

Cameras

So many cameras...what's the difference?



Imager

Black and white (monochrome) cameras produce video in black, white, and shades of gray in between. Black and white cameras are typically more sensitive than color cameras (produce images at lower light levels) and are typically lower cost.

Color cameras produce video in color. Color cameras are typically less sensitive than black and white since more light is required to produce an accurate color image. Color cameras are typically more expensive than black and white.

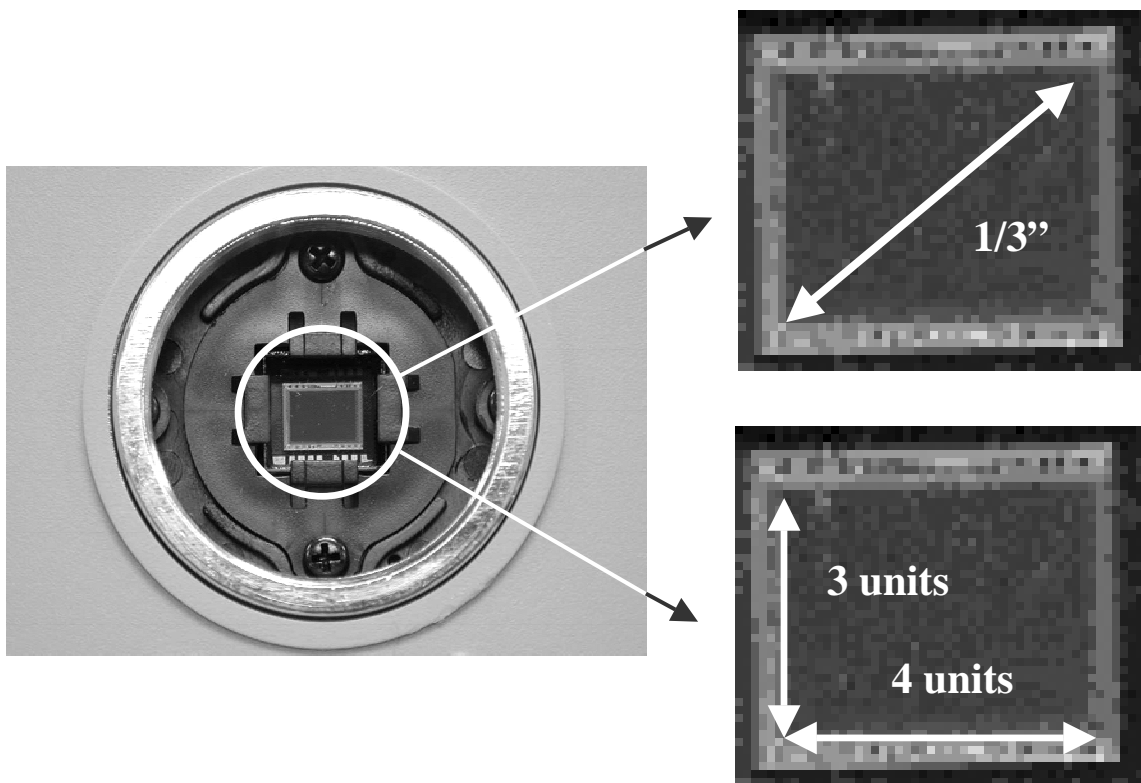
Day/night color cameras produce video in color under favorable lighting conditions, and switch over to black and white when the lighting gets too low for color. The transfer may be done mechanically, electronically, or using dual imagers. The mechanical transfer involves a motorized filter that slides over the imager during color operation. In an electronic transfer, the change is accomplished electronically. A day/night camera with dual imagers has a color and a black and white camera side by side in the same housing, each camera with its own lens. The camera selects which imager/lens is providing the most favorable picture and switches to that one.



Some day/night cameras have an adjustable transfer threshold (the point at which the camera transfers from color to black and white) and some cameras have a set threshold. A camera's fixed threshold for transfer may be too low or too high for the installers or customers preferences. What one person considers usable color video may be different than what another person considers it to be. Cameras with a set threshold could present a problem in poorly lit interior applications (parking garage, etc) because the camera will never have enough light to transfer to color, effectively making it a black and white only camera.

Imager Format

Imager format is the usable portion of the imager measured diagonally across the chip. The most common formats today are 1/3" and 1/4". 1/3" is most common on full body style cameras (traditional box cameras, where camera and lens are sold separately). 1/4" is common on specialty cameras (cameras built into a housing or dome, where the camera and lens are packaged together).



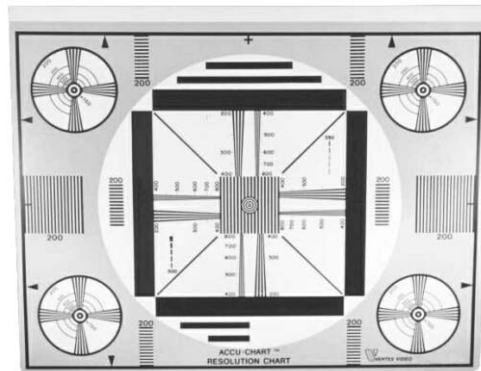
Aspect Ratio

Aspect ratio is the ratio of image height to imager width. It means the image is 4 units wide to 3 units high. The aspect ratio of CCTV equipment is 4:3. This applies to the cameras and the display equipment.

Most televisions in the US are 4:3 aspect ratio. (the newer HDTV format for broadcast (and most movies) is 16:9).

Resolution

Cameras will typically be rated in lines of horizontal resolution. The higher the resolution rating the sharper and more detailed the picture will be. Camera resolution may be measured electronically or by using a resolution chart.



Industry Average Resolutions

Type/Resolution	Standard	High
Black and White	350 to 450 lines	550 to 600 lines
Color	300 to 420 lines	460 to 520 lines

Standard Resolution or High Resolution?

High resolution cameras will provide sharper, higher detail pictures, but at an additional cost over standard resolution cameras. However, your system is only as good as it's weakest link. If you are viewing video from a high resolution camera on a low resolution monitor you will be viewing a low resolution image.

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Sensitivity

Sensitivity is the amount of light required to produce an image from the camera. Sensitivity is usually stated in lux or foot-candles. One foot-candle is approximately equal to 10 lux.

Typical Natural Source Light Levels

Unobstructed sun	100,000 lux
Sun with light cloud	70,000 lux
Sun with heavy cloud	20,000 lux
Sunrise or sunset	500 lux
Twilight	4 lux
Full moon	0.1 lux
Starlight	0.0005 lux

Light Level vs. Sensitivity

The above light levels are based on a source measurement. CCTV cameras use light reflected from a target being illuminated by the source. The amount of light reflected from the source to the camera is typically much less than the actual light source level.

The Sensitivity Game

To further complicate matters, there is no industry standard for camera sensitivity testing. Different manufacturers use different methods and standards for testing the sensitivity of their cameras. Some of the factors involved are

reflectivity, lens used, usable video, point of measurement, and scene illumination.

Reflectivity

More light reflected from the source means more light reaches the imager. Most manufacturers test using 75-90% reflective surface. This certainly gives the camera a more favorable rating, but it is not indicative of a real world application. Many manufactures do not state the percent reflectance used for testing.

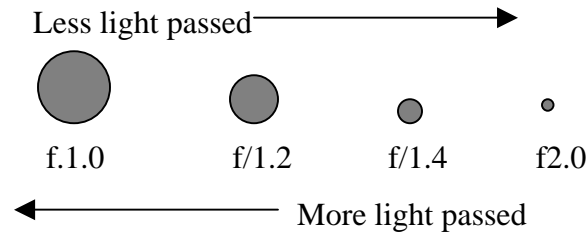
Average Surface Reflectivity

Snow	90%
Wall (painted white)	85%
Sand	50%
Parking lot with cars	40%
Concrete	35%
Grass	30%
Brick	25%
Black(asphalt,empty parking lot)	5%

Lens

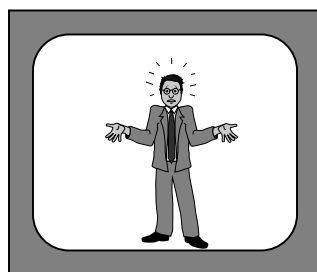
A lens's ability to pass light is stated in f-stop (or f-number). The lower the f-stop of a lens, the more light it will pass. An f/2.0 will pass *half* as much light as an f/1.4 lens, conversely, and f/1.0 lens will pass *twice* as much light as an f/1.4 lens. Most manufactures state the f-number of the lens used.

When comparing cameras, the key is to be sure the specifications being compared are using a lens with the same f-number.

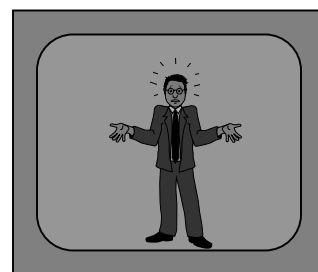


Usable Video

A full strength video signal is 1 volt. Usable video is a signal that is less than 1 volt, but still enough to produce an image on a monitor. The problem with usable video is there is no industry standard for this rating. What one person considers a usable picture may be totally unacceptable to another. When a manufacturer tests his camera's sensitivity, he may test it to a light level that will produce signal below full video. This will give the camera a better lower lux rating, but the acceptability of the video is a matter of opinion.



Full Video

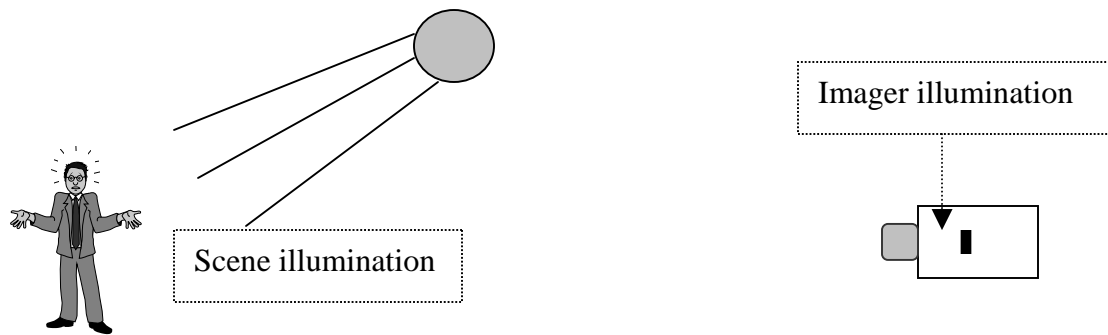


"Usable Video"

Is this acceptable to your customer?

Point of Measurement

The place that the illumination level is tested has a significant impact on the rated sensitivity of the camera. A level tested at the imager (after the light has passed through the lens) will be significantly lower than a level tested before the lens. Most manufacturers do not state where the level was checked.



Scene vs. Imager Illumination

Scene illumination ratings typically measure the light source directly. The reflectivity of the target and the scene as a whole affect the will affect the rated sensitivity. A scene with snow (90% reflectivity) will produce an image with 1/3 less light than a scene with grass (30% reflectivity). Imager illumination ratings typically measure the light after it has passed through the lens. Imager illumination ratings are much lower than scene illumination ratings, since the light is being measured at its lowest strength.

How Much Light Do I Need?

Manufacturers test their cameras sensitivity under the most favorable conditions. While some will state the test conditions (f-stop of lens, scene reflectivity), many do not. The industry average is 75-90% scene reflectivity with an f/1.2 lens. Using these figures, the light required for a particular application can be estimated used the following formula:

$$\begin{aligned} &\text{Camera Sensitivity (lux)} \times \text{Reflectivity Factor} \\ &\times \text{F-Number Factor} \times \text{Other Factor} \\ &= \text{Estimated Required Light Level} \end{aligned}$$

Camera Sensitivity

Use the stated camera sensitivity (lux) from the spec sheet. If the manufacturer states sensitivity with AGC on and off, we recommend using the AGC off figure. If the camera has frame integration, we suggest calculating using with non-integration rating.

Reflectivity Factor

Manufacturers test their cameras using 75-90% reflectivity, but a review of the reflectance chart will show that most applications have a lot lower reflectivity. How many times less reflective is your scene? The difference determines your reflectivity factor. Divide the specification sheet reflectivity by the actual scene reflectivity. If the specification does not state the reflectivity, we suggest using 90%.

Example: 20% reflectivity, $90 / 20 = 4.5$

F-Number Factor

Manufacturers test their cameras with f1.2. If the lens used is not stated, we recommend using f1.2. Divide the square of your lens's f-number by the square of 1.2 (1.44).

Example: f1.4 lens, $(1.4)^2 = 1.96$, $1.96 / 1.44 = 1.36$

“Other” Factor

The camera will spec more sensitive with AGC, the spec will be better with usable video as opposed to full video, and longer shutter speeds collect more light and give better results. These can all weight into the calculation. We suggest assigning a factor of 5.

Take these factors, plus the scene illumination of the spec sheet, and multiply them all together. This will give you an estimate of the required light to produce full video.

Example:

Camera: 2 lux sensitivity rating, reflectivity and f-number of lens not stated

Scene: 25% reflectivity, using f1.6 lens

Reflectivity: $90/25 = 3.6$

F-number: $(1.6)^2 / (1.2)^2 = 2.56 / 1.44 = 1.78$

$2 \times 3.6 \times 1.78 \times 5 = 44.64$ lux required

Scene Lighting Comparisons

The charts below show estimated scene lighting requirements in lux based on camera sensitivity and lens f-number with different scene reflectivity. All these are based on a camera tested using an f1.2 lens with a 90% scene reflectivity. The “camera lux” column show the rated camera sensitivity, the “lens f#” column shows the estimated scene light required using that specific lens.

10% Scene Reflectivity

Camera Lux	Lens f#						
	0.8	1	1.2	1.4	1.6	1.8	2
5	104	158	225	306	401	506	626
2	41	63	90	122	160	203	250
1	21	32	45	61	80	101	125
0.5	10	16	23	31	40	51	63
0.1	2	3	5	6	8	10	13
0.05	1	1.6	2.3	3	4	5	6
0.01	0.2	0.3	0.5	0.6	0.8	1.0	1.3

25% Scene Reflectivity

Camera Lux	Lens f#						
	0.8	1	1.2	1.4	1.6	1.8	2
5	41	63	90	122	160	203	250
2	17	25	36	49	64	81	100
1	8	13	18	24	31	41	50
0.5	4	6	9	12	16	20	25
0.1	0.8	1.3	1.8	2.4	3.2	4	5
0.05	0.4	0.6	0.9	1.2	1.6	2	2.5
0.01	0.08	0.1	0.2	0.2	0.3	0.4	0.5

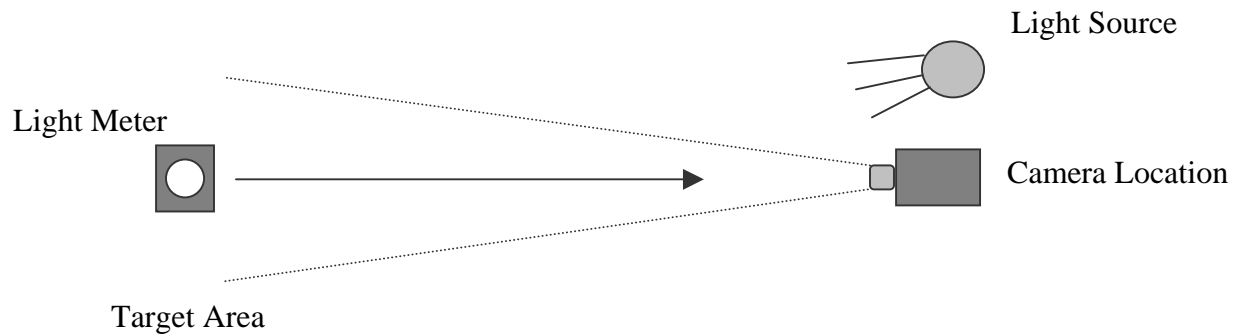
50% Scene Reflectivity

Camera Lux	Lens f#						
	0.8	1	1.2	1.4	1.6	1.8	2
5	21	32	45	61	80	101	125
2	8	13	18	24	32	41	50
1	4	6	9	12	16	20	25
0.5	2	3	5	6	8	10	13
0.1	0.4	0.6	0.9	1.2	1.6	2	3
0.05	0.2	0.3	0.5	0.6	0.8	1	1.3
0.01	0.04	0.06	0.09	0.1	0.16	0.2	0.25

Measuring Your Scene Lighting

Measuring scene lighting requires a light meter. The light reading should be taken during the worst light level conditions the camera will encounter. Outdoor cameras should be tested well after sundown using lighting that will be on after the camera has been installed. Take a reading

with your light meter at the target area being viewed by the camera and aim it at the location the camera will be mounted. Be careful not to aim your meter directly at any light sources, otherwise you will get a false high reading.



Readings vs. Reality

Most light meters read in 1 lux increments, so readings below 1 lux may not be accurate with your average light meter. Due to possible environmental and camera conditions, we recommend that any light level readings below 10 lux be considered borderline. Additionally, we recommend the light measurement be at least 25% greater than your estimated requirement. If your measured light level is less than 10 lux, or less than 25% greater than your estimated requirement, we recommend you test a camera with the lens you intend to use at the location.

When In Doubt, Shoot It Out

Different imagers will perform differently under the same circumstances. If your measured light levels are not 25% greater than your estimations, or if they are other usual or

extenuating circumstances involved in the installation, we recommend a shoot out.

A shoot out involves several cameras (multiple manufacturers and/or multiple models) brought to the site to be tested side by side. To be fair, all cameras in the shoot out should use the exact same lens, power source, and monitor. These can be moved from camera to camera as required, or multiple copies can be used. Connect the cameras to the monitor one by one and make note of which one(s) perform the best in the application. Make your final choice based on the best balance of performance and price.

Not Enough Light?

After all the testing and reviewing has been completed you may still find that the target area is not sufficiently illuminated for your needs. Before requesting your customer add additional lighting, review the products you're using. A more sensitive camera or a lower f-number lens may make the difference.

This document is part of a complete book entitled:
CCTV System Design & Installation

By Charles Aulner and Bryan McLane
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