TECHNICAL GUIDE FOR PHOTOELECTRIC SENSORS

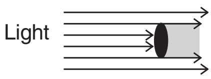
DEFINITIONS

Photoelectric sensors operate by an emitter unit producing a beam of modulated light that is detected by a receiver, either free-standing or in the same housing, and sensing action occurs when the beam is broken by an object. These sensors, like proximity sensors, operate without touching the detected object. A wide range of photoelectric sensors is available to meet virtually any application need.

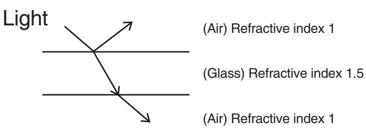
Operating principles

●Properties of light

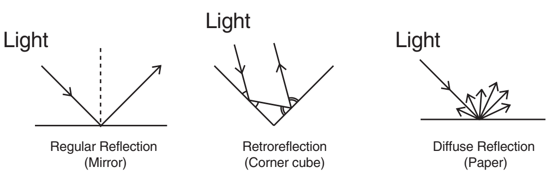
Rectilinear propagation: When light travels through air or water, it always travels in a straight line. The aperture mask on the outside of a thru-scan sensor that is used to detect small objects is an example of how this principle is applied to practical use.



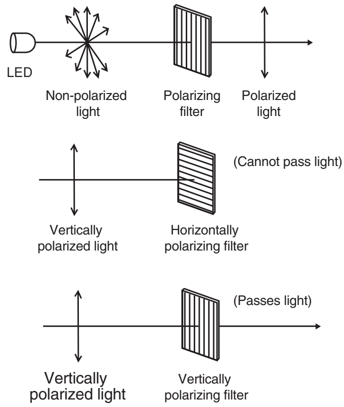
Refraction: Refraction is the phenomenon of light being deflected as it passes obliquely through the boundary between two media with different refractive indices.



Reflection (regular reflection, retroreflection, diffuse reflection): A flat surface, such as glass or a mirror, reflects light at an angle equal to the incident angle of the light. This kind of reflection is called regular reflection. A corner cube takes advantage of this principle by arranging three flat surfaces perpendicular to each other. Light emitted toward a corner cube repeatedly propagates regular reflections and the reflected light ultimately moves straight back toward the emitted light. This is referred to as retroreflection. Most reflectors are comprised of corner cubes that measure several square millimeters and are arranged in a precise configuration. Matte surfaces, such as white paper, reflect light in all directions. This scattering of light is called diffuse reflection. This principle is the detection method used by diffuse-scan sensors.



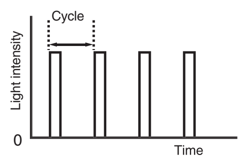
Polarization of Light: Light can be represented as a wave that oscillates horizontally and vertically. Photoelectric sensors almost always use LEDs as the light source. The light emitted from LEDs oscillates in the vertical and horizontal directions and is referred to as non-polarized light. There are optical filters that constrain the oscillations of non-polarized light to just one direction. These are known as polarizing filters. Light from an LED that passes through a polarizing filter oscillates in only one direction and is referred to as linear polarized light. Polarized light oscillating in the vertical direction cannot pass through a polarizing filter that constrains oscillations to a perpendicular direction (e.g., the horizontal direction). The polarized retroreflective sensors and the anti-mutual interference filter accessory for thru-scan sensors operate on this principle.



● Light sources, emission methods

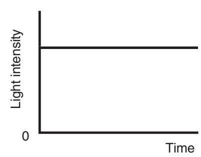
< Pulse Modulated light >

Light is emitted repeatedly at fixed intervals. The effects of ambient light interference are easily removed with this system, enabling long distance detection. In models equipped with anti-mutual interference function, the emission cycle is varied within a specified range to handle coherent light and ambient light interference. The majority of photoelectric sensors use pulse modulated light.

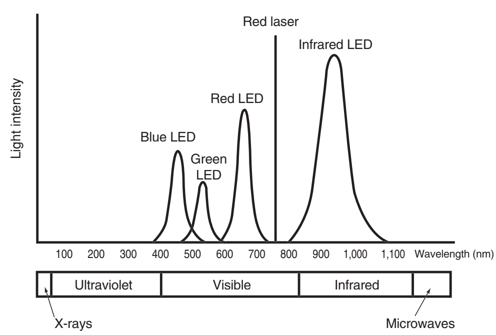


< Non-modulated Light >

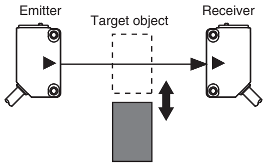
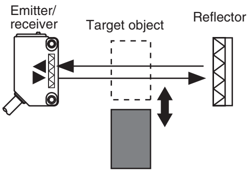
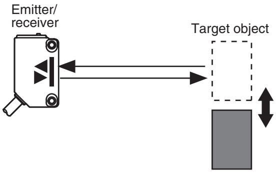
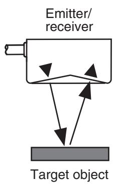
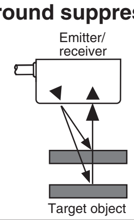
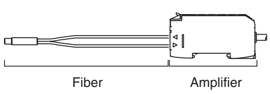
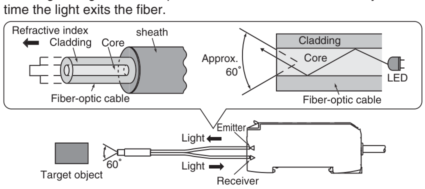
Non-modulated light refers to an uninterrupted beam of light at a specific intensity. Although these sensors have fast response times, their drawbacks include short sensing distances and susceptibility to ambient light interference.



● Light Source Color and Type

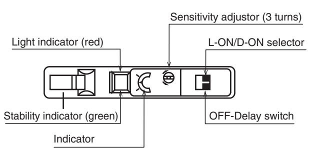


SCANNING TYPE

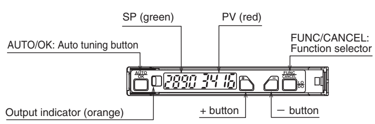
Type	Principle	Major features
Thru scan 	Sensor operates when the light between emitter and receiver is blocked by a target object.	• Long-distance detection. • High accuracy. • A wide range of applications.
Retroreflective **Polarized retroreflective** 	Operation is the same as for a thru-scan sensor, but emitter and receiver are housed in the same unit.	• The optical axis can be set easily. • Wiring and installation work are easy and wiring is necessary for only one device. • Requires areflection.
Diffuse scan 	Light from the emitter is reflected by the target object itself. When the reflected light is detected, the sensor operates.	• Wiring and installation work are needed only for sensor itself, and installation requires little space. • Light axis alignment is not required. • Models capable of color discrimination are available.
Limited diffuse-scan 	Emitter and receiver operate only at a certain angle. Detection occurs only where the emitter and receiver axes meet.	• Influence of background can be reduced. • Operation differential is small.
Background suppression 	A beam of light strikes the target object, which is detected by the difference in the angle of the reflected light.	• No interference from high reflectance backgrounds. • Even if reflectance differs by color or material, target object can be detected reliably. • Small target objects can be detected with high accuracy.
Fiber-optic sensors 	Fiber-optic cable is comprised of a central core with a high refractive index surrounded by cladding with a low refractive index. Repetitive total internal reflection at the boundary of the less refractive cladding guides the light down the fiber-optic cable. The angle of the light traveling through the fiber-optic cable increases to about 60° by the time the light exits the fiber. 	• Highly resistant to noise and other environmental influences with no electrical components in the fiber-optic cable. • Flexible to various applications with variety of fiber unit line up.

Typical consoles of fiber-optic sensors

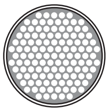
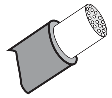
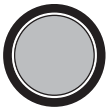
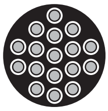
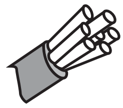
HPX series potentiometer tuning fiber-optic sensors



HPX-AG digital fiber-optic sensors



Fiber-optic cable types and characteristics

Cross section	Structure	Features	Effective applications	Typical models
Unbreakable (Multi-core) 	 (Integrated cores)	● Bending does not almost affect light intensity. ● Allowable bend radius:1 mm or 2 mm.	Compared to conventional regular fibers: ● As easy to install as soft electrical wiring. ● Never have to worry about the bending radius. ● Touching fibers does not affect light intensity.	Thru scan: **HPF-T025** Diffuse scan: **HPF-D030**
Regular (single core) 		● Efficient light transmission at relatively long scanning ranges. ● Allowable bend radius: 10 or 20 mm.	General use, low cost.	Thru scan: **HPF-T003** Diffuse scan: **HPF-D002**
Bend-tolerant (bundle) 	 (separate cores)	● Excellent bending-resistance characteristics. Repeated bending: 1,000,000 times min. (typical example) ● Allowable bending radius: 4 mm.	Resists damage when mounted to moving parts	Thru scan: **HPF-T008** Diffuse scan: **HPF-D037**

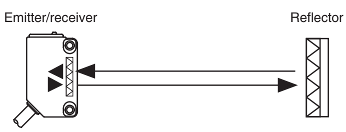
GLOSSARY

Thru-scan sensor

A beam (light) receiver and emitter face each other. An object that passes between them is detected when the light intensity transmitted drops because of the object.

Retroreflective sensor

An integrated beam (light) emitter-receiver and a reflector face each other. An object that passes between them is detected when the light intensity drops because of the object.



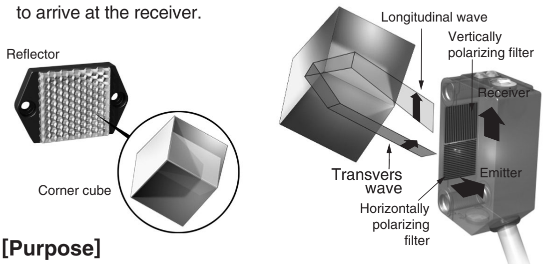
Polarized retroreflective sensor

This relatively new type of sensor solves a problem of conventional retroreflective sensors. Conventional models cannot reliably detect highly reflective target objects because the beam reflected by the reflector cannot be distinguished from light reflected by the target object. However, the use of polarized light allows reliable detection of highly reflective objects, and is nearly as reliable as thru scan sensing.

[Principles]

This function and structure uses the characteristics of the reflector and the polarizing filters built into the polarized-retroreflective sensors to receive only the light reflected from the reflector.

- The waveform of the light transmitted through a polarizing filter in the emitter changes to polarization in a horizontal orientation.
- The orientation of the light reflected from the triangular pyramids of the reflector changes from horizontal to vertical.
- This reflected light passes through a polarizing filter in the receiver to arrive at the receiver.

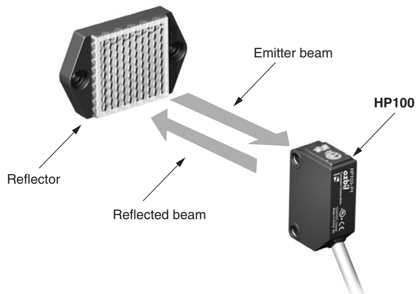


[Purpose]

This method enables stable detection of targets with a mirrorlike surface. Light reflected from these types of objects cannot pass through the polarizing filter on the receiver because the orientation of polarization is kept horizontal.

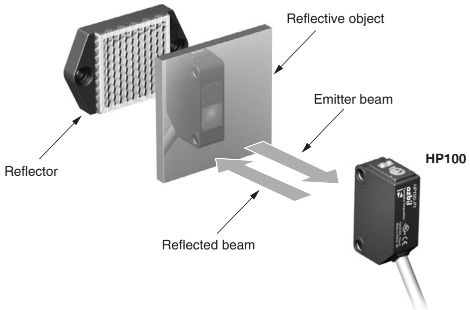
● Beam strikes polarizing reflector

The beam is polarized in the horizontal plane by the emitter. When the light strikes the reflector, its plane of polarization is rotated 90°.



● **Beam strikes a normal reflective surface**

The target object reflects light waves without changing their plane of polarization. These reflected waves are eliminated by a filter.



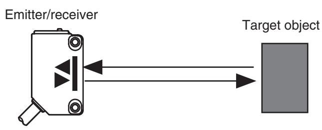
When a polarized retroreflective sensor is used to detect highly reflective object or objects that disturb polarization, detection might be inconsistent. In such case, take the following countermeasures:

Examples of target object that might cause faulty operation:
- Target object covered with a transparent film
- Semi-transparent target object (semi-transparent case, etc.)
- Mirror or highly reflective mirrorlike object

Countermeasures:
- Mount the sensor at a slight angle to the target object.
- Increase the distance between the sensor and the target object.
- Lower the sensitivity setting of the sensor.

Diffuse-scan sensor

A beam emitter and a beam receiver are located in close proximity. A passing or approaching object is sensed by the change in the quantity of reflected light caused by the object.

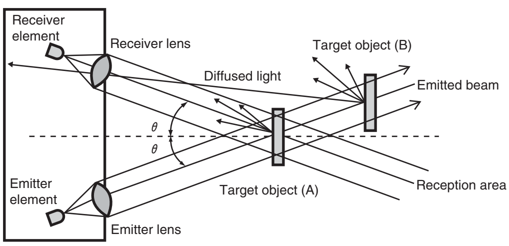


Limited diffuse-scan sensors

Limited diffuse-scan sensors

Detection method

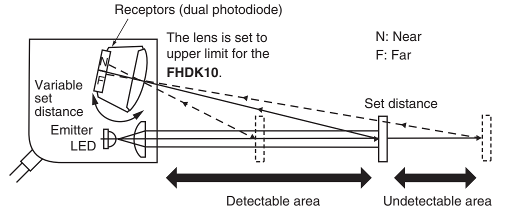
In the same way as for diffuse-scan sensors, limited diffuse-scan sensors receive light reflected from the target object to detect it. The emitter and receiver are installed to receive only regular-reflection light, so only objects that are a specific distance (area where light emission and reception overlap) from the sensor can be detected. In the figure on the right, the target object at (A) can be detected while the object at (B) cannot.



Background suppression sensors

Detection method

The receiver in the sensor is a dual photodiode. Target objects closer to the present position are detected by means of beam concentrated position on the photodiode.



[Features of background suppression sensors]

- Operation not greatly affected by target object surface conditions or color.
- Operation not greatly affected by the background.

Beam emitter

This includes a light source, such as a light-emitting diode (LED), and an optical system (lens).

Beam receiver

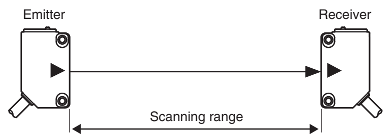
The receiver uses a photoelectric conversion device, such as a photo transistor, to detect the beam from the emitter through an optical system (lens).

Scanning range

This is the range within which the photoelectric sensor operates reliably.

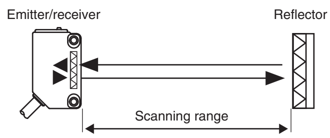
● **Thru-scan sensor**

The maximum distance between emitter and receiver at which operation is reliable.



● **Retroreflective sensor**

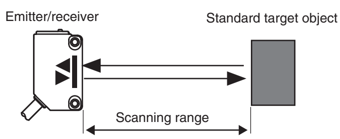
The maximum distance between sensor and reflector at which operation is reliable.



● **Diffuse-scan sensor**
(wide beam, limited scan, and background suppression types)

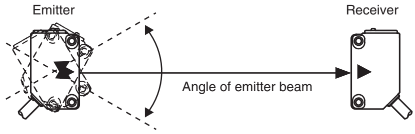
The maximum distance at which operation is reliable with a standard target object.*

*For diffuse-scan sensors, since the reflected light level differs depending on the color, material, and size of the target object, a white non-lustrous paper of suitable size for the model is generally used as a standard target object.



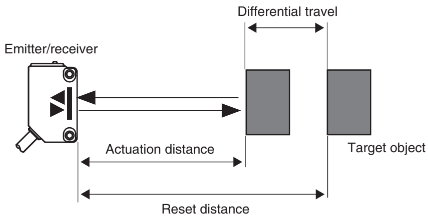
Operating angle (area)

This term is used for thru scan and retroreflective sensors. It is the angle within which the sensor will operate. If this angle is too small, optical axis adjustment is difficult. When it is too large, the sensor is vulnerable to interference from nearby photoelectric sensors.



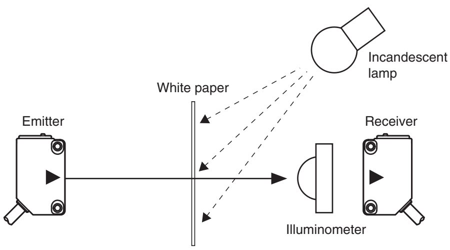
Differential travel

This is the ratio of (reset distance - actuation distance) to scanning range under standard operating conditions, with a standard target object.



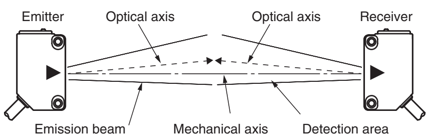
Operating ambient light

This is the maximum ambient light level at which the photoelectric sensor can operate normally.



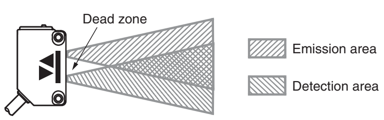
Optical axis

Optical axis: The axis from the center of the lens to the center of the beam for the emitter, and the axis from the center of the lens to the center of the detection area for the receiver.
Mechanical axis: The axis perpendicular to the center of the lens.



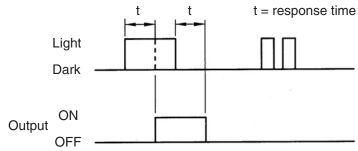
Dead zone: The dead zone outside of the emission and detection areas near the lens surface in background suppression sensors, limited diffuse-scan sensors, diffuse-scan sensors, and polarized-retroreflective sensors. Detection is not possible in this area.

Example of diffuse-scan sensor



Response time

The time required to output a signal after a target object enters the detection area of the sensor. (No output for dark or light status shorter than the response time.)



Timers

For models with timer function, output pulse width and output timing can be set by the user.

ON delay

ON-delay timer delays the output timing or disables short-time outputs. It is used to avoid output chattering or to control detection position.

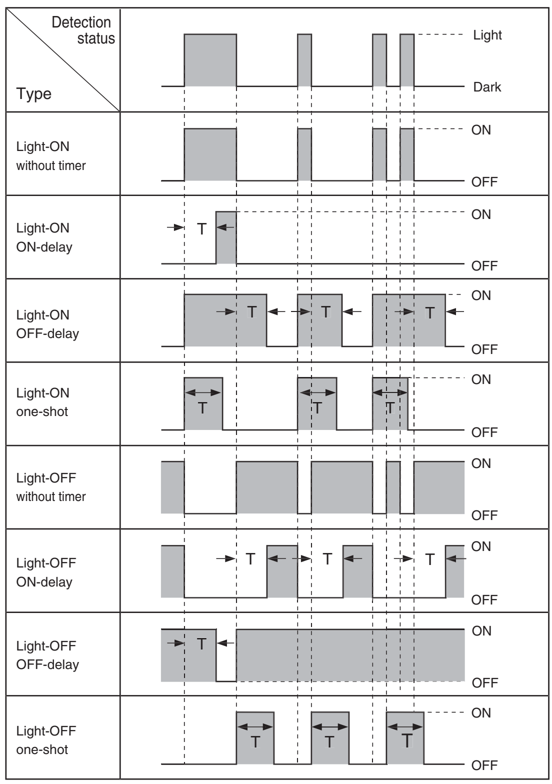
OFF delay

OFF-delay timer extends the output time. It is effective when the sampling speed of connected device is low comparing with the sensor output.

One shot

One-shot timer fixes the output time constant. Output time can be constant regardless of target object size.

Time chart

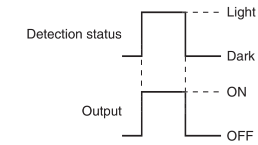


T: timer

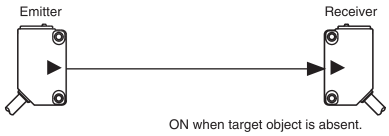
Available timer types depend on the sensor model. Some sensor models have complex timer function combining ON-delay and one-shot.

Light-ON

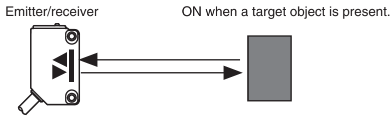
An operating mode in which the sensor turns ON when the light intensity entering the receiver increases to a specified level.



●Thru-scan/retroreflective sensor

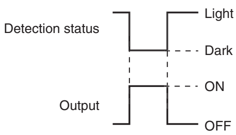


●Diffuse-scan sensor

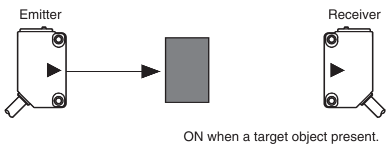


Dark-ON

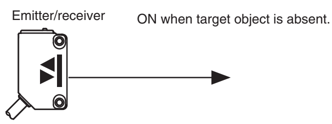
An operating mode in which the sensor turns ON when the light intensity entering the receiver decreases to a specified level.



●Thru-scan/retroreflective sensor

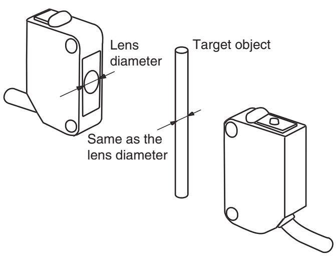


●Diffuse-scan sensor



Relationship of lens diameter and sensitivity to the smallest permissible target size

With a thru-scan sensor, the lens diameter determines the smallest permissible target size. A small object can be more easily detected midway between the emitter and the receiver that it can be off center between the emitter and receiver. An object smaller than the lens diameter can be detected by varying the sensitivity level. Check the specifications of the sensor for details.



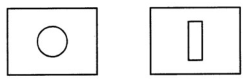
Standard target object

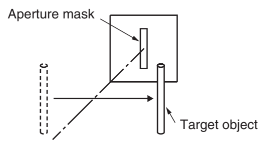
To determine the scanning range of the diffuse-scan sensor, uniform target object (Kodak 90 % white paper) is used. The target size, which is larger than the emission beam diameter, depends on the sensor models.

Examples
HP100 series: 30 cm x 30 cm
HPX-AG series (with diffuse-scan fiber unit): 50 cm x 50 cm
HPJ series: 10 cm x 10 cm

Aperture mask

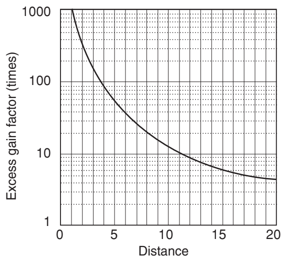
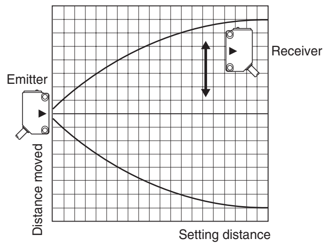
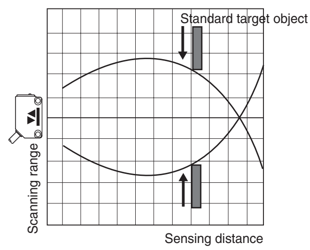
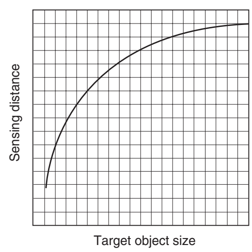
Aperture masks reduce the effective optical area of the emitter and receiver. Round or rectangular masks are most often used.





GENERAL CHARACTERISTICS OF PHOTOELECTRIC SENSORS

Terms used in photoelectric sensor characteristics diagrams are explained below.

Item	Meaning	Characteristics diagram	Explanation or application
Excess gain	This is an indication of the output level of the photoelectric element as determined by the light intensity striking the receiver. Generally, it is expressed as a relative amount, with the required light level set at 1. This characteristic applies to thru-scan, retroreflective, and diffuse-scan sensors.		Indicates whether enough light is emitted at the setting and scanning ranges.
Parallel displacement	This characteristic applies to thru-scan and retroreflective sensors. The receiver (for thru-scan sensors) or reflector is moved perpendicularly to the optical axis, and the points at which the sensor is actuated are noted.		Indicates how diffusely the emitter beam is spread. Provides information about mutual interference when a number of photoelectric sensors are parallel to each other.
Detection area	This characteristic applies to diffuse-scan sensors. A standard target object is moved perpendicularly to the optical axis, and the points at which the switch is actuated are noted.		Indicates how diffusely the emitter beam is spread. Provides information about mutual interference when a number of photoelectric sensors are parallel to each other.
Target object size vs. distance	This characteristic applies to diffuse-scan sensors. The detection range is noted for different sizes of target object, with the sensor set to its maximum sensitivity.		Provides information required to detect objects that are smaller than the standard target object.

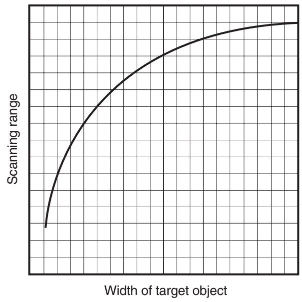
TIPS AND PRECAUTIONS

Photoelectric sensors have individual and common properties which must be considered for proper operation. Common properties are treated below.

1. Effects determined by the target object

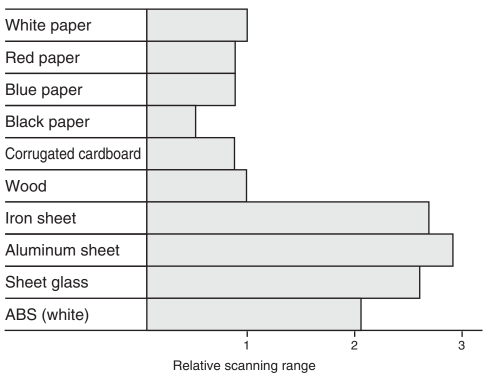
1.1 Target object size

Generally a thru-scan sensor can detect any object larger than the smallest permissible target size. Some types of target, however, must be at least several times the minimum size (e.g., moving path). The scanning range of a retroreflective photoelectric sensor depends on the size of the target object.



1.2 Target object materials

A thru-scan sensor can only detect opaque objects. A sensor with a tuning function is required to detect semi-transparent objects. The scanning range of a diffuse-scan sensor depends on the target object materials. The relative scanning ranges for various materials are shown below.



1.3 Target object speed

The following equation tells how the width and speed of a target object affects the response time of a photoelectric sensor.

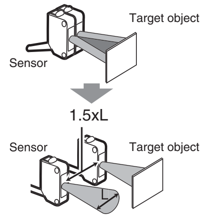
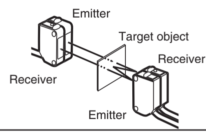
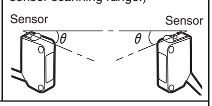
W≧VT + A

W: Width of a detectable object (m)
V: Passing speed of the object (m/s)
T: Response time of photoelectric sensor (s)
A: Minimum width of target object for the photoelectric sensor (m)

2. Mounting

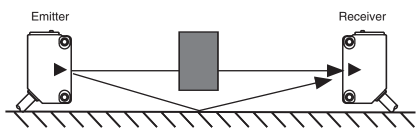
2.1 Mutual interference

Incorrect operation may occur due to mutual interference of photoelectric sensors mounted in close proximity. The following measures can be taken to avoid mutual interference.

Countermeasures	Thru-scan sensors	Diffuse-scan sensors
Use a sensor with anti-mutual interference function.	If sensors are mounted in close proximity, use sensors with anti-mutual interference function, such as **HP100** series (excluding thru-scan model), **HPX** series and **HPX-AG** series. Anti-mutual interference function is not effective between different sensor models. Even for the same sensor models with anti-mutual interference function, digital PV indication might fluctuate. In this case, take additional countermeasures.	
Install an anti-mutual interference filter.	For the **HP100**, etc., installing an anti-mutual interference filter allows gang-mounting (up to 2 units). Anti-mutual interference filter: **HP100-U01**	—
Separate sensors to distance where interference does not occur.	Check the parallel displacement characteristics, and install the sensors accordingly at a distance at least 1.5 times the parallel displacement range.	Separate the sensors by at least 1.5 times the detection area.  Detection area depends on target surface conditions. Check the detection after mounting.
Alternate emitters and receivers.	Gang mounting of sensors is possible by alternating the emitters with the receivers in a zigzag fashion (up to two units). However, if the target object is close to the photoelectric sensors, light from the adjacent emitter may be received and cause the sensor to change to the incident light state. 	—
Offset the optical axes.	If there is a possibility that light from another sensor may enter the receiver, change the position of the emitter and receiver, place a light barrier between the sensors, or take other measures to prevent the light from entering the receiver. (Light may enter even if the sensors are separated by more than the scanning range.)	If sensors are mounted in opposite each other, slant the sensors as shown in the following diagram. (This is because the sensors may affect each other and cause output chattering even if separated by more than the sensor scanning range.) 
Adjust the sensitivity.	Lowering the sensitivity will generally help.	

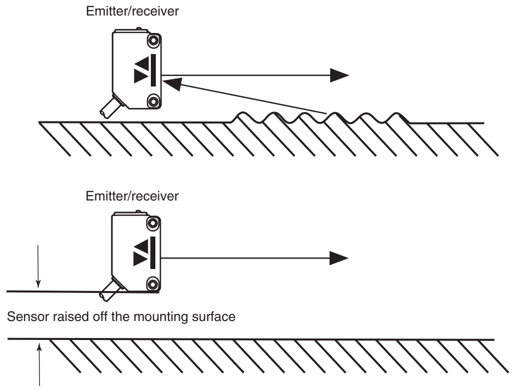
2.2 Reflection from surrounding objects

A flat surface (especially a smooth surface) may compromise performance. Reflected light may cause unreliable operation (as illustrated below). Raise or lower the sensor or use a light-shielding plate to ensure reliable operation.



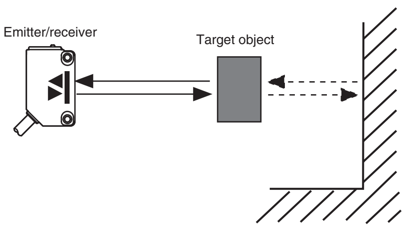
2.3 Interference from the mounting surface

Irregularities in a rough surface may be detected as target objects, causing unreliable operation, as illustrated below. Raise or lower the sensor or alter that operating angle to ensure reliability.



2.4 Influence from the background

The background behind target objects may affect the operation of diffuse-scan sensors, depending on its luminance and reflectivity. Generally, a black background is desirable.



2.5 Power ON/OFF

● Power reset time

The sensor will be ready to detect approximately 10 to 100 ms after the power is turned ON. If the sensor and the load are connected to separate power supplies, turn ON the sensor power before turning ON the load power.

● Turning OFF power

An output pulse may be generated when the power is turned OFF. It is recommended that the load or load line power be turned OFF before the sensor power is turned OFF.

2.6 Light intensity saturation in minute target detection

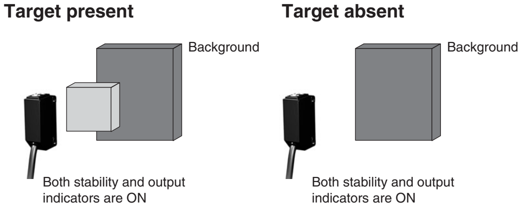
Use the aperture mask (sold separately or included). It is effective to saturation due to a short scanning distance (no light level difference in different detection status).
Available for **HP100** series, **HPJ** series, **HPF-T021T**, **HPF-T021WT**, etc.

2.7 Light intensity saturation in minute level difference

Receiving light intensity saturation may occur in detecting transparent or semi-transparent target with thru-scan sensors, or in detecting target-background level difference. There are two kinds of saturations: saturation in circuit and saturation in indication.

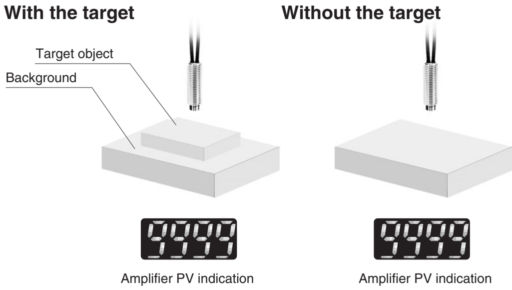
● Saturation in circuit

(No indicator status change in detection status change)



The situation does not change even adjusting the tuning potentiometer in target present status.

● Saturation in indications



● Countermeasures

Sensors with self-contained amplifiers

①For thru-scan sensors, separate the emitter and the receiver.
②For diffuse-scan sensors, separate the sensor from background.
③For diffuse-scan sensors, slanting the sensor to the background decreases the reflection from the background in case of regular reflection material (mirror, mirror-finished stainless steel, etc.)

*The detection performance also depends on hysteresis, minimum detectable level difference. Light intensity saturation is not always the cause of the detection failure of minute level difference.

Fiber-optic sensors
HPX-AG series

①Set to the anti-saturation mode, or to the sensing type with higher response speed.
②Separate the two fiber units, or separate the fiber unit from background.

HPX series potentiometer tuning fiber-optic sensor

①Turn the tuning potentiometer to MIN direction and check if the problem is solved.
②Separate the two fiber units, or separate the fiber unit from background.

*For diffuse-scan fiber units, light intensity may have a certain level even without the target due to the fiber internal reflection called crosstalk. In this case, detection remains the light status at the maximum sensitivity. Execute the BGS (an auto-tuning type of **HPX-AG** series, etc.) or other tuning.

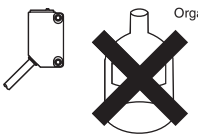
*When a polarized retroreflective sensor is used to detect highly reflective object or objects that disturb polarization, detection might be inconsistent. In such case, take the following countermeasures:

Examples of target object that might cause faulty operation:	● Target object covered with a transparent film ● Semi-transparent target object (semi-transparent case, etc.) ● Mirror or highly reflective mirrorlike object.
Countermeasures:	● Mount the sensor at a slight angle to the target object. ● Increase the distance between the sensor and the target object. ● Lower the sensitivity setting of the sensor.

3. Environment

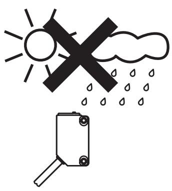
3.1 Effects of dirt and dust

Various parts of recent photoelectric sensors are made of plastic. These parts (access windows, lenses, and reflectors) are easily damaged when soiled and must be cleaned regularly. Clean them by wiping softly with a clean cloth. Water and a neutral detergent may be used. Do not use organic solvents such as benzene, acetone, or paint thinner: the sensor may be damaged. Optical parts made of glass can be cleaned quickly with alcohol.



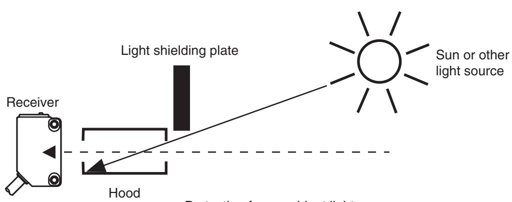
3.2 Ingress protection

Generally, the performance of a photoelectric sensor is not guaranteed when it is subject to rain or sprayed water, or when there are water drops or dew on the lens surface. Therefore, it is necessary to carefully select a sensor with characteristics that are appropriate for the environment where it will be used.



3.3 Effects of ambient light

Malfunction may occur due to the influence of strong light sources, such as the sun, spotlights, or infrared lamps in the range of the receiver's optical axis. Change the location or angle of the sensor to prevent strong rays from directly striking the receiver lens. Ambient light can be prevented from affecting the light receiver by using a hood or light shielding plate, as shown below.



Protection from ambient light

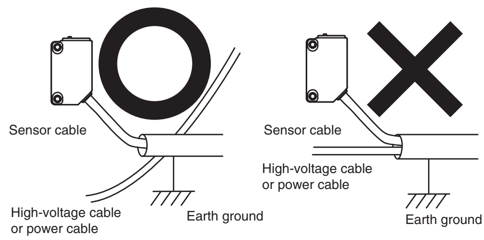
4. Wiring

4.1 Power

Malfunction may occur as a result of high-frequency noise from a switching regulator. If a switching regulator must be used, ground its frame.

4.2 Connections

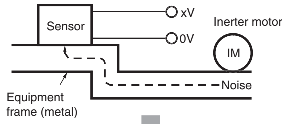
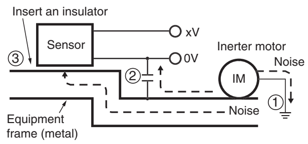
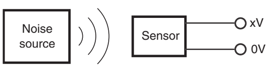
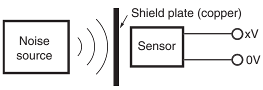
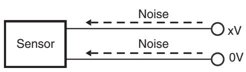
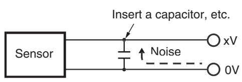
Be sure to correctly connect the sensor to the power and to the load. If there are high voltage or power lines near a photoelectric sensor cable, isolate the sensor cable to prevent surge or noise influence. Connect leads securely using crimp terminals or the like. If extending the cable, use wire of at least 0.3mm2 in cross-sectional area for sensors with built-in amplifiers. The cable length should not exceed 100m. Consider the effects of increased noise due to cable extension. Tightening the cord with excessive tension might cause line break. Do not apply a force of more than 50 N. When using a load which generates an inrush current above the switching capacity, such as a capacitive load or incandescent lamp, connect a current-limiting resistor between the load and the output terminals. (Otherwise, the output short-circuit protection function will be activated.) Do not bend the part of the cable nearest to the amplifier beyond the bend radius of 30 mm. Avoid continuous bending stresss.



Do not use the same conduit

***Noise**

Countermeasures for noise depend on the path of noise entry, frequency components, and wave heights. Typical measures are as given in the following table:

Type of noise	Noise intrusion path and countermeasures
Common mode noise (Inverter noise) (Common noise applied between the equipment frame and the +V and 0-V lines, respectively.)	Before countermeasures Noise enters from the noise source through the frame (metal).  After countermeasures ① Ground the inverter motor (to 100Ω or less). ② Ground the noise source and the power supply (0-V side) through a capacitor. ③ Insert an insulator (plastic, rubber, etc.) between the sensor and the equipment frame (metal). 
Radiant noise (Ingress of high-frequency electromagnetic waves directly into sensor, from power line, etc.)	Before countermeasures Noise propagates through the air from the noise source and directly enters the sensor.  After countermeasures ● Insert a shield (copper) plate between the sensor and the noise source (e.g., a switching power supply). ● Separate the noise source and the sensor to a distance where noise does not affect operation. 
Normal mode noise (Power line noise) (Ingress of electromagnetic induction from high-voltage wires and switching noise from the switching power supply)	Before countermeasures Noise enters from the power line.  After countermeasures ● Insert a capacitor (e.g., a film capacitor), noise filter (e.g., ferrite core or insulated transformer), or varistor in the power line. 

***Work required for unconnected leads**

Unused leads for self-diagnosis outputs or other special functions should be cut and wrapped with insulating tape to prevent contact with other terminals.

***Repeated bending**

Normally, the sensor cable should not be bent repeatedly.

5. Scanning range in fiber unit extension

HPF-T003 thru-scan fiber unit, standard length 2 m
Extended to 5 m → Scanning range decrease by approx. 20 %
Extended to 10 m → Scanning range decrease by approx. 40 %

Scanning range for **HPF-D002** similarly decreases diffuse-scan fiber unit.
These are examples of decrease for general-use, regular-diameter fiber units.

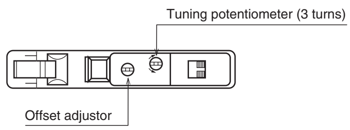
6. HPF-EU05 fiber-optic cable extension unit causions

The scanning range will be decreased by 1/4 times from original. For the wet fiber units, available fiber unit — amplifier combination is determined.

Catalog listing	Total length	HPX-AG		HPX-ET	HPX-H	HPX-A	Remarks
		nL	HP				
HPF-T032	10m	OK	OK	NG	OK	NG	Some liquids may be undetectable. Check the detection before use.
HPF-D040	10m	OK	OK	OK	OK	NG	
HPF-D027	7m	OK	OK	NG	OK	NG	
HPF-D033	7m	OK	OK	NG	NG	NG	

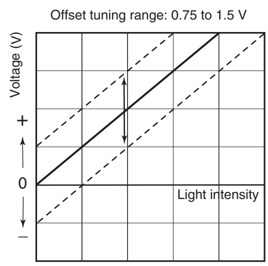
7. Tuning of HPX-MA analog output fiber-optic sensor

The **HPX-MA** has 1-5 V dc light level analog output. Its tuning potentiometer and offset adjustor have the following functions:



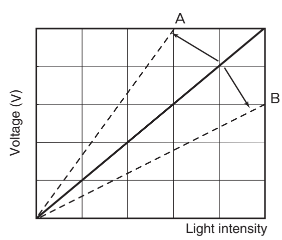
Offset tuning

The solid line in the chart is the original output voltage. Offset tuning is to shift this voltage (+ ** V or −** V). Offset tuning range means possible shift voltage range.



Sensitivity tuning (range)

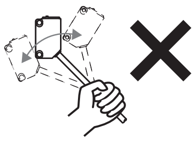
Sensitivity tuning adjusts the output gain. The solid line in the chart is the original output voltage. Output voltage for the same light intensity can be raised (A) or lowered (B). The sensitivity tuning range depends on the scanning distance or target condition.



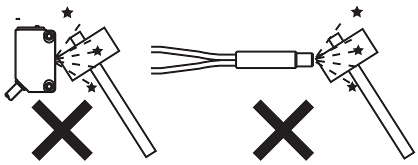
HANDLING

1. General handling

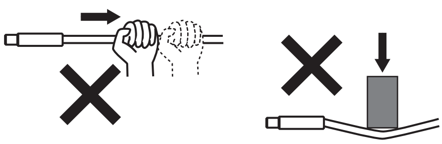
- Do not swing the photoelectric sensor by the cable. Do not pull excessively on the cable of the photoelectric sensor.



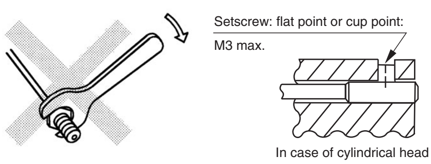
- Do not strike or scratch the sensing head.



- Do not use photoelectric sensor fiber-optic cables made of plastic where organic solvents are present.
- Do not bend the fiber part of a fiber optic sensor excessively or subject it to unreasonable force.



- Do not apply excessive tightening torque to the head a fiber optic sensor.



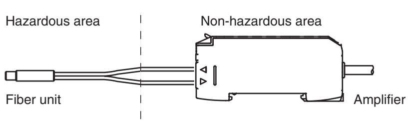
Head shape	Allowable tightening torque
M3/M4 screw	0.8N·m
M6 screw	1 N·m
Cylindrical	0.3 N·m

Typical values are shown. Refer to the specifications of each fiber unit model for specified torque.

- If a fiber optic sensor must be used where there is heavy vibration, secure the fiber unit to prevent movement. Make sure that there is no vibration where the fiber unit is coupled with the amplifier unit.

2. Fiber-optic photoelectric sensors in explosive gas atmospheres

Fiber unit structure transmit only light beam. Since optical energy does not act as an ignition source, the fiber unit normally can be installed in the hazardous area, and the amplifier unit can be installed in a non-hazardous area. Before use, check the explosion-proof requirements for facilities or equipment.



3. Sticking aperture mask

Peel the back paper to stick the aperture mask (sold separately or included). Fit the aperture mask outline to the sensing face. The aperture mask might be peeled off if oil or dust is on the sensing face. Be sure to wipe it before sticking.

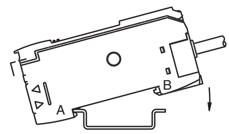
4. Precautions for handling fiber-optic sensors

● Mounting the amplifier

Mount the amplifier on the dedicated bracket (**HPX-PA04**, optional part) or DIN rail.

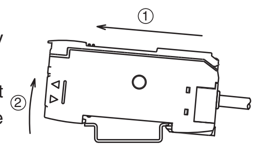
①Insert one rail of the bracket or DIN rail into the slot at point A.

②Push the unit downwards until the second rail clicks into place at point B. When mounting the amplifier on the DIN rail, always secure it with the **HPF-PA03** end plate (optional part).



● Dismounting the amplifier

If the amplifier is pushed forward firmly ①, the front lock will release. The amplifier can then be pulled out ② and detached, as shown in the figure.

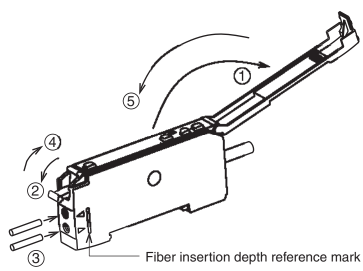


● Expansion-unit attachment to the main unit for reduced wiring models (HPX-AG series)

① Peel the seal off the connector of the units to be attached.
② Mount side by side on a DIN rail.
③ Slide the expansion units over to so that the connectors connect.
④ Use an end plate (**HPX-PA03**, sold separately) to hold the expansion units in place.
⑤ When dismounting, slide each expansion unit off one by one.

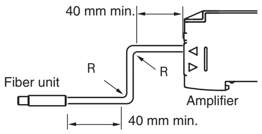
● Inserting optical fibers into the amplifier

① Open the cover.
② Move the fiber clamp lever forwards to the release position.
③ Firmly insert the tip of each fiber into the holes in the amplifier. For the insertion depth of the fiber, refer to the reference mark on the side of the unit.
④ Return the lever to the clamp position.
⑤ Close the cover.

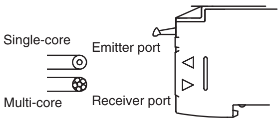


Handling Precautions

- If the fiber is thin, first insert it into the thin fiber adapter so that the fiber projects approximately 0.5 to 1 mm from the top of the adapter. After that, insert the adapter into the hole in the amplifier until it is in contact with the end, and then fix it firmly.
- Do not bend the cable within 40 mm (in case of thin fiber: 10 mm) of its junction with the amplifier unit or the sensing head. Bending beyond the allowable bend radius might cause shortening the scanning range or fiber break.



- When connecting a coaxial reflection type fiber unit to the amplifier, insert the single-core fiber into the port for light emission and the multi-core fiber into the receiver port.



- The scanning range and indication value might vary depending on individual variability, mounting conditions or fiber unit types.

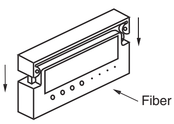
5. Fiber unit cautions

● Cutting fiber-optic cables

Use the dedicated cutter (included with the unit) to cut the fiber. High and low temperature-proof fibers cannot be cut.

① Insert the fiber cable to the desired cutting length into one of the previously unused holes in the cutter.
② Push down the blade in one strong and smooth motion.
③ Do not reuse a hole once used to cut a fiber cable.

- If the sensing face is dirty, wipe with a soft, clean cloth. Do not use benzine, thinner or other organic solvents.
- Fiber insertion condition or fiber cutting condition may shorten the scanning range by approx. 20 %.
- For details about the specifications of the fiber unit and cautions for use, refer to the specifications.



⚠ CAUTION

To avoid injury, do not disassemble the dedicated cutter.

● Heat-resistant fiber unit

Fiber head color might change in high temperature.

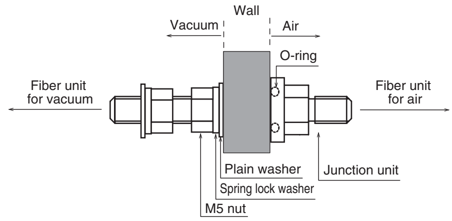
● HPF-V series vacuum fiber units

Although flanges, fiber units for vacuum and lens units are washed with IPA, baking is required before use.

● Mounting junction cautions

A junction unit uses O-ring to obtain sealing performance. Do not weld it the chamber wall. Doing so might tarnish the internal glass rod.

Available wall thickness: 8 to 10 mm
Recommended mounting hole: 5 +0.2 +0.1 mm dia.
Recommended surface roughness of wall: 1.6 Ry

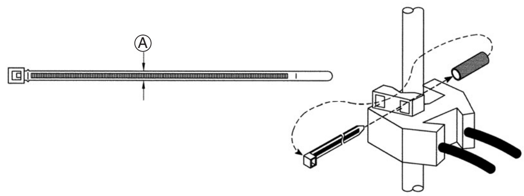


6. Wet sensor cautions

Fiber unit structure transmit only light beam. Since optical energy does not act as an ignition source, the fiber unit normally can be installed in the hazardous area, and the amplifier unit can be installed in a non-hazardous area. Before use, check the explosion-proof requirements for facilities or equipment.

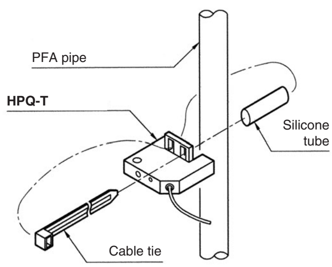
● Mounting HPF-T032/T034 pipe-mounted fiber units

As shown below, mount the fiber unit using the included cable ties and anti-slip tubes. Firmly tighten the two upper and lower cable ties and then cut off any extra length. If an additional cable tie is required, use one no more than 2.5 mm wide.



● Mounting HPQ-T pipe-mounted liquid-level sensors

The **HPQ-T** is pipe-mounted using either an M3 screw or cable tie. When mounting the sensor with a cable tie, be sure to secure the sensor by passing the cable tie through silicone tube to prevent the sensor from slipping.



- Do not deform the pipe in mounting the **HPQ-T** with cable tie.
- Detection stability depends on the transmissivity and refractive index of the pipe and liquid. Check the operation before use.
- Water drops, bubble or fogging may cause faulty detection.
- In case dripping causes output chattering, use a timer in connected device to cancel it. Delay timer is available for amplifiers of fiber-optic sensors.
- The **HPQ-T** does not have ingress protection structure. Be careful for use in liquid splashing environment.

● Mounting HPQ-D liquid leak detectors

Mount the sensor horizontally. After locking the mounting base in position, insert the sensor body onto the mounting base and fix it in place by tilting down the locking clasp of the sensor.

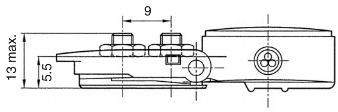
Fastening with screws

Remove the knock-out holes of the mounting base and place the sensor on two stainless steel (etc.) M4 stud bolts welded on the metal pan. Secure with two M4 nuts. For the PFA type, mount similarly with one M3 stud bolt.

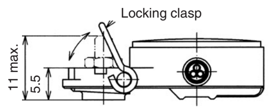
Mounting with adhesives

The PVC bracket type can be mounted with adhesive. If the mounting surface is PVC (vinyl chloride), the same material as the bracket, the use of monomeric adhesives for vinyl choride is recommended. However, be sure to check the specifications of the adhesive to be used, taking into consideration the material of the other mounting surfaces.

HPQ-D1□



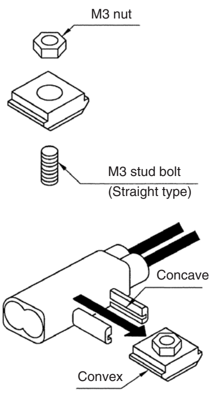
HPQ-D2□



(Unit: mm)

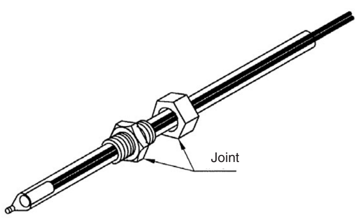
● Mounting HPF-D040 liquid leak fiber-optic detectors

When using an SUS mounting base, insert the welded M3 stud bolt into the hole of the mounting base, and then fasten with an M3 nut (not supplied). Then put the ridges of the dedicated mounting base into the grooves of the fiber-optic sensor, and then slide the base forward until it is in place.



● Mounting HPF-D027/D033 tank-level fiber-optic cables

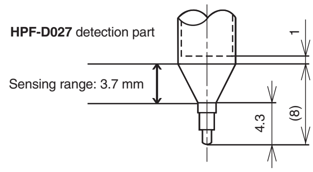
To install the fiber-optic sensor, use a commercially available fluorine-rein joint that matches the outside diameter of the PFA tube.



- The following may cause unstable sensing:

① Bubbles on conical portion of sensing head.
② Chemical precipitate on conical portion of sensing head.
③ High density liquid

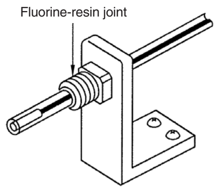
- Some liquid properties, such as milky white color, may be undetectable.
- Do not scratch or deform the fiber unit tip. Doing so may cause unstable sensing. Protect it (esp. the conical part) from impact. In case dripping causes output chattering, use a timer.



The level at which liquid is detected differs according to surface tension and wet condition of **HPF-D027** detection part.

● Mounting HPF-T029/T035/D014 chemical-proof fiber-optic cables

- To install the fiber-optic sensor, use a commercially available fluorine-resin joint that matches the outside diameter of the PFA tube.
- The bend radius of the protective tube must be more than the minimum bend radius specified for each fiber unit. If it is less than the minimum bend radius, it may damage the fiber unit.
- Do not apply excessive tension to the fiber-optic cable.

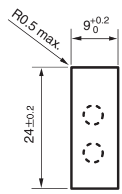


7. HPF-EU05 fiber-optic cable extension unit

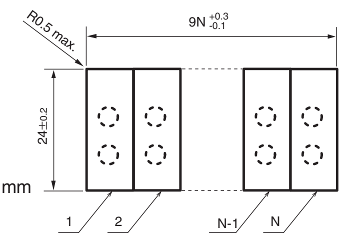
The scanning range will be decreased by 1/4 times from original.

Recommended mounting hole

Single-mounted



Gang-mounted



Panel thickness: 1.0 to 2.0 mm

Refer also to User's Manual and Specifications of each model.