 nm the loss is 14 %, These lenses show an orange color if you look through the scope from the objective side. Orange because it is the complimentary color to blue.

The transparency of the system is also determined by the light reflected back from the surfaces of the lenses glued together. This factor is referred to as the glass index difference. The losses by reflections are for a good quality system about half of a percentage for each surface. In a system with, for instance, six different glue layers, a good system will loose 3 % of the light, while in a not so good system the losses are 3 times as much or 9 %. For Zeiss 2,5-10x48, the total loss of light due to the glass index difference is 2,9 %.

A third factor determining the transparency of the system is the coating of the lenses. The lenses are coated for reducing the amount of light reflected back towards the eye side of the system from the lenses exposed to air. The glass index difference described above takes care of the surfaces glued together in the system. An uncoated lens system is reflecting as much as 8 %, while a 3 layer coating will reduce the reflections down to 2 % and a super quality system will reduce the reflections down to 0,2 % for each surface.

A 4th factor, applicable to variable scopes only, is the size of the ocular. The bigger the ocular, the better the brightness of the scope. This factor will be elaborated later on in this manual.

A 5th factor is the position of the aiming eye. With the aiming eye exactly where it should be, i. e. in the third focal point, the picture of the target is at the brim of the lens system and thus sharper than the eye being off the third focal point.

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THE BRIGHTNESS INDEX, BRIGHNESS I
AND
THE TWILIGHT FACTOR, BRIGHNESS II

It is tempting to find an index calculated from the easily accessible objective diameter and magnification and from these simple data calculate the brightness of different scopes to compare them. To a big extent this is only playing with figures.

During daylight conditions, the human eye pupil varies from 1,6 mm in bright sunlight to 4,8 mm in twilight. In extreme cases, when the eye is adopted for darkness the eye pupil can be as big as 7 mm. For non-Orientals the eye pupil varies from 2 to 4 mm. The theoretical value of the exit pupil of a scope is obtained by dividing the diameter of the objective of the scope by its magni-fication. A 2,5-10x50 scope where we use the X10 magnification the exit pupil will be 50/10 or 5.

Brightness I

In order to compare different scopes, a brightness index is created by squaring the exit pupil. A scope 2,5-10x50 will show a theoreti-cal brightness index of 5x5 or 25. Thus, the bigger the objective di-ameter and the smaller the magnification, the better the theoretical brightness of the scope.

However, if we use magnification 10 on a scope with 56 mm objective lens, the exit pupil of the scope is 5,6 (56/10) and the exit pupil of the eye is 4,8. Thus, the eye cannot benefit from the light obtained by the big objective with magnification less than 11,67 (56/4,8). Thus, a brightness index exceeding 23 do not bene-fit to the practical brightness of a scope. It is not a coincidence that Zeiss makes their 2,5-10 variable scopes with a 48 mm objective lens.

In most cases the theoretical value of the exit pupil and the real exit pupil is not the same. The indicated objective and the real objective size is not the same.

Scopes with an exit pupil exceeding the exit pupil of the human eye gives the advantage that the eye can be placed within the area of the exit pupil of the scope and not exactly in the center of the optical axis, but at the expense of a heavier scope. Then, of course, the bigger the objective, the more light is coming into the scope, but the eye cannot take advantage of the extra light even when using low magnifications.

Brightness II

Another index created for the same purpose as the brightness index above is the twilight factor. Obtained by taking the square root of the magnification multiplied by the objective diameter. A 2,5-10x50 scope will thus get a twilight factor of 23,6 (the square root of 50x10). The bigger the magnification and the bigger the objec-tive diameter, the better the twilight factor.

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BRIGHTNESS III

The indexes Brightness I and Brightness II can be totally mislead-ing as they don’t take care of the transmission of the lens system, and they totally ignore the ocular part of the scope. What we are looking for is the capability of a certain scope to picture the target area during twilight conditions. The picturing depends on the illu-mination of the target area and the contrast between the different objects in the target area. Please, note that we are talking about the target area and not just the target, indicating the difference between astronomic optics and hunting optics. Zeiss is going for astronomic optimization meaning to picture a specific point in the target area. The question is why.

The major factors for showing the capability of picturing the target area during twilight conditions is the transmission of the lens system during nighttime as measured according to the DIN standard and the amount of light passing through the scope from the objective side passing the ocular and finally the aiming eye. During darkness the eye pupil has a diameter of maximum 4,8 mm as mentioned earlier. We are thus considering both the “intensity” of the light and the amount of light.

The bigger the objective, the more light can pass into the lens system. Consequently, a fairly simple formula can be made by multiplying light intensity by the amount of light considering the capacity of the aiming eye. The amount of light is a factor of the magnification used, and the target area seen through the scope.

The light intensity is the transmission measured as a per-centage of the light at the ocular side of the light at the objective side.

Let’s use the following abbreviations:

O the objective diameter

M the magnification

F the field of view

A the angle of view

R the eye relief
V the amount of light reaching the aiming eye
H the eye pupil at darkness i.e. 4,8

This gives us:
A=arctg(F/100)
V=2xRxtg(AxM/2)
And thus Brightness III = O/H(VxVxT/HxH)

The Brightness III index is a better index than both Brightness I and Brightness II, but still it is not perfect. A big ob-jective diameter and few lenses will fool this formula. Thus, the ob-jective diameter should not be more than 48. Same with the number of lenses; they should be no less than 9.

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MANUFACTURING OF LENSES

The optical axis of the lens

The optical axis of the lens has to be exactly in the center of the lens. And especially when it is mounted in the scope. If not it caus-es a so called decenter. All the lenses have to have exactly the same optical center. The manufacturer has to place the thickest zone of the lens exactly in the middle of the lens. If not it will disturb the light rays passing through the lens system. The centering of the lenses can be calculated. If the lens is rotated any decenter in the lens will cause the focusing beam to diverge and trace out a circle at the rear focal plane. For a high quality lens the deviation should be less than 0,01 mm.

The radius of the lens

The radius of the curvature of the lens determines the power of the lens and determines the path length of the ray passing. It also de-termines the power of the surface. Manufacturing tolerance for the radius of curvature should be as low as 0,1 % for a high quality lens.

The surface of the lens

The surface quality of the lens includes defects as scratches and even pits in the surface referred to as the dig designation. May be caused by the polishing process. The surface quality is calculated as the diameter of the dig in microns divided by 10. 60-40 is regarded as precision quality and 20-10 as high precision quality.

The index of refraction

Due to dispersion the index of refraction varies with the wave-length meaning that different light from red to purple will have dif-ferent focal lengths. The index of refraction is measured as the ratio of the speed of light measured in vacuum to the speed in the lens system.

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THE POSITION OF THE RETICLE

The position of the reticle can be either in the ocular focal point or in the objective focal point – the 2 positions in a scope where the light beams are focused. The third position where the light beams are focused is the eye relief.

The reticle can be made by wire or by glass. Glass is stur-dier, but effects the light transmission and thus also the brightness.

The objective focal point is referred to as the first focal point as it is the first point where the light beams are concentrated measured from the objective side of the scope. While the ocular fo-cal point is referred to as the second focal point as the light beams are focused the second time measured from the objective side.

When the reticle is placed in the objective/first point, the size of the reticle will change with magnification. The reticle can then be used as a rangefinder. Most high-quality scopes have the reticle in the first/objective focal point. However, the reticle will have a slight distortion and may look bent at the brim. But on the other hand, the target area will have less distortion than scopes with the reticle in the ocular/second point.

Most scopes on the market have the reticle in the sec-ond/ocular focal point. The reticle will remain the same over the magnifications. Just because the objective lens is the moving part in a variable scope.

Looking at the pros and cons of the position of the reticle it is not obvious that the reticle should be in the first/objective focal point. It takes a highly qualified scope manufacturer to make a good quality scope with the reticle in the first/objective focal point. Provided the lenses are properly designed and manufactured there won't be any parallax problems when changing the magnification when the reticle is in the first/objective position. With the reticle in the second/ocular position a thin wire can be used as a reticle. However, there will be problems reducing the parallax, and also problems reducing the deviation from the optical axis over the magnifications.

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THE OBJECTIVE DIAMETER OF THE SCOPE

The objective diameter decides to a certain extent the size of the ex-it pupil of the scope. The bigger the objective diameter the more light will get into the scope. The bigger the objective diameter the bigger the field of view. Which is true only under specific design conditions.

The secret behind as good quality scope is the so-called angle beams, which are the beams off the center of the lens. These light beams are the most difficult ones to handle for a scope manu-facturer. A radical solution used is simply to cut off these light beams by a diaphragm or even by a frame located in one of the 2 focal points. Evidently, this will reduce the real lens diameter but not the theoretical lens diameter. In this way a high-quality scope and a low-quality scope can have the same theoretical brightness, but not the same practical brightness.

As indicated earlier the formula for the theoretical Exit Pupil is the objective lens diameter divided by the magnification. For a 2,5-10x50 scope it will be 50 divided by 10.

However, if the practical lens diameter is 30 mm in 50 mm objective scope thus the Exit Pupil is 30 divided by 10.

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THE OCULAR DIAMETER OF THE SCOPE

A bigger ocular lens will allow for a wider field of view, depending on the eye relief, the length of the scope and a few other factors.

The ocular diameter has an effect on the brightness of the scope under certain conditions. From the ocular towards the aiming eye the light beams are focused in the eye relief.

The bigger the ocular lens, the more light beams from the lens system could be used by the aiming eye. We have discussed this factor under the heading Brightness III.

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THE TUBE DIAMETER OF THE SCOPE

The bigger the tube diameter the shorter the scope. A big tube di-ameter increases the field of view of the scope.

As the objective diameter of most scopes is between 40 to 50 mm, it will be possible to increase the mid tube diameter from todays one inch and 30 mm to 40 mm. The effect of this can be seen when we compare or Reitz Lux 2,5-10x50 with a 40 mm mid tube – which by the way we have stopped manufacturing – with Zeiss 2,5-10x48 with a 30 mm tube. At X10 our Reitz has a field of view of 4 m while Zeiss has a field of view of 3,8 m meaning al-most the same. However, if we go down to the lowest magnifica-tion our Reitz had a field of view of 20 m compared to Zeiss 11 m.

The tube diameter also has a bearing on the light beams passing the first/objective focal point. For a variable scope with magnification exceeding X4, a one-inch tube is sufficient, but be-low X4 the tube has to be 30 mm to let all the light beams pass the ocular system. If we go down to a magnification of X2,5 we need a 40 mm mid tube. Taking Zeiss 2,5-10x48 as an example it uses on-ly 22 mm of the ocular lens area at X2,5 (11 m field of view at 100 m. 11/100 gives us 6,28 degrees. With an eye relief of 80 mm it will end up to 22 mm)

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THE PARALLAX

May be the best demonstration of the parallax phenomenon is to put your finger at arm length distance and then simultaneously aim by your finger as an aiming device with your right and your left eye. Then you see that the aiming point is changing. It is this phe-nomenon that is referred to as the parallax. Same if you aim with a scope and slightly move your head when aiming. If the reticle is moving from the target there is a parallax in the scope. Each lens system has a parallax at short distance even if there is a possibility to adjust the parallax at almost any distance. Hunting scopes are ad-justed to be parallax free at 100 m or 100 yards. And air gun scopes at 10 m.

There is a parallax difference between scopes with the ret-icle in the first/objective focal point and scopes with the reticle in the second/ocular focal point. The parallax is less in scopes with the reticle in the first/objective focal point.

Then there is a parallax caused by the distance between the barrel and the optical axis of the scope as we have to allow for the mounts. Plus half of the barrel and half of the diameter of the objective of the scope. Thus, we have a distance of about 50 mm and we need a parallax adjustment also for this. Our Reitz scopes have a system taking care of this parallax.

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THE DEVIATION FROM THE OPTICAL AXIS

The deviation from the optical axis is only applicable for variable scopes with the reticle in the second/ocular focal point. For variable scopes with the reticle in the first/objective point the reticle is moving with the magnitude.

The deviation is measured by a collimator with and with-out the impact simulating the recoil.

When changing the magnification from the lowest to the highest the aiming point should be the same over the magnifica-tions. To obtain this the scope has to be manufactured with a very good precision. Thus, most scopes have a deviation from the opti-cal axis. A deviation of 20 mm at 100 m is acceptable for passing the Japanese inspection. For the Chinese manufacturers each one has its own standard for the deviation. The Zeiss scopes are well within 5 mm deviation, which is a good proof of a top-quality scope.

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THE FIELD OF VIEW

The wider the field of view of a scope, the easier it is to find the target. Especially when the target is moving.

The field of view depends on 5 factors:

The first is the magnification used. The smaller the mag-nification, the wider the field of view. Which is quite obvious.

The second factor is the eye relief. The shorter the eye re-lief, the wider is the field of view.

The third factor is the ocular diameter. The bigger the oc-ular diameter, the wider the field of view. Please, note that we are talking about the real ocular diameter. Any part in the ocular cover-ing the edge of the ocular will decrease the field of view.

The fourth factor is the mid tube diameter. A 30 mm tube diameter has a wider field of view than an one-inch tube.

And fifth and finally, the shorter the scope, the wider the field of view.

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THE EYE RELIEF

The eye relief is the distance between the aiming eye and the ocular lens. At this point we have the third focal point where the light beams are conforming.

The eye relief has to be long enough for not endanger the aiming eye to the recoil. This distance should be about 70 mm long, with a tolerance of about 15 mm.

The shorter the eye relief, the wider the field of view.

Obviously, hand gun scopes should have a big ocular lens allowing for an about 500 mm eye relief in order to give a fair field of view.

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THE TUNNEL EFFECT

In most variable scopes you can see the inner tube of the scope when aiming at higher magnifications. The smaller the tube diame-ter, the more tunnel effect, i.e. the more you see of the inner tube. The tunnel effect can be figured out by making a simple calcula-tion.

Let’s take a 2,5-10x48 as an example. Here the field of view is 3,8 m at 100 m at X10 as we have learnt in our previous calculations. And 11 m at 100 m at magnification 2,5

By using the more general angle measure – the Angle of View – we get the field of view as and angle. The Angle of View is 2,17 degrees at X10 (Atg (3,8/100)) and 6,28 at X2,5 (Atg (11/100)).

Now we can calculate the Angle of View at the ocular side. 2,17 times the magnification is 2,17x10= 21,7 degrees.

The magnification for the Field of View of 11m at 100 m is

21,7 /6,28 = 3,45

Thus, from magnification 3,45 to 2,5 the Field of View is the same and this is referred to as the tunnel effect.

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THE MOA CONCEPT

MOA means Minute of Angle. Thus, it is a measure for an angle. 1 MOA is 1/60 of a circle and referred to as one degree.

If you want to know how much you have to adjust in cen-timeters at a distance of 100 meters you can use the formula

Tan(1/60)x100=0,02909 meter = 2,9centimeters

If your gun is spreading the rounds ½ MOA you calculate tan((1/60)/2))times the distance resulting in 1.45 cm at 100 meters.

If your gun is adjusted for 100 meters and then you adjust it by 1 MOA then you adjust your aiming point looking through the scope by 2.9 cms and thus your new round will hit 2,9 cms higher.

When the distance b has the same length as the radius r, the angle is 1 radian. Radians are defined as the distance along the unit circle. As the unit circle has the radius 1 then the periphery is 2?. A com-plete circle - 360 degrees – is thus the same as 2? rad. Meaning that 1 rad is the same as 57,3 degrees.
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THE MOUNTING OF YOUR SCOPE

The most important for a good mounting is the mounting of the barrel to the stock. If the barrel isn't perfectly tied to the stock there will be problems with the hit probability.
Equally important is the mounting of the scope to the ring mounts. If the mounting is building up tensions the scope will be slightly bent. This may happen if the holes for the mounts aren't properly drilled into the barrel and then the mounts should be tight-ly attached to the barrel.
The mount rings have to be exactly parallel to the barrel both horizontally and vertically. You can check this by placing a ruler on top of the mounts.
Please, refrain from using simple, adjustable mount rings. Use sturdy type of mount rings.
It is claimed that steel mounts are better than aluminum mounts. With the same amount of material, the weight of the alu-minum mount is one third of the weight of a steel mount. What we want is a scope which is as light as possible. A sturdy aluminum mount is better than a steel mount as we are using scopes made by aluminum.