KEYENCE

VOL.2

Beginner's Guide to Vision Systems

Users that are new to vision systems may have the idea that they are complicated and take a lot of time and effort to install and setup. There are indeed a wide variety of models available that include many lighting and control options and it can seem overwhelming. However, having a good understanding of the key points to selecting and installing a vision system, any user can successfully employ a vision system to improve quality control and production yield rates. This series of guides explains the procedures and key points for selecting, installing and operating a machine vision system.

Volume 2: **Selecting the devices required for inspection: Lighting and Lens**

The key steps to successfully installing a vision system

1 Selecting the devices required for inspection

Choose the correct devices that meet the inspection requirements.

- Camera
- Controller
- Lighting
- Lens
- Monitor

2 Sensing and judgment

Perform testing on the actual target with the vision system.

- Reference parts for OK and NG products
- Inspection cycle time
- Variety of inspection items

3 Selecting the installation location and procedure

Review the specific installation locations.

- Target in motion / stationary
- Environmental conditions, including ambient light and vibration

4 Controls for automation

Review the I/O controls for the vision system.

- Image capture timing
- Judgment output
- PLC control
- Data output

5 On-site testing

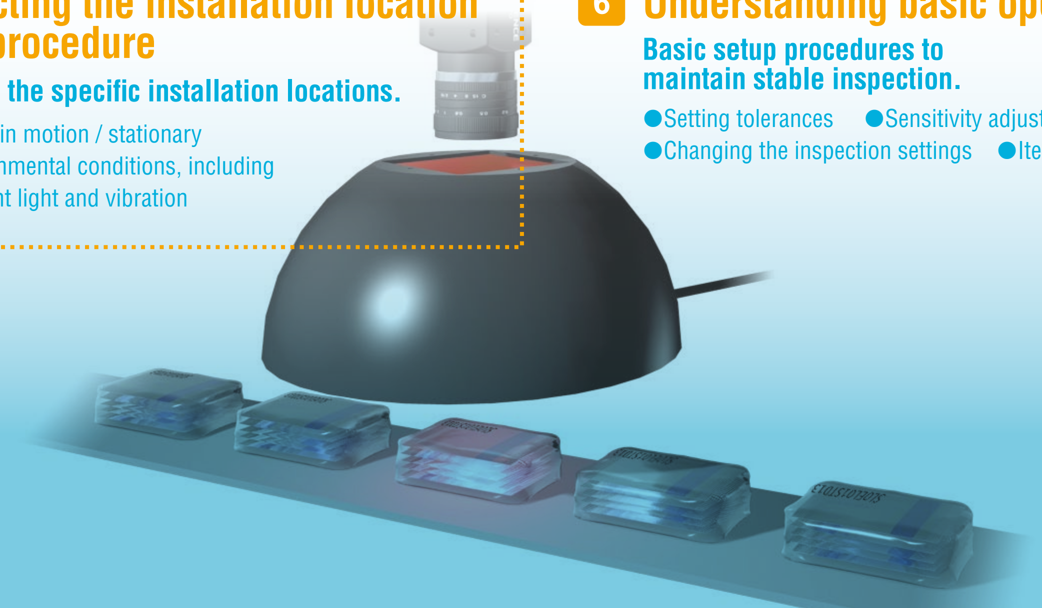
Test the vision system on the actual production line.

- Fine setup adjustment
- Statistics
- I/O control check

6 Understanding basic operations

Basic setup procedures to maintain stable inspection.

- Setting tolerances
- Sensitivity adjustment
- Changing the inspection settings
- Item registration



Device selection 2: Choosing the proper lighting

LED lights are commonly used in machine vision image processing. There are three steps in the process of selecting the best lighting for the inspection requirements.

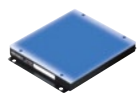
1. Determine the direction of emission
2. Determine the lighting type and shape
3. Determine the lighting color (wavelength)

[Standard lighting types (for LED lights)]


Coaxial
CA-DX


Low angle
CA-DL

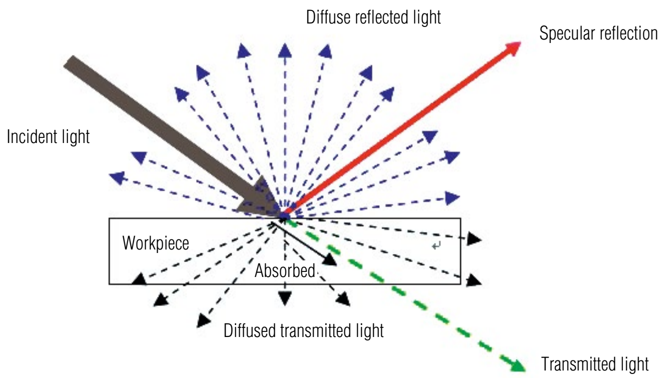

Direct ring
CA-DR


Backlight
CA-DS


Dome
CA-DD


Bar
CA-DB

Selecting the light 1 Determining the direction of emission (specular reflection, diffuse reflection, transmission)



Basics of Light When incident light (brown arrow) hits the surface of the part, light broadly separates and travels in four different directions.

1. **Specular reflection reflecting off at the same angle**
2. **Diffuse reflected light that diffuses on the surface of the part**
3. **Transmitted light that passes straight through the part**
4. **Diffuse transmitted light that transmits scattering across the surface of the part**

Using the incident light as 100%, the ratio of light specularly reflected is called specular reflectance, the ratio of other reflected light is called diffuse reflectance, and the sum of the two is called total reflectance.

There are three main types of lighting directions used with machine vision.

(1) Specular reflection type

Lens receives light that specularly reflected off the target, which works effectively with parts with reflective properties, such as a glass substrate.

(2) Diffuse reflection type

Lens receives uniformly distributed light while releasing the specularly reflected light. This type is effective for inspections done through transparent tapes in order to ignore reflective parts.

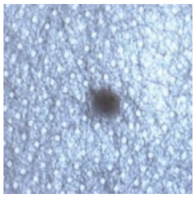
(3) Transmission type

Light is emitted from behind the target to detect the silhouette with the transmitted light. This type is useful for parts that easily pass light, such as non-woven fabric.

(1) Example of specular reflection type
Glass substrate flaw inspection

(2) Example of diffuse reflection type
Microchip print inspection over film

(3) Example of transmission type
Foreign particle detection in non-woven fabric

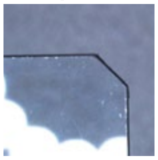


Selecting the light 2 Determining the lighting type and shape

After determining the lighting direction, select the lighting type (model) based on the inspection requirements, background, and ambient environment.
From the lighting options for each lighting direction, select the suitable lighting type as illustrated below.

Typical lighting type for each lighting direction			
Specular reflection	Coaxial light	Ring light	Bar light
Diffuse reflection	Low angle light	Ring light	Bar light
Transmission	Light source	Bar light	———

1 Example of detection by specular reflection



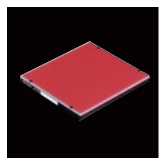
[Select the lighting based on the part and inspection requirements]

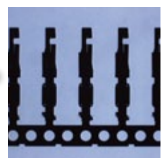
1 Light reflects onto the surface of the glass
▼
2 Need to clarify the difference between the glass and background
▼
3 Emission perpendicular to the part is optimal
▼
4 Space can be provided above the part
▼
Coaxial light is the best selection

2 Example of detection by transmission

[Select the lighting based on the part and inspection requirements]

1 Metal part has an uneven surface and does not allow for uniform specular reflection
▼
2 Shaping defects can be detected by silhouette using transmitted light
▼
3 Lighting can be set up behind the part
▼
Backlight is the best selection





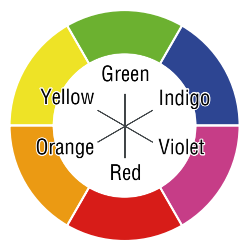
Selecting the light 3 Determining the lighting color/wavelength

The final step is to decide the color of the lighting that works the best for the part and background.
White is generally selected when using a color camera. However, when using a black-and-white camera, the following knowledge becomes more important.

Complementary colors Pairs of colors opposite each other on the complementary color circle are called complementary colors. When complementary color light is shined on a color, the color becomes close to black.

Wavelength Light appears as a different color depending on the difference in wavelength. For example, light with longer wavelength (red) passes through films easily while light with shorter wavelength (blue) is more prone to diffusion with unevenness in the surface, such as scratches.

Complementary color circle



Non-visible light ◄ | ◄ Visible light ► | Non-visible light ►

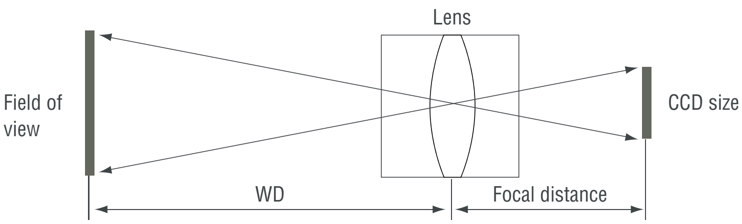
Ultra-violet light	Violet	Indigo	Blue	Cyan	Green	Yellow-green	Yellow	Orange	Red	Infrared light
	380	430	480	490	500	560	580	595	650	780

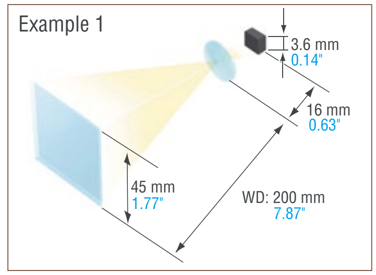
(Unit: nm)

Device selection 3: Choosing the proper lens

Selecting the lens 1 How to calculate the focal distance and field of view

One of the lens specifications is focal distance. Typical lens sizes used in factory automation include 8 mm 0.31", 16 mm 0.63", 25 mm 0.98", and 50 mm 1.97". You can calculate the working distance (WD), which is the point at which the camera comes into focus, from the field of view (FOV) and focal distance necessary for the target to be captured.





The WD and FOV values depend on the lens' focal distance and image sensor size. For WDs greater than the minimum WD where a close-up ring is unnecessary, the WD can be estimated using the following proportion.

WD: Viewing angle = Focal distance: sensor size

Example 1: When using lens with a focal distance of 16 mm (0.63") and the image sensor size is 3.6 mm (0.14"), WD should be 200 mm (7.87") in order to have a field of view of 45 mm (1.77").

Selecting the lens 2 How to increase the depth-of-field (range of heights at which the lens remains in focus)

(1) Lens with shorter focal distance has a greater range of depth.

(2) As the distance to the target gets farther, the deeper the range of depth becomes.

→Note that the depth-of-field is smaller when using a close-up ring or macro lens.

(3) The smaller the opening of the aperture, the deeper the range of depth is.

→It is easier to obtain focus using aperture zoom and bright light.

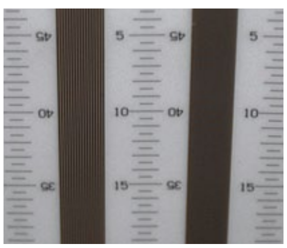
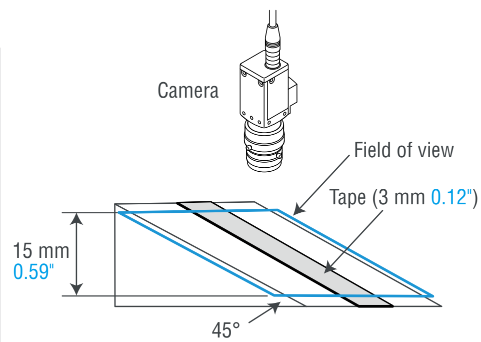


Image captured using smaller aperture (CA-LH25)

Image captured with max. aperture (CA-LH25)

This example compares the image captures obtained with a smaller aperture and max. aperture when capturing a target that has a tape attached to indicate the height on a slope as shown in the figure below.



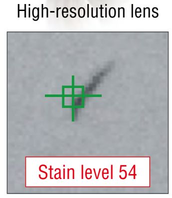
Selecting the lens 3 Contrast ratio based on lens performance

The images on the right show the same target, captured using KEYENCE's high-resolution lens CA-LH16 and standard lens CV-L16. The difference in the images derives from the differences in lens material and structure. Selecting a high-resolution lens depending on the application can provide images with higher contrast.

Lens	CA-LH16/CV-L16
Inspection target	Copying paper
Field of view	60 mm 2.36" / Stain size: approx. 0.3 mm 0.01"

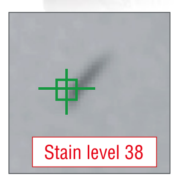
CA-LH16

High-resolution lens



CV-L16

Standard lens



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