Hanwha Vision

White Paper

Differences Between Camera Lens Specifications and Real-World Performance

Technical Analysis for Accurate Understanding

October 2025

1. Introduction

When purchasing a security camera, customers expect the information on the product specification sheet to match its actual performance. However, some manufacturers exaggerate critical elements such as the lens 'focal length' and 'FoV.' This white paper presents verified cases where the focal lengths listed by manufacturers differ from real-world measurements. For example, a lens specified as 2.7–13.5 mm by the manufacturer was measured at approximately 3.2–10 mm in actual testing. Although these differences may appear minor, they can have a significant impact on image quality and overall system performance:

- Narrower field of view → Can create blind spots in surveillance footage
- Reduced zoom capacity → Loss of detail when identifying faces or vehicle license plates
- More cameras required → Increased equipment and installation costs

This White Paper explains why these discrepancies occur, how users are affected, and provides a guide for expected field of view based on Hanwha Vision’s reliable data.

2. Why Focal Length Matters

2.1. Background of Focal Length Usage

In 1889, Kodak produced the world's first celluloid film, and in 1893, Edison developed the movie projector, leading to the popularization of 35mm film. The 35mm film standard was internationally registered in 1909 (ISO), which made 35mm lenses common for film cameras and later DSLR cameras. Because 35mm was the dominant format for a long time, focal length alone was a reliable indicator of the lens's field of view.

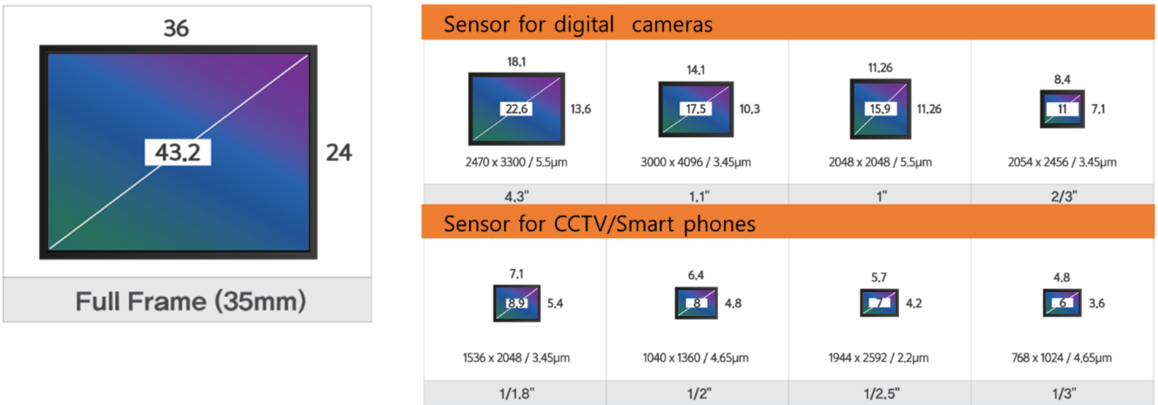

Figure 1: Image Sensor Sizes

As shown in Figure 1, image sensors have diversified and shrunk in size due to different usage scenarios. This causes narrower fields of view despite identical focal lengths. Therefore, lens specifications now often indicate an equivalent focal length based on the 35mm film standard (equivalent FoV), allowing direct comparison of field of view changes that cannot be inferred from actual focal length alone.

Equivalent focal length refers to the focal length in millimeters that would produce the same field of view on a 35mm film camera.

While focal length formerly provided an intuitive understanding of the field of view in 35mm film standards, the use of various sensor sizes today makes the concept of equivalent focal length essential for comparing fields of view.

Field of View (FOV)	35mm Full Frame	Four Thirds (2 X)	1/2.3" digital camera
Ultra-Wide (114°–94°)	14 mm–20 mm	7 mm-10 mm	2.5 mm-3.6 mm
Wide (84°–63°)	24 mm–35 mm	14 mm-17.5 mm	4.3 mm-6.5 mm
Standard (47°)	50 mm	25 mm	9 mm
Telephoto (28°–8°)	85 mm–300 mm	42.5 mm-150 mm	15.2 mm-53.6 mm
Super Telephoto (6°–3°)	400 mm–1000 mm	200 mm-500 mm	71.6 mm-179 mm

Table 1: Field of View Classification Standard for Film Cameras

2.2. Definition of Focal Length

The focal length of a lens is the distance from the lens's optical center to the image sensor (also called the imaging plane), usually expressed in millimeters (mm). It is measured from the point where light rays traveling parallel to the optical axis converge to a single point to the surface of the sensor. This value indicates how strongly the lens converges or diverges light and is directly related to the lens's light-gathering ability and magnification.

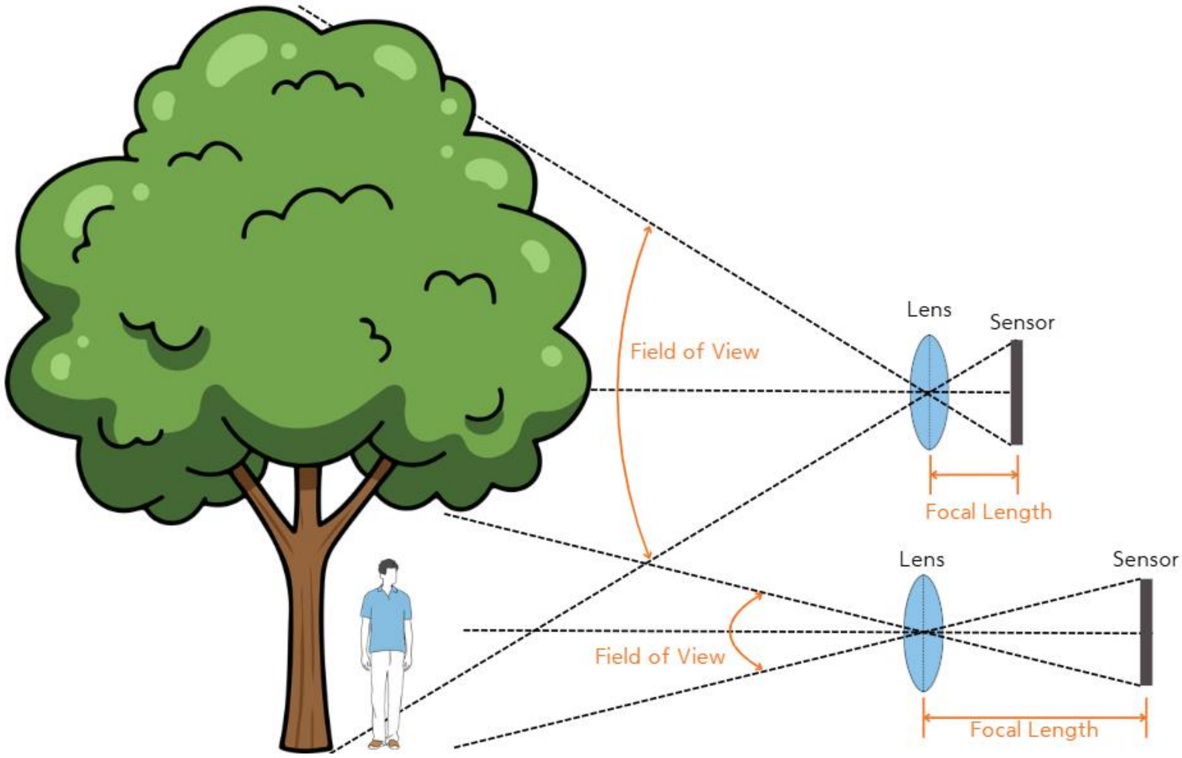

Figure 2: Comparison of Field of View by Focal Length

As illustrated in Figure 2, shorter focal lengths provide wider fields of view, allowing the capture of a larger surrounding area. Conversely, longer focal lengths yield narrower fields of view, enlarging objects within the frame.

Lenses for CCTV cameras are categorized into fixed focal length lenses, vari-focal lenses, and zoom lenses. Among these, zoom and vari-focal lenses can be adjusted within a specified focal length range, which directly affects camera performance and image quality. Therefore, focal length is a core specification that determines coverage (how wide an area one camera can observe) and magnification (how much detail can be enlarged). If the focal length is exaggerated, more cameras may be necessary to compensate for insufficient coverage, leading to disadvantages in long-distance surveillance.

3. Field of View (FoV), Sensor, and Focal Length Relationship

The camera's field of view is determined by three key factors, as shown in Figure 3 lens focal length, image sensor size, and optical distortion of the lens.

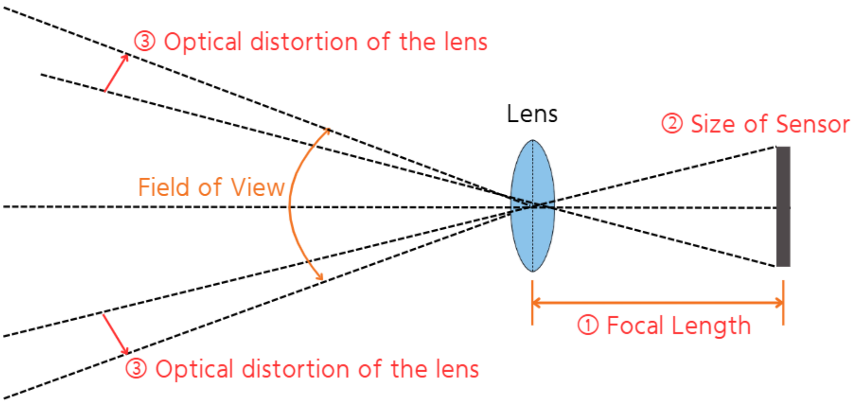

Figure 3: Factors Affecting Field of View

As the focal length increases, the field of view narrows and the subject appears larger than seen by the human eye, as illustrated in Figure 4. Conversely, shorter focal lengths provide a much wider field of view, making subjects appear smaller within the frame compared to normal human vision. In camera terminology, this is referred to as zooming in (Tele) or zooming out (Wide).

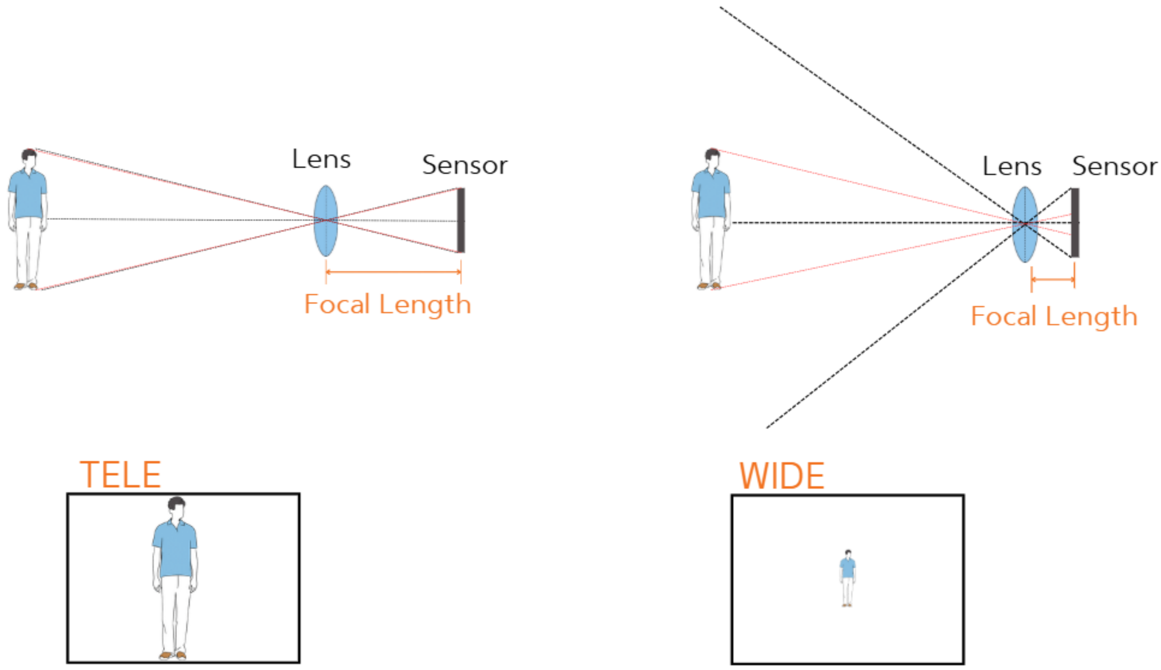

Figure 4: Field of View Changes Depending on Focal Length
(Comparison between Telephoto and Wide Scenes)

Additionally, as Figure 5 shows, larger sensor sizes increase the field of view, thereby allowing more area to be captured.

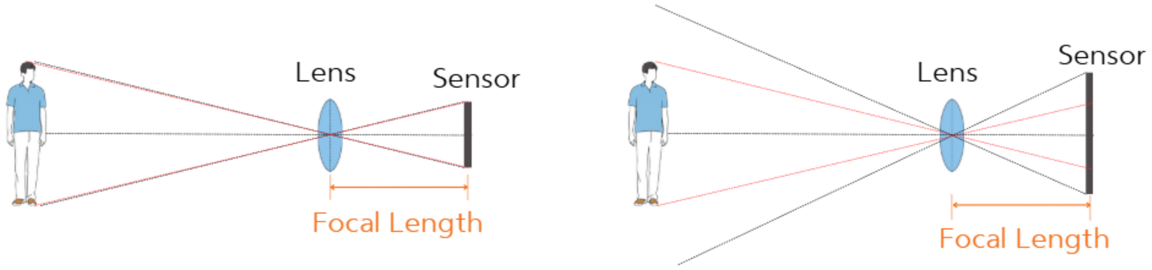

Figure 5: Field of View Differences by Sensor Size

Generally, the field of view is calculated based on the lens's focal length and the camera's image sensor size (pixel size × effective pixel count). Image sensors come in two main types: CCD (Charge Coupled Device) and CMOS (Complementary Metal Oxide Semiconductor). Recently, CMOS sensors have greatly improved in image quality and sensitivity and have become the dominant technology in video processing.

Sensors are typically rectangular, using the concept of "effective pixels" to represent the portion capturing actual image data. Pixel count and cell size are specified in CMOS sensor datasheets, which help determine the sensor's physical size and enable prediction of the field of view.

Because larger sensors tend to have larger cell sizes, resolution — calculated as sensor size multiplied by pixel count — is used alongside focal length to compute field of view.

The general formulas to calculate the angle of view are:

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- Horizontal Field of View (HFOV): $\mathrm{HFOV} = 2 \times \tan^{-1}\left(\frac{d_h}{2f}\right)$

  Where, d_h = sensor Horizontal dimension, f = focal length
- Vertical Field of View (VFOV): $\mathrm{VFOV} = 2 \times \tan^{-1}\left(\frac{d_v}{2f}\right)$

  Where, d_v = sensor Vertical dimension, f = focal length
- Diagonal Field of View (DFOV): $\mathrm{DFOV} = 2 \times \tan^{-1}\left(\frac{d}{2f}\right)$

  Where, d = sensor Diagonal dimension, f = focal length

Here, the focal length ‘f’ is the distance from the lens center to the image sensor plane, and the sensor dimensions are derived from pixel count multiplied by pixel size. However, as shown in Table 2, the calculated field of view values often differ from actual measured HFOV values.

	Model A	Model B	Model C
Sensor Horizontal Length	1/2.8" CMOS (2.0μm × 2592 px)		
Focal Length (f)	2.4mm	3.0mm	4.0mm
Calculated HFOV	95°	82°	66°
Measured HFOV	123°	100°	80°

Table 2: Comparison of Calculated and Measured Horizontal FoV for 1/2.8" 5MP Sensors

This discrepancy is due to optical distortion of the lens. Shorter focal lengths tend to have greater distortion, which expands the effective field of view. Larger sensor sizes can also increase distortion. Including distortion in the formula results in the following adjusted calculations:

Adjusted Horizontal FoV:

- $\mathrm{HFOV} = 2 \times \tan^{-1}\left(\frac{d_h}{2f(1+Dst_h)}\right)$

  where d_h = sensor Horizontal dimension, f = focal length,
  Dst_h = Optical distortion at sensor Horizontal dimension

- $\mathrm{VFOV} = 2 \times \tan^{-1}\left(\frac{d_v}{2f(1+Dst_v)}\right)$

  where d_v = sensor Vertical dimension, f = focal length,
  Dst_v = Optical distortion at sensor Vertical dimension

- $\mathrm{DFOV} = 2 \times \tan^{-1}\left(\frac{d}{2f(1+Dst)}\right)$

  where d = sensor Diagonal dimension, f = focal length,
  Dst = Optical distortion at sensor Diagonal dimension

4. Specification Distortion Issues and Hanwha Vision's Reliability

4.1. Reality of Focal Length Notation

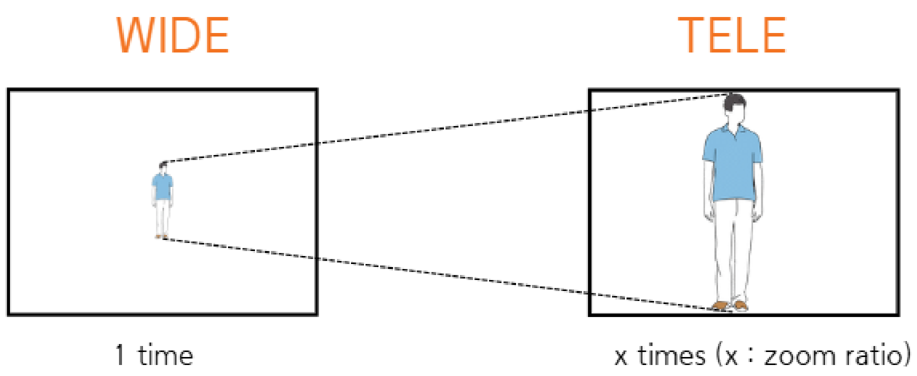
Recently, some camera brands no longer list the actual focal length and field of view in their product specifications. Instead, they use the lens manufacturer's data directly, which can lead to confusion for users

	Company A		**Company B**		**Company C**		**Actual Meaning**
	Focal length on **spec sheet** (mm)	**Measured** Focal length (mm)	Focal length on **spec sheet** (mm)	**Measured** Focal length (mm)	Focal length on **spec sheet** (mm)	**Measured** Focal length (mm)	
Wide	2.8	3.458	2.8	3.308	2.7	3.2	Reduced FoV, weaker zoom
Tele	12	9.113	12	9.955	12	10	
Zoom Ratio	4.3x	2.6x	4.3x	3x	4.4x	3.1x	

Table 3: Comparison between Manufacturer Stated and Measured Values

Some manufacturers mark vari-focal lenses as '2.7–13.5mm' or '2.8–12mm', but real usable focal length ranges may fall short of '3.2–10mm' as measured.

The zoom ratio, indicating how much an object can be magnified, is determined by the ratio of Tele focal length to Wide focal length:



Zoom Ratio = Tele Focal Length ÷ Wide Focal Length

Since zoom ratio depends on focal length, discrepancies between measured and specified focal lengths lead to user expectations not being met.

Testing cameras with the same 2MP resolution reveals that performance differences exist even when specifications appear the same:

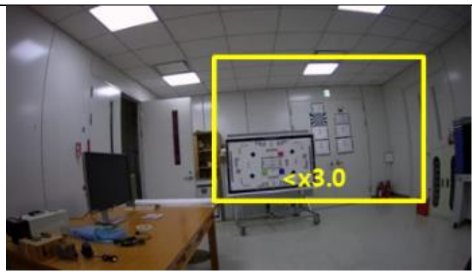
	Hanwha Vision	Company A
Focal length on spec sheet (mm)	2.8~12mm (4.3x)	2.8~12mm (4.3x)
Measured Field of View (degree)	120°(Wide)~27°(Tele)	113°(Wide)~33°(Tele)
Wide scene		
Tele scene		
Ratio		

Table 4: Differences in Stated Specification vs Measured Zoom Ratio

4.2. Reality of Focal Length Notation

Relying solely on focal length might result in unmet performance expectations; thus, FoV specifications have become an important indicator for camera selection. Checking FoV permits more accurate site-appropriate product selection and visualization of blind spots in design plans.

Purchasing based only on focal length can lead to discrepancies between specified and actual focal lengths. FoV guarantees allow exact comparison during installation simulation, aiding users. Additionally, checking FoV helps verify if a manufacturer's vari-focal lens specs are falsely advertised.

However, actual measured FoV values can at times be narrower than those listed in datasheets, risking unforeseen blind spots and decreased image quality during installation.

Hanwha Vision samples and measures real lenses before release, clearly stating focal lengths and FoVs, providing higher reliability than competitors.

For example, a Hanwha Vision camera using a 1/2.8" sensor with 2592-pixel horizontal resolution shows a 101° HFoV at 3.2mm focal length and 110° at 2.8mm. Competitors claiming 2.75mm focal length boast 103° HFoV, but actual measurement was only 101°, indicating significant overstatement.

Thus, focal length and FoV specs of competitors are deemed exaggerated; the actual focal length range is likely 3.2–10mm.

	Hanwha Vision Camera		**Other Vender**
Sensor	1/2.8" 5M (2592 x 1944)	1/2.8" 4M (2592 x 1520)	1/2.8" 5M (2592 x 1944)
Spec Focal Length (x zoom)	3.2~10mm (3.125×)	2.8 ~ 12mm (4.28×)	2.75~13.5mm (4.91×)
Spec HFoV	101° ~ 31°	110° ~ 26°	103° ~ 32°
Measured HFoV			101° ~ 31°

Table 5: Specified vs Measured Horizontal FoV

5. Zoom Ratio Measurement Methods

Zoom ratio is an important performance metric for vari-focal lenses, expressed as the ratio between Wide and Tele focal lengths. This can be verified by measuring the size ratio of an object cast on the image sensor. However, for high-zoom lenses, the accuracy of denominator (Tele size at Wide zoom) measurement heavily affects zoom ratio reliability, making precise measurement challenging.

Assuming a 2MP video image @1920x1080 resolution, with numerator measured as 1080 pixels, if denominator is measured as 33 pixels, zoom ratio would be 32.7x; if 34 pixels, then 31.8x.

$$\text{Zoom Ratio} = \frac{\text{Wide Image Size}}{\text{Tele Image Size in Wide}} = \frac{A_{(wide)}}{A_{(Tele)}} = \frac{1080}{33.8} = 32.0 \text{ times}$$

Actual object size ratios can also be used to calculate zoom.

$$\text{Zoom Ratio} = \frac{\text{Object size on Wide}}{\text{Object size on Tele}} = \frac{B_{(wide)}}{B_{(Tele)}} = \frac{320\text{m}}{10\text{m}} = 32.0 \text{ times}$$

However, this requires sufficient object distance (infinity focus), and measurement at equal Wide and Tele distances – constraints that complicate measuring object size at Wide zoom.

Alternately, focal length ratios can be used, but require specialized measurement equipment. Hanwha Vision frequently uses professional devices to measure focal lengths during development and evaluation phases. Reported zoom ratios are based on these focal length specifications.

$$\text{Zoom Ratio} = \frac{\text{Focal length in Tele}}{\text{Focal length in Wide}} = \frac{f_{(Tele)}}{f_{(wide)}} = \frac{140.8\text{mm}}{4.4\text{mm}} = 32.0 \text{ times}$$

For vari-focal lenses (rather than high-zoom lenses), object size or image size ratios can be directly identified.

6. Expected Field of View by Focal Length

When actual measurements are difficult, predicted FoV can be calculated considering expected optical distortions. In Table 6, for example, if a manufacturer uses a 5MP 1/2.8" CMOS sensor with a 2.8–12mm vari-focal lens, expected HFoV values would be roughly 110° at wide angle and 26° at telephoto. FoV values outside this expected range warrant verification of focal length specs.

■ Expected angle of view based on sensor size for 2M resolution (1920 horizontal pixels)

Sensor size	1/2"						
Focal length	**2.4mm**	**2.8mm**	**3.0mm**	**4.0mm**	**6.0mm**	**10.0mm**	**12.0mm**
Calculation FoV	112.6°	104.3°	100.4°	84.0°	61.9°	39.6°	33.4°
Expected distortion	-0.5 ~ -0.6	-0.4 ~ -0.5	-0.35 ~ -0.45	-0.25 ~ -0.35	-0.2 ~ -0.3	0 ~ -0.1	0 ~ -0.1
Expected field of view (FoV	**143° ~ 150°**	**130° ~ 137°**	**123° ~ 131°**	**100° ~ 108°**	**74° ~ 81°**	**40° ~ 44°**	**33° ~ 37°**

Sensor size	1/2.8"						
Focal length	**2.4mm**	**2.8mm**	**3.0mm**	**4.0mm**	**6.0mm**	**10.0mm**	**12.0mm**
Calculation FoV	98.5°	89.7°	85.7°	69.7°	49.8°	31.1°	26.1°
Expected distortion	-0.35 ~ -0.45	-0.3 ~ -0.4	-0.3 ~ -0.4	-0.20 ~ -0.30	0 ~ -0.1	0 ~ -0.1	0 ~ -0.1
Expected field of view (FoV	**121° ~ 129°**	**110° ~ 118°**	**106° ~ 114°**	**82° ~ 90°**	**50° ~ 55°**	**31° ~ 34°**	**26° ~ 29°**

■ Expected field of view based on sensor size for 4M, 5M resolution (2592 horizontal pixels)

Sensor size	1/1.8"						
Focal length	**2.4mm**	**2.8mm**	**3.0mm**	**4.0mm**	**6.0mm**	**10.0mm**	**12.0mm**
Calculation FoV	114.9°	106.6°	102.8°	86.4°	64.1°	41.2°	34.8°
Expected distortion	-0.5 ~ -0.6	-0.4 ~ -0.5	-0.35 ~ -0.45	-0.30 ~ -0.40	-0.2 ~ -0.3	0 ~ -0.1	0 ~ -0.1
Expected field of view (FoV	**145° ~ 151°**	**132° ~ 139°**	**125° ~ 133°**	**107° ~ 115°**	**76° ~ 84°**	**41° ~ 45°**	**35° ~ 38°**

Sensor size	1/2.8"						
Focal length	**2.4mm**	**2.8mm**	**3.0mm**	**4.0mm**	**6.0mm**	**10.0mm**	**12.0mm**
Calculation FoV	94.4°	85.6°	81.7°	65.9°	46.7°	29.1°	24.4°
Expected distortion	-0.35 ~ -0.45	-0.3 ~ -0.4	-0.25 ~ -0.35	-0.20 ~ -0.30	0 ~ -0.1	0 ~ -0.1	0 ~ -0.1
Expected field of view (FoV	**118° ~ 126°**	**106° ~ 114°**	**98° ~ 106°**	**78° ~ 86°**	**47° ~ 51°**	**29° ~ 32°**	**24° ~ 27°**

■ Expected field of view based on sensor size for 8M resolution (3840 horizontal pixels)

Sensor size	1/1.2"						
Focal length	**2.4mm**	**2.8mm**	**3.0mm**	**4.0mm**	**6.0mm**	**10.0mm**	**12.0mm**
Calculation FoV	133.4°	126.6°	123.4°	108.6°	85.7°	58.2°	49.8°
Expected distortion	-0.8 ~ -0.9	-0.6 ~ -0.7	-0.6 ~ -0.7	-0.40 ~ -0.50	-0.3 ~ -0.4	-0.1 ~ -0.2	0 ~ -0.1
Expected field of view (FoV	**170° ~ 175°**	**157° ~ 163°**	**156° ~ 162°**	**133° ~ 140°**	**106° ~ 114°**	**63° ~ 70°**	**50° ~ 55°**

Sensor size	1/1.8"						
Focal length	**2.4mm**	**2.8mm**	**3.0mm**	**4.0mm**	**6.0mm**	**10.0mm**	**12.0mm**
Calculation FoV	116.0°	107.8°	104.0°	87.7°	65.2°	42.0°	35.5°
Expected distortion	-0.5 ~ -0.6	-0.4 ~ -0.5	-0.4 ~ -0.5	-0.30 ~ -0.40	-0.2 ~ -0.3	0 ~ -0.1	0 ~ -0.1
Expected field of view (FoV	**145° ~ 152°**	**133° ~ 140°**	**130° ~ 137°**	**108° ~ 116°**	**77° ~ 85°**	**42° ~ 46°**	**35° ~ 39°**

Sensor size	1/2.8"						
Focal length	**2.4mm**	**2.8mm**	**3.0mm**	**4.0mm**	**6.0mm**	**10.0mm**	**12.0mm**
Calculation FoV	98.5°	89.7°	85.7°	69.7°	49.8°	31.1°	26.1°
Expected distortion	-0.35 ~ -0.45	-0.3 ~ -0.4	-0.3 ~ -0.4	-0.20 ~ -0.30	0 ~ -0.1	0 ~ -0.1	0 ~ -0.1
Expected field of view (FoV	**121° ~ 129°**	**110° ~ 118°**	**106° ~ 114°**	**82° ~ 90°**	**50° ~ 55°**	**31° ~ 34°**	**26° ~ 29°**

Table 6: Expected Field of View across Different Resolutions and Sensor Sizes.

7. Conclusion

When choosing a camera, relying only on listed specifications can be misleading—especially if details like lens focal length, field of view, sensor size, and resolution aren't fully understood. Real-world performance can differ from what's shown on paper, leading to results that may not meet expectations.

By comparing products through real tests and pre-installation simulations, you can better anticipate actual performance, simplify setup, and reduce overall system costs.

At Hanwha Vision, we earn customer trust through honest and transparent specifications based on verified, real-world data. This approach gives you accurate information and clear guidance for selecting the right product—strengthening both your confidence and our brand's reliability.

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