

Hybrid Level Gauge

HC-10

Installation & Operation Manual

TOKYO
KEIKI







Before you read this manual

Please read this manual carefully and follow directions before installing and operating the device. TOKYO KEIKI INC. is not at all liable for an injury and/or a damage resulting from misuse of this device by the user that is contrary to these cautionary notes.

This manual contains important information for using our level gauge safely and correctly, as well as preventing potential risks and damages that may occur when using the device. Read the explanations below carefully and familiarize yourself with the symbols before reading the manual.

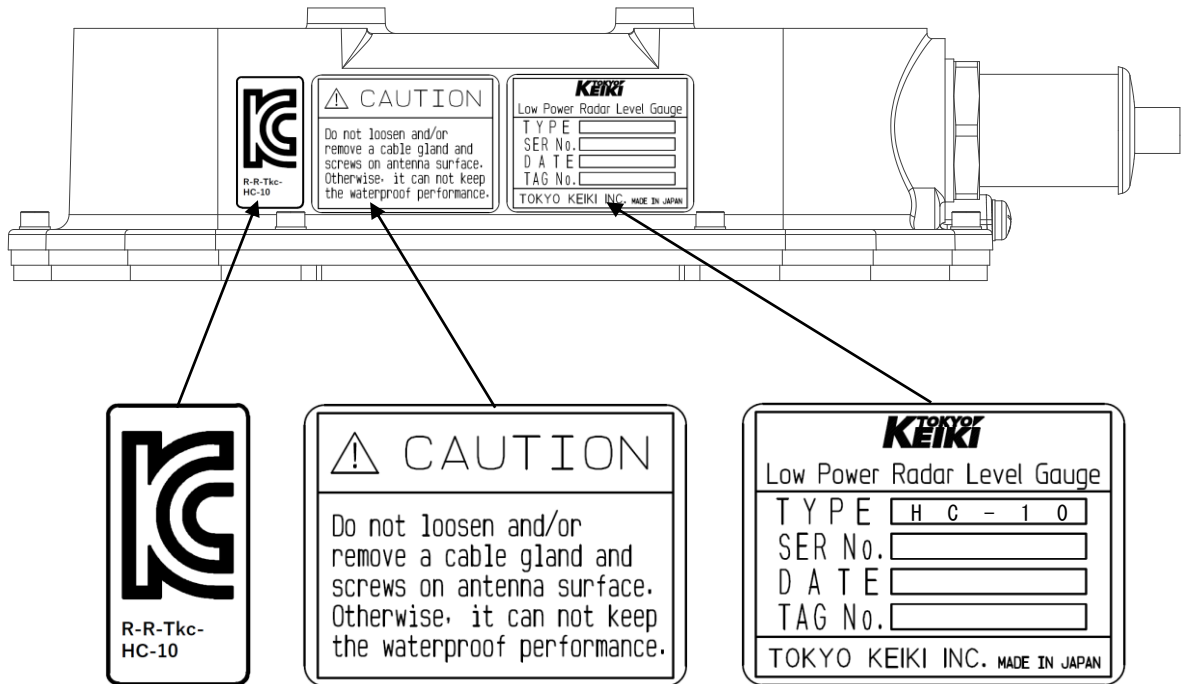
Safety symbols

The following are the meanings of the safety indications used in this manual and on the device.

 DANGER	Indicates that incorrect usage may result directly in <u>death or serious injury</u> to the operator.
 WARNING	Indicates that incorrect usage may result in <u>death or serious injury</u> to the operator.
 CAUTION	Indicates that incorrect usage may result in <u>injury to the operator or damage to the equipment</u> .
	Indicates referring to information for usage of functions or features. (Marked on the device)
Note	Indicates attention to handling information regarding functions or features.
	Indicates the protective conductor terminal.
	Indicates the ground terminal. (functional earth terminal)

Label

Important information is written on the label of a transmitter. Please check the information before using it.



Introduction

Thank you for selecting our Hybrid Level Gauge HC-10. This manual includes explanations regarding HC-10. Read this manual carefully before operation to ensure an adequate understanding of the device.

Proper use of the Operation Manual

The following points must be observed:

1. Ensure that the manual is supplied to the operator of the device. The representative or dealer of this device must provide this manual to the user who will actually operate the device.
2. Carefully read the manual. The contents of this manual are very important and should be read completely.
3. Store the manual in a safe and accessible location. The manual is essential for appropriate operation of the device. The storage location and person in charge should be determined after careful consideration.
4. If the manual is lost, please contact the representative. A new manual is available for purchase.
5. If any labels on this device are damaged, please contact our sales office.
6. Reprinting, transmitting or reproducing of this manual is prohibited.

Precautions regarding the Manual

1. This manual was written in accordance with the standard specifications of original device. In case of discrepancies between written specifications and approved drawings, the drawings should be given precedence.
2. This manual details the operation, function and performance of the device and does not guarantee the customer's specific application.
3. The contents of this manual may be subject to change without notice.
4. We have written thoroughly about the contents of this manual, but if you find any mistakes or omissions regarding the contents, please contact us or the representative you purchased.
5. Any changes to the specifications, structures or parts that do not affect functionality or performance may not be revised each time.
6. The company name and product name used in this manual are trademarks of each company. Also, TM or R marks are not shown in the contents or figures.

Prohibitions and Precautions for Safety

For your safety, please observe the following.

WARNING

- Please observe the safety instructions in this manual. We cannot guarantee the safety if the device is handled contrary to the instructions.
- Modification of the device is strictly prohibited. We are not responsible for any damages or defects caused by the remodeling.

CAUTION

When carrying this device, be careful not to be injured by falling.

CAUTION

This device is not an explosion proof specification. Please refrain from using it in dangerous places.

Restrictions and Precautions necessary to maintain the device

The following must be observed in order to maintain the device.



CAUTION

- Do not drop or bump the unit and the transducer.
- Do not use the unit in environmental conditions (ambient temperature, ambient humidity) other than those prescribed in this manual.
- Do not use in environments where the pressure receiving part and the antenna surface of microwave transmitter are frozen.
- Do not use the unit with a power supply other than the one prescribed in this manual.
- Do not use damaged or worn-out cables (power cables, coaxial cables, signal cables).
- Do not loosen or disassemble the screw of cable ground of microwave transmitter. Waterproofing will be lost.
- Do not touch the pressure receiving part. Due to scratches and deformations, the prescribed performance will not be obtained.
- Do not attempt to modify or disassemble the device. Contact the manufacturer in the event of a malfunction.
- Please observe the following regarding equipment transportation.
 - a) Observe the temperature range of the specifications when transporting.
 - b) Ship it in packaging condition.
- Please observe the following regarding device storage.
 - a) Observe the temperature range of the specification when storing.
 - b) Avoid direct sunlight.
 - c) Avoid vibrations or shocks.
 - d) Avoid places where corrosive gases are present.
 - e) Avoid places with high humidity.

Please observe all of the following. If you do not observe, you can output incorrect measurement values.



CAUTION

- Observe the site requirements described in this manual.
- Use within the specified power and voltage, ambient temperature and humidity in the specifications.
- Do not cause vibration or shock to the device.
- Place the main unit, transducer and cable in a location without noise interference. It may cause malfunction.
- If the signal level is not detected or abnormal measurement is detected, an alarm is output. In this case, take appropriate action.
- Be sure to use the instructions in the manual when changing settings on the main unit. Incorrect settings will result in poor performance or incorrect measurement values (Output signals).



CAUTION

This equipment has been evaluated for conformity in business environments and may cause radio interference when used in home environments.

Precautions for use

Before using it, please check the device, specifications (including options) and defects.

(6: Blank)

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Chapter 1. Configuration

1.1 Device Overview

This device is a combination of a level gauge that uses the propagation time of microwaves to measure the distance from the antenna to the liquid surface (Radar Level Gauge) and a level gauge that uses the measurement of liquid pressure to measure the distance from the liquid surface to the pressure receiving part (Pressure Level Gauge). The level measurement method switches automatically depending on the liquid level, with radar level measurement performed when the Radar Level Gauge and the liquid surface are far apart, and level measurement by Pressure Level Gauge when the Radar Level Gauge is submerged. In general, by installing a Pressure Level Gauge in a way that it does not come into contact with the liquid, it is possible to minimize the negative effects on measurement such as adhesion or clogging of the pressure sensor.

Pressure Level Gauge measures liquid level from absolute pressure. This means that it is not affected by errors in measurement caused by clogging or leakage in the atmospheric pressure compensation tube. Furthermore, our device is equipped with a function that automatically compares and calibrates the measurement values obtained by Pressure Level Gauge with those obtained by a Radar Level Gauge, which helps to suppress errors caused by atmospheric pressure fluctuations.

1.2 Device Configuration

The configuration of device is shown in Fig. 1-1. The device is divided into a transmitter that operates as a Radar Level Gauge and a pressure sensor that operates as a Pressure Level Gauge, and they are connected to each other via a sensor cable. A power cable extends from the transmitter to supply power to the device and output measurement values through it.

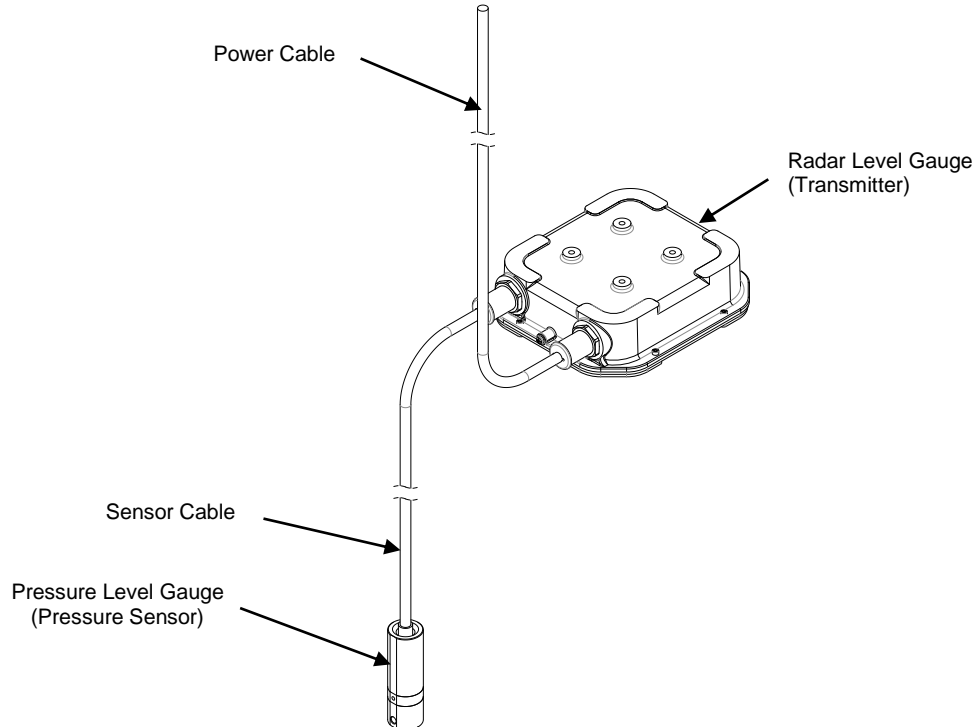


Fig. 1-1 Device Configuration

1.3 System Configuration

By connecting a computer with a HART modem, the device can be adjusted using configuration software (optional). Power can be supplied from a power supply unit, PLC, DCS, etc. An example of a system configuration is shown in Fig. 1-2.

For details on how to adjust the device, refer to the configuration software manual.

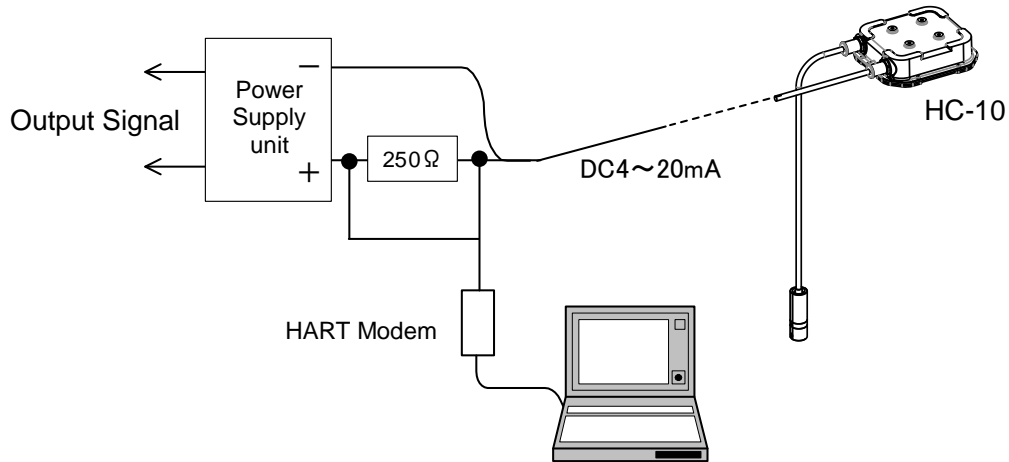


Fig. 1-2 System Configuration

Chapter 2. Installation

2.1 Caution

⚠ Caution

If the installation method or location is not appropriate, it may be measured incorrectly. Please read this manual carefully before installing it.

2.1.1 Measurement Range of Radar Level Gauge

This device is a combination of Radar Level Gauge and Pressure Level Gauge. As shown in Fig. 2-1, the measurement range is 10 meters down from the reference point, and 8 meters up from the reference point. Make sure that the liquid surface is within the measurement range of Radar Level Gauge.

2.1.2 Installation Environment

This device is intended for use in sewerage. Please do not use it outdoors as it may cause deterioration due to ultraviolet rays.

2.2 Installation Location

2.2.1 Installation of Radar Level Gauge

When installing a Radar Level Gauge, please observe the following.

- Please install the device in a place where there are no reflectors that cause disturbance, microwave interference, or pipes that cause obstruction in the beam area. For beam areas, refer to the range shown in chapter 2.3
- Place the mounting fixture horizontally to ensure proper microwave irradiation to the liquid level. (Within $\pm 1^\circ$)
- To prevent deposit from sticking, install the device so that it does not come into contact with liquid at normal water level.

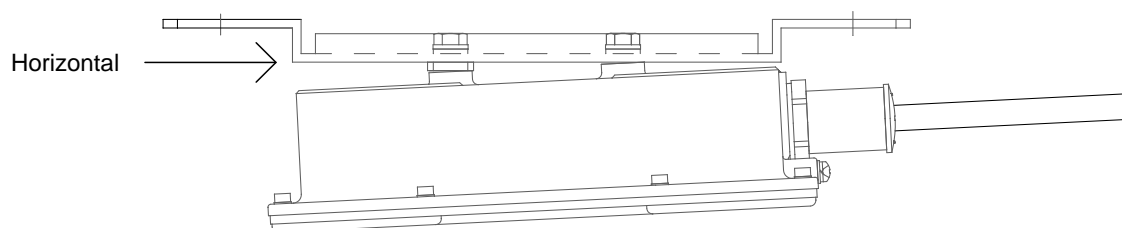


Fig. 2-1 Installation location of Radar Level Gauge

2.2.2 Installation of Pressure Level Gauge

When installing a Pressure Level Gauge, observe the following.

- In order to prevent deposit from sticking and clogging to the pressure receiving part, please install the Pressure Level Gauge so that it does not come into contact with liquid.
- Install the Pressure Level Gauge at 0.5-1.0m below the radiation face of the Radar Level Gauge as shown in Fig. 2-3.
- Install the Pressure Level Gauge with the pressure receiving part facing downward as shown in Fig. 2-4.
- Please install the Pressure Level Gauge using a mounting fixture (Option) to prevent it from flowing into the water flow. An example of installation is shown in Fig. 2-5.
- Install the Pressure Level Gauge so that it does not fall within the beam area of Radar Level Gauge.

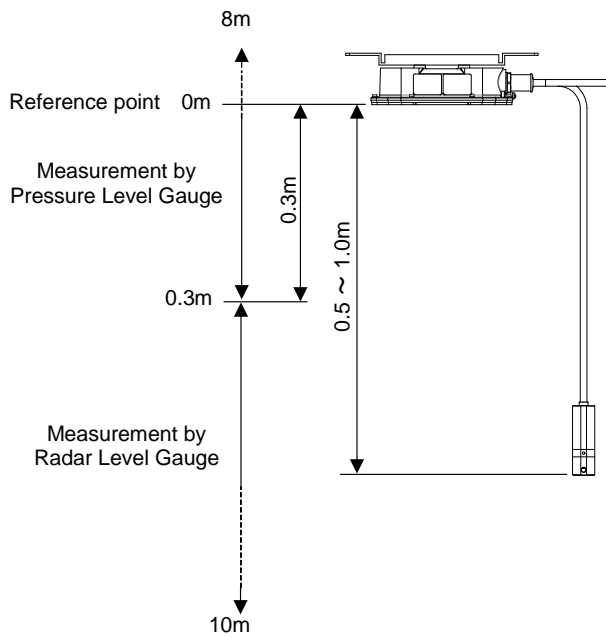


Fig. 2-2 Measurement range

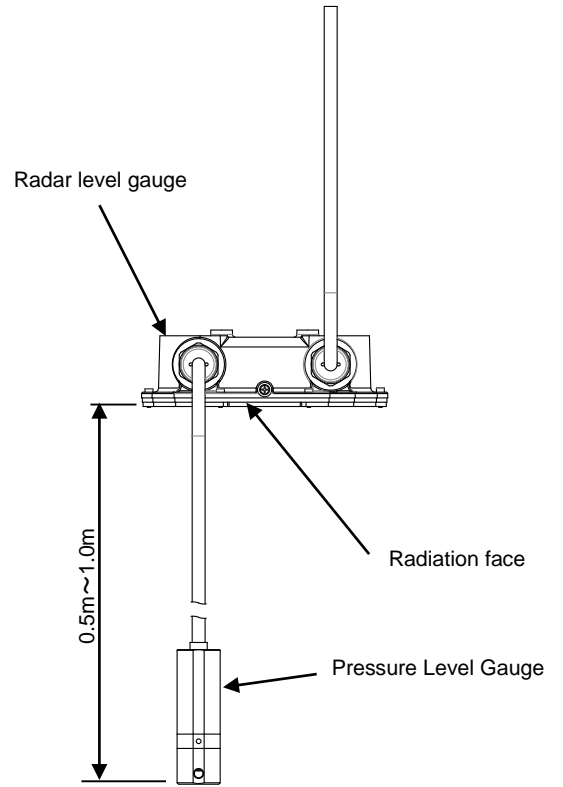


Fig. 2-3 Installation location of Radar Level Gauge

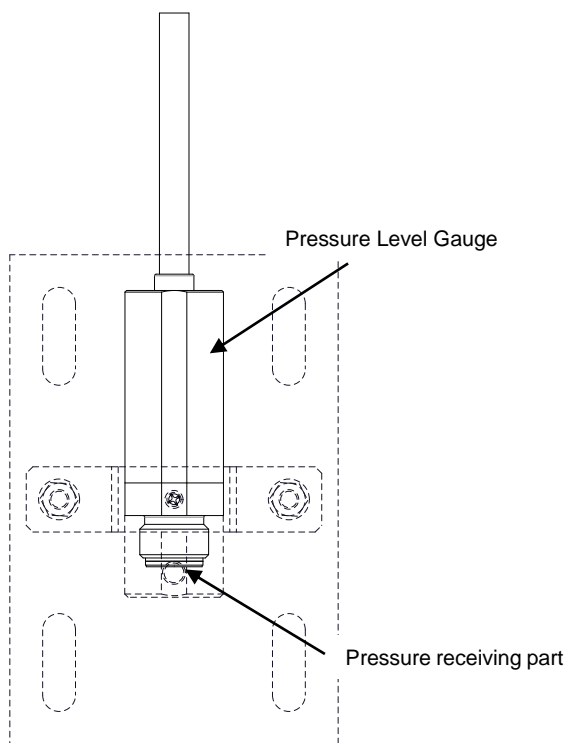


Fig. 2-4 Installation direction of Pressure Level Gauge

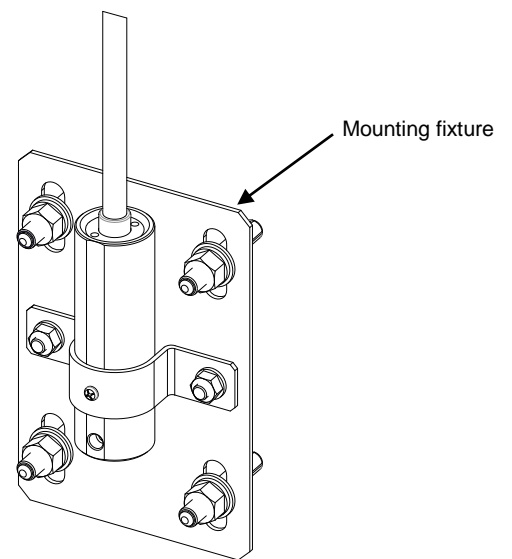


Fig. 2-5 Example of installing a Pressure Level Gauge (Option: Mounting Fixture)

2.3 Beam Area

Beam area of this device has different beam angles depending on the direction shown in Fig. 2-6. When installing, use the range shown in List 2-1 and Fig. 2-7 as a guide for beam area.

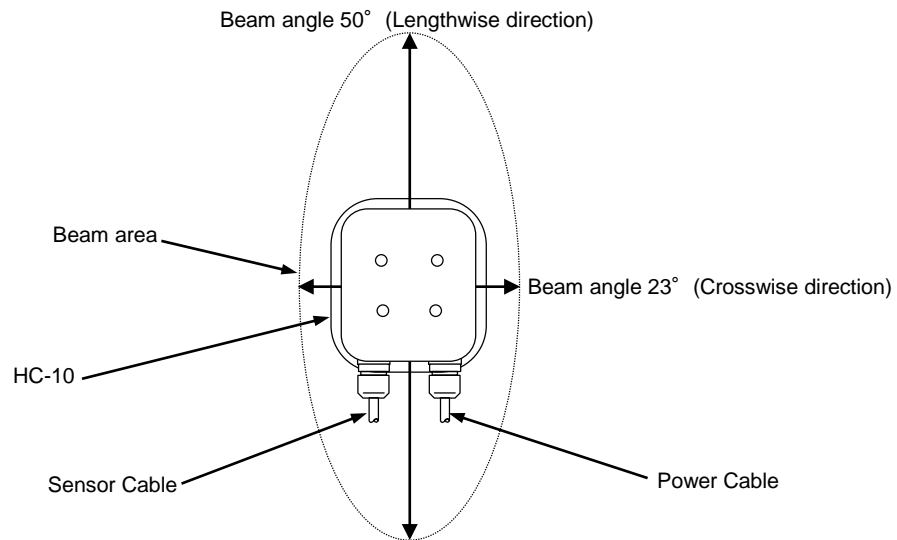


Fig. 2-6 Beam angle

List 2-1 Beam angle & Beam area

Distance (m)	Beam area (m)	
	Lengthwise direction (Cable direction) Beam angle* = 50°	Crosswise direction Beam angle* = 23°
2	1.9	0.8
4	3.7	1.6
6	5.5	2.4
8	7.5	3.3
10	9.3	4.1

* -3dB Half-power beam angle

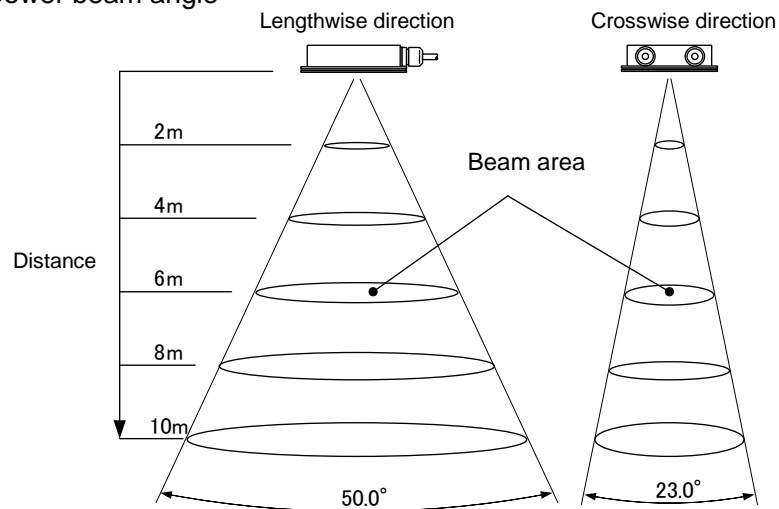


Fig. 2-7 Beam area

2.4 Effect on the Measurement Range

In addition to reflectors in the beam area, interference, obstacles, there are other factors that affect the measurement range. These are listed below.

- Compared to calm fluid surfaces, measurement range of turbulent surfaces is reduced due to poorer reflection.
- Deposit buildup on the antenna, foaming on liquid surfaces, powder granules in air suspension and other interior tank conditions may affect measurement range and performance.
- Measurable range may be varied when area of target fluid surface is smaller than radiated beam area.

2.5 Recommended Installation Example

Following installation examples are recommended.

2.5.1 Installation for Waterway

When using HC-10 in a waterway, install the device with lengthwise direction of transmitter head to be same direction of flow direction as below. Also, please install the cable outlet on the downstream side. Also please keep the required free space from the wall.

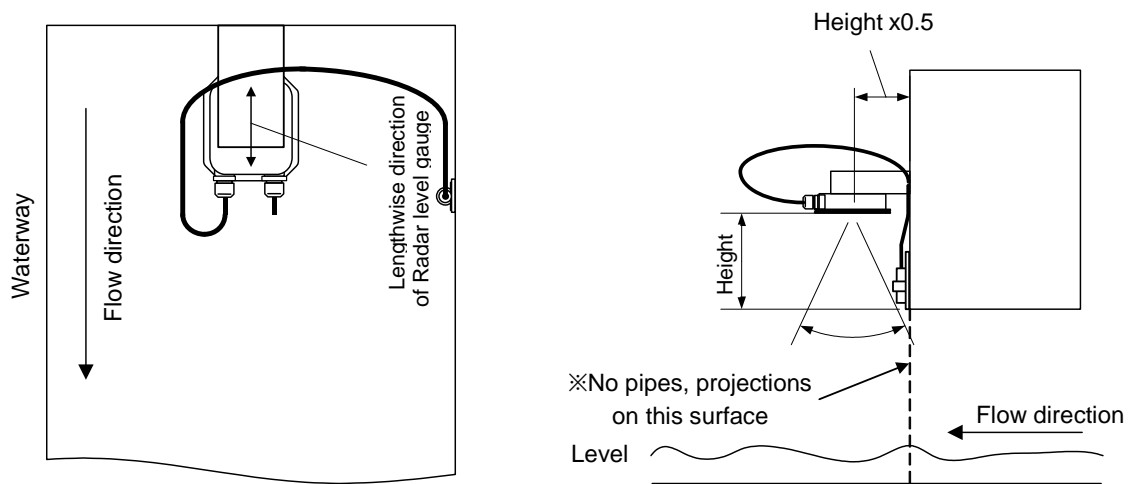


Fig. 2-8 Example of wall side mounting installation

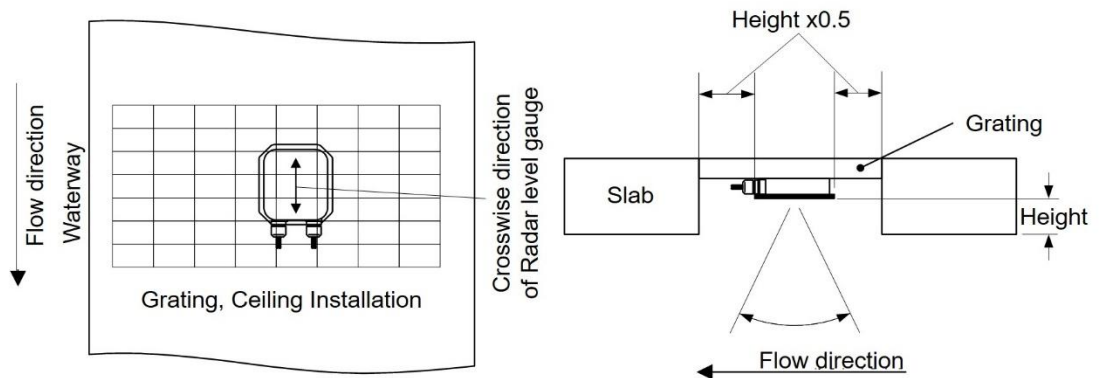


Fig. 2-9 Example of top roof mounting installation below grating cover

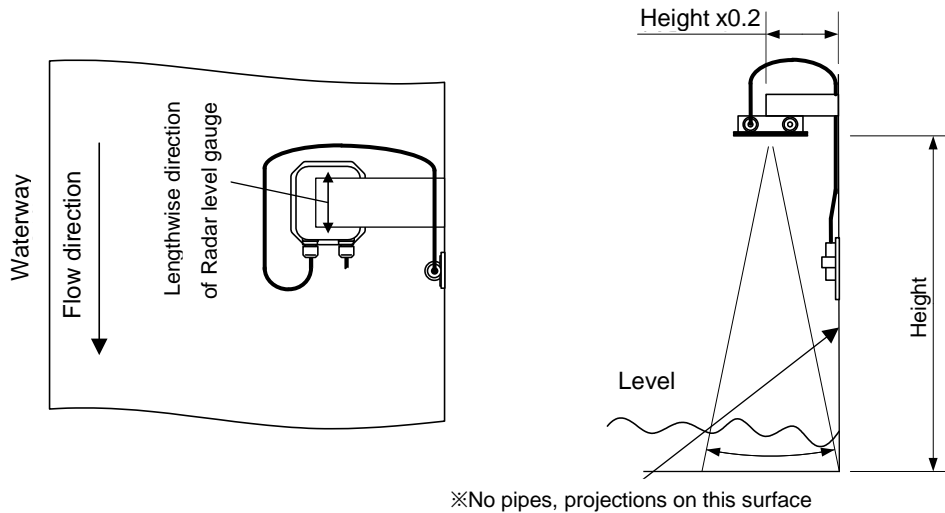


Fig. 2-10 Example of wall side mounting installation for Inlet water level measurement

2.5.2 Installation for Storage Tank

When installing HC-10 on the ceiling of a tank, please avoid installing the device at the center of tank, because the reflection of side beam will affect stable measurement.

Besides, please set the lengthwise direction of HC-10 install to be parallel against the nearest tank wall. In such case, required free space to the nearest tank wall will be more than [measuring range x 0.2].

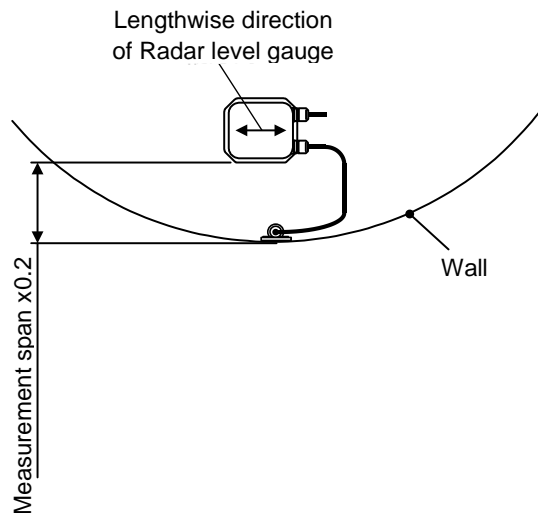


Fig. 2-11 Example of Tank Installation

※ Any obstructions, which set as parallel to fluid surface in, the radiated beam area may contain big disturbance noise. In such case, reflection plate will be one of the solutions to reduce its reflection.

2.5.3 Installation in Manhole

When installing inside a manhole, please pay attention to the flow direction of the waterway and the distance from the wall according to 2.5.1 Installation for Waterway.

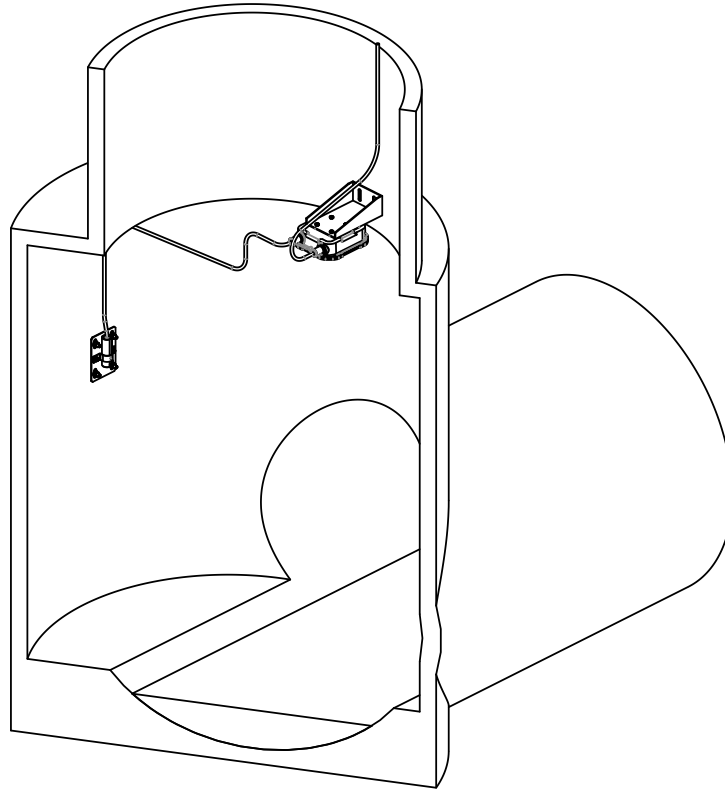


Fig. 2-12 Installation in Manhole

Chapter 3. Electrical Installation

3.1 Wiring Connection

(1) Transmitter Side

⚠ Caution

- Do not remove cable glands or any screws that attached with main unit. In case of removal it, main unit can not satisfy performance of protection class.

Any cable work must be done at the end side of cable, not at the cable entry of the main unit.

If cable extension is required, please use chemical binder at the end of cable to keep water protection class.

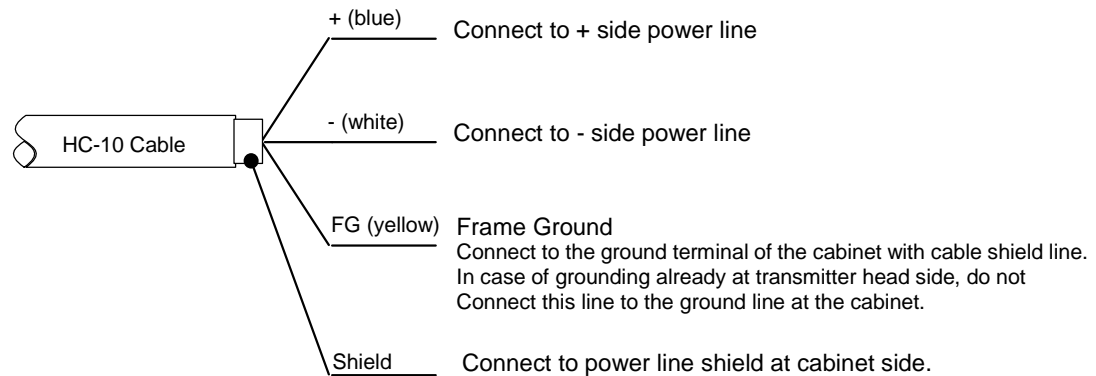


Fig. 3-1 Wiring Connection

- The grounding method varies depending on the installation conditions of the equipment. Please refer to Section 3.5 for details.

(2) Connection for Commissioning Software

Sample connection for commissioning software through PC is indicated as below Fig.3-3. Any analog recorder can be connected instead of HART modem.

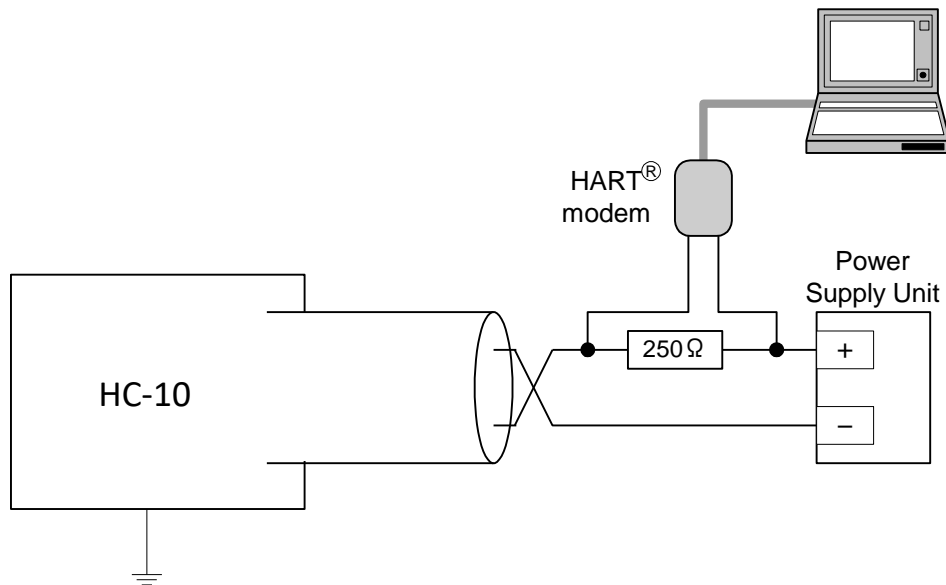


Fig. 3-2 Connection to Commissioning Software

3.2 Cables

Please use the cable attached to the product. When extending the cable, use the following cables.

Requirement	Use shielded twisted cable 2-Core or 3 Core. Cross-sectional area of conductor is 0.2 ...2.5mm ² . (AWG24 ... 14) Recommended cable; EM-KNEE-SB/F (1.25sq x 3C, OD 9mm)
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3.3 Load

Allowable load resistance is shown in Figure 3-3.

The maximum load resistance value at the maximum supply voltage of this equipment is indicated by ① in Figure 3-3.

(Example: The maximum supply voltage for this equipment is 36 VDC, so the maximum load resistance is 909Ω.)

The resistor typically used for HART modem is 250Ω ② in Fig. 3-3 shows the voltage (DC21.5V) at 250Ω. In addition, ③ in Figure 3-3 shows a load resistance value of 360Ω at DC24V.

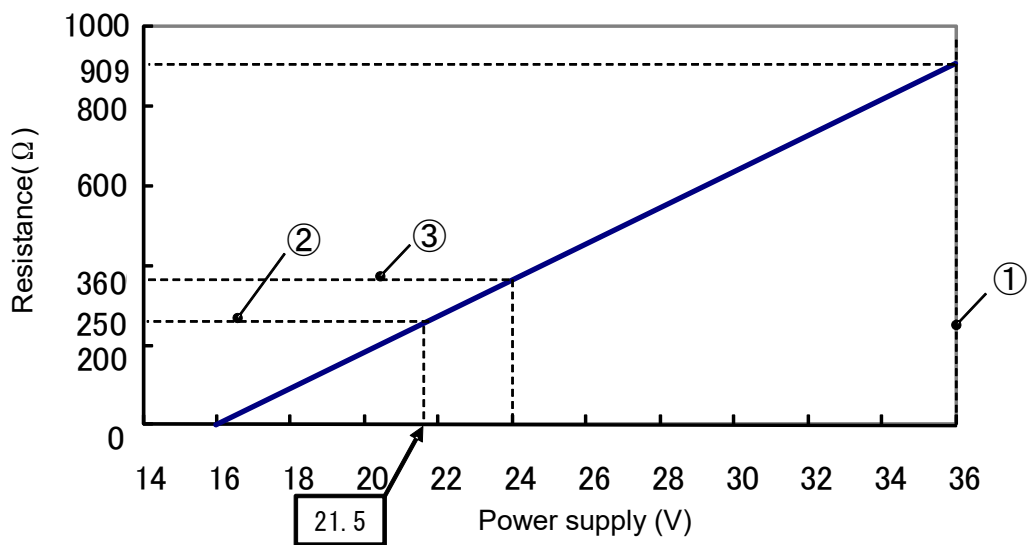


Fig. 3-3 Load resistance

Minimum load for HART®	250Ω
Maximum load	360Ω (at DC24V)

3.4 Power Supply

Requirement	16...36VDC
Current capacity	22mA

3.5 Grounding

The terminal must be connected to earth ground prior to connection to any other equipment. The grounding resister should be less than 100 ohm.

(1) Example of Connecting only with Attached Standard Cable or Extended with 3-Core Shielded Cable

Please connect with shield & FG line to grounding line at power source side as below.

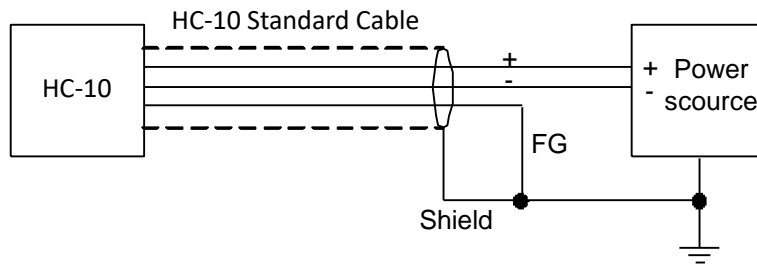


Fig. 3-4 Example of installation 1

(2) Extended 2-Core Cable with Shield

Please connect shield line to FG line at connection part, then grounding at power source side as below.

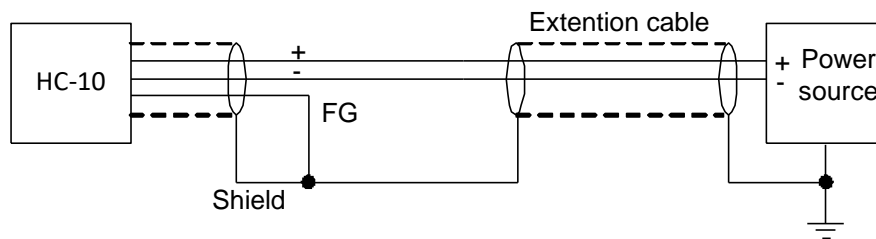


Fig. 3-5 Example of installation 2

(3) With Lightning Arrester

Please connect only FG line to arrester grounding line.

The shield of extension line should be taken at ground line of power source side as below.

The lightning arrester should be installed nearby HC-10 transmitter head.

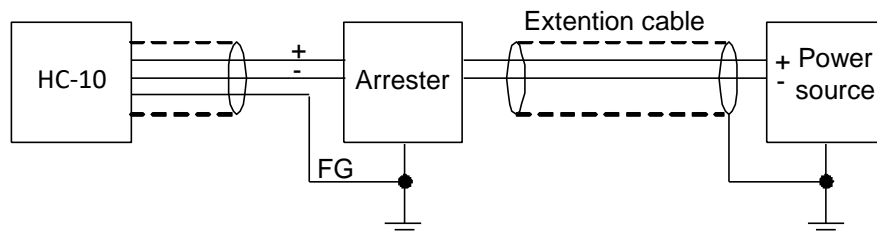


Fig. 3-6 Example of installation 3

(4) When Base of the Mounting Position made by Metal Parts which connected with the Grounding Line already.

Please connect the grounding terminal nearby cable entry to the ground.

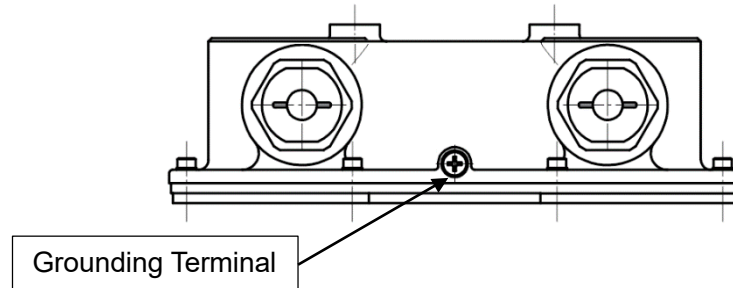


Fig. 3-7 Grounding terminal position

Do not use FG line, only with cable shield connects to grounding line as below.

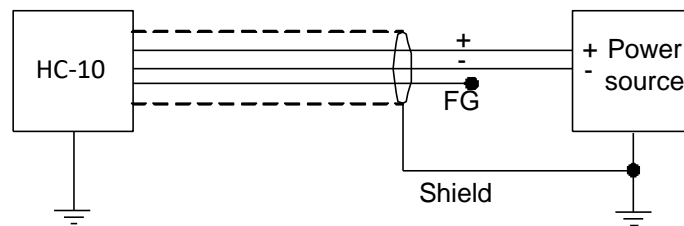


Fig. 3-8 Example of installation 4

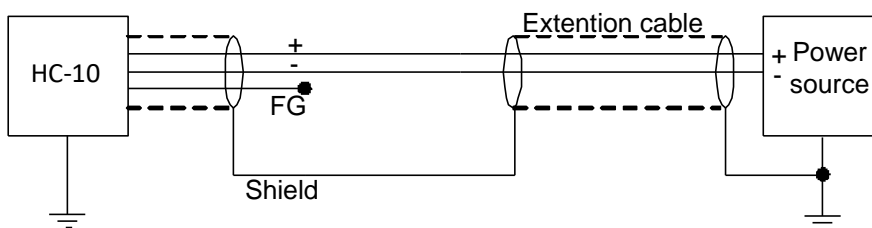


Fig. 3-9 Example of installation 5

Chapter 4. Specifications

4.1 Main Unit Specifications

4-1 Main Specifications

Purpose	Level Measurement	
Measurement Principle	Microwave Pulse Echo/Pressure Sensor Combined	
Microwave	Frequency	5.8 GHz
	Transmitting Power	Less than 35 μ V/m @3m
Antenna Type	Micro-Strip Antenna	
Half Power Beam Width	Lengthwise:50° Crosswise:23°	
Media	Target Media	Water
	Dielectric Constant	$\epsilon_r \geq 10$
Applicable Waterway	Over 200R (ϕ 400)	
Measurement Range	Radar Level: 10m under the reference point Pressure Level: 8m over the reference point	
Measurement Cycle time	1 sec	
Supply Voltage	DC 16V ~ 36V (2 wire)	
Allowable Resistance	Less than 360 Ω (24V)	
Analog Output	Current Range	DC 4mA ~ 20mA
	Resolution	0.4 μ A
	Alarm Output	Hold/Low(3.9mA)/High(22mA)
	Temperature Drift ^{*1}	$\pm 0.05\%$ FS/10K and less than 0.5%FS p-p
Digital Output	Communication Protocol	HART Communication ^{*3}
	Resolution	1mm
Averaging Time	1 ~ 120 sec	
Surge Immunity	IEC61000-4-5 (2 nd edition) Level-4 (COM 4kV / DIF 2kV)	
EMC Directive	EN 61000-4-4	
Ambient Temperature	-20°C ~ +70°C (In not frozen water when pressure sensor is under water)	
Storage and Transport Temperature	-40°C ~ +80°C	
Vibration Resistance	9.8m/s ² (1G) @9Hz~200Hz	
Pressure Resistance	0.1MPa(Under water 10m)	
Material	Housing	SCS14
	Flat Radar Antenna	Rigid PVC heat-resistant grade
	Pressure Sensor	SUS316L / Epoxy
	Cable Grand	SUS316 / 66Nylon
	Power Cable Cover	PE
Sensor Cable Cover	PVC	
IP rating	IEC 60529 (JIS C0920) IP68 (Under water 10m / 24h)	
Power Cable	3 Core Cable with Shield(10 m)	
Sensor Cable	3 Core Cable with Shield(2 m)	
Dimension	192(W) \times 172(L) \times 54(H) ^{*2}	
Weight	Approx. 4.5kg	

*1 The actual output is also affected by the temperature dependence of the sensor.

*2 Dimensions excluding cable gland, power cable, sensor cable and pressure sensor.

*3 Not compatible with HART standards.

4-2 Sensor Specifications

Microwave Pulse Radar	
Measurement Range	0.3~10m from reference point
Repeatability	$\sigma < 1\text{mm}$
Accuracy*1	$\pm 5\text{mm}$ (0.3~5m) $\pm 10\text{mm}$ (5~10m)
Temperature Drift*2	$\pm 3\text{mm}/10\text{K}$ and less than 20mm p-p

Pressure Sensor	
Measurement Range	-8~0.3m from reference point
Repeatability	$\sigma < 5\text{mm}$
Accuracy*1	$\pm 50\text{mm}$ *4
Temperature Drift*2, 3	$\pm 50\text{mm}/20\text{K}$ and less than 100mm p-p (-20~50°C)
Installation Location	0.5~1.0m in front of Radar Sensor

*1 Accuracy in our measurement environment. Accuracy may not be guaranteed depending on the installation environment. Deviation by strong, high frequency electromagnetic fields within EN61326-1 $\leq \pm 50\text{mm}$.

*2 In the case of analog output, the measured value is further affected by the temperature dependency of the analog output.

*3 Except when frozen

*4 If the device is worked while submerged in water, accuracy of pressure sensor may deteriorate.

4.2 Options

Options

Wall Mounting Fixture	Material : SUS304 or SUS316 Selectable
Ceiling Mounting Fixture	Material : SUS304 or SUS316 Selectable
Pressure Sensor Mounting	Material : SUS316L
CD-R	Config Soft Operation Manual(pdf) are included.

4.3 Model Code

Main unit

HC - 1 0 -

<Spec>

S : For waste water

Flat antenna Rigid PVC heat-resistant grade

4.4 Dimension

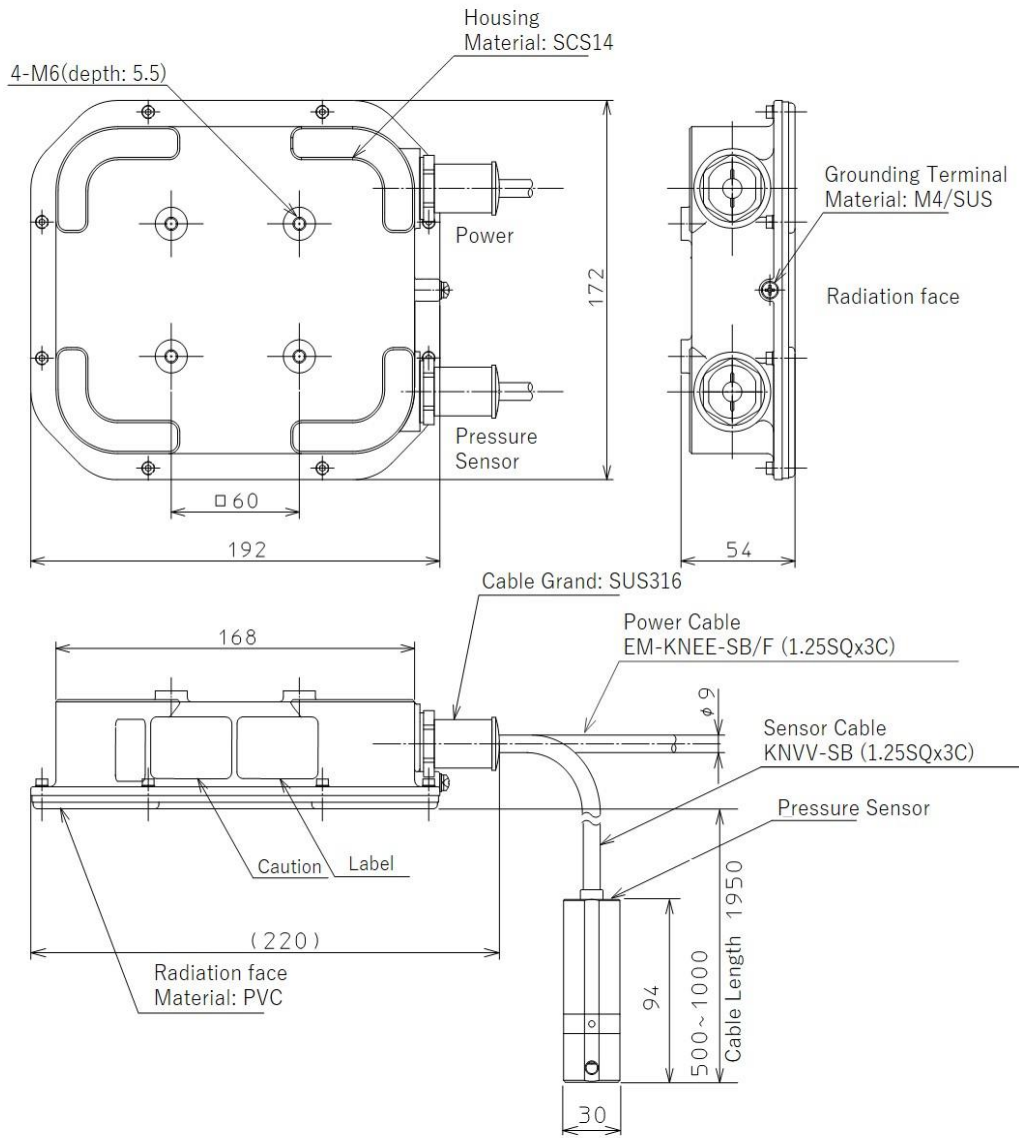


Fig. 4-1 Dimension (Without Mounting Fixture)

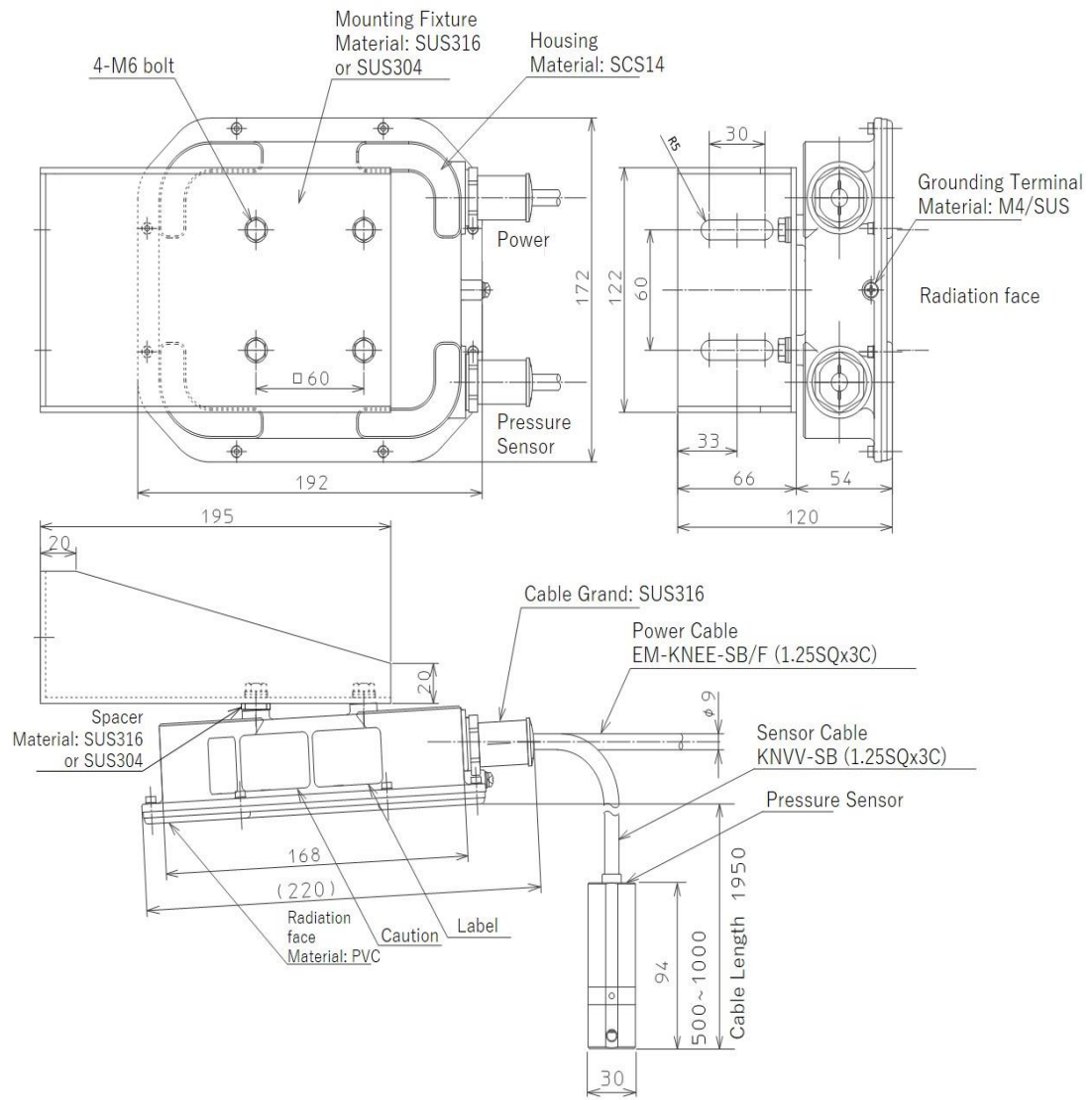


Fig. 4-2 Dimension (With Mounting Fixture)

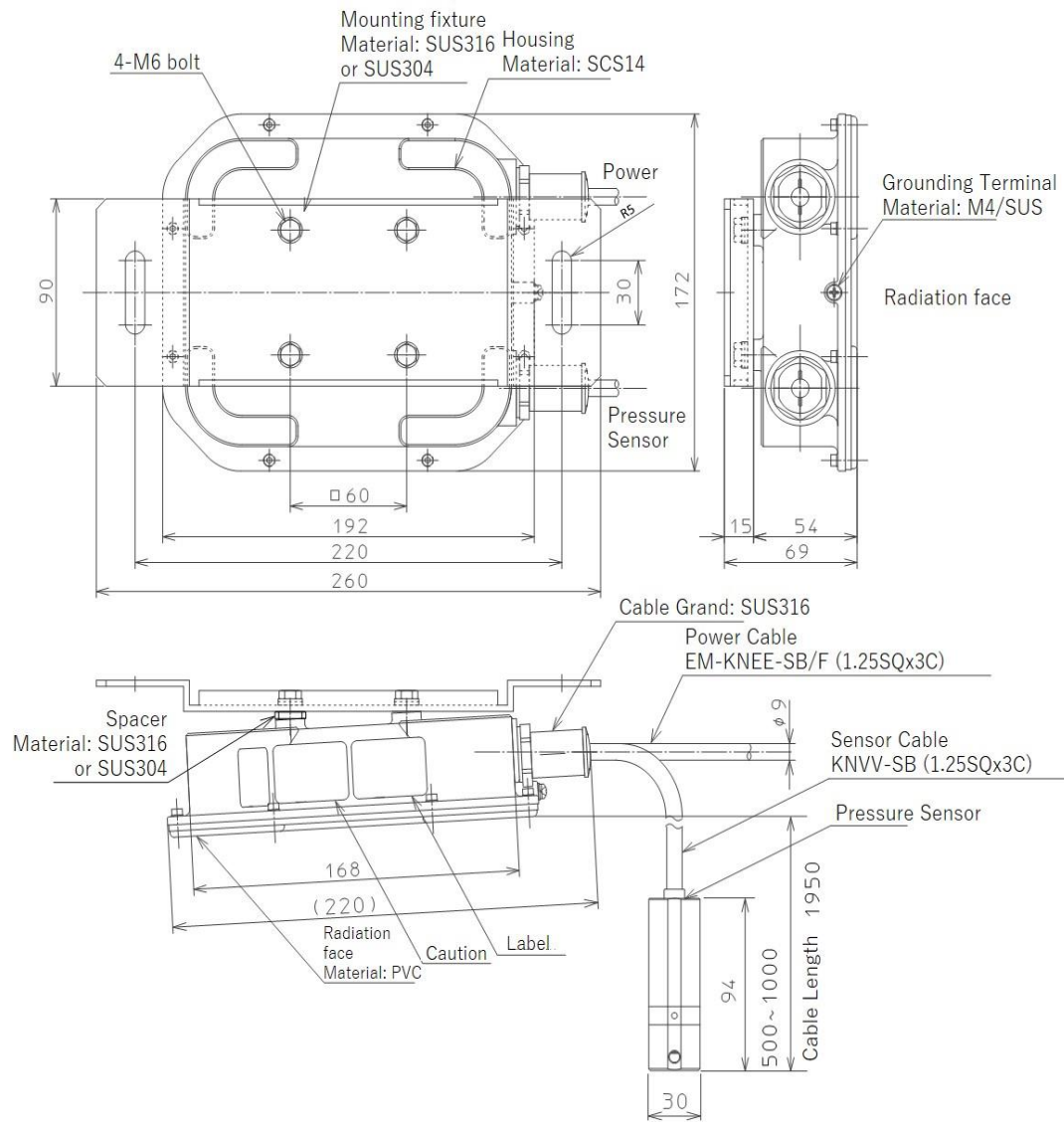


Fig. 4-3 Dimension (With Ceiling Mounting Fixture)

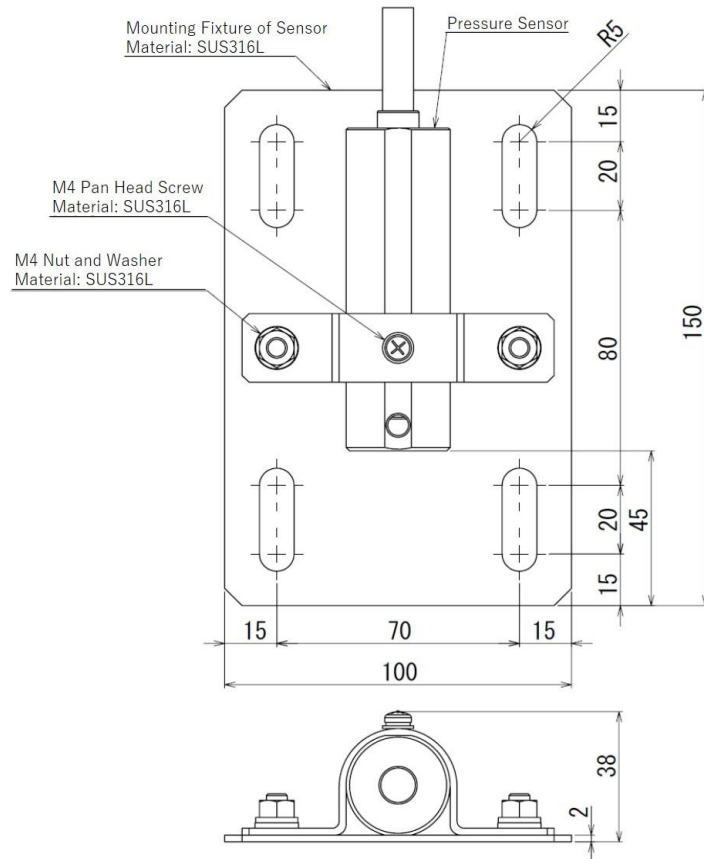


Fig. 4-4 Dimension (Mounting Fixture of Sensor)

Chapter 5. Measurement Principle of Hybrid Level Gauge HC-10

5.1 Measurement Principle

5.1.1 Measurement by Radar Level Gauge

HC-10 utilizes the microwave pulse radar with frequency of 5.8 GHz. By measuring the propagation time to the object, the distance can be calculated.

Microwave pulses radiated from the antennas of this device installed in the waterway are reflected on the surface of the object, received again by the antenna and transmitted to the electronic part of the body. The distance D to the object is measured by multiplying 1/2 of the propagation time t by the propagation speed c.

$$D = c \times (t / 2) \dots \dots (1)$$

D : Distance
c : Propagation speed
t : Propagation time

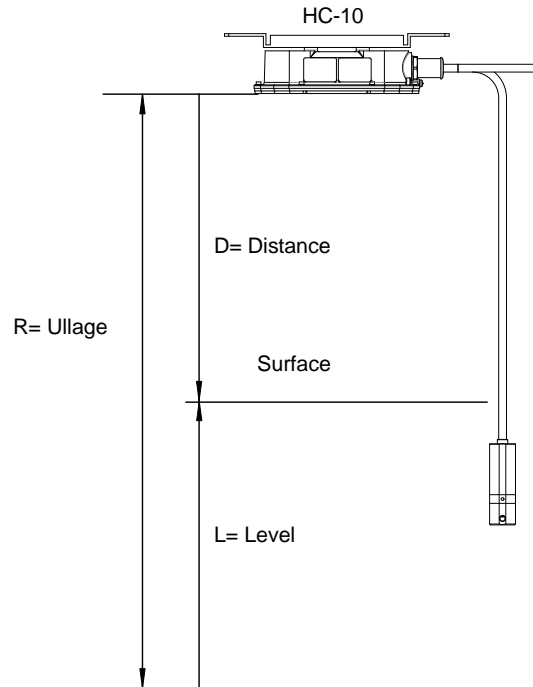


Fig. 5-1 Measurement principle of Radar Level Gauge

As shown in formula (2), the level L can be measured by subtracting the distance D to Ullage R.

From formula (1)

$$L = R - D \dots \dots (2)$$

L : Level
R : Ullage

5.1.2 Measurement by Pressure Level Gauge

The pressure sensor of this device is an absolute pressure sensor, and can measure the sum of liquid pressure and atmospheric pressure. As shown in formula (3), the liquid pressure P_G can be obtained by subtracting the atmospheric pressure P_0 to the measurement result of absolute pressure P .

$$P_G = P - P_0 \quad \dots \dots (3)$$

P : Absolute pressure
 P_G : Liquid pressure
 P_0 : Atmospheric pressure

The water depth W from pressure sensor is calculated by using liquid pressure P_G measured by pressure sensor, the specific gravity ρ of the object, and gravitational acceleration.

$$W = P_G / (\rho \times g) \quad \dots \dots (4)$$

W : Water depth from Pressure Sensor
 ρ : Specific gravity
 g : Gravitational acceleration

The level L can be measured by using the water depth W from pressure sensor, the ullage R , and the sensor separation distance α .

$$L = R - (\alpha - W) \quad \dots \dots (5)$$

α : Sensor separation distance

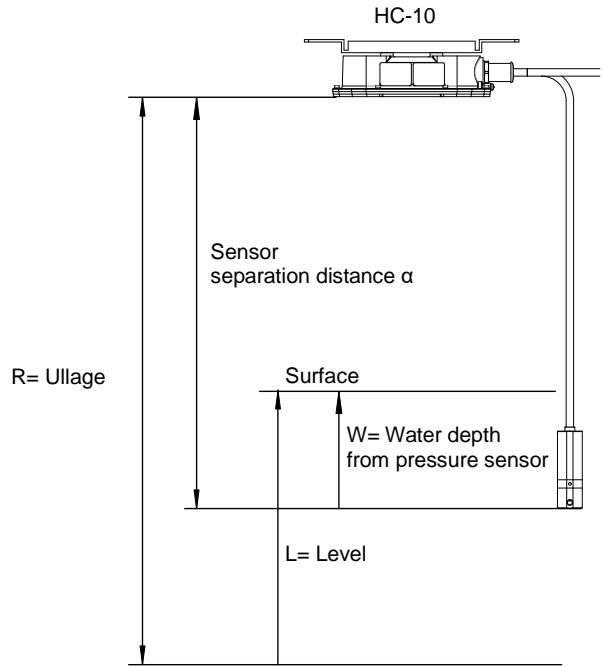


Fig. 5-2 Measurement principle of Pressure Sensor

5.1.3 Suppression of Atmospheric Pressure Fluctuation Error

HC-10 has a function to calibrate the measured value of Pressure Level Gauge, and automatically suppresses the influence of errors due to atmospheric pressure fluctuation. Using the measured value by radar sensor L_M which is not affected by atmospheric pressure fluctuation as a reference, and calculate the difference from the measured value by pressure sensor L_P , atmospheric pressure fluctuation error L_E generated in the pressure sensor can be calculated.

$$L_E = L_M - L_P \dots \dots (6)$$

- L_E : Atmospheric pressure fluctuation error
- L_M : Measured value by Radar Sensor
- L_P : Measured value by Pressure Sensor

The size of atmospheric pressure fluctuation error L_E is stored inside the device, and by calibrating value measured with pressure sensor, atmospheric pressure fluctuation error is suppressed.

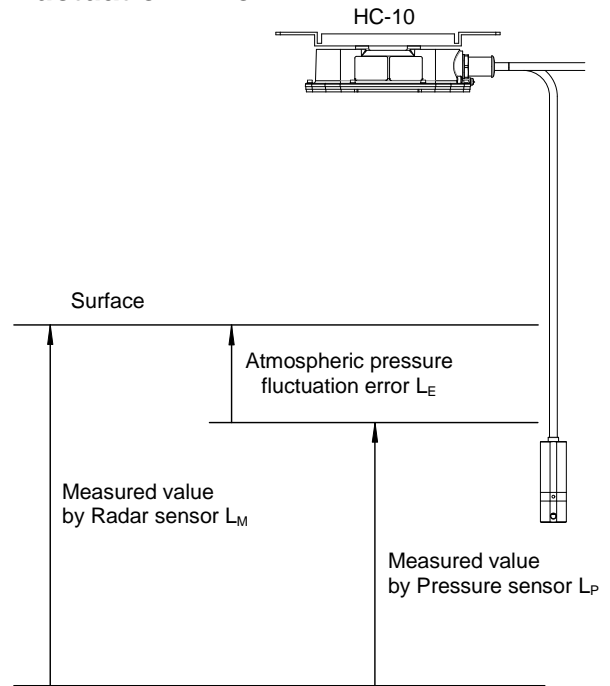


Fig. 5-3 Suppression of Atmospheric Pressure Fluctuation Error

5.1.4 Switching of Sensors

This device enables a wider range of measurement by automatically switching between two level gauges, Radar type and Pressure type. The switching point of the sensors is 0.3m below antenna of the radar sensor, which is the reference point. If the liquid surface is below the switching point, it is measured with a radar sensor. And if the liquid surface is above the switching point, it is measured with a pressure sensor.

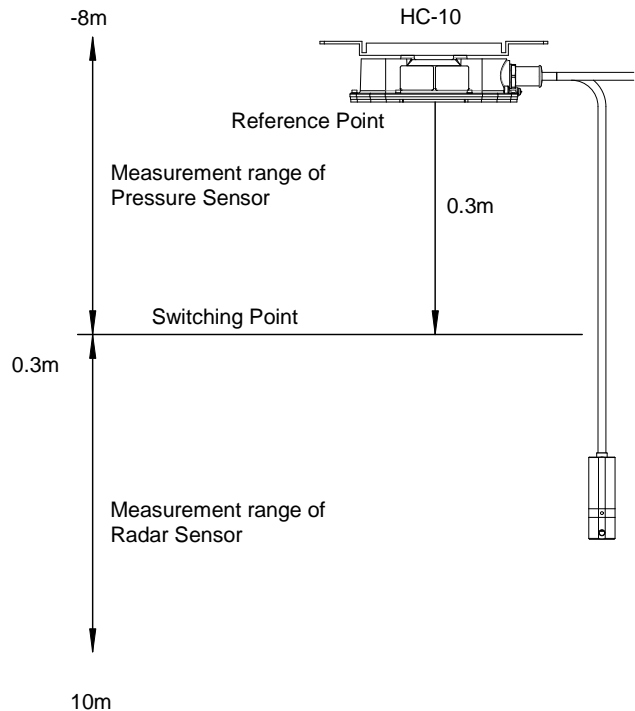


Fig. 5-4 Switching of Sensors

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Issue TOKYO KEIKI INC.
Measurement Systems Company
2-16-46, Minami-Kamata, Ohta-Ku,
Tokyo 144-8551, Japan
TEL 03-3737-8621
FAX 03-3737-8665
URL <https://www.tokyokeiki.jp/>

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