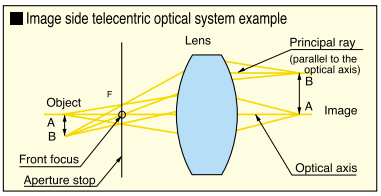
Lens

Performance

Telecentric optical system

An optical system where the principal ray is parallel to the lens optical axis. An optical system where the light comes from an object toward a lens and stays parallel to the optical axis, even outside the axis, is called an object side telecentric optical system. A system where the light comes from a lens toward an image and stays parallel to the optical axis, even outside the axis, is called an image side telecentric optical system. Telecentric optical systems indicated in this catalog are object side telecentric optical systems.



Resolution (mm)

Resolution is a measure of how closely spaced two points may be before they cannot be distinguished. For example, 1μm resolution means that two points that are 1μm away from each other can be distinguished. Resolution values in this catalog are lenses' theoretical resolutions. The following is a formula to calculate theoretical resolution based on an aplanatic lens's ray diffraction. (Rayleigh formula)

$$\text{Resolution}=\frac{0.61 \times \lambda}{NA}$$

λ : Wavelength, 0.61: Constant

Resolving power (line/mm)

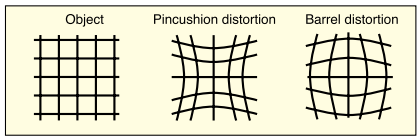
Resolving power indicates the number of black and white lines distinguished within 1mm in an image through a black and white grid-like chart lens. It is expressed by line/mm. For example, 100 line/mm means that black and white pitch 1/100mm (10μm) can be distinguished. The width of both the black and white lines is 1/200mm (5μm).

Horizontal TV resolution (TV line)

The total number of black and white horizontal stripes on a TV monitor screen. It is expressed in TV lines. For example, 200TV lines of horizontal TV resolution means that 100 white horizontal lines and 100 black horizontal lines can be distinguished on a TV monitor screen. When measuring resolving power, a pair of black and white lines is counted as one line. However, for TV lines, one pair is counted as 2TV lines. For example, if a 1/2-inch CCD camera is used with a lens of 50 lines/mm resolving power, horizontal TV resolution on a TV monitor screen is calculated as follows; 50 x 6.4 (CCD width) x 2 = 640TV lines

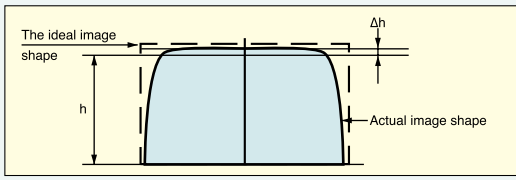
Distortion (%)

Lens's aberration where a straight object outside of the optical axis appears curved. Positive distortion of a straight line is called pincushion distortion while negative distortion is called barrel distortion.



TV distortion (%)

Image distortion on a TV monitor. The closer to zero, the better the performance.



$$\text{TV distortion (\%)}=\frac{\Delta h}{2h} \times 100$$

The curve amount on the long side is considered as distortion. Percentage of the depth of distortion Δh against vertical screen is TV distortion.

Aperture efficiency Marginal light quantity (%)

Aperture efficiency indicates the brightness difference between the optical axis of the image formation plane and its surrounding area when an evenly bright object is captured with a lens. It is expressed by percent (%) assuming that the center brightness is 100. It is one of a lens's optical characteristics. Marginal light quantity in this catalog is aperture efficiency.

Shading (%)

Shading is the brightness difference between TV monitor's center and its edges when an evenly bright object is captured with a lens and CCD-TV camera. It is expressed by percent (%). Generally, this percentage is calculated based on power ratio of light receiving elements and CCD elements. Shading indicates comprehensive performance of a lens and TV camera. To make shading small, telecentric optical system is used.

Chromatic aberration

In lenses' optical systems, positions where images are formed and image magnification differ according to light's wavelength. Rays with different wavelengths have different colors. This is called chromatic aberration. Aberration on the optical axis is called chromatic aberration on the axis and magnification difference is called magnification chromatic aberration.

Distance

WD (Working Distance) (mm)

Distance from the front end of a lens system to the object under inspection.

Focal length f (mm) Back focus / front focus

Focal length is the distance from the optical system's principle point to the focal point. Distance from the vertex of the last lens to the back focal point is called back focal length. Distance from the vertex of the first lens to the front focal point is called front focal length.

Depth of field

Depth is the distance between the nearest and farthest points that appear in acceptably sharp focus when an object is shifted back and force from the best focal point. Depth range of the object side is called depth of field.

$$\text{Depth of field}=2(\text{permissible circle of confusion} \times \text{effective Fno} \div \text{magnification}^2)$$

Images through lenses theoretically form as points. Acceptable blur on an acceptably clear image is called the permissible circle of confusion

Depth of focus

Depth is the distance between the nearest and farthest points that appear in acceptably sharp focus when a CCD is shifted back and force from the best focal point. Depth range of the image side is called depth of focus.

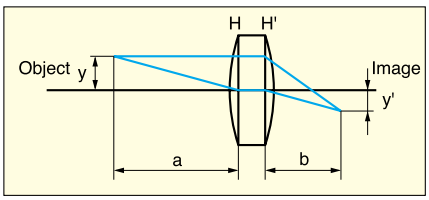
Flange back (mm)

Distance from the front of the camera mount thread to the image plane.

C-mount standard

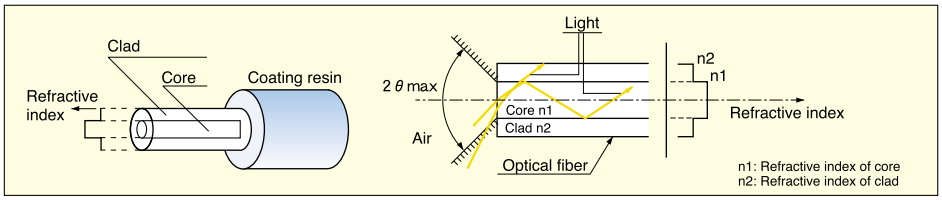
One of the standards for screws to mount lenses provided by JIS B 7127.

Name	Basic outside diameter	No. of screw threads (for 25.4mm)	Flange back
U1	25.400mm	32 threads	17.526mm

Brightness	Numerical aperture NA, NA'	When the half angle that an object makes on the entrance pupil is u and refractive index is n, n x sin u is called object side numerical aperture, NA. When the half angle that an image makes on exit pupil is u' and refractive index is n', n' x sin u' is called image side numerical aperture, NA'. NAs in this catalog indicate object side numerical apertures. Numerical aperture is an important value that expresses a lens's resolution and brightness. NA=n x sin u NA'=n' x sin u' The higher the NA, the greater the resolution and brightness are.
	F Number F No	The value indicates a lens's brightness. It is calculated by dividing the lens's focal length by the lens's effective diameter (entrance pupil D mm) looking from object side. It can be also calculated by NA and lens's optical magnification (ß). The smaller the number, the brighter the lens is. F No=f/D= ß / (2 x NA) =1/ (2 x NA')
	Effective F No	The value indicates a lens's brightness when an object is located in finite distance, namely its actual brightness. The higher the optical magnification (ß), the darker the lens is. Effective F No= (1 + ß) x F No
Magnification	Optical magnification ß	Image size ratio against the object size. ß =y' / y =b / a =NA / NA' **=CCDcamera element size /actual size of field of view** 
	Electronic magnification	Electronic magnification is a magnification of an image on a CCD camera when it is displayed on a monitor screen.
	Monitor magnification	Monitor magnification is a magnification of an object displayed on a monitor screen through a lens. Monitor magnification = (optical magnification ß) x (electronic magnification) (Calculation example) Optical magnification ß = 0.2 x , CCD size 1/2" (diagonal line 8mm), monitor 14" : Electronic magnification = 14 x 25.4 ÷ 8 = 44.45(times) Monitor magnification = 0.2 x 44.45 = 8.89(times) (1 inch = 25.4mm)
	Field of view	Field of view is the size of a viewed object that can be taken when the lens is attached to a CCD-TV camera. The size of field of view is (CCD format size) / (optical magnification ß). (Calculation example) Optical magnification ß = 0.2x, CCD size 1/2" (4.8mm long, 6.4mm wide) : Size of field of view Length = 4.8/0.2 = 24(mm) Width = 6.4/0.2 = 32(mm)

Illumination

Luminous quantity	Beam (lm)	Indicates light quantity outputted from a light source. It is expressed by lm (lumen).
	Luminous intensity (cd=lm/sr)	Light quantity outputted from a light source is indicated by the amount of beam per unit solid angle. It is expressed by cd (candela) = lm/sr (solid angle).
	Luminosity (lx=lm/m²)	Indicates an object's surface brightness when light outputted from a light source illuminates it. It is expressed by lx (lux) = lm/m². m² indicates the object's surface area.
	Brightness (nt=cd/m²)	Indicates luminous intensity of a light source per unit area. It is expressed by nit = cd/ m² or stilb=cd/cm².
Filters	Color temperature°K	Spectral energy distribution of light outputted from a light source is indicated by color temperature K (Kelvin). Light source with a lower value is reddish and high value is bluish. Color temperature changing filters are used to quickly change a light source's color temperature.
	Polarizing filter	This filter shades strong, harmful light reflected by glass, metal, or water surface.
	ND filter	Also known as a gray filter, this filter reduces light quantity without influencing colors.
	Color temperature changing filter	Used to change color temperature. Wavelength can be selected.
	Diffusing filter	Diffuses light outputted from a light source to reduce unevenness of illumination.
	Infrared ray blocking filter	Visible rays permeate this filter but infrared rays do not. There are two types of filters that block infrared rays; ones that absorb infrared rays are called heat absorbing filters or insulating filters and ones that reflect infrared rays with their multi-layered structure are called cold filters.
Lamps	Halogen lamp	A type of incandescent lamp with filler gas and a very small amount of halogen gas. Halogen cycle prevents the blackening of valve walls. As a result, its light output and color temperature are more stable as compared to regular incandescent lamps.
	Metal halide lamp	A color rendering, bright lamp that utilizes illumination of metal halides and mercury.

Fibers	Optical fiber	Optical fiber consists of two optical fields; the core that light goes through and the clad that surrounds the core. There are plastic, multi-component glass, and quartz glass fibers. 
	Numerical aperture NA	Indicates the characteristics to receive rays transmitted to optical fiber ends. It is determined by refractive index of core and clad that compose optical fiber. $NA=\sqrt{n_1^2-n_2^2}$
	Light-receiving angle θ	An angle that optical fiber can receive rays. $\theta=2\sin^{-1}(NA)$

Cameras and monitors

Cameras and monitors	CCD	Solid imaging element. Stands for Charge-Coupled Device. * Frame transfer CCD Signal charge is photoelectric-converted at the light-receiving part and is transferred to the storage array. It is read out of the horizontal transfer CCD line by line. * Interline transfer CCD Signal charge is photoelectric-converted at the light-receiving part and is transferred to a vertical register all at once. It is then transferred to the vertical direction and is read out of the horizontal transfer CCD line by line.
	Square grid	CCD pixel with the same length and width. Size correction is unnecessary during image processing.
	Aspect ratio	The ratio of width to height in a TV monitor. 4:3 aspect ratio is used for our devices because it is gentle to your eyes when you watch a screen for a long time. Some medical equipment such as X-ray use 1:1.
	Overscan Underscan	Overscanning is to make about 10% of a camera's effective image, ringing just after blacking, and marginal distortion on a TV monitor's CRT screen invisible. Underscanning is to make the entire image visible at one time. Usually, monitors are set at overscanning.
	Interlaced (Non-interlaced)	Every other scanning line is scanned at twice as much frequency in order to decrease flicker. This method is called interlaced scanning. Vertical resolution becomes 1/2. There is a method to scan from the left top corner to the right bottom corner called non-interlaced or sequential scanning. In this method, frame shutter operation is possible and vertical resolution for movable objects does not decline.
	Synchronism	To match timing for a TV camera to take an image. There is both horizontal and vertical direction synchronism. When horizontal synchronism of a camera and monitor is off, image runs left and right. When vertical synchronism is off, image runs up and down.
	AGC	A function to automatically adjust the gain of the internal circuit (Automatic Gain Control) in order to maintain a constant TV camera signal output.
	AWB	Color balance for color TV cameras and color monitors is called white balance. Having white objects automatically appear white is called Auto White Balance.
	Gamma (γ) correction	Gamma is a transfer characteristic of input and output signals in photoelectric transducers such as cameras and monitors. Cameras have a gamma correction circuit in order to display natural images on a monitor. Television systems should have a gamma of one.
	Electronic shutter	CCD imaging elements can gain electric signals that are proportionate to exposure time responding to the strength of light. Shutter speed can be controlled by electrically controlling light storage time that is equivalent to the exposure time. Shutter timing control can be done inside the camera or via an external control signal (external trigger shutter).
	ALC function	ALC (Auto Light Control) function is to automatically change electric shutter's speed according to brightness of an object and make output signal constant. It is like controlling a lens's iris.
Signaling systems	NTSC	The standard color television signal format for Japan and the US. Vertical scanning frequency: 59.94Hz. Horizontal scanning frequency: 15.734Hz. Aspect ratio is 4:3.
	PAL	The standard color television signal format for Europe and China. Vertical scanning frequency: 50Hz. Horizontal scanning frequency: 15.625Hz.
	EIA	B/W camera signal format. 30 pieces/second, 60 of field rate, horizontal scanning frequency: 15.75Hz. Mainly used in Japan and the US.
	CCIR	B/W camera signal format. 25 pieces/second, 50 of field rate, horizontal scanning frequency: 15.625Hz. Mainly used in Europe and China.
	Frame rate	The number of image frames taken per second. 30 frames/second in EIA format.
Image quality	SN ratio (decibel)	Comparison of TV camera output signal and noise signal included in it. Ratio of rated signal output and output when light is blocked is expressed in decibel values.
	Smear	Where a bright belt-like image appears on a screen when very bright spotlight comes into the image. CCD TV cameras sometimes cause this because stored electric charge overflows.
	Flicker	Flicker occurs when an image is taken under fluorescent lighting.
	Blooming	When a strong light enters an image, it makes the surrounding area appear whitish.