

# Eyepiece Selection

## Guide

Demystifying focal length, AFOV, exit pupil, and eye relief.

Build the right kit for your scope. Don't overspend, don't underspend.



## Why eyepieces matter as much as your scope

Your telescope collects light. Your eyepiece delivers that light to your eye. **The image you actually see is shaped by the eyepiece** — its quality, its design, its compatibility with your scope's focal ratio. A good eyepiece on a modest scope produces an enjoyable view; a bad eyepiece on an excellent scope produces a mediocre one.

Eyepieces are also the equipment that **survives every other upgrade**. You'll go through two or three telescopes over a long observing career, but premium eyepieces last forever and transfer to whatever scope you have next. Investing in good eyepieces is investing in every scope you'll ever own.

### The first thing to know

Don't buy expensive eyepieces for your first telescope. The included eyepieces (usually a 25mm and a 10mm Plössl) are adequate to learn with. Spend 6-12 months observing with what came in the box. You'll discover what you actually use most often, what limitations bother you, and what would solve them. Then upgrade — informed.

# The math you need to know

Magnification, field of view, exit pupil — quickly

## Magnification

**magnification = telescope focal length ÷ eyepiece focal length**

Example: A 1200mm focal length scope with a 25mm eyepiece gives  $1200/25 = 48\times$  magnification. Swap to a 10mm and you get  $1200/10 = 120\times$ . Swap to a 6mm and you get  $1200/6 = 200\times$ .

## True Field of View (TFOV)

**TFOV = AFOV ÷ magnification**

TFOV is the actual width of sky you see (in degrees). AFOV (Apparent Field of View) is a specification of the eyepiece — typically 50° for cheap Plössls, 82° for modern wide-fields, 100°+ for premium ultra-wides.

Example: A 50° AFOV Plössl at 50× shows  $50/50 = 1^\circ$  of sky (twice the Moon's diameter). An 82° AFOV Nagler at 50× shows  $82/50 = 1.64^\circ$  of sky (more than 3 Moon diameters). Wider AFOV means more 'spacewalk' feel — you see more of the surroundings.

## Exit pupil

**exit pupil = telescope aperture ÷ magnification**

The diameter of the cone of light leaving your eyepiece — measured in mm. **Should match your eye's pupil size.** A young observer's dark-adapted pupil dilates to ~7mm; older observers have smaller pupils (5-6mm typical past age 50). An exit pupil larger than your eye wastes light. An exit pupil smaller than your eye is fine, just dim. **Sweet spot: 2-5mm** for general observing.

Example: An 8" (200mm) scope at 50× has  $200/50 = 4\text{mm exit pupil}$  (excellent). At 200×,  $200/200 = 1\text{mm exit pupil}$  (very small — image is dim and only useful on bright targets). At 25×,  $200/25 = 8\text{mm exit pupil}$  (wasteful for older observers — light overflows your pupil). The 'lowest useful magnification' for a given scope = aperture in mm ÷ 7.

## Useful magnification range

### Maximum useful magnification

**~50× per inch of aperture.** A 4-inch scope tops out around 200×; an 8-inch around 400×; a 12-inch around 600×. Beyond this is empty magnification — bigger but blurrier. Atmospheric seeing usually limits you well below this on most nights anyway.

**Minimum useful magnification**

**aperture in mm ÷ 7.** An 8-inch (200mm) scope's minimum useful is  $200/7 \approx 28\times$ . An eyepiece giving lower magnification produces an exit pupil too large for your eye (light is wasted).

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**Typical practical range**

Most observing happens between minimum and  $\sim 250\times$ . The sweet spot for deep-sky is 30-150 $\times$ ; planetary targets benefit from 150-400 $\times$  when seeing allows.

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# Apparent field of view, visualized

## How AFOV changes what you see

All five eyepieces below would show the same magnification — only the AFOV differs. The dark circle is what you actually see; the surrounding ring is what you'd see if your eyepiece had a wider field. The wider the eyepiece, the more 'immersive' the view feels.



50° Plössl



68° wide-field



82° Nagler



100° Ethos

### 50° (Plössl, Kellner, Orthoscopic)

Standard for budget eyepieces. Tunnel-vision feel. Sharp center, but small. Adequate for planetary observing where you're focused on a single small target.

### 65-72° (Wide-field — Tele Vue Panoptic, Pentax SMC, ES 68°)

The 'comfortable' zone. Big enough that the field stop disappears from peripheral attention. Affordable middle ground.

### 82° (Tele Vue Nagler, Explore Scientific 82°)

Genuine 'spacewalk' feel. The eyepiece field disappears from awareness. The standard for serious modern eyepieces.

### 100°+ (Tele Vue Ethos, Explore Scientific 100°)

Floating in space. You can't see the field stop without consciously looking for it. Premium eyepieces — \$700+ each.

# Eye relief — critical for glasses wearers

## The distance from eyepiece to your eyeball

Eye relief is how far back from the eyepiece your eye must be to see the full field of view. **Wear glasses?** You need at least 15mm of eye relief to see the whole field through your glasses. **Don't wear glasses?** Anything 8mm+ is comfortable. Eye relief is one of the most-overlooked specs and one of the most consequential for actual enjoyment.

### Typical eye relief by design

Plössl: roughly 70% of focal length (so a 6mm Plössl has ~4mm eye relief — too tight for most). Orthoscopic: similar. Nagler: 12-14mm typically. Pentax XW: 20mm. Tele Vue Delos: 20mm. Most premium eyepieces target 18-20mm to support glasses.

### If you wear glasses

Either keep them on (need 15mm+ eye relief) or take them off for observing (any eye relief works). Most observers take their glasses off and use the eyepiece focuser to compensate for nearsightedness. Astigmatism is the harder case — glasses required, must have long-eye-relief eyepieces.

### Designs to look for

**Pentax XW** series: 20mm eye relief across all focal lengths, 70° AFOV, premium quality. **Tele Vue Delos**: 20mm eye relief, 72° AFOV. **Explore Scientific 82° Series**: 16mm eye relief in most focal lengths. All glasses-friendly.

### Designs to avoid (for glasses)

Standard Plössls under 12mm focal length — eye relief becomes uncomfortably tight. Cheap zoom eyepieces — eye relief usually too short.

# Eyepiece designs

## From Plössl to Ethos — what the names mean

<b>Plössl</b>	<b>50° AFOV</b> , 4-element design. The standard 'kit eyepiece'. Sharp center, soft outer edges in fast (f/5 or below) scopes. \$30-80 each. Best value for slow scopes (f/8+); inexpensive premium in series like the Tele Vue Plössl (\$120) or Vixen NPL.
<b>Orthoscopic</b>	<b>40-45° AFOV</b> , 4-element. Even tighter view than Plössls. Highest contrast and sharpness for any modern design — preferred by serious planetary observers. Eye relief typically tight. \$80-200. Brand: Baader Classic Ortho, Zeiss/Carl Zeiss Jena.
<b>Erfler / 'wide-angle 65-70°'</b>	<b>~65-70° AFOV</b> , 5-6 element. Older wide-field design. Edge softness in fast scopes. Modern budget wide-fields like Skywatcher SWA, Celestron Ultima Edge are based on Erfler-derivative designs. \$60-150.
<b>Nagler (Tele Vue, designed by Al Nagler)</b>	<b>82° AFOV</b> , 6-9 element. Set the standard for modern wide-field eyepieces in 1981. Sharp to the edge in any scope down to f/4. \$300-500 each. The standard of comparison for premium wide-fields.
<b>Ethos (Tele Vue)</b>	<b>100° AFOV</b> , 9-10 element. Tele Vue's premium line. Floating-in-space feel. \$600-900 each. The peak of mainstream commercial eyepiece design.
<b>Pentax XW</b>	<b>70° AFOV</b> , 8-element. 20mm eye relief at every focal length. Crisp, neutral, slightly less wide than Naglers but with better eye relief. \$300-500 each. Many serious observers' favorite.
<b>Tele Vue Delos</b>	<b>72° AFOV</b> , 8-element. 20mm eye relief. The Tele Vue answer to Pentax XW. Premium quality, glasses-friendly. \$300-400 each.
<b>Explore Scientific 82° / 92° / 100°</b>	Modern Chinese-manufactured wide-fields. 80% of the performance of equivalent Tele Vue at 30-50% of the cost. <b>The best price/performance in serious eyepieces.</b> \$150-400 each.
<b>Zoom eyepieces (Baader Hyperion, Tele Vue, Svbonny)</b>	Single eyepiece covering a focal length range (e.g., 8-24mm). Convenient — change magnification without changing eyepieces. Tradeoff: optical performance is good but not great, narrow AFOV at long focal lengths. \$150-400. Useful as a 'do-everything' eyepiece for travel.
<b>Cheap kits (Celestron 8-24mm zoom + Plössl set)</b>	\$50-100 sets sold for beginners. Acceptable for learning the sky but limited. Save up for better individual eyepieces rather than buying a 'kit'.

# Building an eyepiece kit

## Three eyepieces is enough

You don't need a drawer full of eyepieces. **Three well-chosen eyepieces cover the realistic magnification range for any scope:** a low-power wide-field for star fields and large nebulae, a medium-power for most deep-sky work, a high-power for planets and small targets. Add a Barlow lens to double your collection effectively without buying more glass.

## Choosing the three focal lengths

Calculate from your scope's focal length. For a typical 1200mm dobsonian:

<b>Low power (wide-field)</b>	Aim for ~50x magnification with maximum exit pupil that doesn't waste light. For 1200mm scope: 25-32mm eyepiece gives 38-48x and a generous field. For an 8" f/6 dob, the lowest useful is around 35x (gives 7mm exit pupil). 32mm Plössl is the standard low-power choice.
<b>Medium power (general use)</b>	100-150x. The 'workhorse' magnification for most deep-sky and lunar work. For 1200mm scope: 9-13mm eyepiece. A 13mm or 12mm gives ~92-100x — comfortable on most galaxies and nebulae.
<b>High power (planetary, small targets)</b>	200-300x when atmosphere allows. For 1200mm: 4-6mm eyepiece. A 6mm gives 200x — Saturn's rings, Jupiter's Great Red Spot, lunar craters. On exceptional nights, you can push higher.
<b>Add a Barlow</b>	A 2x Barlow doubles every eyepiece's magnification. Your 25mm becomes a 12.5mm, your 12mm becomes a 6mm, etc. <b>Three eyepieces + 2x Barlow = effectively 6 magnifications.</b> Premium Barlows (Tele Vue Powermate, Baader Q-Turret) preserve eyepiece performance; cheap Barlows degrade it.

## Sample kits by budget

<b>\$200 budget kit</b>	32mm Plössl (\$60), 12mm Plössl (\$60), 6mm Plössl (\$60), 2x Barlow (\$30). Adequate for any beginner scope.
<b>\$500 mid-range</b>	30mm Explore Scientific 82° (\$230), 14mm Explore Scientific 82° (\$150), 6mm Explore Scientific 82° (\$120). Three eyepieces, all wide-field, big upgrade from kit Plössls.
<b>\$1000 enthusiast kit</b>	31mm Tele Vue Nagler T5 (\$420), 13mm Tele Vue Nagler T6 (\$330), 7mm Tele Vue Nagler T6 (\$300). Premium wide-fields. Will last decades.
<b>\$2000+ premium kit</b>	21mm Tele Vue Ethos (\$770), 13mm Tele Vue Ethos (\$660), 6mm Tele Vue Ethos (\$580). 100° AFOV across the kit. Best money can buy in production eyepieces.
<b>Glasses-friendly kit (~\$1000)</b>	30mm Pentax XW or Baader Hyperion (\$400), 14mm Pentax XW (\$350), 7mm Pentax XW (\$350). 20mm eye relief throughout. Premium quality with glasses on.

**Don't buy the whole kit at once**

Buy the medium-power first — that's the eyepiece you'll use 60% of the time. Use it for a few months. Then buy the low-power. Use both for a few months. Then high-power last. This gives you time to discover which AFOV you prefer (you may find 82° sufficient and not need 100°), how important eye relief actually is to you, and whether you actually use the high power often enough to justify it. Many observers eventually realize they prefer one or two eyepieces and don't need the third.

# Filters

## The cheap upgrades that change what you see

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Filters thread into the eyepiece (1.25" or 2" filter threads on the eyepiece barrel). Different filters serve completely different purposes:

### Light pollution and nebula filters

**UHC (Ultra High Contrast)** Broadband nebula filter. Passes the wavelengths nebulae glow at ( $H\alpha$ , OIII,  $H\beta$ ), blocks much of the rest. **Dramatic improvement for emission nebulae** like the North America, Veil, and Heart/Soul nebulae from light-polluted skies. \$90-200. Brands: Lumicon UHC, Astronomik UHC, Tele Vue Nebustar, ZWO UHC.

**OIII (Oxygen III)** Narrowband filter for OIII emission. Even more selective than UHC. **Brings out planetary nebulae** dramatically (Ring, Dumbbell, Helix), and the Veil Nebula complex. Slightly dim view (only OIII gets through). \$130-300. Brands: Lumicon OIII, Astronomik OIII.

**$H\beta$  (Hydrogen Beta)** Narrowband for  $H\beta$ . Useful only for a handful of specific objects: California Nebula, Horsehead Nebula, Cocoon Nebula. Nicheist of the nebula filters. \$130-250. Don't buy this until you've used UHC and OIII for a while.

### Color filters (for planets)

**Yellow #12** Enhances Mars's dark albedo features and the lunar terminator. ~\$15.

**Blue #80A** Brings out Jupiter's belts and reduces glare. ~\$15.

**Red #25** Enhances Mars's polar caps. Useful for atmospheric phenomena. ~\$15.

**Variable polarizer** Dims bright targets (Moon, Venus) without color cast. Adjustable density. \$30-50. Highly recommended for lunar observing.

### Solar filters

**Critical safety note:** Solar filters go on the FRONT of the telescope, NOT in the eyepiece. Eyepiece-mounted solar filters can crack from focused heat and direct concentrated sunlight at your eye. See the Solar Observing Guide for the safe approach.

# Final advice

## Common mistakes and how to avoid them

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### Don't buy a 'set' if you can avoid it

Eyepiece sets (\$100-300 with 5-7 eyepieces and a Barlow) seem like value but usually include focal lengths you don't need and skip the ones you do. Three good individual eyepieces beat a set of seven mediocre ones.

### Premium eyepieces in fast scopes are worth it

Cheap eyepieces show their flaws (edge distortion, chromatic aberration, internal reflections) much more in fast scopes (f/5 or below) than slow ones (f/8+). Dobsonians, photo-Newtonians, and fast refractors benefit dramatically from quality eyepieces. Slow SCTs are more forgiving.

### AFOV preference is personal

Some observers love 100° eyepieces; others find them disorienting and prefer 70°. Try before you buy if possible — at a star party, ask to look through someone else's eyepieces. Don't assume more is better.

### Eye relief gets more important as you age

Aging eyes lose pupil dilation (your max pupil shrinks from 7mm at age 20 to 5mm at age 60). And glasses become more common. If you're 50+, prioritize 18-20mm eye relief — it transforms the experience.

### Used market is excellent for premium eyepieces

Tele Vue, Pentax, and other premium eyepieces hold value extraordinarily well — typically 70-85% of new price even after a decade. Buying used premium eyepieces from Cloudy Nights Classifieds or Astromart can save 20-30% on equivalent quality. Inspect carefully (lens scratches and coating damage are dealbreakers).

### Don't chase eyepiece magnification you can't use

If you live in light-polluted skies with poor seeing, your scope rarely shows useful detail above 200x. Buying a 4mm eyepiece for a scope that maxes out at 200x wastes money. Match your eyepiece kit to your actual observing conditions.

### Quality lasts forever; quantity doesn't

A 30-year-old Tele Vue Nagler still outperforms a brand-new budget eyepiece. Premium eyepieces never wear out, never go obsolete (designs are decades old), and survive every scope upgrade. Cheap eyepieces are a recurring cost; premium eyepieces are a one-time investment.

### If you read nothing else: the universal recommendation

**Most observers, most of the time, would be best served by three eyepieces:** a 25-32mm low-power wide-field, a 12-14mm medium-power, and a 6-7mm high-power — all from the Explore Scientific 82° line (\$120-230 each, ~\$600 total). Adds a 2x Tele Vue Powermate (\$240) for double-coverage. \$840 for an eyepiece kit that will outlive your current scope and produce satisfying views of everything from the full Pleiades to the Cassini Division. If budget allows, upgrade to Tele Vue Naglers in the same focal lengths for an extra \$700-900 — improvement is real but incremental.