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**User's  
Manual**

**Vortex Flowmeter  
VY Series  
Maintenance Manual**

IM 01F07A01-02EN

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# Vortex Flowmeter VY Series Maintenance Manual

IM 01F07A01-02EN 3rd Edition

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# 1. INTRODUCTION

Thank you for purchasing a VY Series Vortex Flowmeter. This manual describes maintenance procedures for VY Series Vortex Flowmeters. You can refer to the related manuals for this instrument listed in Table 1.1 in the Vortex Flowmeter VY Series Installation Manual (IM 01F07A01-01EN). Manuals for each product can be downloaded from the Yokogawa website. Be sure to read these manuals to ensure correct use of the products.

Website address:

<https://www.yokogawa.com/library/>

## ■ Regarding This Manual

- This manual should be provided to the end user.
- The contents of this manual may be changed without prior notice.
- All rights are reserved. No part of this manual may be reproduced in any form without Yokogawa's written permission.
- Yokogawa makes no warranty of any kind with regard to this material, including, but not limited to, implied warranties of merchantability and suitability for a particular purpose.
- All reasonable effort has been made to ensure the accuracy of the contents of this manual. However, if any errors or omissions are found, please inform Yokogawa.
- The specifications covered by this manual are limited to those for the standard type under the specified model number break-down and do not cover custom-made instruments.
- Please note that this manual may not be revised for any specification changes, construction changes or operating part changes that are not considered to affect function or performance.
- Yokogawa assumes no responsibilities for this product except as stated in the warranty.
- If the customer or any third party is harmed by the use of this product, Yokogawa assumes no responsibility for any such harm owing to any defects in the product which were not predictable, or for any indirect damages.

## ■ Safety and Modification Precautions

- When handling this instrument, follow the safety precautions described in this document for protection and safety of personnel, this instrument and systems that incorporate this instrument. Yokogawa does not guarantee the safety of this instrument if the customer has failed to comply with these precautions.
- Modification of the product in question without the authorization of Yokogawa is strictly forbidden.
- When an explosion protected type instrument has been repaired or modified by the customer and cannot be restored to its original condition, the explosion protective structure of this instrument will be impaired and a hazardous condition will arise. Be sure to consult Yokogawa regarding repairs and modifications.

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The following safety symbol marks are used on this product and in this manual.



## WARNING

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A WARNING sign denotes a hazard. It calls attention to procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death of personnel. This document presents precautions for avoiding such hazards should such a situation arise.

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## CAUTION

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A CAUTION sign denotes a hazard. It calls attention to procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of the product. This document presents precautions for avoiding such hazards should there be a physical risk to the user's well-being or damage to equipment.

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## IMPORTANT

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An IMPORTANT sign denotes that attention is required to avoid damage to the instrument or system failure.

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
## NOTE

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A NOTE sign denotes information necessary for essential understanding of operation and features.

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Various symbols are marked on the instrument itself. The meanings of these symbols are as follows.

 Functional ground terminal

 Direct current

 Handling precaution

This is attached to locations where this manual must be referenced to protect personnel safety and devices.

- When handling this instrument, follow the safety precautions described in this document and other precautions for the protection and safety of this instrument and systems that incorporate this product. When these precautions are not complied with, the protection functions of this instrument may be impaired or instrument functions may not be fully demonstrated. In this case, Yokogawa makes no guarantee whatsoever for the quality, performance, functions, and safety of the product.
- When performing the installation of protective and safety circuits for this instrument or control systems, such as lightning protection systems or devices on this instrument or on systems controlled by this instrument, or the foolproof or failsafe design of processes and lines that use this instrument or control systems, and the design and installation of other protective and safety circuits, the customer should implement this appropriately at their own judgment. Also, the customer should separately consider achieving the above by devices other than this instrument, and prepare devices accordingly.

- When replacing the parts of this instrument, be sure to use only parts specified by Yokogawa.
- This product is not designed or manufactured to be used in critical applications that directly affect or threaten human lives. Such applications include nuclear power equipment, devices using radioactivity, railway facilities, aviation equipment, air navigation facilities, aviation facilities, and medical equipment. If so used, it is the user’s responsibility to include in the system additional equipment and devices that ensure personnel safety.
- Modification of this instrument is strictly forbidden.
- If this instrument is modified or replaced, each explosion protection accreditation is invalidated.
- This instrument should be disposed of in accordance with local and national legislation/ regulations.

**Table 1.1 Related Documents**

<b>Document title</b>	<b>Document No.</b>
Vortex Flowmeter VY Series	GS 01F07A00-01EN
FSA130 Magnetic Flowmeter/Vortex Flowmeter Verification Tool	GS 01E21A04-01EN
Vortex Flowmeter VY Series Read Me First Vortex Flowmeter VY Read Me First	IM 01F07A21-01Z1
Vortex Flowmeter VY Series Safety Manual	IM 01F07A21-02EN
Vortex Flowmeter VY Series Installation Manual	IM 01F07A01-01EN
Vortex Flowmeter VY Series Maintenance Manual	IM 01F07A01-02EN
Vortex Flowmeter VY Series HART Communication Manual	IM 01F07A02-01EN
Vortex Flowmeter VY Series Verification Tool	IM 01F07A04-01EN
Vortex Flowmeter VY Series FM (USA) Explosion Protection Type	IM 01F07A03-01EN
Vortex Flowmeter VY Series FM (Canada) Explosion Protection Type	IM 01F07A03-02EN
Vortex Flowmeter VY Series ATEX Explosion Protection Type	IM 01F07A03-03EN
Vortex Flowmeter VY Series IECEx Explosion Protection Type	IM 01F07A03-04EN
Vortex Flowmeter VY Series Japan Explosion Protection Type	IM 01F07A03-05JA
Vortex Flowmeter VY Series INMETRO Explosion Protection Type	IM 01F07A03-07PT
Vortex Flowmeter VY Series NEPSI Explosion Protection Type	IM 01F07A03-08ZH
Vortex Flowmeter VY Series KOREAN Explosion Protection Type	IM 01F07A03-10KO

# 1.1 Using This Instrument Safely

## (1) Maintenance



### WARNING

- Maintenance of the vortex flowmeter should be performed by trained personnel with knowledge of safety. No operator shall be permitted to perform any operations relating to maintenance.
- Do not open the cover in wet weather or humid environments. When the cover is opened, the stated enclosure protection is not applicable.
- For details on maintenance, read the maintenance manual in the related documents indicated in Table 1.1. Perform only maintenance that is described in this manual. Do not perform other maintenance. If other maintenance is necessary, contact your nearest sales office or Service Center.
- When opening and closing the cover, pay sufficient care to handling of screws and O-rings to prevent damage and attachment of foreign objects.
- Some of the electronic components used on this product are susceptible to damage as a result of static electricity. Take sufficient care when handling electronic components by, for example, wearing wrist straps to prevent charging by static electricity and not directly touching electronic components, circuits and other components susceptible to static electricity.
- Wiring, switch settings, and maintenance should be performed in an environment where the ambient temperature is -40°C or higher (the ambient temperature is -30°C or higher for the display).

## (2) Modification

Yokogawa will not be liable for malfunctions or damage resulting from any modification made to this instrument by the customer.

## (3) Product Disposal

The instrument should be disposed of in accordance with local and national legislation/regulations.

## (4) Authorized Representative in EEA

In relation to the CE Marking, The authorized representative for this product in the EEA (European Economic Area) is: Yokogawa Europe B.V. Euroweg 2, 3825 HD Amersfoort, The Netherlands

## (5) CE Marking

CE marking is displayed on the nameplate for non-explosion protected type devices and ATEX explosion protected type devices. Products with CE marking are in compliance with the statutory requirements of the applicable EU directives.

## (6) EU RoHS Directive

EN IEC 63000:2018

## (7) Morocco Conformity Mark

This conformity mark indicates that the product complies with Moroccan requirements.

## 1.2 Warranty

- The terms of this instrument that are guaranteed are described in the quotation. We will make any repairs that may become necessary during the guaranteed term free of charge.
- Please contact our sales office if this instrument requires repair.
- If the instrument is faulty, contact us with concrete details about the problem and the length of time it has been faulty, and state the model and serial number. We would appreciate the inclusion of drawings or additional information.
- The results of our examination will determine whether the flowmeter will be repaired free of charge or on an at-cost basis.

### ■ The guarantee will not apply in the following cases:

- Damage due to negligence or insufficient maintenance on the part of the customer.
- Problems or damage resulting from handling, operation or storage that violates the intended use and specifications.
- Problems that result from using or performing maintenance on the instrument in a location that does not comply with the installation location specified by Yokogawa.
- Problems or damage resulting from inappropriate re-installation after delivery.
- Problems or damage resulting from disasters such as fires, earthquakes, storms, floods, or lightning strikes and external causes.
- Problems or damage resulting from repairs or modifications not performed by Yokogawa or someone authorized by Yokogawa.

### ■ Trademarks

- "HART" is the registered trademark of FieldComm Group.
- All the brands or names of Yokogawa Electric's products used in this manual are either trademarks or registered trademarks of Yokogawa Electric Corporation.
- Product names and company names in this document are trademarks or registered trademarks of the respective companies.
- In this document, trademarks or registered trademarks are not marked with "™" or "®".

# 2. HANDLING PRECAUTIONS

This section describes the precautions to follow when handling the product. Be sure to read this section before using the product. For information other than that described in this section, refer to the related section.

If you have any problems or questions, contact your nearest YOKOGAWA service center or sales representative.

## 2.1 Checking Model and Specifications

This instrument is inspected thoroughly before it is shipped from the factory. When this instrument is delivered to the installation site, check its external appearance for damage, and make sure that all parts for installation are provided.

Be sure that you have your model number (MODEL) and serial number (No.) available when contacting Yokogawa.

The model code and specifications given on the nameplate are those current when this product was shipped from the factory. It is not possible to change the nameplate after shipment.

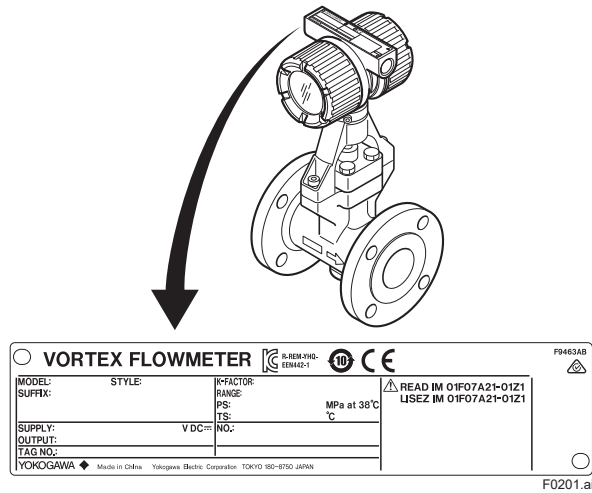


Figure 2.1(a) Example of Nameplate (Integral Type)

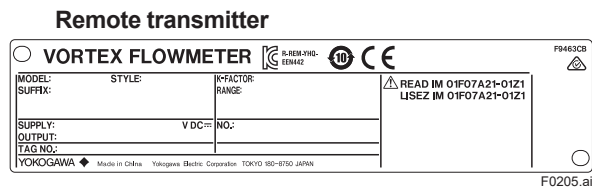
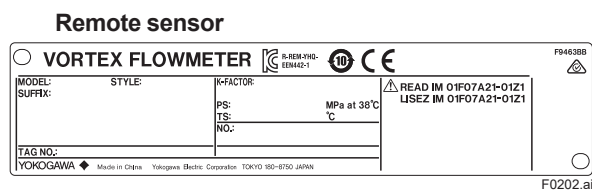


Figure 2.1(b) Example of Nameplate (Remote Type)



## 2.2 Transportation and Storage Precautions

To prevent damage to the vortex flowmeter due to accidents during transportation, it should be carried in its original packing condition.

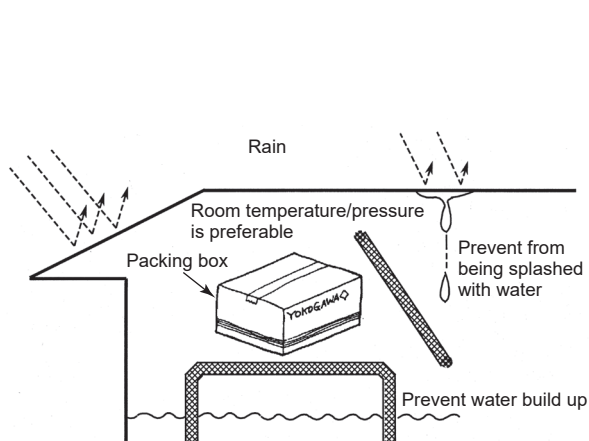
Deterioration of insulation, corrosion or other abnormalities may occur due to unexpected situations if the vortex flowmeter is stored for a long period of time after it is delivered to the user site. When it is anticipated that the vortex flowmeter will be stored for a long time, pay attention to the following points.

- (1) The vortex flowmeter should be stored in its original packing condition in the storage location.
- (2) Select a storage location that fulfills the following conditions:
  - A place where it will not be exposed to rain or water
  - A place subject to minimal vibrations or shocks
  - Temperature and humidity levels should be as follows: The preferred ambient temperature and humidity levels are +25°C and approximately 65% RH.

Ambient temperature: -40 to +85°C, -50 to +85°C(/LAT)

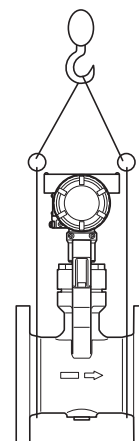
Humidity: 0 to 100% RH (no condensation)

- (3) When storing a vortex flowmeter after use, completely clean the flowmeter to ensure that there is no measured fluid remaining in its piping line and on the shedder bar.
- (4) If the vortex flowmeter is carried to the installation site and is stored without being installed, rain water might get inside and impair the instrument's performance. Install, wire and perform other installation work immediately after transporting the vortex flowmeter to the installation site.
- (5) The vortex flowmeter is a heavy instrument. When moving the vortex flowmeter, always use a trolley and have at least two people carry it. When winching instruments, winch by the method shown in Figure 2.3.



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Figure 2.2 Storage Site Precautions



F0204.ai

Figure 2.3 Winching Method

## 3. MAINTENANCE

### IMPORTANT

In the case of Dual-Sensor (Welded) Type, the orientation of the transmitter cannot be changed. Others follow the general type.

### 3.1 Changing the Orientation of the Transmitter Case and Sensor Terminal Box



#### WARNING

- In the case of an explosion protected type instrument, make sure that no explosive atmosphere conditions are present.
- When removing or installing the transmitter case, pay careful attention to the handling of O-rings to prevent damage and adhesion of foreign matter.
- Replace O-rings if they are damaged or deformed.
- If there is no lubricant on the O-rings, apply silicone-based grease.

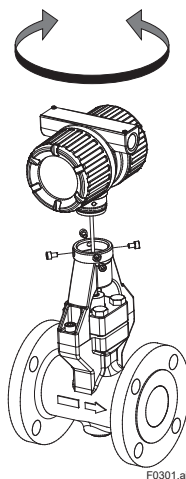


#### CAUTION

Repairs and modifications to this instrument can only be performed at the Yokogawa factory.

The orientation of the transmitter case and sensor terminal box can be changed in 90-degree increments (four directions). Follow the procedure below to change the orientation.

- (1) Remove the hexagon socket head cap screw (4 places) that secure the transmitter case and bracket.
- (2) Rotate the case to the desired orientation.  
To prevent strain on the internal cable, do not rotate the case more than 180 degrees at this time.  
Note: The orientation may have been specified when ordering the instrument. Check the status of the internal cable while rotating the case.
- (3) Tighten the hexagon socket head cap screw with the case in the desired orientation.  
(Tightening torque: 3 N·m)



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Figure 3.1 Changing the Orientation of the Transmitter Case and Sensor Terminal Box

## 3.2 Removing and Rotating the Indicator

### IMPORTANT

In the case of an explosion protected type instrument, modification by the user is prohibited.



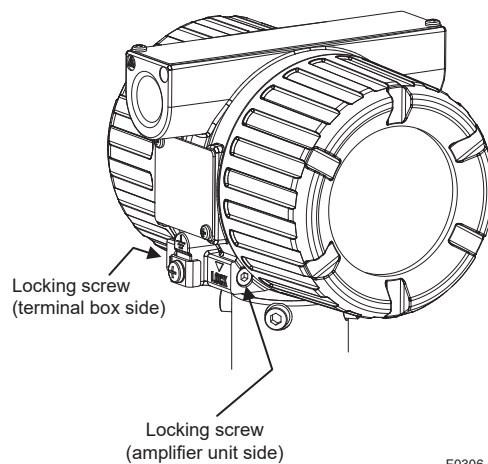
### WARNING

- In the case of an explosion protected type instrument, make sure that no explosive atmosphere conditions are present.
- When opening and closing the cover, pay careful attention to the handling of screws and O-rings to prevent damage and adhesion of foreign matter.
- Replace O-rings if they are damaged or deformed.
- If there is no lubricant on the O-rings, apply silicone-based grease.



### CAUTION

- In the case of an explosion protected type instrument, the covers and screws must be returned to the original condition.
- In the case of a flameproof protected type instrument, turn the locking screws shown in Figure 3.2 to the right to unlock the cover before removing it. When installing the cover, make sure to turn the locking screws to the left to lock the cover.



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Figure 3.2 Locking Screws

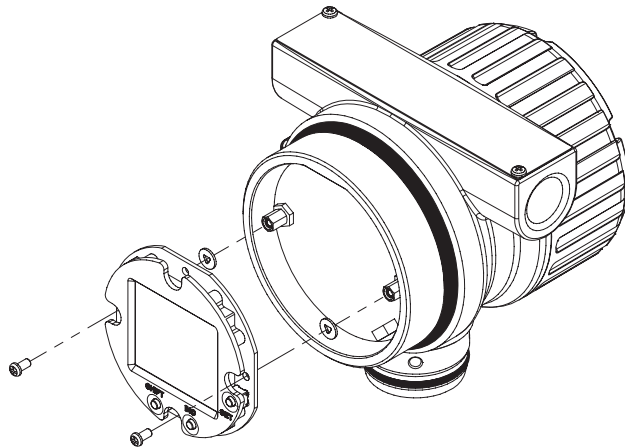
Follow the procedure below to remove and rotate the indicator.

- (1) Turn the power OFF.
- (2) Remove the cover. When opening the cover of a flameproof type instrument, turn the locking screws to the right to unlock the cover.
- (3) Loosen the two indicator mounting screws.
- (4) Pull the indicator out straight using your hands.
- (5) Remove the screws and washers from the printed circuit board, then reinstall in the desired position by tightening the screws and washers.
- (6) When installing the indicator, perform the removal procedure in reverse to return the parts to their original positions, then tighten the indicator mounting screws. The indicator installation angle can be rotated in 90-degree increments. (Refer to the table below.)
- (7) Install the cover. When installing the cover on a flameproof type instrument, make sure to turn the locking screws to the left to lock the cover.



**CAUTION**

Pay attention not to break the connector pin, and make sure that the connector (male) of the amplifier unit and the connector (female) of the display unit are assembled correctly.



	Direction of display		
	Not specified or 0° rotation	+90° rotation	-90° rotation
Integral Flowmeter	<p>→ Flow direction</p>	<p>Flow direction</p>	<p>Flow direction</p>
Remote Sensor	<p>Installation example</p>	<p>Installation example</p>	<p>Installation example</p>

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**Figure 3.3 Removing and Installing the Indicator**

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## 3.3 Removing the Amplifier Unit

### IMPORTANT

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Do not twist the amplifier unit when removing or installing it. Doing so may damage the connector pins.

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### WARNING

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- In the case of an explosion protected type instrument, make sure that no explosive atmosphere conditions are present.
  - When opening and closing the cover, pay careful attention to the handling of screws and O-rings to prevent damage and adhesion of foreign matter.
  - Replace O-rings if they are damaged or deformed.
  - If there is no lubricant on the O-rings, apply silicone-based grease.
- 

Follow the procedure below to remove the amplifier unit.

- (1) Turn the power OFF.
- (2) Remove the cover. When opening the cover of a flameproof type instrument, turn the locking screws to the right to unlock the cover.
- (3) Loosen the two amplifier unit mounting screws with a 5.5 mm socket nut driver, and pull the amplifier unit out straight.  
If the instrument is equipped with an indicator, remove the indicator before removing the amplifier unit. Follow the procedure described in Section 3.2 to remove the indicator.

## 3.4 Installing the Amplifier Unit

### IMPORTANT

Make sure to follow the procedure below when installing the amplifier unit. The amplifier unit may not function properly if it is installed without following the procedure exactly as described.

Follow the procedure below to install the amplifier unit.

- (1) Place the amplifier unit in the transmitter case so that the flat side at the top of the amplifier unit fits against the flat surface inside the transmitter case.
- (2) Insert the ends of the two amplifier unit mounting guide pins into the mounting holes.
- (3) Lightly press the upper and lower parts of the amplifier unit simultaneously to insert the amplifier unit into the transmitter case. Take care not to touch the electronic components of the amplifier unit when pressing it in.
- (4) Tighten the amplifier unit mounting screws to secure the amplifier unit. If the instrument is equipped with an indicator, follow the procedure described in Section 3.2 to install the indicator.
- (5) Install the cover. When installing the cover on a flameproof type instrument, make sure to turn the locking screws to the left to lock the cover.

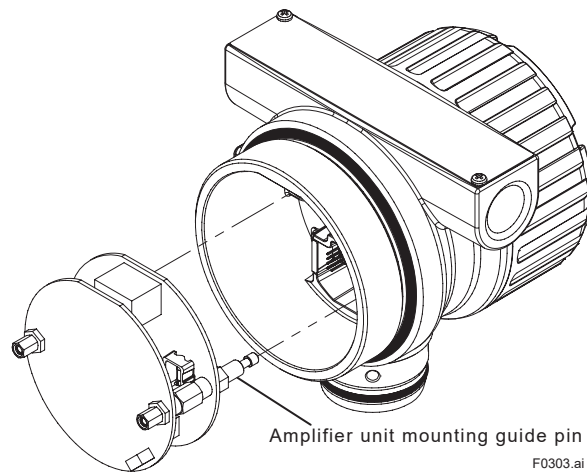


Figure 3.4 Removing and Installing the Amplifier Unit

## 3.5 Removing and Installing the Shedder Bar

### IMPORTANT

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- The accuracy is not guaranteed after removing and replacing the shedder bar. If you require an accuracy guarantee, we recommend having the Yokogawa factory perform shedder bar removal and replacement.
  - Shedder bar replacement should be performed by trained personnel with knowledge of the product characteristics and safety.
- 



### WARNING

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- In the case of an explosion protected type instrument, make sure that no explosive atmosphere conditions are present.
  - Before removing the shedder bar, stop the flow and remove any remaining fluid.
  - When removing or installing the shedder bar, pay careful attention to the handling of the transmitter case O-rings and shedder bar O-rings to prevent damage and adhesion of foreign matter.
  - Replace O-rings if they are damaged or deformed.
  - If there is no lubricant on the O-rings, apply silicone-based grease.
  - When replacing or removing the shedder bar, always replace the gasket with a new one.
- 



### CAUTION

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If the shedder bar is not properly reinstalled after replacing or removing it, the readings may be affected when operation resumes.

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### NOTE

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For Dual-Sensor (Welded) Type, the orientation of the transmitter should be the same as when shipped.

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- (1) Remove the four transmitter case mounting bolts shown in Figure 3.5, and remove the transmitter case from the bracket.

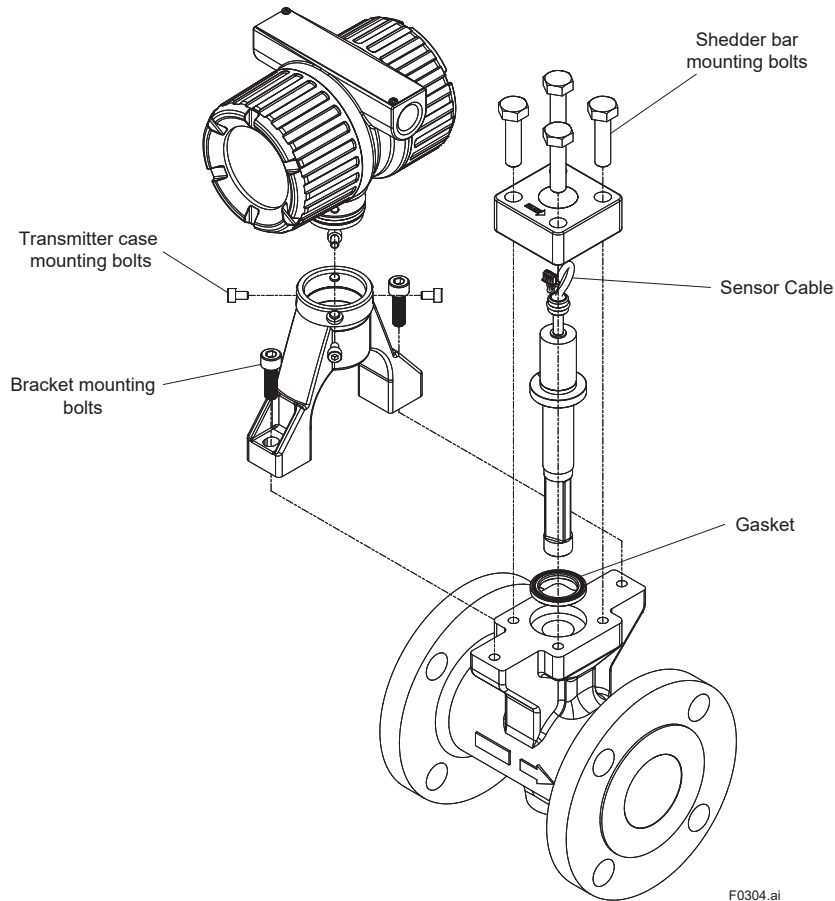


Figure 3.5 Removing the Shedder Bar



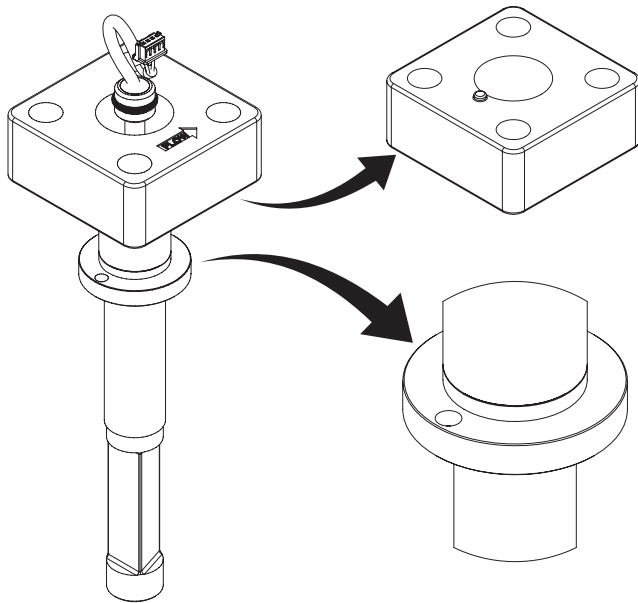
**CAUTION**

The sensor cable is connected to the transmitter case. To prevent strain on the connector, disconnect the sensor cable when the transmitter case is about 5 cm away from the bracket.

- (2) Remove the two bracket mounting hexagon socket head cap screw that secure the bracket to the instrument, and remove the bracket from the instrument while paying careful attention to the sensor cable.
- (3) Remove the shedder bar mounting bolts (2 to 10 bolts) and washers, then remove the shedder bar fixing block and shedder bar with attention to the sensor cable. The instrument may not be equipped with the washers and shedder bar fixing block due to the specifications.
- (4) To assemble, perform steps (1) to (3) in reverse.  
Fix the transmitter mounting hexagon socket head cap screw and the bracket mounting hexagon socket head cap screw with the following torques:  
Fix the bolts with the following torques:  
3 N•m for transmitter case mounting bolts  
13 N•m for bracket mounting bolts
  - a. Always replace the gasket with a new one.  
  
Before assembling, make sure that no foreign matter is adhering to the seal surface that the gasket makes contact with.
  - b. Check that the fluid flow direction and the direction of the shedder bar are as shown in Figure 3.7.

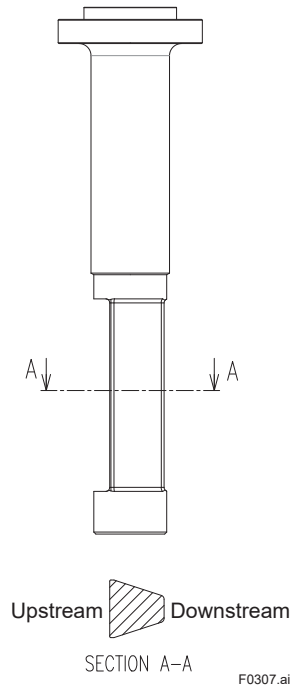


- c. Check that the pin of the shedder bar fixing block is aligned with the pin hole of the shedder bar as shown in Figure 3.6.



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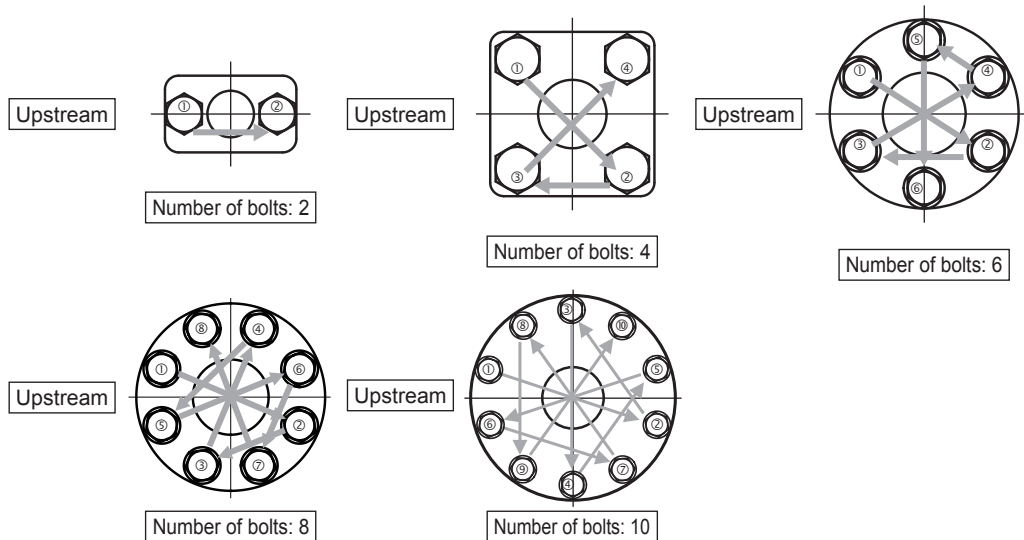
Figure 3.6 Installing the Shedder Bar



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Figure 3.7 Shedder Bar Installation Direction

- d. Tighten the shedder bar fixing bolts to the appropriate tightening torque value as shown in Table 3.1 and Table 3.2. Partially tighten each bolt equally 3 to 4 times until the tightening torque value is reached. Read Figure 3.8 for the bolt tightening sequence.



F1105.ai

Figure 3.8 Bolt Tightening Sequence



**CAUTION**

Since the bolts are near the sensor, the readings may be affected if the bolts are not evenly tightened. Unevenly tightened bolts may also cause fluid to leak. Make sure that the bolts are tightened evenly to the appropriate tightening torque value.

- a. In the case of a high temperature type instrument or option code /SPG, tighten the bolts once to tightening torque value A, then loosen the bolts and tighten them again to tightening torque value B. When loosening the bolts, stop once they are partially loosened, and do not loosen them completely.

**Table 3.1 Tightening Torque Values**

Model code/Type of body			Tightening torque [N·m]		
-0: General type -6: Dual-Sensor	-1: Reduced bore type (1 size reduction)	-2: Reduced bore type	A, B: General type, E: Cryogenic type	C, D: High temperature type, /SPG	
				A	B
VY015-0,6	VY025-1	VY040-2	16	16 *1	16 *1
VY025-0,6	VY040-1	VY050-2	12	18	12
VY040-0,6	VY050-1	VY080-2	12	18	12
VY050-0,6	VY080-1	VY100-2	12 *2	18 *2	12 *2
			18 *3	27 *3	18 *3
VY080-0,6	VY100-1	VY150-2	21 *2	32 *2	21 *2
			32 *3	48 *3	32 *3
VY100-0,6	VY150-1	VY200-2	21 *2	32 *2	21 *2
			49 *3	74 *3	49 *3
VY150-0,6	VY200-1	-----	69	98	69
VY200-0,6	-----	-----	69	98	69
VY250-0	-----	-----	157	210	140
VY300-0	-----	-----	157	210	140
VY400-0	-----	-----	160	240	140

\*1: For /SPG (stainless steel gasket plated with silver) only

\*2: For ASME/JPI Class 150, 300 JIS 10K, 20K, and EN PN 10, 16, 25, 40

\*3: For ASME/JPI Class 600, 900, and JIS 40K

**Table 3.2 Tightening Torque Values (High Pressure Reduced Bore Type)**

Model code/Type of body	Tightening torque [N·m]
-4: High pressure reduced bore type (1 size reduction)	
VY025-4	12
VY040-4	37
VY050-4	37
VY080-4	37
VY100-4	50
VY150-4	78



**CAUTION**

For instruments with custom specifications, make sure to read the accompanying manual.

- b. After replacing the shedder bar, take care not to damage the sensor cable when installing the bracket and transmitter case.
- c. After assembly, make sure that no fluid leaks from the vortex flowmeter.

## 3.6 Replacing the Lightning Protector Module

For details on replacing the lightning protector module, read the Vortex Flowmeter VY Series Installation Manual listed in the related documents in Table 1.1.

## 3.7 Calculation Formulas

### (1) Flow rate calculation

The flow rate is calculated based on the following formulas, where N is the count number of generated vortices.

#### a) Instantaneous flow rate (actual flow rate unit) (RATE)

$$\text{RATE} = N \times 1 / \Delta t \times \varepsilon_r \times \varepsilon_e \times \varepsilon_r \times 1 / K_T \times U_k \times U_{TM}$$

$$K_T = K_M \times U_{KT} / \{1 + E_t (T_r - 15) \times 10^{-5}\}$$

#### b) Instantaneous flow rate (%) (RATE (%))

$$\text{RATE (\%)} = \text{RATE} \times 1 / F_S \times 100$$

#### c) Totalized value (TOTAL)

$$\text{TOTAL} = \text{TOTAL} + \Delta \text{TOTAL}$$

$$\Delta \text{TOTAL} = \text{RATE} \times \Delta t \times 1 / T_R \times 1 / U_{TM}$$

#### d) Pulse output frequency (PULSE FREQ)

- For scaled pulse:

$$\text{PULSE FREQ} = \text{RATE} \times 1 / P_R \times 1 / U_{TM}$$

- For unscaled pulse (no unit calculation):

$$\text{PULSE FREQ} = N \times 1 / \Delta t \times 1 / P_R$$

#### e) Flow velocity (V)

$$V = N \times 1 / \Delta t \times 1 / K_T \times U_{KT} \times 4 / \{\pi \times D^2\}$$

#### f) Reynolds number (Re)

$$\text{Re} = V \times D \times \rho_f \times 1 / \mu \times 1000$$

N: Number of input pulses (pulse)

$\Delta t$ : Time corresponding to N (sec)

$\varepsilon_r$ : Instrument error correction coefficient

$\varepsilon_e$ : Compressible fluid expansion correction coefficient

$\varepsilon_r$ : Reynolds correction coefficient

$K_T$ : K factor for operating temperature (p/l)

$K_M$ : K factor at 15°C (p/l)

$E_t$ : Expansion coefficient

$U_{KT}$ : K factor unit conversion coefficient

$U_k$ : Flow rate unit conversion coefficient (Read "(2) Flow rate unit conversion coefficient (Uk)" below.)

$U_{TM}$ : Time unit conversion coefficient (example: /m (min) = 60)

$P_R$ : Pulse rate

$T_r$ : Temperature at operating conditions (°C)

$F_S$ : Flow rate span

$T_R$ : Total rate

D: Inner diameter of vortex flowmeter sensor section (mm)

$\mu$ : Viscosity coefficient (mPa·s)

$\rho_f$ : Density at operating conditions (kg/m<sup>3</sup>)

**(2) Flow rate unit conversion coefficient (U<sub>k</sub>)**

The flow rate conversion coefficient U<sub>k</sub> is calculated according to the measured fluid and the selected flow rate unit, as indicated below.

**a) Steam**

For M (mass):

$$U_k = \rho_f \times U_{\rho f} \times U_k \text{ (kg)}$$

For Q<sub>f</sub> (flow rate):

$$U_k = U_k \text{ (m}^3\text{)}$$

**b) Gas**

For Q<sub>n</sub> (flow rate):

$$U_k = \{P_f / P_n\} \times \{(T_n + 273.15) / (T_f + 273.15)\} \times 1 / K \times U_k \text{ (Nm}^3\text{)}$$

For M (mass):

$$U_k = \rho_f \times U_{\rho f} \times U_k \text{ (kg)}$$

For Q<sub>f</sub> (flow rate):

$$U_k = U_k \text{ (m}^3\text{)}$$

[Flow rate unit] N: Normal conditions

**c) Liquid**

For Q<sub>f</sub> (flow rate):

$$U_k = U_k \text{ (m}^3\text{)}$$

For M (mass):

$$U_k = \rho_f \times U_{\rho f} \times U_k \text{ (kg)}$$

**d) For user-specified units**

$$U_k = U_k \text{ (User)}$$

**(3) Mass flow rate calculation (for instruments with built-in temperature sensor and analog input)****a) Steam**

In the case of saturated steam, calculate the mass flow rate by using the built-in saturated steam table to determine the density based on the measured temperature value.

In the case of superheated steam, calculate the mass flow rate by using the built-in steam table to determine the density based on the measured temperature value. For the pressure, use the fixed value input in the parameters or the analog input value from an external pressure gauge.

$$M = \rho_f \times Q_f$$

**b) Gas**

In the case of gas, perform temperature/pressure correction based on the measured temperature value, and calculate the volumetric flow rate at normal conditions. For the pressure, use the fixed value input in the parameters or the analog input value from an external pressure gauge.

$$Q_n = Q_f \times \{P_f / P_n\} \times \{(T_n + 273.15) / (T_f + 273.15)\} \times 1 / K$$

**c) Liquid**

In the case of liquid, perform a secondary correction for the change in density based on the temperature.

For the calculation, use the measured temperature value to determine the change in density.

$$M = Q_f \times \rho_n \times \{1 + a_1 \times (T_f - T_n) \times 10^{-2} + a_2 \times (T_f - T_n)^2 \times 10^{-6}\}$$

[Additional notes]

$$a_1 = \{(k_1 - 1) \times \Delta T_2^2 - (k_2 - 1) \times \Delta T_1^2\} / \{(\Delta T_1 \times \Delta T_2^2 - \Delta T_2 \times \Delta T_1^2) \times 10^{-2}\}$$

$$a_2 = \{(k_1 - 1) \times \Delta T_2 - (k_2 - 1) \times \Delta T_1\} / \{(\Delta T_1^2 \times \Delta T_2 - \Delta T_2^2 \times \Delta T_1) \times 10^{-6}\}$$

$$k_x = 1 + a_1 \times \Delta T_x \times 10^{-2} + a_2 \times \Delta T_x^2 \times 10^{-6}$$

$$\Delta T_x = T_x - T_n$$

$$(x = 1, 2)$$

M: Mass flow rate

$Q_n$ : Volumetric flow rate at normal conditions

$Q_f$ : Volumetric flow rate at operating conditions

$T_f$ : Temperature at operating conditions (°C)

$T_{ft}$ : Measured temperature (°C)

$T_n$ : Temperature at normal conditions (°C)

$P_f$ : Pressure at operating conditions (kPa)

$P_n$ : Pressure at normal conditions (kPa)

K: Deviation factor

$\rho_n$ : Density at normal conditions (kg/m<sup>3</sup>)

$\rho_f$ : Density at operating conditions (kg/m<sup>3</sup>)

$\rho_{ft}$ : Density determined from measured temperature (kg/m<sup>3</sup>)

$U_{pf}$ : Density unit conversion coefficient

$U_k$  (kg),  $U_k$  (Nm<sup>3</sup>),  $U_k$  (m<sup>3</sup>): Flow rate unit conversion coefficient

$a_1$ : Primary correction coefficient for liquid

$a_2$ : Secondary correction coefficient for liquid

(Example) Using  $U_k$  (kg) coefficient to convert unit from kg

For kg:  $U_k$  (kg) = 1

For metric ton:  $U_k$  (kg) = 0.001

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# Revision Information

- Title: Vortex Flowmeter VY Series Maintenance Manual

<b>Edition</b>	<b>Date</b>	<b>Page</b>	<b>Revised Item</b>
1st	Feb. 2022	-	New publication
2nd	Aug. 2022	4	Table 1.1 Add IMs for Ex-proof.
		8	Added temperature range of /LAT.
		9	Add IMPORTANT.
		14	Add NOTE.
		17	Add specification code of dual-sensor.
3rd	Jan. 2023	5	Add an item for WARNING.