Camera formats

The first thing to note when selecting a lens is the camera format. Cameras will be quoted as 1/2", 1/3" or occasionally 1/4". This refers to the format of the camera (chip size).
In itself it gives no measure of a camera's performance although generally the smaller the format size, the smaller the light gathering area of the sensor. It is provided for information to enable the installer to match the camera to the correct lens. ***COP Body Cameras are 1/3"***

IMPORTANT

The format size of a lens must be equal to or greater than the format size of the camera it is being used on. If the lens is of smaller format size than the camera then the corners of the scene being viewed will be cut-off.
You can use a ½" lens with a 1/3" camera. But you can not use a 1/3" lens with a ½" camera.

Camera Lens Mounts

A CCTV lens will be specified as either C or CS Mount, COP CE body cameras can be either C or CS mount. Both types of lens look very similar and there is nothing that can be physically measured on a lens, e.g. thread diameter or pitch, to determine whether it is C or CS.
The difference between the two types is the position of the focused image behind the lens.
CS lenses focus 12.5 mm behind the lens whereas C lenses focus 17.5mm behind.

Most new lenses tend to be CS mount because they are smaller and therefore cheaper to manufacture.
Ideally the camera mount and the lens mount should be the same but it is possible to use a C Mount lens on a CS Mount Camera by using a 5mm spacing ring supplied with all COP CE body cameras.

CCTV lens types and uses

There are two main types of lens used in CCTV, these are fixed focal length types and zoom lenses i.e. with variable focal length (vari-focal).
The focal length of a lens defines its effective viewing angles both horizontally and vertically.
Hence the focal length of the lens determines the size of a particular image on the monitor screen or the area of the scene being covered by the camera.

Fixed focal length lenses.

For 1/2" format lenses on a 1/2" format camera, the following lens focal lengths are commonly available:.

Lens Focal Length	Horizontal Viewing Angle	Vertical Viewing Angle
3.6mm	84deg.	66 deg.
4.5mm	72deg.	56deg.
6mm	56deg.	43deg.
12mm	30deg.	22deg.

For 1/3" format lenses on a 1/3" format camera, the following lens focal lengths are commonly available.

Lens Focal Length	Horizontal Viewing Angle	Vertical Viewing Angle
2.8mm	75 deg.	59 deg.
4mm	56 deg.	43deg.
8mm	30 deg.	22deg.

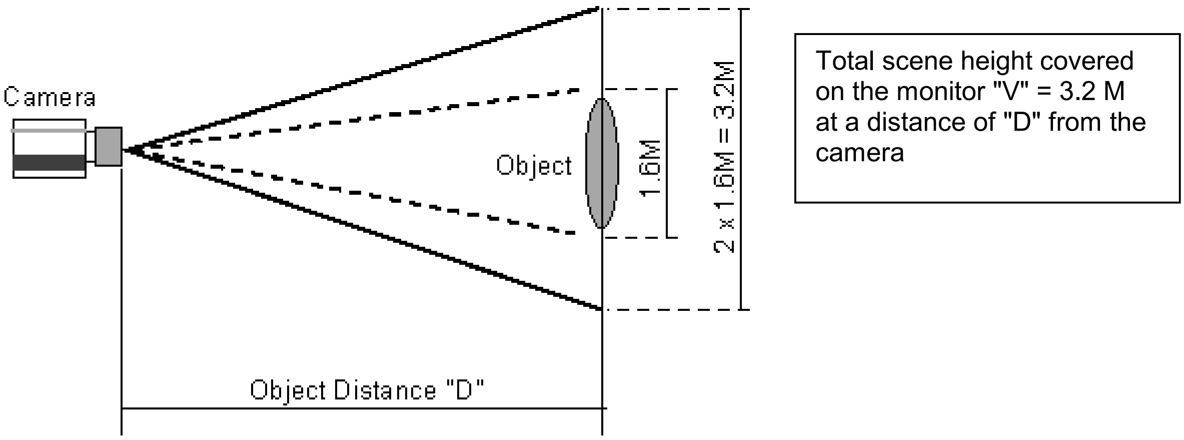
Note that a 6mm 1/2" format lens on a 1/2" camera gives approximately the same angles of view as a 4mm 1/3" format lens on a 1/3" camera.

If a 1/2" format lens is used on a 1/3" format camera then the viewing angles obtained will be 2/3 of those obtained if the lens was used on a 1/2" format camera.

Lens selection for image size

The choice of focal length of lens fitted to a camera affects how big a particular object, e.g. a person, will appear on the monitor screen or a video recording from the camera. Obviously, the bigger the image appears on the screen, the better the chances of recognising or identifying a person being viewed or recorded.

Home Office recommendations to be incorporated into European Standards for CCTV Systems specify that in order to be able to recognise a person he or she must occupy at least 50% of the monitor height. Also if it necessary to be able to positively identify an unknown person then his or her image must occupy 120% or more of the screen's height.



When designing a system it is assumed that the person to be recognised or identified is the European Standard height of 1 .6m tall and is standing upright!
Hence for recognition, if a 1.6m person must occupy 50% of screen height, then the monitor must cover no more than 2 x 1 .6m = 3.2m at the distance from the camera where the person is standing.

Using a lens calculator this shows that with an 8mm lens fitted on a 1/3" format camera, the person must be no more than 8m from the camera in order to be able to be recognized.

Lens selection for different lighting conditions

Most CCTV lenses are equipped with an iris that consists of four or six opaque metal vanes which are arranged to give a roughly circular hole or aperture through which light can pass and then fall on the camera sensor surface. The vanes can be driven together to alter the size of the lens aperture to control the amount of light falling on the sensor and hence alter the picture brightness.

Aperture Ratio

The size of the aperture is defined by an aperture ratio or f- number where:

f-number or Aperture Ratio = Focal Length of Lens / Diameter of Aperture

For example a 6mm lens at f1.0 has an aperture of 6mm in diameter.
The same lens at f1.4 has an aperture of 4.25mm in diameter.
Hence the area has halved and so has the amount of light allowed to pass through the lens.
Most lenses are marked with f-numbers; with each mark equaling one 'stop' i.e. a halving of the area of the aperture through which light can pass.
The standard f-number series is hence f1.0, f1.4, f2, f2.8, f4, f5.6, f8, f11, f16, f22 and each successive mark represents a halving of the aperture area from the one previous.
The smaller the f-number, the larger the lens aperture and so the more light the lens can collect!

Control methods for lens iris.

Manual Iris lenses
The simplest type of iris control is termed 'Manual Iris'. The lens is equipped with a ring on the body that can be turned to alter the aperture directly. In CCTV systems this can only be used generally in fixed lighting conditions or where the camera is readily accessible and it is not inconvenient to have to continually adjust the lens for correct picture brightness.

Auto-Iris Lenses
A far more common arrangement is to use auto-iris lenses where the iris vanes are driven by a galvanometer or servo motor which is controlled by an 'iris-amplifier' circuit within the lens, the control input of which is the video signal from the camera itself. Hence an auto-iris lens is used where the lighting level is liable to continuous changes e.g. outdoors where lighting can change from full sunlight down to near total darkness. The connections for an auto-iris lens are as shown below :-

Red = 12v (pin 1)
Black = 0v (pin 4)
White = Video (pin 3)

In this arrangement, as a scene gets brighter the video level increases. This is sensed by the lens and the iris is driven to give a smaller aperture, hence letting less light onto the sensor and so causing the video level to be reduced. Damping is applied to prevent the lens from hunting i.e. causing the picture to continually change brightness.

The relationship between actual video level and corresponding aperture size can be adjusted by the installer using two control potentiometers on the lens. These pots are usually marked 'Level' or 'Gain' and 'ALC' or 'P-A', abbreviations for Average Level Control and Peak-to-Average respectively.

Direct-Drive Lenses (FCS)
These are a development on auto-iris lenses where the motor or galvanometer coil moving the iris vanes in the lens is driven directly by the camera, hence 'Direct-Drive' . There is no active electronics in the lens and hence they are simpler, smaller and cheaper than an equivalent auto-iris lens. They must be used with a camera capable of driving 'DD' lenses and this is normally identified by the presence of the characteristic 4-pin square 'Hi-Rose' (Panasonic) plug on the side of the camera.

Direct Drive lenses have no adjustment controls other than focus (and angle of view in the case of Vari-focal lenses).
Picture brightness is now controlled by a level setting on the camera.
DD lenses slightly less flexible and optimisable for outdoor use.

Correct setting of an auto-iris lens

The iris controls of a lens should be adjusted when the lighting levels are at or near the highest that the camera will be subject to. Never adjust an iris setting of an outdoor camera when light levels are low. If you do then it will almost certainly be necessary to re-adjust them in daylight.

Set the P-A pot to fully average. Point the camera at a bright scene or the brightest part of the scene to be viewed and adjust the level pot until the bright part of the picture just over-exposes and then adjust the pot down slightly until the bright areas are not overexposed. If it is required to make the lens stop down when a highlight enters the picture ,e.g. a door opening, then adjust the P-A pot towards peak. If the average control is adjusted then the level control selling should again be checked and adjusted if necessary.

Other Lens Types

Vari-focal Lenses
Often it is not possible to determine the focal length of a lens required to meet a particular application or perhaps the angle of view required is not provided by one of the standard lenses available. Hence, narrow range, manually zoomed lenses have been developed to meet these application needs. These are known as ‘Van-focal’ lenses, (‘Variable focal length’) and are available in a number of different configurations. The exact angle of view can be set on installation but it is important to ensure that the angle required is within the range available from the lens.

Pin-Hole Lenses
These are primarily used for covert surveillance. They have very small front ‘objective’ lenses which mean that they can be put behind very small holes and be virtually undetectable. Straight and right-angled models are available to facilitate the mounting of the camera and to reduce the depth required behind the concealing surface. Due to the small objective lens, pin-hole lenses cannot gather as much light as conventional lenses and so their use dictates that the scene illumination is better than would otherwise be required.

Typically the maximum apertures available on pin hole lenses is F2.5 to F3.5 which is approximately 2 to 3 stops less than standard lenses. Hence between 4 and 8 times the normally quoted minimum scene illumination is required for the camera to produce a useable picture.

Aspherical lenses
Most commonly available lenses are made from glass or high quality clear plastic which has been ground to a very precise spherical shape in order to achieve its optical properties of being able to refract and focus light. Using spherical shapes gives very good results when the light passes at or near to the center of the lens, but as light passes through the points further from the center, small refraction errors are introduced which get worse the further from the lens center that the light passes. This effectively limits the maximum light gathering area or aperture-ratio (f-number) that a spherical lens may have.

Aspherical lenses are ground not into spheres but other carefully calculated, complicated shapes, which reduce the errors in light refraction. Hence an aspherically ground lens can have a much larger effective light gathering area i.e. its aperture-ratio (f-number) can be much smaller. The maximum aperture of a standard spherical lens is typically fl .4 whereas that of an aspherical lens is f1.0 or f0.8

Aspherical lenses are more expensive than standard lenses due to the more complicated and time-consuming grinding techniques that are necessary in their production. However their use can often be justified because it can preclude the need for a more sensitive, and hence expensive, camera or increasing of the site illumination.

Depth of field

Depth of field is the range of distances from the camera/lens for which the image obtained is in sharp focus. Hence a large depth of field will have images of objects from as little a 1 m from the front of the camera through to images of objects at infinity all in sharp focus.
The depth of field for a camera and lens is greatest at smallest aperture of the lens and vice-versa. If a lens aperture is set open e.g. at f1 .4, this will let most light into the camera but the depth of field will be at its narrowest. It is important therefore, when focusing a camera and lens to ensure that the iris setting is as large as, or larger than, it is ever going to be when in normal use. If this is not done then the camera can be focused and give perfectly good pictures during the day but when night falls, the iris will open and the image to be viewed will go out of focus.
Focusing of CCTV cameras should be done either at night under worst case lighting conditions or the lens should be fooled into thinking it is night by placing an optical filter (ND2 or 3) over it to open the aperture fully and then focus the camera on the scene to be viewed.

Zoom lenses
For CCTV applications these are almost exclusively motorised types to enable zooming and focusing of the lens from remote control positions.
Zoom ratios i.e. the ratio of maximum to minimum focal lengths are most commonly either 6:1 or 10:1. The viewing angles obtained are shown below:

1/2" format **Zoom Ratio**	**Focal Length Range**	**Horiz. View Angle (Wide)**	**Horiz. View Angle (Telephoto)**
6:1	8-48mm	44deg.	8deg.
10:1	8-80mm	44deg	4.7deg.

1/3" format Zoom Ratio	**Focal Length Range**	**Horiz. View Angle (Wide)**	**Horiz. View Angle (Telephoto)**
6:1	5.7 - 34.2 mm	46 deg.	8.1deg.
10:1	6 - 60mm	44deg.	4.7deg.

Nearly all zoom lenses used in CCTV surveillance applications are auto-iris type although 'motorised iris' types are available where the iris can be driven directly by a suitable control system.

Suggested settings for COP body cameras.

V Phase adjust 240 volt cameras only
This is used to adjust the vertical phase on the 240-volt cameras, this is to ensure that the cameras will display correctly when using a quad display unit.

BLC
The cameras are fitted with a backlight compensator, this is used to compensate for very bright areas in the picture. In order to counter this problem switch the BLC switch to ON and the camera will try and adjust to compensate for this problem.

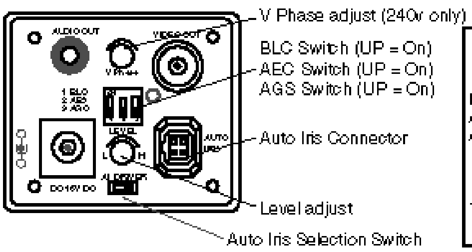
AGC
The Auto Gain Control can be switched off by selecting off on the AGC switch. This controls an amplifier that is used to boost the video signal; this may also amplify any noise and may result in a poor picture quality.

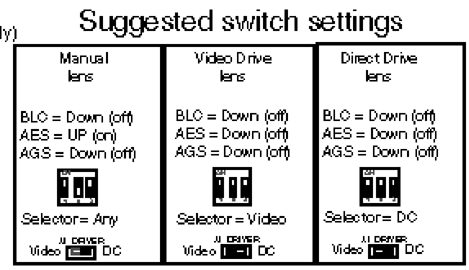
AES
The Automatic Electronic Shutter is used when a manual or fixed iris lens is fitted this will allow the camera to adjust to varying light levels. The AES should be switched off when an Auto iris lens is fitted.

Video Drive Lens
If a Video Drive lens is fitted connect the Iris lead to the four-pin connector on the camera and set the auto iris selection switch to Video Drive.

Direct Drive Lens
If a Direct Drive lens is fitted connect the Iris lead to the four-pin connector on the camera and set the auto iris selection switch to DC Drive the level may be adjusted by turning the Level adjust.

Level Adjust
The level adjust is used when a direct drive lens is fitted, the level adjust is used to set the size of the aperture for normal conditions. Turn the level adjust so that the picture appears very dark then turn the level adjust the opposite way until the picture is just to bright, then turn the level adjust back until the desired picture brightness is achieved.





Simple Field of View Calculator

This chart allow you to estimate the image area that can be obtained using various combinations of lens and cameras.

How to Use this Chart

1. Select focal length of lens (e.g 8mm)
2. Select camera format (e.g 1/3")
3. Select distance between camera and object in metres (e.g 20m)

This shows that by using a 8mm lens on a 1/3" camera the horizontal field of view will be 33° and that at 20 metres the monitor image will be 8 metres high and 11 meters wide.

FOCAL LENGTH IN MM	FIELD OF VIEW (HORIZONTAL)	FORMAT H = HEIGHT W = WIDTH	DISTANCE BETWEEN CAMERA AND OBJECT IN METRES						
			1	5	10	20	30	50	100
4mm	63°	1/3" H	0.8	4.0	8.0	16.0	---	---	---
		w	1.1	5.5	11.0	21.0	---	---	---
	88°	1/2" H	1.2	5.9	12.0	---	---	---	---
		w	1.6	7.9	16.0	---	---	---	---
6mm	38°	1/3" H	0.6	2.7	5.5	11.0	17.0	28.0	55.0
		w	0.8	3.7	7.6	15.0	22.0	37.0	75.0
	58°	1/2" H	0.8	4.0	7.2	16.0	24.0	40.0	---
		w	1.1	5.3	11.0	21.0	32.0	53.0	---
8mm	33°	1/3" H	0.4	2.0	4.0	8.0	12.0	20.0	40.0
		w	0.6	2.7	5.5	11.0	16.0	27.0	53.0
	43°	1/2" H	0.6	3.0	5.9	12.0	16.0	30.0	59.0
		w	0.8	4.0	7.9	16.0	24.0	40.0	79.0
12.5mm	20°	1/3" H	0.3	1.3	2.6	5.0	7.5	13.0	26.0
		w	0.4	1.7	3.4	7.0	10.0	17.0	34.0
	29°	1/2" H	0.4	1.9	3.6	7.6	11.0	19.0	38.0
		w	0.5	2.5	5.1	10.0	15.0	25.0	51.0
25mm	10°	1/3" H	0.1	0.7	1.3	2.6	3.8	6.5	13.0
		w	0.2	0.9	1.7	3.4	5.0	8.5	17.0
	15°	1/2" H	0.2	0.9	1.9	3.8	5.7	9.5	19.0
		w	0.3	1.3	2.5	5.1	7.6	13.0	25.0
50mm	5°	1/3" H	0.1	0.3	0.7	1.3	1.9	3.2	6.5
		w	0.1	0.4	0.9	1.7	2.6	4.3	8.5
	7°	1/2" H	---	0.4	1.0	2.0	2.8	4.7	9.8
		w	---	0.6	1.3	2.5	3.8	6.3	13.0
75mm	3°	1/3" H	---	0.2	0.4	0.9	1.3	2.1	4.3
		w	---	0.3	0.6	1.2	1.7	2.9	5.5
	5°	1/2" H	---	0.3	0.6	1.3	1.9	3.2	6.4
		w	---	0.4	0.8	1.7	2.5	4.2	8.4
100mm	2°	1/3" H	---	0.2	0.3	0.7	1.0	1.6	3.4
		w	---	0.2	0.4	0.9	1.3	2.1	4.3
	3°	1/2" H	---	0.2	0.4	0.9	1.4	2.4	4.7
		w	---	0.3	0.6	1.3	1.9	3.2	6.3
160mm	1°	1/3" H	---	---	0.2	0.4	0.6	1.0	2.0
		w	---	---	0.3	0.6	0.8	1.3	2.7
	2°	1/2" H	---	---	0.3	0.6	0.9	1.5	3.0
		w	---	---	0.4	0.8	1.2	2.0	4.0