

FIBER OPTIC SENSOR GUIDE

Thank you for purchasing Autonics product.

Before use, be sure to read the safety considerations and use them correctly.

Autonics

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Selecting Fiber Optic Sensors

It is an element to select a fiber optic sensor. Select the right product for each element for the most optimal detection. You can check the details by referring to the contents.

① Installation environment Identify the surrounding environment factors (position, temperature, background, etc.) and a sensing target.

② Sensing type Select a fiber optic unit in consideration of the installation environment.

Through-beam type, retroreflective type, convergent reflective type

③ Features Select a fiber optic unit in consideration of usage.

■ Head shapes

Typical installation

- Threaded head type
- Cylindrical head type
- Molded plastic head type

Installation flexibility

- Flat type (integrated bracket type)
- L-shaped type
- Perpendicular head type
- SUS head type
- U-shaped head type
- Wide area head type

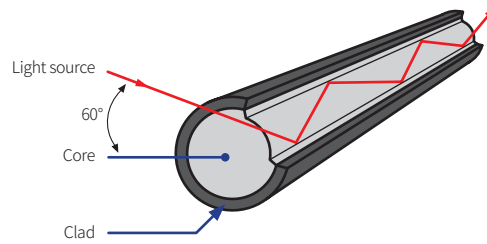
■ Environmental conditions

- Heat-resistant type
- Vacuum-resistant type
- Bending-resistant type (R5)
- Flexible type (R1, R2)

④ Select the amplifier Select a fiber optic amplifier in consideration of its function. For detailed information, refer to the manual of each amplifier.

What is a Fiber Optic Sensor?

The fiber optic sensor consists of a fiber optic amplifier and a unit. The amplifier emits and receives light energy and converts it to an electrical signal. The unit, a product for transmitting the light energy of the amplifier over a long distance, transmits the light to the detecting position and backs to the amplifier. The structure of the fiber optic unit is a bundle of fibers made of plastic or glass. In the figure below, the fiber is formed with a core that guides the light and a clad that protects the core. Light from one side of the fiber repeats total reflection at the boundary between the core and clad and goes ahead to the other side.



Since the fiber has no built-in circuits or components, it can safely transmit light even in a hazardous environment. The features of lightweight and flexibility allow it to withstand vibration and mechanical shock. The fiber can be used in space with many restrictions or environment that is hard to detect.

Considerations When Selecting Fiber Optic Units

■ Sensing type

Through-beam type



- Two fiber cables are connected to each hood in parallel.

Retroreflective and convergent reflective type



- Two parallel fiber cables are connected to one hood.
- The color and background of the sensing target may affect to retroreflective type.
- The convergent reflective type is hardly affected by the background.

■ Material

Plastic

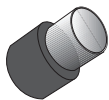
- Strength**
- Since it generally consists of a single fiber, it supports to install in very narrow spaces.
 - With its excellent flexibility, it can detect an object even in environments with repetitive curves. Unlike glass optical fibers, cutting the desired length of fiber optic unit is available in the field. However, consider that repetitive bending and cutting surfaces affect the light transmission and sensing performance.
 - It has less attenuation of signal than glass optical fiber.
- Weakness**
- Covering materials are used to protect plastic optical fibers as they are vulnerable to environments exposed to high temperatures or various chemicals and solutions.
 - It is available to use a protection tube for cable.

Glass

- Strength**
- It is generally used in environments where there is a risk of corrosion and humidity.
 - Most of the glass optical fibers are very robust, showing stable sensing performance even at high temperatures.
 - Some models are provided for use in vacuum environments.
- Weakness**
- It is vulnerable to repeated or excessive bending, so there is a possibility that the core can be damaged compared to the plastic-type.

■ Bend radius

Standard



Structure Single core

Bend radius R30 or R15

- Features**
- High-efficiency light transmission
 - Long sensing distance

Flexible

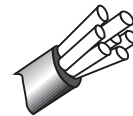


Structure Multi core
(A large number of ultra-fine cores are all surrounded by the cladding)

Bend radius R1 or R2

- Features**
- A small amount of variations in light intensity caused by bending
 - Easy to install in a place with many curves, and neatly arrange the wires

Bending-resistant



Structure Bundle
(Consisted of several independent cores)

Bend radius R5

- Features**
- Suitable for environments with a lot of repetitive bending (robot hand)
 - No damage even installed on the moving part

Temperature

Heat-resistant

- It supports up to 350 °C for high-temperature environments.

Vacuum-resistant

- It supports up to 350 °C for high-temperature and vacuum environments.
- Convergent reflective type: $\leq 350\text{ °C}$
- Through-beam and retroreflective type: $\leq 250\text{ °C}$

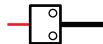
Head type

Threaded and Cylindrical head



- The most common shape in the fiber optic unit, using a bracket or set screw for installation.
- In particular, the threaded type has a screw thread shape such as M6, M4, etc., so easy to install.

Flat head



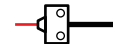
- It is an integrated bracket that combines with the bracket and the fiber optic unit, no need to use an additional mounting bracket.
- The variety of shapes and thinness support no limitations on the space for installation.
- Provides top view, side view, flat view, L-type top view, side + top view

L-shaped and Perpendicular head



- The head or cable direction of the fiber optic unit is at a right angle.
- Minimizes deterioration of curvature that can occur when installing at a direction of the right angle.

Molded plastic head



- The plastic housing makes a relatively economical product and has a square head shape.

SUS head



- The threadlike and sleeve-shaped head enables this unit to be installed in small spaces.
- SUS material has a high resistance to shock.

U-shaped head



- The U-shape head supports sensing distance as a fixed length of its width.
- This unit can be used to detect an edge of an object or a falling object.

Wide area head

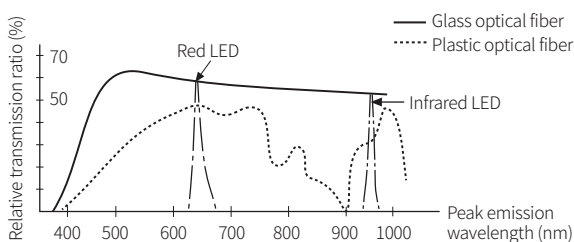


- This unit has a wider width compared to other head types.
- It can be used for a large for the inconstantly moving sensing target.
- The wide sensing area makes it easy to detect falling objects.

Cautions When Selecting Fiber Optic Units

Optical transmission rate

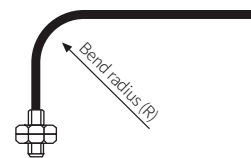
The optical transmission rate is decided by the wavelength, the light source of the amplifier, the material, and the length of the fiber optic unit. The graph below shows the optical transmission rate according to the wavelength, material, and light source.



The range of wavelength showing stable performance is wider for the glass optical fiber than the plastic-type. In general, as the length of the fiber optic unit is getting longer, the light transmission rate is decreasing, and the red LED is more efficient than the infrared light source.

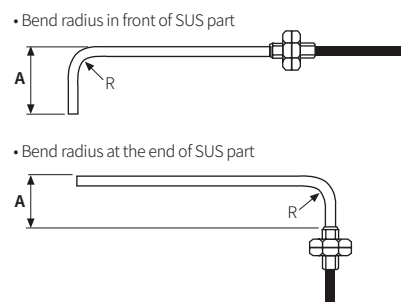
Bend radius

The bend radius of the fiber optic unit means the degree of a curve at which no deterioration in sensing performance occurs. The fiber optic unit can be bent due to the flexibility, but the optical transmission rate may decrease rapidly depending on the degree. Be sure not to bend the cable less than the bend radius for the fiber optic unit.



⚠ The bend radius of SUS type fiber optic unit

If the length of A is less than 10 mm, do not bend the cable.



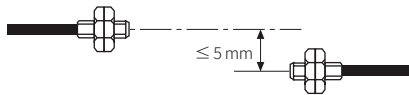
Installation

■ Cautions during installation

- Be sure to install the fiber optic amplifier in a safe place.
- The light emitted from the fiber optic unit spreads to a cone-shaped degree of 60°. The level of received light can be lower when the sensing distance is long due to the diffusion of the light. Install the unit as close as possible to the sensing target.
- Install a shield around the receiving part of the fiber optic unit to block strong light sources (sunlight, spotlight).
- Keep the cables of the fiber optic sensor separately or use a single pipe. If the cables are arranged with the high voltage lines and power lines as the same pipe, it may cause malfunction or failure of the product.

■ Installation

- Refer to each manual of amplifier for For the insertion depth of the fiber optic unit.
- Be sure to install the through-beam type of fiber optic unit that its optical axis is within 5 mm.



- Do not apply excessive force to the hood and cable of the fiber optic unit. It may result in product damage.

Diameter of the hood	Tensile strength of cable
Ø 0.5	≤ 1 kgf
Ø 1.0	≤ 3 kgf

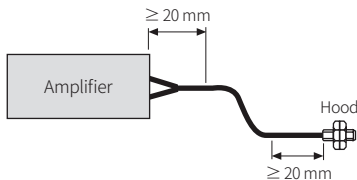
- Fix the threaded head and cylindrical head types of fiber optic units like the table below.

Threaded head type		Cylindrical head type	
Diameter	Tightening Torque	Diameter	Tightening Torque
M3	≤ 3 kgf · cm	≤ M3	≤ 2 kgf · cm
M4	≤ 8 kgf · cm		
M6	≤ 10 kgf · cm		

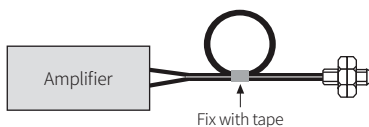
- Fix the hood of the fiber optic unit like the table below.

Proper installation	Improper installation

- The cables near the insertion part of the fiber optic amplifier and the hood of the unit have a high possibility will be broken. Do not bend the cable within the length of 20 mm or more like the figure below.



- After installing the fiber optic unit, keep the remained cable like the figure below. Wind a cable once to reduce vibrations.



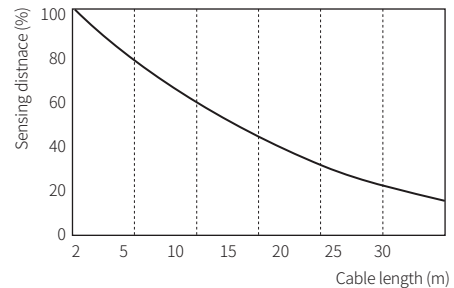
■ Maintenance

- If the sensing surface of the fiber optic unit is contaminated by foreign substances, clean it with a dry cloth. Do not use the organic solvent based on thinner.

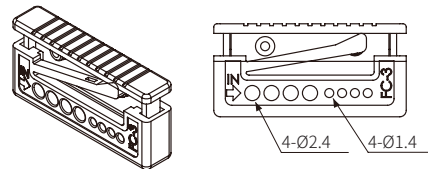
■ Cautions for cutting fiber optic cable

- Use the supplied cutter. Do not cut the cable with a cutting nipper or stationery (the cutter, scissors).
- Use the cable after inserting it into the hole of the cutter and cut it with the desired length. Consider the sensing distance that varies depending on the cable length of the fiber optic unit. Excessive cable extension reduces the sensing distance.

[Ex] Fiber optic unit: FD-620-10, sensing target: non-glossy white paper

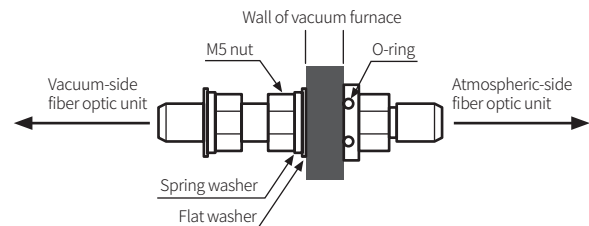


- Cut the cable by pressing the cutter at once to avoid cracking or scratching the surface. The cutting surface can reduce the sensing distance up to 20%.
- Do not reuse the hole of the cutter.



■ Using the fiber optic coupler

- Be sure to mount the fiber optic coupler with the vacuum-resistant fiber and the atmospheric fiber. The coupler transmits light by sealing the vacuum and the atmosphere side.
- The fiber optic coupler uses an O-ring. Be cautious that welding with the wall of the vacuum furnace may blur the glass rod inside.



- Thickness of installation plate: 8 - 10 mm
- Diameter of mounting hole: $\text{Ø} 5.0 + 0.1, -0.1 \text{ mm}$
- Roughness of O-ring contact with surface: 1.6 Ry

APPENDIX

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IP Code (protection against dust and water)	VI

Safety Certification for Product and Component

- For detailed certification information, visit the website of each certification body.
- For the status of certification on our product, visit the Autonics website.

■ CE

- Country: European Union



CE marking is the conformity marking, meaning that it complies with all Directives of the Council of European Union regarding safety, health, environmental, and consumer protection standards.

If a product judged to be a risk to the consumer's health, safety, and environmental protection, is sold in the European market, the CE mark must be affixed. It is an essential certification for entry into the European market.

■ UL Listed

- Country: United States



UL listing is the American standard for safety. It is a non-mandatory standard, but most States mandate this standard. This certification is highly favored by consumers.

UL Listed Mark means the end product meets standards of safety.

■ TR CU

- Country: Eurasian Economic Union



The EAC certification is accredited by five member countries of the Eurasian Economic Union (EAEU): Russia, Kazakhstan, Belarus, Armenia, and Kyrgyzstan.

Regulated products without the EAC mark are prohibited to access the markets of 5 members of EAEU.

- Type of certification
: Certificate of Conformity (CoC),
Declaration of Conformity (DoC)

■ KC

- Country: Republic of Korea



The KC certification mark must be affixed on an imported or domestically manufactured electrical product that is to be distributed or sold in Korea.

Type of certification: safety certification, EMC certification

- Safety certification: Korean Agency for Technology and Standards (KATS) affixes and manages the KC certification mark for electrical appliances, household goods, and children's products by dividing the steps into safety certification / safety confirmation / supplier's declaration of conformity (SODC) according to the different levels of potential danger.
- EMC certification: Manufacture, sale, or import for equipment that may cause harm to the radio environment and broadcasting communication network, or that may cause or receive significant electromagnetic interference, the KC certification mark is issued through electromagnetic compatibility (EMC) testing.

■ S-Mark

- Country: Republic of Korea



The S-Mark is the optional certification system to prevent industrial accidents. Korea Occupational Safety and Health Agency (KOSHA) conducts a comprehensive evaluation for the safety and reliability of product, and the capability of quality control in manufacturing.

Due to non-mandatory, there is no regulation or disadvantage on the uncertified product.

■ UL Recognized

- Country: United States



UL listing is the American standard for safety. It is a non-mandatory standard, but most States mandate this standard. This certification is highly favored by consumers.

UL Recognized Mark means the components intended for use in a complete product or system meet standards of safety.

■ KCs

- Country: Republic of Korea



The Minister of Employment and Labor evaluates the safety of hazardous or dangerous machinery, equipment, facilities, protective devices, and protective equipment based on the 'safety certification standards.' Occupational Safety and Health Agency (Ulsan, in South Korea) certifies safety through comprehensive tests complying with the 'safety certification standards.'

Any person who intends to manufacture, import, or change major structural parts of products subject to safety certification, must obtain this certification.

■ TUV NORD

- Country: Germany



TUV is a leading German private certification body that has been responsible for many testing and certification tasks related to safety in the industry for a long time. It is intended to protect people and property from fire and other accidents. Currently, TUV is conducting tests and inspections on safety and quality in various industries such as machinery, electronics and electricity, automobiles, chemical facilities, nuclear power, and aircraft. It is voluntary standards, and certification is issued complying with various EU Directives and German safety regulations.

■ Metrology Certification

- Country: Russia



Metrology Certification is a certificate for measuring and test equipment. Registration of measuring equipment is currently being revised and implemented following the Russian Federal Law, and is managed and supervised by the measurement authority, which is the subject of the certification. Measurement authorities review and test measuring equipment to be used in the Russian Federation based on the State System of Measurement (SSM), issue certificates, and manage them in the government's online database for users and buyers to browse.

■ CCC

- Country: China



The China Compulsory Certificate system (CCC) is a compulsory mark for products that met Chinese technical standards and are allowed to be imported by the Chinese government. Foreign-imported industrial products are examined through CCC certification process whether they meet safety standards or not. The certified products are distributed and sold with the CCC mark or factory code according to the product. CCC certification is administered by the China Quality Certification Center (CQC).

■ PSE

- Country: Japan



PSE is a compulsory certification administered by the Ministry of Economy, Trade and Industry (METI) and governs by the Electrical Appliances Safety Law in Japan. The purpose is to minimize the occurrence of harm and damage caused by electrical equipment by regulating the manufacture and sale of electrical appliances and bring an engagement of the private sector to ensure the safety of electrical appliances. Manufacture, import, and sell electrical appliances in the Japanese market, the technical standards for those products must be satisfied and the PSE certification mark must be displayed.

■ GOST

- Country: Russia



GOST is national technical standards set by the Euro Asian Council for Standardization, Metrology and Certification (EASC). The abbreviation GOST stands for GOSudarstvennyy STandart, which means State Union Standard in Russian. The current GOST standard includes over 20,000 titles and is widely used in common in the Commonwealth of Independent States (CIS) (12 countries). All countries of the CIS currently adopt and use the GOST standard, but the certificates issued by each country and the subject of the issuing certification body are different, so each country's GOST certificate can be regarded as a different certificate. The national standards of Russia are the GOST R, those of Kazakhstan are GOST K, etc.

■ China RoHS

- Country: China



China RoHS is the Chinese government regulation to control and eliminate the environmental impact of toxic and hazardous substances and elements in electrical/ electronic equipment. China's Measures for the Administration of the Control of Pollution by Electronic Information Products like the EU RoHS Directive have been enacted, and regulate additional hazardous substances compare to EU RoHS. Marking a logo or label for marking information is mandatory. In addition, there is a certification system before selling the product to ensure its conformity by conducting test analysis. Products to be exported to China will be screened prior to customs entry. Customs entry is only permitted for products that meet conformance standards.

Communication Standards

- For detailed information on communication, visit the related association's website.

■ EtherNet/IP

EtherNet/IP™

EtherNet/IP is an industrial network protocol that conforms Common Industrial Protocol to standard Internet. It is one of the leading industrial protocols in the United States and is widely used in a variety of industries, including factories.

EtherNet/IP and CIP technologies are managed by ODVA, Inc., a global trade and standards development organization founded in 1995 with over 300 corporate members.

EtherNet/IP uses the most widely adopted Ethernet standards - Internet Protocol and IEEE 802.3 - to define functions for the transport, network, data link, and physical layer. CIP uses object-oriented design to provide EtherNet/IP with services and device profiles needed for real-time control and to promote consistent implementation of automation functions across a diverse ecosystem of products.

■ DeviceNet

DeviceNet

DeviceNet is a digital multidrop network to interconnect industrial controllers and I/O devices. DeviceNet provides users a cost-effective network for distribution at no cost, deploys and manages simple devices across the architecture.

DeviceNet uses CAN (Controller Area Network), a network technology used in automobile vehicles, for its data link layer, and this network is used in almost all industries. DeviceNet is approved by CENELEC for its official standard and is also used as a global standard.

■ ProfiNet



PROFINET, designated and announced by PI (PROFIBUS & PROFINET), is the open standard for industrial Ethernet in automation technology. It provides solutions for process automation, factory automation and motion control. It enables the integration of existing fieldbus systems such as PROFIBUS, Interbus and DeviceNet into an open Ethernet-based network. PROFINET, the protocol for communication, configuration and diagnosis in the network, uses Ethernet standard as well as TCP, UDP, IP. It achieves fast and safe data exchange, enabling the concepts of innovative machine and plant. Thanks to its flexibility and openness, PROFINET offers the users a freedom in building machine and plant architectures and significantly increases plant availability by optimal use of resources available to users.

■ CC-Link



CC-Link is the open field network and the global standard with SEMI certification. As high-speed field network, CC-Link can process both control data and information data at the same time. With a high communication speed of 10 Mbps, it supports a transmission distance of 100 meters and connects to 64 stations.

It achieved high-speed response of up to 10 Mbps, guaranteeing punctuality. With CC-Link, complex production lines can be simplified and built at low cost. There are advantages of reducing the cost of wiring components, shortening the wiring construction period, and improving maintainability.

CLPA provides a memory map profile that allocates data for each product type. CC-Link compatible products can be developed based on this profile, and users can use the same program for connection and control even if existing product is replaced to other vendors' one.

■ EtherCAT



EtherCAT (Ethernet for Control Automation Technology) is an Ethernet-based fieldbus system developed by Beckhoff Automation. After releasing the technology from ETG (EtherCAT Technology Group) in 2003, it is standardized in IEC 61158 since 2007. It is a communication method that uses the frame according to IEEE 802.3 and physical layer and is an Ethernet protocol-based automation software that requires low jitter, short cycle time, and reduced hardware cost.

EtherCAT supports almost all topologies which have the advantage of flexibility and user-friendly. Due to the high-speed network, EtherCAT is suitable for applications requiring simultaneous operation.

■ HART



HART is the global standard for digital information communication via analog wires between smart devices and control or monitoring systems.

It is the duplex communication protocol and supports various analog I/O modules with HART connection. It sends and receives digital information through 4-20 mA current. It provides a reliable and long-term solution for plant operators who seek the benefits of smart devices with digital communication while maintaining existing facilities for analog instrumentation and plant wiring. Many sites that have applied the HART protocol can access to many digital process, maintenance and diagnostic information.

■ ProfiBus



ProfiBus is the open standard commonly used for process automation in the production site.

- Configuration
 - Master: It determines data traffic, transmits messages, and performs as role of Active Station.
 - Slave: It means I/O devices, valves, motor drivers, transmitters, etc. Slave receives a message and transmits the message depending on the Master's request.
- Up to 124 slaves and 3 masters can be connected to one communication line, and the communication method uses the half duplex method. Each device is connected to the bus in parallel and each device has its network address, so the installation location is irrelevant. Each device can be moved or removed during the communication.





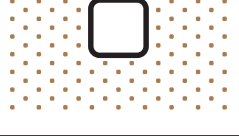
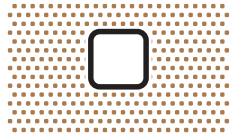
IP Code (protection against dust and water)

IEC (International Electro-technical Commission) Standard


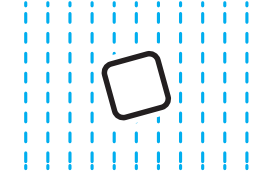

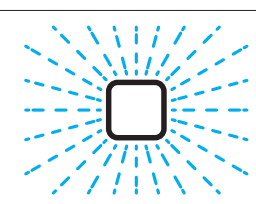
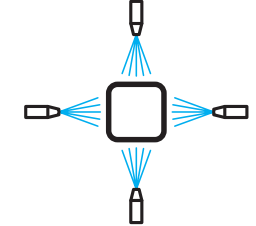
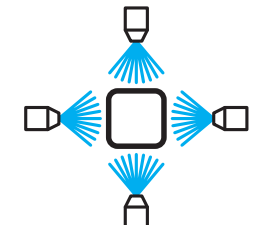
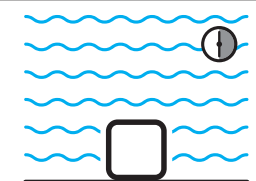
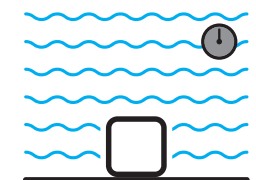
The IP Codes are defined in the IEC standard 60529.



1 Degree of protection against dust (protected from solid foreign objects)

Numeral	Degree of protection	Degree of protection
0	Non-protected	
1		Protection against the objects with 50 mm diameter or more. The object probe, sphere of 50 mm diameter, must not fully penetrate. - Test means : Rigid sphere without handle or guard. - Test force: 50 N ± 10%
2		Protection against the objects with 12.5 mm diameter or more. The object probe, sphere of 12.5 mm diameter, must not fully penetrate. - Test means : Rigid sphere without handle or guard. - Test force: 30 N ± 10%
3		Protection against the objects with 2.5 mm diameter or more. The object probe, sphere of 2.5 mm diameter, must not fully penetrate. - Test means : Rigid steel rod with edges free from burrs. - Test force: 3 N ± 10%
4		Protection against the objects with 1 mm diameter or more. The object probe, sphere of 1 mm diameter, must not fully penetrate. - Test means : Rigid steel rod with edges free from burrs. - Test force: 1 N ± 10%
5		Protection against the dust with or without pressure. - Dust-protected enclosures allow a limited quantity of dust to penetrate; complete protection against contact. Test duration: 8 hours Dust (the talcum powder) : It must be able to pass a square-meshed sieve that its nominal wire with 50 µm diameter; the nominal width of a gap between wires 75 µm. The amount of talcum powder: 2 kg/m ³
6		Protection against the dust under pressure. - Dust-tight enclosures do not allow any dust to penetrate. Test duration : 2 hours (a volume of dust: 40 to 60 / hour) 8 hours (a volume of dust: less than 40 / hour) Depression : Less than 2 kPa (20 mbar) on the manometer. Dust (the talcum powder) : It must be able to pass a square-meshed sieve that its nominal wire with 50 µm diameter; the nominal width of a gap between wires 75 µm. The amount of talcum powder: 2 kg/m ³

2 Degree of protection against ingress of water (protected from liquids)

Numeral	Degree of protection	Degree of protection
0	Non-protected	
1		Protection against vertically falling water drops. Water drops flow over the whole area of four sides on a fixed and tilting enclosure. - Test duration : 10 min (2.5 min in each of four sides)
2		Protection against vertically falling water drops when the enclosure is tilted up to 15° from its normal position. Uniform flow of water drops over the whole area of the enclosure. - A rotation speed of turntable: 1r / min - Test duration: 10 min
3		Protection against spraying water at an angle up to 60° on either side of the vertical. The oscillating tube has spray holes over an arc of 60° either side of the center point. It sprinkles through an angle of 120° and 60° on either side of vertical. Then, the enclosure is turned through a horizontal angle of 90°, and continue the test for 5 min. - Test duration : 10 min (5 min in each of sides) - Mean flow rate per hole: 0.07 L/min
4		Protection against splashing water from any direction. - No harmful effects on the product. The oscillating semicircle tube with spray holes sprinkles through an angle of 360°. - Test duration: 10 min - Mean flow rate per hole: 0.07 L/min
5 ⁰¹⁾		Protection against projecting water in jets from any direction. - No harmful effects on the product. Spraying a stream of water from the test nozzle (internal diameter: Ø 6.3 mm) at all directions. - Test duration: 3 min - Distance from nozzle to enclosure surface : 2.5 to 3 m - Delivery rate: 12.5 L/min ± 5%
6 ⁰¹⁾		Protection against powerfully projecting water in jets from any direction. - The product is hermetically sealed. Spraying a stream of water from the test nozzle (internal diameter: Ø 12.5 mm) at all directions. - Test duration: 3 min - Distance from nozzle to enclosure surface : 2.5 to 3 m - Delivery rate: 100 L/min ± 5%
7 ⁰²⁾		Protection against temporary immersion in water under defined conditions of pressure and time. - The product is hermetically sealed. Immersion in water under defined conditions - Test duration: 30 min - Water level: 1 m
8 ⁰²⁾		Complete protection against continuous immersion in water. - The product is hermetically sealed. Immersion in water under defined conditions. - Test duration: more than 8 hours - Water level: 10 m

01) The degree of protection against spraying does not guarantee the effects of immersion.

02) The degree of protection against immersion does not guarantee the effects of spray.

■ DIN (Deutsche Industrie Normen) Standard

The DIN standard is defined in the DIN 40050-9.

IP 1 2

① Degree of protection against dust (protected from solid foreign objects)

Same as IEC standard

② Degree of protection against ingress of water (under high temperature and high pressure)

Letters	Degree of protection	
9K	Water resistance under high temperature and high pressure	Protection against high-temperature vapor and high-pressure water at all directions. - No harmful effects on the product.

■ JEM (Japan Electrical Manufacturers' Association) Standard

The JEM standard is defined in the JEM 1030.

IP 1 2 3

① Degree of protection against dust (protected from solid foreign objects)

Same as IEC standard

② Degree of protection against ingress of water (protected from liquids)

Same as IEC standard

③ Degree of oil proof / oil resistance

Letters	Degree of protection	
F	Oil proof type	Protection against oil drop and oil powder in all directions - Even if oil penetrates in the product, it operates normally.
G	Oil resistant type	Protection against oil drop and oil powder in all directions - Special coating prevents penetration of oil into the product.

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Dimensions or specifications on this manual are subject to change and some models may be discontinued without notice.