Worksheet for Helping to Determine which Eyepieces to Choose for Use with a Telescope

10/10/14

Telescope Specs: 80 — Selected Telescope Model: **80mm f/6 Refractor** — (for reflectors) Is a **Paracorr** used? [Y/N]=> **N**

Aperture = **80** mm =======> 3.1 inches — **6** mm = Max Exit Pupil for Eyeball

6.0 <= Calculated Focal(F)-ratio (Fast telescope if <6, Slow if >10)

use 5 mm if older or in significant ambient light
use 7 mm (or more) if young & dark adapted
Exceeding 7mm may show a reflector's secondary obstruction

Focal Length = **480** mm =======> 19 inches
480

Wide Field (Low Power) Eyepiece Constraint: 47 mm <= *(if 1.25 barrel, then use 27) (if 2-inch use 47, unless with smaller SCT)*

Max Clear Aperture for Eyepiece Barrel = **47** mm <= *(if 8-in SCT, then use 38, C-6=25.4, C-9.25=45 [baffle hole size limit])*

default EP AFOV: **50**

(optional) Enter EP FL in mm (longer FLs on the left)=>

(optional) Select current/desired eyepiece type =>

Eyepiece Apparent Field of View (AFOV) in deg =	50	50	50	50	50	50

(Eyepiece "A","B","D,"E", & "F" apparent field of view (AFOV) values are used to roughly estimate TFOV)

Here are some of MANY opinions on basic EP choices and uses!

WARNING: All numbers are APPROXIMATE!

"Minimalist" Approaches

Mag	Mag/inch
16x	5
31x	10
63x	20
79x	25
94x	30
157x	50
189x	60

Misc Reference

EP w/FL>56 mm are VERY hard to find

EP = eyepiece, FL = focal length, mag = magnification

mag = Scope_FL / EP_FL
Exit Pupil = Aperture / mag
F-ratio = Scope_FL / Aperture
rough TFOV = AFOV / mag
TFOV=57.3 x FldStop / Scope_FL
instead of 57.3 in these calcs, used 56 to adjust for edge distortion issues

	19mm to 8mm	6mm to 4mm	3mm to 2mm	<== ***Three "Essential" EPs [2]***	
	25x to 60x	80x to 120x	150x to 200x	*(1x-2x-3x is a similar method)* ***[7]***	
	VERY LOW POWER is used as a "Finder" and also for Open Clusters, Large Nebula, and Asterisms	**LOW POWER** is used for Wide Views of Open Clusters and Medium-Size Nebula	**MEDIUM POWER** is used for General Viewing of Globular Clusters and Planetary Nebula	**HIGH POWER** is used for (with okay seeing) viewing Planets, Luna, Double Stars, and Galaxies	**VERY HIGH POWER** is used for (if great seeing) viewing Planets, Luna, and Double Stars	**EXTREME PWR** is used for viewing very close Double Stars (& maybe Luna)
1st Priority for Purchasing ==========>	==========>	**Eyepiece "A"**			
2nd Priority for Purchasing	**Eyepiece "C"**	**Eyepiece "B"**			
	(perhaps only one low power EP, "B" or "C")				
3rd Priority for Purchasing ==========>	==========>	==========>	==========>	**Eyepiece "D"**	
4th Priority for Purchasing ==========>	==========>	==========>	==========>	==========>	**Eyepiece "E"** *(maybe)*	**Eyepiece "F"** *(perhaps omit)*

~Max TFOV = **5.48** (deg) (per EP clear aperture)

Some experienced observers will advise others to have many, many EPs so that one may always choose based on the viewing conditions & object, but that's too advanced for here. Ditto for zoom eyepieces.

*Using a Barlow Lens w/EP "A", "B" or "D" may substitute => (see below *)*

[1]

per [6] ==>	LOW POWER	LOW POWER	MEDIUM POWER	MEDIUM POWER	HIGH POWER	VERY HI POWER
using **specific EP exit pupils** (in mm) =	6.0 (max exit pupil)	**4.0**	**2.0**	**1.3**	**0.8**	**0.5**
	(can be manually changed to use exit pupils other than 4, 2, 1.3, 0.8 and 0.5 mm)					
Associated Eyepiece Focal Length (mm) =>	36.0	24.0	12.0	7.8	4.8	3.0
	Longer FL EPs will work but the view is dimmed, & if there's a secondary mirror, a dark area may be seen					
		4.0 mm	2.0 mm	1.3 mm	0.8 mm	0.5 mm
Eyepiece Magnification =>	13x	20x	40x	62x	100x	160x
Rough True Field of View (TFOV) =>	3.75 deg	2.50 deg	1.25 deg	0.81 deg	0.50 deg	0.31 deg
* using a **2.0** x Barlow with EP "D"=>	| |	| |	| |	|=====> ==========>		3.9 mm
Equivalent FL of Barlowed EP "A"=>	| |	| |	|=====> ==========>		6.0 mm	- - -
Equivalent FL of Barlowed EP "B"=>	| |	|=====> ==========>		12.0 mm	- - -	- - -
Equivalent FL of Barlowed EP "C"=>	|=====> ==========>		18.0 mm	- - -	- - -	- - -
Barlowed Exit Pupil =>	- - -	- - -	3.0 mm	2.0 mm	1.0 mm	0.7 mm
Barlowed Magnification =>	- - -	- - -	27x	40x	80x	123x
Rough True Field of View (TFOV) =>	- - -	- - -	1.88 deg	1.25 deg	0.63 deg	0.41 deg

If a Barlow (or telecentric) lens results in duplicate focal lengths or excessive magnification, another multiplier (1.6x, 1.8x, etc.) may be better.

Source: Jim Kaminski, October 2014

per [6] ==>	LOW POWER	LOW POWER	LOW POWER	MEDIUM POWER	MEDIUM POWER	HIGH POWER
[3] Or **use a 1.4x progression of focal lengths** - surface brightness for extended objects varies with the square of focal length [3],						
Starting EP FL defaults to a barrel- or exit pupil-limit		<= a starting low power EP FL may be entered here (optional)				
Eyepiece Focal Length (mm) =>	36.0	25.5	18.0	12.7	9.0	6.4
Eyepiece Exit Pupil =>	6.0 mm MAX	4.2 mm	3.0 mm	2.1 mm	1.5 mm	1.1 mm
Eyepiece Magnification =>	13x	19x	27x	38x	53x	75x
Rough True Field of View (TFOV) =>	3.75 deg	2.65 deg	1.88 deg	1.33 deg	0.94 deg	0.66 deg
* using a **2.0** x Barlow with EP "D"=>	| |	| |	| |	|=====>	==========>	6.4 mm
Equivalent FL of Barlowed EP "A"=>	| |	| |	|=====>	==========>	9.0 mm	- - -
Equivalent FL of Barlowed EP "B"=>	| |	|=====>	==========>	12.7 mm	- - -	- - -
Equivalent FL of Barlowed EP "C"=>	|=====>	==========>	18.0 mm	- - -	- - -	- - -
Barlowed Exit Pupil =>	- - -	- - -	3.0 mm	2.1 mm	1.5 mm	1.1 mm
Barlowed Magnification =>	- - -	- - -	27x	38x	53x	75x
Rough True Field of View (TFOV) =>	- - -	- - -	1.88 deg	1.33 deg	0.94 deg	0.66 deg

Factor	(Factor x Aperture in mm = Magnification) *[4] & [5]*	Magnification	Mag/Inch	EP Focal Length	EP Exit Pupil	*typically*
0.13	Minimum useful magnification - largest dark-adapted pupil	10	3x/in	46 mm	7.7 mm	**EP "C"**
0.20	(for better contrast [darker sky] or with ambient light pollution)	16	5x/in	30 mm	5.0 mm	EP "B"
0.25	Comfortable viewing - best balance of eye-relief & magnification	20	6x/in	24.0 mm	4.0 mm	EP "B"
0.40	Wide views - Planets & Luna with large apertures	32	10x/in	15.0 mm	2.5 mm	**EP "A"**
0.50	Lowest power to see all detail (eye resolution matches scope)	40	13x/in	12.0 mm	2.0 mm	**EP "A"**
0.80	Planets, Messier objects - typ astigmatism has minimal effects	64	20x/in	7.5 mm	1.3 mm	EP "D"
1.00	Point Source Airy Disc becomes visible - no additional resolution	80	25x/in	6.0 mm	1.0 mm	EP "D"
1.20	Normal high power, double stars - floaters are more noticeable	96	30x/in	5.0 mm	0.8 mm	EP "D"
1.60	(High power when seeing is less turbulent)	128	41x/in	3.8 mm	0.6 mm	**EP "E"**
2.00	Maximum useful magnification	160	51x/in	3.0 mm	0.5 mm	EP "F"
2.35	Close doubles, rough telescope star testing	188	60x/in	2.6 mm	0.4 mm	EP "F"
4.00	For some double stars, telescope star testing	320	102x/in	1.5 mm	0.3 mm	EP "F"
500	***<== General magnification limit imposed by atmospheric turbulence***		(mag/Aperture)	(FL/mag)	(Aperture/mag)	

	Mag/Inch of Aperture	EP Exit Pupil	Useful for: *[6]*	*typically*
LOW POWER	3.6 to 9.9x/in	7.0 to 2.6 mm	Finding objects, observing large angular sized open clusters, large faint nebula.	**EP "B" or "C"**
42 to 15.4 mm	(11x to 31x)		General sweeping of Milky Way, viewing of entire moon. Best power for nebula filters.	
MEDIUM POWER	10 to 18.9x/in	2.5 to 1.3 mm	Somewhat smaller deep-sky objects such as galaxies, some diffuse nebulae,	**EP "A" or "B"**
15.2 to 8.1 mm	(31x to 60x)		smaller open clusters, and moderate to large planetary nebula.	
HIGH POWER	19 to 31.9x/in	1.3 to 0.8 mm	Observing fine planetary and lunar detail. Better resolution of stars in globular clusters.	**EP "D"**
8.0 to 4.8 mm	(60x to 100x)		Poor seeing may compromise views at this power in apertures larger than 5 inches.	
VERY HI POWER	32 to 46.9x/in	0.8 to 0.5 mm	Study of certain specific planetary details, and resolving tight double stars.	**EP "E"**
4.8 to 3.2 mm	(101x to 148x)		Eye defects like motes and floaters detract (along with the somewhat lower light level).	
EXTREME POWER	47 to 75x/in	0.5 to 0.3 mm	Double stars at the instrument's limit, or detecting elongation of unresolved doubles.	**EP "F"**
3.2 to 2.0 mm	(148x to 236x)		Up to 60x/inch in small instruments may allow beginners to see gross planetary detail.	

[1] Try 7, 4, 2, 1, and .5 mm exit pupils (An Eyepiece Primer - Al Nagler) [www.skytonight.com/equipment/basics/3311076.html?showAll=y&c=y]

Other Sources: Forums on www.cloudynights.com, with edits *Idea from [Lawrence Sayre] post on 7/20/08 - Worksheet Assembled by JimK*

[2] = [SteveCoe] (1/2/06): Buy one eyepiece that gives you 30-60X, buy another that give you 80-120X and one more that gives you 150-200X.

[3] = Alexis Cousein [sixela] (2/17/07) also, two eyepieces with focal lengths in a 1.4x progression will give four 1.4x focal lengths using a 2x Barlow

[4] = ? & John [dvb & magredc5] (8/17/05) & per www.astro-tom.com/technical_data/useful_formulas.htm

[5] = Don Pensack [Starman1] (2/17/07) [7] = Don Pensack [Starman1] (12/18/12), where x=35 power for 4" scopes, x=50 for 8", x=60 for 10", x=70 for 12"

[6] = [David Knisely] (2/20/07, 12/23/05, 7/29/05, & article 4/17/03) *{TFOV progression criteria (1.0/0.75/0.5 deg) are not addressed}*

80mm f/6 Refractor

Worksheet for Helping to Determine which Eyepieces to Choose for Use with a Telescope

10/10/14

Telescope Specs: 203 — Selected Telescope Model: **8-inch f/10 SCT** — (for reflectors) Is a **Paracorr** used? [Y/N]=> **N**

Aperture = **203** mm =======> 8.0 inches — **6** mm = Max Exit Pupil for Eyeball

10.0 <= Calculated Focal(F)-ratio — *use 5 mm if older or in significant ambient light*

Focal Length = **2030** mm =======> 80 inches — (Fast telescope if <6, Slow if >10) — *use 7 mm (or more) if young & dark adapted*

2030 — *Exceeding 7mm may show a reflector's secondary obstruction*

Wide Field (Low Power) Eyepiece Constraint: 38 mm <= *(if 1.25 barrel, then use 27) (if 2-inch use 47, unless with smaller SCT)*

Max Clear Aperture for Eyepiece Barrel = **38** mm <= *(if 8-in SCT, then use 38, C-6=25.4, C-9.25=45 [baffle hole size limit])*

default EP AFOV: **50**

(optional) Enter EP FL in mm (longer FLs on the left)=>

(optional) Select current/desired eyepiece type =>

Eyepiece Apparent Field of View (AFOV) in deg =	50	50	50	50	50	50

(Eyepiece "A","B","D,"E", & "F" apparent field of view (AFOV) values are used to roughly estimate TFOV)

Here are some of MANY opinions on basic EP choices and uses!

WARNING: All numbers are APPROXIMATE!

"Minimalist" Approaches

Misc Reference — *EP w/FL>56 mm are VERY hard to find*

EP = eyepiece, FL = focal length, mag = magnification

mag = Scope_FL / EP_FL

Exit Pupil = Aperture / mag

F-ratio = Scope_FL / Aperture

rough TFOV = AFOV / mag

TFOV=57.3 x FldStop / Scope_FL

instead of 57.3 in these calcs, used 56 to adjust for edge distortion issues

Mag	Mag/inch
40x	5
80x	10
160x	20
200x	25
240x	30
400x	50
480x	60

	81mm to 34mm	25mm to 17mm	14mm to 10mm		
	25x to 60x	80x to 120x	150x to 200x	<== ***Three "Essential" EPs [2]***	
				(1x-2x-3x is a similar method) ***[7]***	
	VERY LOW POWER is used as a "Finder" and also for Open Clusters, Large Nebula, and Asterisms	**LOW POWER** is used for Wide Views of Open Clusters and Medium-Size Nebula	**MEDIUM POWER** is used for General Viewing of Globular Clusters and Planetary Nebula	**HIGH POWER** is used for (with okay seeing) viewing Planets, Luna, Double Stars, and Galaxies	**VERY HIGH POWER** is used for (if great seeing) viewing Planets, Luna, and Double Stars	**EXTREME PWR** is used for viewing very close Double Stars (& maybe Luna)
~Max TFOV = **1.05** (deg) (per EP clear aperture) — 1st Priority for Purchasing	==========>	==========>	**Eyepiece "A"**			
2nd Priority for Purchasing	**Eyepiece "C"**	**Eyepiece "B"**				
(perhaps only one low power EP, "B" or "C")						
*Using a Barlow Lens w/EP "A", "B" or "D" may substitute => (see below *)* — 3rd Priority for Purchasing	==========>	==========>	==========>	**Eyepiece "D"**		
4th Priority for Purchasing	==========>	==========>	==========>	==========>	**Eyepiece "E"** *(maybe)*	**Eyepiece "F"** *(perhaps omit)*

Some experienced observers will advise others to have many, many EPs so that one may always choose based on the viewing conditions & object, but that's too advanced for here. Ditto for zoom eyepieces.

[1]

per [6] ==>	LOW POWER	LOW POWER	MEDIUM POWER	MEDIUM POWER	HIGH POWER	VERY HI POWER
using **specific EP exit pupils** (in mm) =	6.0 (max exit pupil)	**4.0**	**2.0**	**1.3**	**0.8**	**0.5**
		(can be manually changed to use exit pupils other than 4, 2, 1.3, 0.8 and 0.5 mm)				
Associated Eyepiece Focal Length (mm) =>	is barrel-limited	40.0	20.0	13.0	8.0	5.0
Largest EP FL w/Max Field of View (mm) =>	**42.6**	<= EPs of longer FL (& same FOV) CAN work but generally have darker FOV edges)				
Giving an Exit Pupil of =>	4.3 mm	4.0 mm	2.0 mm	1.3 mm	0.8 mm	0.5 mm
Eyepiece Magnification =>	48x	51x	102x	156x	254x	406x
Rough True Field of View (TFOV) =>	1.05 deg MAX	0.99 deg	0.49 deg	0.32 deg	0.20 deg	0.12 deg
* using a **2.0** x Barlow with EP "D"=>	| |	| |	| |	|=====> ==========	==========>	6.5 mm
Equivalent FL of Barlowed EP "A"=>	| |	| |	|=====> ==========	==========>	10.0 mm	- - -
Equivalent FL of Barlowed EP "B"=>	| |	|=====> ==========	==========>	20.0 mm	- - -	- - -
Equivalent FL of Barlowed EP "C"=>	|=====> ==========	==========>	21.3 mm	- - -	- - -	- - -
Barlowed Exit Pupil =>	- - -	- - -	2.1 mm	2.0 mm	1.0 mm	0.7 mm
Barlowed Magnification =>	- - -	- - -	95x	102x	203x	312x
Rough True Field of View (TFOV) =>	- - -	- - -	0.52 deg	0.49 deg	0.25 deg	0.16 deg

If a Barlow (or telecentric) lens results in duplicate focal lengths or excessive magnification, another multiplier (1.6x, 1.8x, etc.) may be better.

	per [6] ==>	LOW POWER	LOW POWER	MEDIUM POWER	MEDIUM POWER	HIGH POWER	VERY HI POWER
[3]	Or **use a 1.4x progression of focal lengths** - surface brightness for extended objects varies with the square of focal length [3],						
	Starting EP FL defaults to a barrel- or exit pupil-limit		<= a starting low power EP FL may be entered here (optional)				
	Eyepiece Focal Length (mm) =>	42.6	30.1	21.3	15.1	10.7	7.5
	Eyepiece Exit Pupil =>	4.3 mm	3.0 mm	2.1 mm	1.5 mm	1.1 mm	0.8 mm
	Eyepiece Magnification =>	48x	67x	95x	135x	191x	270x
	Rough True Field of View (TFOV) =>	1.05 deg MAX	0.74 deg	0.52 deg	0.37 deg	0.26 deg	0.19 deg
	* using a **2.0** x Barlow with EP "D"=>	| |	| |	| |	|=====>	==========>	7.5 mm
	Equivalent FL of Barlowed EP "A"=>	| |	| |	|=====>	==========>	10.7 mm	- - -
	Equivalent FL of Barlowed EP "B"=>	| |	|=====>	==========>	15.1 mm	- - -	- - -
	Equivalent FL of Barlowed EP "C"=>	|=====>	==========>	21.3 mm	- - -	- - -	- - -
	Barlowed Exit Pupil =>	- - -	- - -	2.1 mm	1.5 mm	1.1 mm	0.8 mm
	Barlowed Magnification =>	- - -	- - -	95x	135x	191x	270x
	Rough True Field of View (TFOV) =>	- - -	- - -	0.52 deg	0.37 deg	0.26 deg	0.19 deg

Factor	(Factor x Aperture in mm = Magnification) *[4] & [5]*		**Magnification**	**Mag/Inch**	**EP Focal Length**	**EP Exit Pupil**	*typically*
0.13	Minimum useful magnification - largest dark-adapted pupil		26	3x/in	77 mm	7.7 mm	**EP "C"**
0.20	(for better contrast [darker sky] or with ambient light pollution)		41	5x/in	50 mm	5.0 mm	EP "B"
0.25	Comfortable viewing - best balance of eye-relief & magnification		51	6x/in	40.0 mm	4.0 mm	EP "B"
0.40	Wide views - Planets & Luna with large apertures		81	10x/in	25.0 mm	2.5 mm	**EP "A"**
0.50	Lowest power to see all detail (eye resolution matches scope)		102	13x/in	20.0 mm	2.0 mm	**EP "A"**
0.80	Planets, Messier objects - typ astigmatism has minimal effects		162	20x/in	12.5 mm	1.3 mm	EP "D"
1.00	Point Source Airy Disc becomes visible - no additional resolution		203	25x/in	10.0 mm	1.0 mm	EP "D"
1.20	Normal high power, double stars - floaters are more noticeable		244	30x/in	8.3 mm	0.8 mm	EP "D"
1.60	(High power when seeing is less turbulent)		325	41x/in	6.3 mm	0.6 mm	**EP "E"**
2.00	Maximum useful magnification		406	51x/in	5.0 mm	0.5 mm	EP "F"
2.35	Close doubles, rough telescope star testing		477	60x/in	4.3 mm	0.4 mm	EP "F"
4.00	For some double stars, telescope star testing	**Mag is Too High=>**	812	102x/in	2.5 mm	0.3 mm	EP "F"
500	***<== General magnification limit imposed by atmospheric turbulence***			(mag/Aperture)	(FL/mag)	(Aperture/mag)	

	Mag/Inch of Aperture	**EP Exit Pupil**	**Useful for:** *[6]*	*typically*
LOW POWER	3.6 to 9.9x/in	7.0 to 2.6 mm	Finding objects, observing large angular sized open clusters, large faint nebula.	**EP "B" or "C"**
71 to 25.7 mm	(29x to 79x)		General sweeping of Milky Way, viewing of entire moon. Best power for nebula filters.	
MEDIUM POWER	10 to 18.9x/in	2.5 to 1.3 mm	Somewhat smaller deep-sky objects such as galaxies, some diffuse nebulae,	**EP "A" or "B"**
25.4 to 13.4 mm	(80x to 151x)		smaller open clusters, and moderate to large planetary nebula.	
HIGH POWER	19 to 31.9x/in	1.3 to 0.8 mm	Observing fine planetary and lunar detail. Better resolution of stars in globular clusters.	**EP "D"**
13.4 to 8.0 mm	(152x to 255x)		Poor seeing may compromise views at this power in apertures larger than 5 inches.	
VERY HI POWER	32 to 46.9x/in	0.8 to 0.5 mm	Study of certain specific planetary details, and resolving tight double stars.	**EP "E"**
7.9 to 5.4 mm	(256x to 375x)		Eye defects like motes and floaters detract (along with the somewhat lower light level).	
EXTREME POWER	47 to 75x/in	0.5 to 0.3 mm	Double stars at the instrument's limit, or detecting elongation of unresolved doubles.	**EP "F"**
5.4 to 3.4 mm	(376x to 599x)		Up to 60x/inch in small instruments may allow beginners to see gross planetary detail.	

[1] Try 7, 4, 2, 1, and .5 mm exit pupils (An Eyepiece Primer - Al Nagler) [www.skytonight.com/equipment/basics/3311076.html?showAll=y&c=y]

Other Sources: Forums on www.cloudynights.com, with edits *Idea from [Lawrence Sayre] post on 7/20/08 - Worksheet Assembled by JimK*

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[4] = ? & John [dvb & magredc5] (8/17/05) & per www.astro-tom.com/technical_data/useful_formulas.htm

[5] = Don Pensack [Starman1] (2/17/07) [7] = Don Pensack [Starman1] (12/18/12), where x=35 power for 4" scopes, x=50 for 8", x=60 for 10", x=70 for 12"

[6] = [David Knisely] (2/20/07, 12/23/05, 7/29/05, & article 4/17/03) *{TFOV progression criteria (1.0/0.75/0.5 deg) are not addressed}*

8-inch f/10 SCT

Worksheet for Helping to Determine which Eyepieces to Choose for Use with a Telescope

10/10/14

Telescope Specs: 302 — Selected Telescope Model: **12-inch f/5 Newtonian** — (for reflectors) Is a **Paracorr** used? [Y/N]=> **Y**

Aperture = **302** mm =======> 11.9 inches — **6** mm = Max Exit Pupil for Eyeball

5.7 <= Calculated Focal(F)-ratio — *use 5 mm if older or in significant ambient light*

Focal Length = **1725** mm =======> 68 inches (Fast telescope if <6, Slow if >10) — *use 7 mm (or more) if young & dark adapted*

1725 ***A Paracorr increases FL by 1.15x*** — *Exceeding 7mm may show a reflector's secondary obstruction*

Wide Field (Low Power) Eyepiece Constraint: 47 mm <= *(if 1.25 barrel, then use 27) (if 2-inch use 47, unless with smaller SCT)*

Max Clear Aperture for Eyepiece Barrel = **47** mm <= *(if 8-in SCT, then use 38, C-6=25.4, C-9.25=45 [baffle hole size limit])*

default EP AFOV
50

(optional) Enter EP FL in mm (longer FLs on the left)=>

(optional) Select current/desired eyepiece type =>	Nagler	Nagler	Ethos	Ethos	Ethos	Ethos
Eyepiece Apparent Field of View (AFOV) in deg =	82	82	100	100	100	100

(Eyepiece "A","B","D,"E", & "F" apparent field of view (AFOV) values are used to roughly estimate TFOV)

Here are some of MANY opinions on basic EP choices and uses!

Mag	Mag/inch
59x	5
119x	10
238x	20
297x	25
357x	30
594x	50
713x	60

Misc Reference *EP w/FL>56 mm are VERY hard to find*

EP = eyepiece, FL = focal length, mag = magnification

mag = Scope_FL / EP_FL

Exit Pupil = Aperture / mag

F-ratio = Scope_FL / Aperture

rough TFOV = AFOV / mag

TFOV=57.3 x FldStop / Scope_FL

instead of 57.3 in these calcs, used 56 to adjust for edge distortion issues

WARNING: All numbers are APPROXIMATE!

	69mm to 29mm	22mm to 14mm	12mm to 9mm	*"Minimalist" Approaches* <== ***Three "Essential" EPs [2]*** *(1x-2x-3x is a similar method)* ***[7]***	
	25x to 60x	80x to 120x	150x to 200x		
	VERY LOW POWER is used as a "Finder" and also for Open Clusters, Large Nebula, and Asterisms	**LOW POWER** is used for Wide Views of Open Clusters and Medium-Size Nebula	**MEDIUM POWER** is used for General Viewing of Globular Clusters and Planetary Nebula	**HIGH POWER** is used for (with okay seeing) viewing Planets, Luna, Double Stars, and Galaxies	**VERY HIGH POWER** is used for (if great seeing) viewing Planets, Luna, and Double Stars	**EXTREME PWR** is used for viewing very close Double Stars (& maybe Luna)
1st Priority for Purchasing	==========>	==========>	**Eyepiece "A"**			
2nd Priority for Purchasing	**Eyepiece "C"**	**Eyepiece "B"**				
	(perhaps only one low power EP, "B" or "C")					
3rd Priority for Purchasing	==========>	==========>	==========>	**Eyepiece "D"**		
4th Priority for Purchasing	==========>	==========>	==========>	==========>	**Eyepiece "E"** *(maybe)*	**Eyepiece "F"** *(perhaps omit)*

~Max TFOV = **1.53** (deg) (per EP clear aperture)

Some experienced observers will advise others to have many, many EPs so that one may always choose based on the viewing conditions & object, but that's too advanced for here. Ditto for zoom eyepieces.

*Using a Barlow Lens w/EP "A", "B" or "D" may substitute => (see below *)*

[1]

per [6] ==>	LOW POWER	LOW POWER	MEDIUM POWER	MEDIUM POWER	HIGH POWER	VERY HI POWER
using **specific EP exit pupils** (in mm) =	6.0 (max exit pupil)	**4.0**	**2.0**	**1.3**	**0.8**	**0.5**
		(can be manually changed to use exit pupils other than 4, 2, 1.3, 0.8 and 0.5 mm)				
Associated Eyepiece Focal Length (mm) =>	is barrel-limited	22.8	11.4	7.4	4.6	2.9
Largest EP FL w/Max Field of View (mm) =>	**32.1**	<= EPs of longer FL (& same FOV) CAN work but generally have darker FOV edges)				
Giving an Exit Pupil of =>	5.6 mm	4.0 mm	2.0 mm	1.3 mm	0.8 mm	0.5 mm
Some are Too High Eyepiece Magnification =>	54x	76x	151x	232x	378x	604x (too hi)
Rough True Field of View (TFOV) =>	1.53 deg MAX	1.09 deg	0.66 deg	0.43 deg	0.26 deg	0.17 deg
* using a **2.0** x Barlow with EP "D"=>	| |	| |	| |	|=====>	==========>	3.7 mm
Equivalent FL of Barlowed EP "A"=>	| |	| |	|=====>	==========	> 5.7 mm	- - -
Equivalent FL of Barlowed EP "B"=>	| |	|=====>	==========	> 11.4 mm	- - -	- - -
Equivalent FL of Barlowed EP "C"=>	|=====>	==========	> 16.1 mm	- - -	- - -	- - -
Barlowed Exit Pupil =>	- - -	- - -	2.8 mm	2.0 mm	1.0 mm	0.7 mm
Barlowed Magnification =>	- - -	- - -	107x	151x	302x	465x
Rough True Field of View (TFOV) =>	- - -	- - -	0.76 deg	0.54 deg	0.33 deg	0.22 deg

If a Barlow (or telecentric) lens results in duplicate focal lengths or excessive magnification, another multiplier (1.6x, 1.8x, etc.) may be better.

	per [6] ==>	LOW POWER	LOW POWER	LOW POWER	MEDIUM POWER	MEDIUM POWER	HIGH POWER
[3]	Or **use a 1.4x progression of focal lengths** - surface brightness for extended objects varies with the square of focal length [3],						
	Starting EP FL defaults to a barrel- or exit pupil-limit		<= a starting low power EP FL may be entered here (optional)				
	Eyepiece Focal Length (mm) =>	32.1	22.7	16.1	11.3	8.0	5.7
	Eyepiece Exit Pupil =>	5.6 mm	4.0 mm	2.8 mm	2.0 mm	1.4 mm	1.0 mm
	Eyepiece Magnification =>	54x	76x	107x	152x	215x	304x
	Rough True Field of View (TFOV) =>	1.53 deg MAX	1.08 deg	0.93 deg	0.66 deg	0.47 deg	0.33 deg
	* using a **2.0** x Barlow with EP "D"=>	| |	| |	| |	|=====>	==========>	5.7 mm
	Equivalent FL of Barlowed EP "A"=>	| |	| |	|=====>	==========>	8.0 mm	- - -
	Equivalent FL of Barlowed EP "B"=>	| |	|=====>	==========>	11.3 mm	- - -	- - -
	Equivalent FL of Barlowed EP "C"=>	|=====>	==========>	16.1 mm	- - -	- - -	- - -
	Barlowed Exit Pupil =>	- - -	- - -	2.8 mm	2.0 mm	1.4 mm	1.0 mm
	Barlowed Magnification =>	- - -	- - -	107x	152x	215x	304x
	Rough True Field of View (TFOV) =>	- - -	- - -	0.76 deg	0.54 deg	0.47 deg	0.33 deg

Factor	(Factor x Aperture in mm = Magnification) *[4] & [5]*		Magnification	Mag/Inch	EP Focal Length	EP Exit Pupil	*typically*
0.13	Minimum useful magnification - largest dark-adapted pupil		39	3x/in	44 mm	7.7 mm	**EP "C"**
0.20	(for better contrast [darker sky] or with ambient light pollution)		60	5x/in	29 mm	5.0 mm	EP "B"
0.25	Comfortable viewing - best balance of eye-relief & magnification		76	6x/in	22.8 mm	4.0 mm	EP "B"
0.40	Wide views - Planets & Luna with large apertures		121	10x/in	14.3 mm	2.5 mm	**EP "A"**
0.50	Lowest power to see all detail (eye resolution matches scope)		151	13x/in	11.4 mm	2.0 mm	**EP "A"**
0.80	Planets, Messier objects - typ astigmatism has minimal effects		242	20x/in	7.1 mm	1.3 mm	EP "D"
1.00	Point Source Airy Disc becomes visible - no additional resolution		302	25x/in	5.7 mm	1.0 mm	EP "D"
1.20	Normal high power, double stars - floaters are more noticeable		362	30x/in	4.8 mm	0.8 mm	EP "D"
1.60	(High power when seeing is less turbulent)		483	41x/in	3.6 mm	0.6 mm	**EP "E"**
2.00	Maximum useful magnification	**Mag is Too High=>**	604	51x/in	2.9 mm	0.5 mm	EP "F"
2.35	Close doubles, rough telescope star testing	**Mag is Too High=>**	710	60x/in	2.4 mm	0.4 mm	EP "F"
4.00	For some double stars, telescope star testing	**Mag is Too High=>**	1208	102x/in	1.4 mm	0.3 mm	EP "F"
500	***<== General magnification limit imposed by atmospheric turbulence***			(mag/Aperture)	(FL/mag)	(Aperture/mag)	

	Mag/Inch of Aperture	EP Exit Pupil	Useful for: *[6]*	*typically*
LOW POWER	3.6 to 9.9x/in	7.0 to 2.6 mm	Finding objects, observing large angular sized open clusters, large faint nebula.	**EP "B" or "C"**
40 to 14.7 mm	(43x to 118x)		General sweeping of Milky Way, viewing of entire moon. Best power for nebula filters.	
MEDIUM POWER	10 to 18.9x/in	2.5 to 1.3 mm	Somewhat smaller deep-sky objects such as galaxies, some diffuse nebulae,	**EP "A" or "B"**
14.5 to 7.7 mm	(119x to 225x)		smaller open clusters, and moderate to large planetary nebula.	
HIGH POWER	19 to 31.9x/in	1.3 to 0.8 mm	Observing fine planetary and lunar detail. Better resolution of stars in globular clusters.	**EP "D"**
7.6 to 4.5 mm	(226x to 379x)		Poor seeing may compromise views at this power in apertures larger than 5 inches.	
VERY HI POWER	32 to 46.9x/in	0.8 to 0.5 mm	Study of certain specific planetary details, and resolving tight double stars.	**EP "E"**
4.5 to 3.1 mm	(380x to 558x)		Eye defects like motes and floaters detract (along with the somewhat lower light level).	
EXTREME POWER	47 to 75x/in	0.5 to 0.3 mm	Double stars at the instrument's limit, or detecting elongation of unresolved doubles.	**EP "F"**
3.1 to 1.9 mm	(559x to 892x)	**<=Mag Too High**	Up to 60x/inch in small instruments may allow beginners to see gross planetary detail.	

[1] Try 7, 4, 2, 1, and .5 mm exit pupils (An Eyepiece Primer - Al Nagler) [www.skytonight.com/equipment/basics/3311076.html?showAll=y&c=y]

Other Sources: Forums on www.cloudynights.com, with edits *Idea from [Lawrence Sayre] post on 7/20/08 - Worksheet Assembled by JimK*

[2] = [SteveCoe] (1/2/06): Buy one eyepiece that gives you 30-60X, buy another that give you 80-120X and one more that gives you 150-200X.

[3] = Alexis Cousein [sixela] (2/17/07) also, two eyepieces with focal lengths in a 1.4x progression will give four 1.4x focal lengths using a 2x Barlow

[4] = ? & John [dvb & magredc5] (8/17/05) & per www.astro-tom.com/technical_data/useful_formulas.htm

[5] = Don Pensack [Starman1] (2/17/07) [7] = Don Pensack [Starman1] (12/18/12), where x=35 power for 4" scopes, x=50 for 8", x=60 for 10", x=70 for 12"

[6] = [David Knisely] (2/20/07, 12/23/05, 7/29/05, & article 4/17/03) *{TFOV progression criteria (1.0/0.75/0.5 deg) are not addressed}*

12-inch f/5 Newtonian