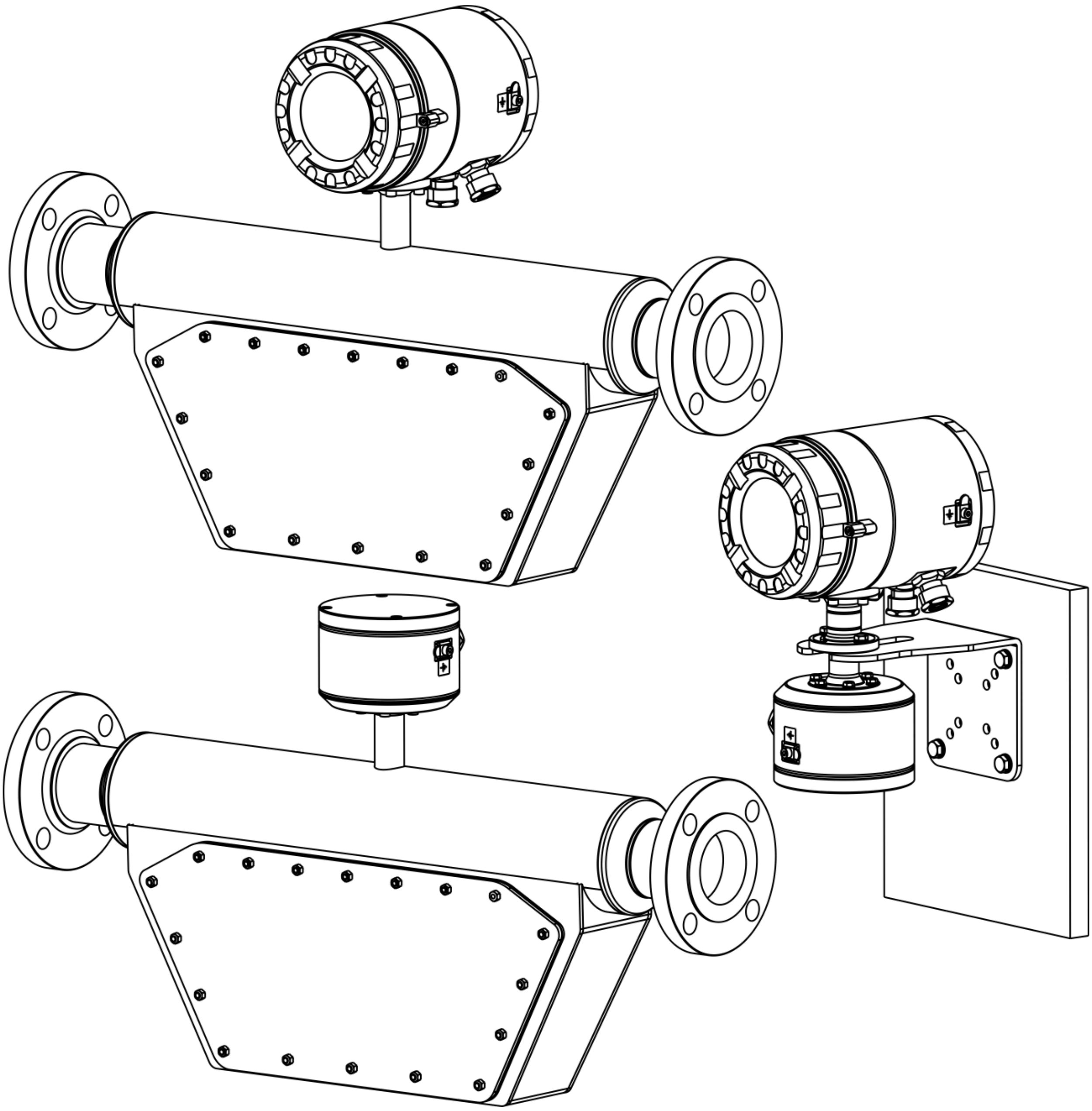
PrismaTech® Coriolis Mass Flowmeter

Instruction Manual for Hazardous Areas (ATEX)



PrismaTech® Instruments

Coriolis Mass Flowmeter **PTMas**

Instruction Manual

PT01UM02EN1.0

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1 Important Information & Safety Guidelines

1.1 About This Manual

This manual provides comprehensive instructions for the installation, operation, maintenance, and troubleshooting of the **PrismaTech**® Coriolis Mass Flowmeter (hereinafter referred to as PTMas-EX). Adhering to the instructions and warnings herein is crucial for safe and efficient operation, ensuring accurate measurements and prolonging the device's lifespan.

- **Read Carefully:** Always read this manual completely before installing, operating, or performing any maintenance on the device.
- **Keep Accessible:** Keep this manual in a readily accessible location near the device for future reference.
- **Qualified Personnel:** Only qualified, trained, and authorized personnel should install, operate, or service this equipment.
- **Safety Symbols:** Pay special attention to all safety symbols and warnings detailed in Section 2 Warning and Symbols of this manual.
- **Local Regulations:** Always comply with local safety regulations, electrical codes, and industry standards applicable to your installation.

1.2 Transportation, Handling & Storage

Proper transportation, handling, and storage are essential to prevent damage to the "PTMas-EX". before installation.

- **Inspect Upon Delivery:** Immediately upon receiving the device, thoroughly inspect the packaging and the device itself for any signs of shipping damage. Report any damage to the carrier and supplier immediately.
- **Original Packaging:** Whenever possible, transport and store the device in its original packaging. The packaging is designed to protect the instrument from shock and environmental factors.
- **Careful Handling:** Handle the device with extreme care. Avoid dropping, sudden impacts, or excessive vibration. Do not lift the device by its electrical connections or display.
- **Lifting:** For heavier units, use appropriate lifting equipment and techniques. Refer to the device's dimensions and weight in Section 4.4 Dimensions for proper handling.

- **Storage Conditions:** If the device is not installed immediately, store it in a clean, dry, vibration-free environment, protected from direct sunlight, extreme temperatures, and humidity. Ensure storage temperatures remain within the specified range of -20°C to 70°C.

1.3 Warranty Information

Control System Co. provides a limited warranty for the "PTMas", ensuring its performance as specified under normal operating conditions.

Standard Warranty: This device is covered by a standard **12-month** warranty from the date of purchase against defects in materials and workmanship. Please refer to your purchase agreement or contact Control System Co. for specific warranty terms and conditions.

Voiding Warranty: The warranty may be voided if:

- The device is installed, operated, or maintained contrary to the instructions in this manual.

- Unauthorized modifications or repairs are performed on the device.
- Non-original spare parts are used.
- The device has been subjected to misuse, neglect, accident, or improper storage or transportation.

Warranty Claims: For warranty claims or technical support, please contact your local distributor or Control System's customer service department with your device's serial number and purchase details.

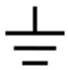
2 Warning and Symbols

This manual uses the following symbols to draw attention to important safety information, potential hazards, and critical instructions. Please ensure you understand these symbols before performing any operation, installation, or maintenance on the device. Strict adherence to these warnings is essential for personnel safety and to prevent damage to equipment and the environment.

2.1 Key Symbols

Signs	Description
	DANGER! This warning indicates an immediate risk of electrical burn.
	DANGER! This warning indicates an immediate risk of burns from heat or hot surfaces.
	DANGER! This danger must be carefully considered, so that even a partial lack of attention to this risk may cause health problems or death. There is also the possibility of serious damage to the user's facilities and production line.
	DANGER! This warning refers to the immediate danger when using this device in a hazardous atmosphere.
	WARNING! Disregarding this safety warning, even if only in part, poses the risk of serious health problem. There is also the risk of damaging the device or parts of the operator’s plant.
	CATUION! Disregarding these instructions can result in damage to the device or parts of the operator’s plant.

2.2 Electrical signs

Signs	Description
	**Direct current** The terminal to which direct current should be connected or from which direct current is taken.
	**Alternating current** The terminal to which alternating current should be connected or from which alternating current is taken.
	**Direct current and alternating current** The terminal to which direct or alternating current should be connected. The terminal from which direct current or alternating current is taken.
	**Ground connection** A grounded terminal that must be connected to a grounding system
	**Ground protective connection** A terminal that must be connected to Ground before any other connection.
	**Equipment connection** A connection that should be connected to the grounding system of the factory in such a way that it can be a potential equalization line or a star grounding system according to the national and local standards of the factory in question.

2.3 Signs used for guidance

Signs	Description
	**Allowed** Showing the methods and operations that the user is allowed to perform when using or installing the device.
	**recommended** Indicates the methods and operations when using or installing the device is preferred over other methods.
	**Prohibited** It indicates the methods and operations that are prohibited when using or installing the device.
	**Installation in the place of mechanical vibrations is prohibited** The presence of mechanical vibrations at the installation site leads to errors in the operation and measurement of the device.
	**Installation in the vicinity of the magnetic field is prohibited** The presence of a magnetic field in the place of installation leads to errors in the operation and measurement of the device.
	Further information
	Visual inspection
	The address of the menus

3 Safety Instructions

3.1 Introduction and Scope

This section of the manual contains vital information and necessary instructions for the safe installation, operation, and maintenance of the "PTMas" Coriolis flowmeter in Hazardous Areas in accordance with the requirements of the ATEX International Scheme. This device is designed and certified for use in explosive gas atmospheres.

Important: This section of the manual must be read before installing the device. This information supplements the general safety instructions and does not replace them. All general safety requirements, as well as specific requirements related to hazardous areas mentioned in this section, must be fully observed. Installation, commissioning, and maintenance of the device in hazardous areas must only be performed by qualified personnel who have sufficient knowledge of hazardous area standards (such as EN/IEC 60079 series) and the requirements of this manual.

Failure to comply with the instructions contained in this manual and the relevant certificates may result in an explosion hazard, damage to equipment, severe injury or death, and will invalidate the device's certifications.

The device is supplied in two main configurations, both certified for use in hazardous areas:

- **Integral Configuration:** The transmitter and sensor are mounted together. This configuration is suitable for installation in Zone 1 and Zone 2 (gas atmosphere) areas.
- **Remote Configuration:** The sensor and its associated intrinsically safe electronic board housing are separated from the transmitter. The sensor and its housing are suitable for installation in Zone 0 (gas atmosphere) areas. The transmitter is suitable for installation in Zone 1 and Zone 2 (gas atmosphere) areas.

The precise ATEX requirements and markings for each configuration are provided in the Technical Specifications section.

3.2 Safety Instructions for Hazardous Areas

In addition to the general safety instructions in Section 5,the following safety instructions are specific to the use of the device in hazardous areas and must be fully complied with:

- **Personnel Competence:** All installation, wiring, commissioning, operation, inspection, maintenance, and repair operations of the device in hazardous areas must be carried out by personnel who have received the necessary training and are familiar with the requirements of relevant hazardous area standards (such as EN/IEC 60079-14 for installation and EN/IEC 60079-17 for inspection and maintenance), as well as the requirements of this manual and the device's certificates.

- **Check Nameplate and Certificates:** Before installation and commissioning, always check the device's nameplate and its Ex marking to ensure the device is suitable (in terms of equipment group, category, protection type, gas group, temperature class, and EPL) for the intended hazardous area. Carefully read the ATEX certificates.

- **Unauthorized Modifications:** Any changes, modifications, or use of non-original parts in the device without written approval from the manufacturer are not permitted. Such actions will invalidate the relevant certifications and create a serious explosion hazard.

- **Temperature Limitations:** The device must only be used within the ambient temperature (Ta) and process temperature (Tp) ranges specified in the technical specifications section and the device's certificates. The surface temperature of the device during normal and fault operation must not exceed the maximum permissible temperature class (T Class).

- **Power Disconnection (for Ex d Enclosures):** Before opening the transmitter enclosure (in both Integral and remote configurations) that uses Flameproof (Ex d) protection, always disconnect the power to the device. After power disconnection, allow sufficient time for the internal and external surfaces of the enclosure to cool down (especially at high temperatures). Opening the enclosure while power is connected or while surfaces are still hot can cause an explosion. These requirements are detailed in the Maintenance section.

- **Wiring Requirements:** Wiring must be carried out in accordance with the instructions in the installation section of this manual, relevant standards (such as EN/IEC 60079-14), and local regulations. The use of certified cable glands and blanking plugs suitable for the protection type and hazardous area is essential.

- **Dependence on Associated Apparatus (Barrier):** The safety of the sensor circuit in Zone 0 depends on the use of an "Associated Apparatus," i.e., a certified intrinsically safe barrier installed outside the hazardous area (Safe Area) **and within the certified transmitter enclosure specifically for this purpose**. The output parameters of the barrier must be compatible with the input parameters of the sensor (as per the technical specifications section) to ensure the intrinsic safety of the sensor.

- **No Manipulation in Zone 0:** In general, no wiring operations, connection/disconnection, opening of the housing, or repairs on the sensor and its housing in Zone 0 are permitted while the system is energized.

- **Do Not Operate if Damaged:** Do not operate the device if it shows any signs of physical damage (e.g., cracks, deformation, severe corrosion) or malfunction that could affect its safety in the hazardous area.

- **Maintain Enclosure Integrity:** Always ensure that all covers, cable glands, and blanking plugs are properly and securely fastened to maintain the Ingress Protection (IP Rating) and the Ex-protection type.

- **Electrostatic Hazards:** Certain surfaces of the device (e.g., non-metallic enclosure parts, labels) may be subject to electrostatic charging. Prevent electrostatic discharge by avoiding cleaning with dry cloths and only using a damp cloth for cleaning.

3.3 Technical Specifications for Hazardous Areas

The following information provides the technical specifications related to the use of the device in hazardous areas based on ATEX certifications. This information is also included on the device's nameplate.

Certificates:

- ATEX Certificate Number: [ATEX Certificate Number]
- ATEX Certification Body: [Name of Issuing Body]

Ex Marking:

- Transmitter:
- ATEX Marking: [Precise ATEX marking for transmitter, e.g., Ex db IIB T4 Gb]
- Sensor & Housing:
- ATEX Marking: [Precise ATEX marking for sensor in Zone 0, e.g., Ex ia IIC T6 Ga]

Marking Description:

CE Ex I 1 G Ex ia IIC T6 Ga

Acc EN 60079-0ff/IEC 60079-0ff

CE mark, Conforms to EU standards

EX logo, Approved use in explosive atmosphere, as specified

Equipment group

I	Mining
II	None mining

Safety Category

1	Very high
2	High
3	Normal

Explosive Atmosphere

G	Gas
D	Dast

Ex = Explosion-proof electrical equipment

Examples of electrical types of protection

	General requirements	IEC 60079-0
"d"	Flameproof enclosure	IEC 60079-1
"e"	Increased safety	IEC 60079-7
"i"	Intrinsic safety (ia, ib)	IEC 60079-11
"t"	Equipment dust ignition protection by enclosure "t" (ta, tb or tc)	EN 60079-31

Explosion groups

	Gases and vapours
IIA	Acetone, benzene, fuel oil, ethanoic acid
IIB	City gas, ethylene, isoprene
IIC	Acetylene, hydrogen, carbon bisulphide
Dust Atmospheres	
IIIA	Fibers and flyings
IIIB	Non-conductive dusts
IIIC	Metal dusts

Temperature classes

Maximum surface temperature		Temperature class
450 °C	842 °F	T1
300 °C	572 °F	T2
200 °C	392 °F	T3
135 °C	275 °F	T4
100 °C	212 °F	T5
85 °C	185 °F	T6

Equipment protection level, EPL

Gases: Ga, Gb or Gc	Dust: Da, Db or Dc

ATEX Related Electrical Data:

- **For Integral Model and Remote Transmitter (Non-IS part):** Supply Voltage and Current: [Nominal voltage and current, e.g.,] 24VDC 500mA
- **Input/Output Specifications:** [Specifications for non-IS signals like 4-20 mA output, if certified for connection in hazardous areas].
- **For Remote Sensor Circuit (ATEX Category 1G / Ex ia IIC Ga):** Sensor Input Parameters (Intrinsically Safe Entity Parameters acc. to EN 60079-11)
    - **Maximum Input Voltage ($\boldsymbol{U_i}$):** [Value from EU-Type Examination Certificate] V
    - **Maximum Input Current ($\boldsymbol{I_i}$):** [Value from EU-Type Examination Certificate] mA
    - **Maximum Input Power ($\boldsymbol{P_i}$):** [Value from EU-Type Examination Certificate] mW
    - **Maximum Internal Capacitance ($\boldsymbol{C_i}$):** [Value from EU-Type Examination Certificate] μF
    - **Maximum Internal Inductance ($\boldsymbol{L_i}$):** [Value from EU-Type Examination Certificate] mH
- **Temperature Specifications:** Ambient Temperature Range (T_a): [Permissible ambient temperature range, e.g., $-40°C$to $+60°C$] This range is extracted from the ATEX EU-Type Examination Certificate.
- **Process Temperature Range ($\boldsymbol{T_p}$):** [Permissible process temperature range]. The relationship between this temperature, the temperature class, and the device's maximum surface temperature is described in the EU-Type Examination Certificate or the "Specific Conditions of Use" section.
- **Specific Conditions of Use ('X'):** The letter 'X' at the end of the ATEX certificate number indicates the presence of specific conditions of use for safe application, which are detailed in Section 8 of this manual. Compliance with these conditions is mandatory to maintain ATEX certification and safety.

3.4 Installation in Hazardous Areas

Installation of the device in hazardous areas must comply with relevant national and international standards (such as EN/IEC 60079-14) and the requirements of this manual and the device's certificates.

3.4.1 General Requirements:

- Only qualified personnel are permitted to install the device.
- Before starting installation, ensure the device is suitable for the intended hazardous area (check nameplate and certificate).
- Comply with local regulations governing the installation of electrical equipment in hazardous areas.
- Before any wiring or connection work, ensure the power is completely disconnected (unless Ex ia requirements specifically permit otherwise).

3.4.2 Physical Installation of the Device:

- Install the device in a location within the permissible ambient temperature (Ta) range, and away from excessive vibration, mechanical damage, and unwanted heat sources.
- Not suitable for installation in dusty areas. (Zone 20, 21, 22)

3.4.3 Cable Glands and Blanking Plugs:

For Ex db Enclosures (Integral Model and Remote Transmitter):

- All cable entries must be fitted with certified Ex d cable glands compliant with EN/IEC 60079-0 and EN/IEC 60079-1, suitable for the cable type (armored or unarmored) and thread type (M20x1.5).
- The cable gland itself must also be certified for the equipment's gas group and temperature class (e.g., IIB/IIC and T4/T6) and bear the appropriate marking (e.g., Ex db IIC Gb).
- Cable glands must be correctly installed and tightened to the appropriate torque (as per the gland manufacturer's instructions) to maintain the flameproof protection of the enclosure.
- All unused cable entries must be securely sealed with certified Ex d blanking plugs from the same manufacturer and in accordance with the same standards and thread type. Necessary washers and seals must be used to maintain the Ingress Protection (IP Rating) and Ex protection type.
- Check the integrity of the gasket on the terminal cover.
- For Remote Sensor Housing in Zone 0 (Ex ia Protection):
- Cable entries to the sensor housing (certified for Zone 0 and Ex ia) must be made using glands or cable entry methods specified in the device's certificate or associated technical documentation. These glands must be certified for intrinsically safe circuits and maintain the appropriate IP Rating of the enclosure (e.g., IP66/IP67) and comply with Ex ia installation

requirements in EN/IEC 60079-14. Special certified glands may be required as stated in 'X' conditions.

- It is recommended that intrinsically safe cables be identified by their light blue sheath.
- All unused cable entries in the sensor housing must also be securely sealed with appropriate certified blanking plugs (as per certificate).
- Check the integrity of the gasket on the junction box.

3.4.4 Wiring:

General Requirements:

- Use cables with adequate insulation, appropriate thermal resistance, and necessary mechanical strength for the environmental conditions.
- Cable sizes must be appropriate for the current and voltage drop.
- All cables and conduits must be protected from mechanical damage throughout the installation route.

Integral Model and Remote Transmitter (Power and Output Wiring):

- Route power and signal cables (non-IS) into the transmitter enclosure through suitable Ex d cable glands.
- Connect wires to the designated terminals according to the wiring diagram in the general manual.
- In accordance with EN/IEC 60079-14, pass the minimum number of conductors through each gland and arrange the wires properly inside the enclosure.
- Intrinsically Safe Circuit (Ex ia) - Remote Sensor Connection in Zone 0 to Transmitter/Barrier:
- This circuit must be wired strictly in accordance with the requirements of EN/IEC 60079-14 and the control drawing for the intrinsically safe system.
- **Circuit Separation:** The intrinsically safe circuit cable (between the sensor and transmitter/barrier) must be kept completely separate from all non-intrinsically safe cables. This separation must be maintained along the entire cable route, in cable trays, junction boxes, and entry points to panels. No non-intrinsically safe cables or wires should enter the intrinsically safe enclosure.
- **Cable Length:** The maximum permissible cable length between the sensor (Zone 0) and the barrier (in the transmitter) is limited based on the intrinsic safety parameters (Ca, La) **of the barrier and** the capacitance and inductance per unit length of the cable used. Ensure to calculate the maximum permissible cable length using the table or formula provided in the technical specifications or certificate.
- **Connection to Barrier:** The cable from the sensor (Zone 0) must be connected to the designated intrinsically safe input terminals in the transmitter (the barrier is integrated into the transmitter and is certified).

- **Earthing in Zone 0:** The intrinsically safe circuit is typically earthed at only one point (usually at the barrier side). There must be no unintended earth connections in Zone 0 or along the cable path. Check the cable's insulation resistance after wiring.

3.4.5 Earthing and Potential Bonding:

- The device's body (both sensor and transmitter) must be effectively and reliably connected to the facility's main earthing system. This connection is made via the designated internal and external earthing terminals.
- For Ex db enclosures, earthing is essential for maintaining safety.
- For intrinsically safe systems, earthing of the barrier on the safe side is essential for proper protection function.
- Equipotential bonding between the device and other metallic equipment in the hazardous area (especially in dusty areas -**if applicable**- and Zone 0) is mandatory to prevent static electricity accumulation and sparking due to potential differences. This must be done in accordance with EN/IEC 60079-14 requirements and local regulations.
- **Specific Conditions of Use ('X'):** Any additional installation requirements mentioned in the technical specifications under 'X' Conditions must be fully observed during installation.

3.5 Operation in Hazardous Areas

- Before commencing operation, ensure the device is correctly installed and wired in accordance with the preceding sections and the certificates.
- Always check the nameplate and Ex marking before operating the device in a hazardous area.
- Operate the device only within the permissible ambient (Ta) and process (Tp) temperature ranges specified in the technical specifications section.
- During operation, periodically visually inspect the device for any physical damage, corrosion, loose connections, or abnormal signs that could affect its safety in the hazardous area.
- Any adjustments or changes to device settings that require opening the enclosure must only be performed after disconnecting power and observing cooling down time (for Ex d enclosures) or outside the hazardous area, unless expressly permitted in the manual or certificate (e.g., some adjustments without opening the enclosure or via special tools).
- In the remote model, no manipulation (such as connecting/disconnecting cables, opening the housing) on the sensor and its housing in Zone 0 is permitted while the system is energized.
- Electrostatic Hazards: Prevent the accumulation of electrostatic charge on the device's surfaces, especially non-metallic parts. For cleaning, use only a damp cloth and avoid dry clothes or alcohol-based solvents that can cause static charge accumulation.

3.6 Maintenance and Repair in Hazardous Areas

Maintenance and repair operations in hazardous areas must be carried out with extreme care and in accordance with the requirements of EN/IEC 60079-17 (Inspection and Maintenance) and EN/IEC 60079-19 (Repair), as well as the instructions in this section.

3.6.1 Periodic Inspections:

- Periodic inspections of the device are essential to maintain its safety in hazardous areas.
- The type and frequency of inspections (e.g., annual visual inspection, more detailed periodic inspection) must be determined based on the area risk assessment, environmental conditions, and the requirements of EN/IEC 60079-17.
- Recommended inspection intervals:

	Activity	Visual inspection	Close inspection	Detailed inspection
		3-month interval	6-month interval	12-month interval
1	Visual inspection of equipment for intactness, removal of dust settlements	X		
2	Check of electrical system for intactness and functionality			X
3	Check of entire system		User's responsibility	

- During inspection, check the following:
- Physical condition of enclosures (absence of cracks, deformation, or damage).
- Condition of cable glands and blanking plugs (tightness, absence of damage, absence of signs of moisture or dust ingress).
- Condition of earthing and equipotential bonding connections (tightness, absence of corrosion).
- Absence of excessive corrosion.
- Accumulation of dust on surfaces. Any significant dust accumulation must be removed to prevent temperature rise.
- Legibility of the nameplate and Ex marking.
- Ensure all screws and fasteners on the enclosure and cable glands are tight.

3.6.2 Work on Flameproof (Ex d) Enclosures - Integral Model and Remote Transmitter:

- Always disconnect power to the device and observe sufficient cooling time (as per safety section) before opening the enclosure.
- After opening the enclosure, inspect the flame path sealing surfaces. These surfaces must be clean, free from corrosion, and without any damage (e.g., cuts, deep scratches, or nicks). Damage to the flame path can compromise explosion protection.

- When re-closing the enclosure, ensure the flame path surfaces are clean. Tighten screws in the correct sequence and to the recommended torque (if applicable) to maintain the permissible gap. Ensure all screws and fasteners are in place and properly tightened.
- Use original or authorized gaskets and seals.

3.6.3 Work on Intrinsically Safe (Ex ia) System - Remote Sensor in Zone 0:

- Any work on the sensor or its housing in Zone 0 while the system is energized is extremely dangerous and generally prohibited.
- If access to the sensor or its housing in Zone 0 is required, strict safety procedures must be followed. This may include:
- Obtaining a hazardous area work permit (e.g., cold work permit).
- Ensuring the complete absence of an explosive atmosphere in the area (continuous gas monitoring or sampling).
- Disconnecting power to the intrinsically safe system from the safe side.
- Using tools and measuring equipment certified for use in Zone 0 (Ex ia).
- When opening the sensor housing in Zone 0, ensure the absence of an explosive atmosphere at the moment of opening.
- Internal electronic components of an intrinsically safe device must not be tampered with or replaced unless authorized by the manufacturer and using original spare parts.
- After any maintenance or wiring modifications to intrinsically safe circuits, it is recommended to verify the insulation resistance of the circuit to ground and between conductors to ensure no unintended connections or shorts exist.

3.6.4 Repairs:

- Repair of components affecting explosion protection (e.g., Ex d enclosures, intrinsically safe circuits) must only be performed by the device manufacturer or repair centers authorized by the manufacturer.
- The use of non-original spare parts or repairs carried out by unqualified individuals or workshops will invalidate the device's certifications and jeopardize its safety.

3.6.5 Cleaning:

- When cleaning the device, use methods that do not generate electrostatic charge. The use of a damp (not wet) cloth is recommended. Avoid high-pressure cleaning or aggressive scrubbing.

3.7 Specific Conditions of Use (‘X’)

As stated in the technical specifications, the end of the device’s ATEX certificate number is marked with the letter ‘X’. The following specific conditions of use are mandatory and must be fully observed to ensure the safety of the device in hazardous areas. Failure to comply with any of these conditions will invalidate the device’s certifications.

- The device must be installed in such a way that it is not subjected to severe mechanical impact.
- For cable connection, only certified Ex d cable glands with M20x1.5 thread and complying with EN 60079-1 shall be used.
- The maximum permissible cable length between the sensor and the transmitter is [500] meters. This length is limited based on the maximum permissible capacitance (Ca) and inductance (La) of the barrier and the capacitance (e.g., [value] pF/m) and inductance (e.g., [value] μH/m) per unit length of the cable used. Ensure that the sum of the sensor’s internal capacitance (Ci) and the total cable capacitance (Ccable) does not exceed the barrier’s maximum permissible capacitance (Ca). Similarly, the sum of the sensor’s internal inductance (Li) and the total cable inductance (Lcable) must not exceed the barrier’s maximum permissible inductance (La). (i.e., $Ci+Ccable \leq Ca$ and $Li+Lcable \leq La$)
- Prevent electrostatic charge accumulation on non-metallic parts of the device. Suitable measures (e.g., cleaning with a damp cloth) must be taken.

4 Introduction

Coriolis mass flowmeters can be of the standard and multivariable type for liquids and gases, allowing simultaneous recording of multiple variables (mass/density/temperature) for different process conditions during measurement operations. The principle of Coriolis flow meter measurement is independent of fluid physical properties such as viscosity and density, providing very high measurement accuracy. The main applications of Coriolis flow meters include measuring the following aspects.

- Oils
- Lubricants
- Fuels
- Liquid and compressed gases
- Solvents Steel Industries
- Power and mining industries

PrismaTech® Coriolis Mass Flowmeter have been designed and built for the mentioned applications with the following features:

- Easy installation
- Easy operation
- Easy maintenance
- Insensitivity to vibrations thanks to the balanced dual-tube measurement system.
- Piping is designed resistant to ensure security against external forces.
- Excellent performance due to high-precision calibration.

4.1 Principles of Operation of Coriolis Mass Flowmeters

In this method, measurement is done based on the Coriolis principle.

Coriolis flowmeters are typically composed of two oscillating tubes. In general, in all types of these flowmeters, fluid passes through the oscillating tubes. The tubes vibrate at their natural frequency and are oscillated by electronic oscillators connected to the tubes. Some coils are used to detect small oscillations or micro motion of the tubes, connected to one of the tubes, and a series of iron rods connected to the adjacent tube, such that with the oscillation of the tubes, a fluctuating voltage is induced in each coil due to the change in the magnetic field generated by the adjacent iron rod.

When fluid moves towards a vibrating point in the flow meter, the pipe applies acceleration or force to it. The moving fluid, to resist the force exerted by the pipe, applies a force back to the pipe. This force will also appear at the outlet of the pipe in the opposite direction. The interaction of these two forces at the inlet and outlet of the pipes causes the pipe to twist. This force is proportional to the mass of the fluid passing through the pipes and is called the Coriolis force, leading to a phase difference and induced voltage in the two coil wires at the ends of the pipes. Therefore, the phase difference or time delay between the input and output waves is directly proportional to the mass flow rate of the fluid.

$$Fc = 2 * \Delta m(v * \omega)$$

Fc= Coriolis Force	V= Radial velocity in a rotational or oscillatory system
Δm = Mobile crime	ω = Rotation Speed

The Coriolis force domain depends on the moving mass Δm, velocity V in the system, and consequently on the mass flow. Instead of a constant angular velocity ω, the sensor uses oscillation.

• In zero flow, when the fluid is stationary, two pipes in phase 1 (Figure 4-1/1) oscillate.

• Mass flow causes a decrease in oscillation at the pipe inlets (Figure 4-1/2) and acceleration at the outlets (Figure 4-1/3).

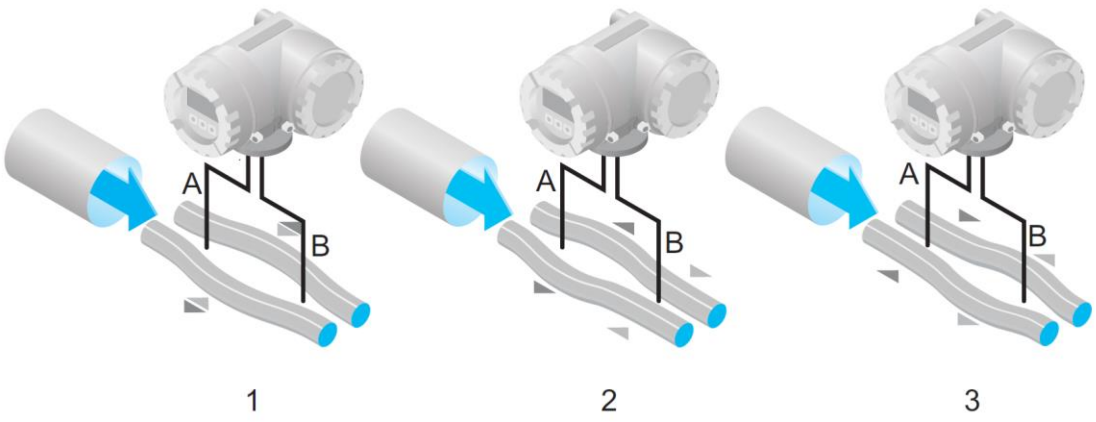


Figure 4-1 Coriolis Law

4.2 Product Configurations

The **PrismaTech**® Coriolis Mass Flowmeter is engineered to meet diverse application requirements, including those in hazardous environments. To provide optimal flexibility and safety, it is available in two distinct configurations: the **Integral Version** and the **Remote Version**. Each configuration offers specific advantages regarding installation and suitability for different hazardous area classifications.

4.2.1 Integral Version

The Integral Version integrates the flow sensor and the transmitter into a single, robust unit. **As shown in Figure 4-2**, this design offers a streamlined installation and is ideal for applications where the entire measurement device can be placed within the designated hazardous area.

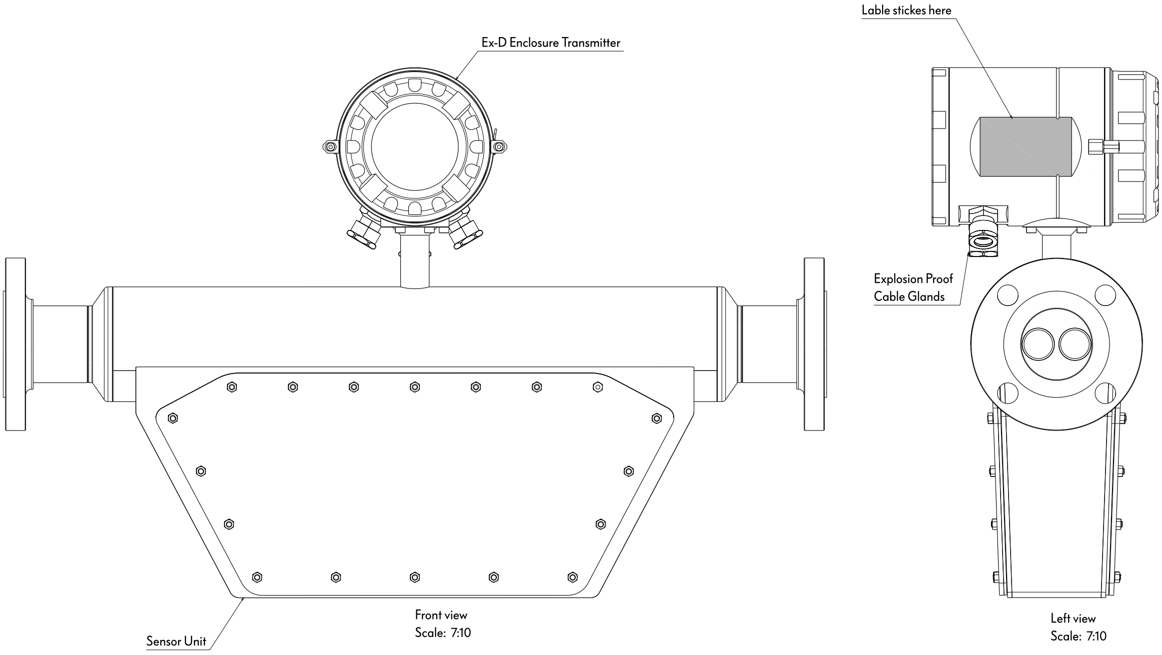


Figure 4-2 Overview of **PrismaTech**® Integral Coriolis Mass Flowmeter

- **Integration:** Sensor and transmitter are directly mounted together, forming a single, pre-assembled instrument.
- **Installation:** Designed for direct mounting in the process line.
- **Hazardous Area Suitability:** The entire Integral unit is certified for installation in **Zone 1** and **Zone 2** hazardous areas, offering reliable performance with flameproof (Ex db) protection for its electrical components.

4.2.2 Remote Version

The Remote Version utilizes a split-architecture design, separating the flow sensor from the transmitter. **As depicted in Figure 4-3**, this configuration is particularly advantageous for applications requiring the sensor to be located in highly hazardous areas, while the transmitter can be positioned at a more accessible or less hazardous location.

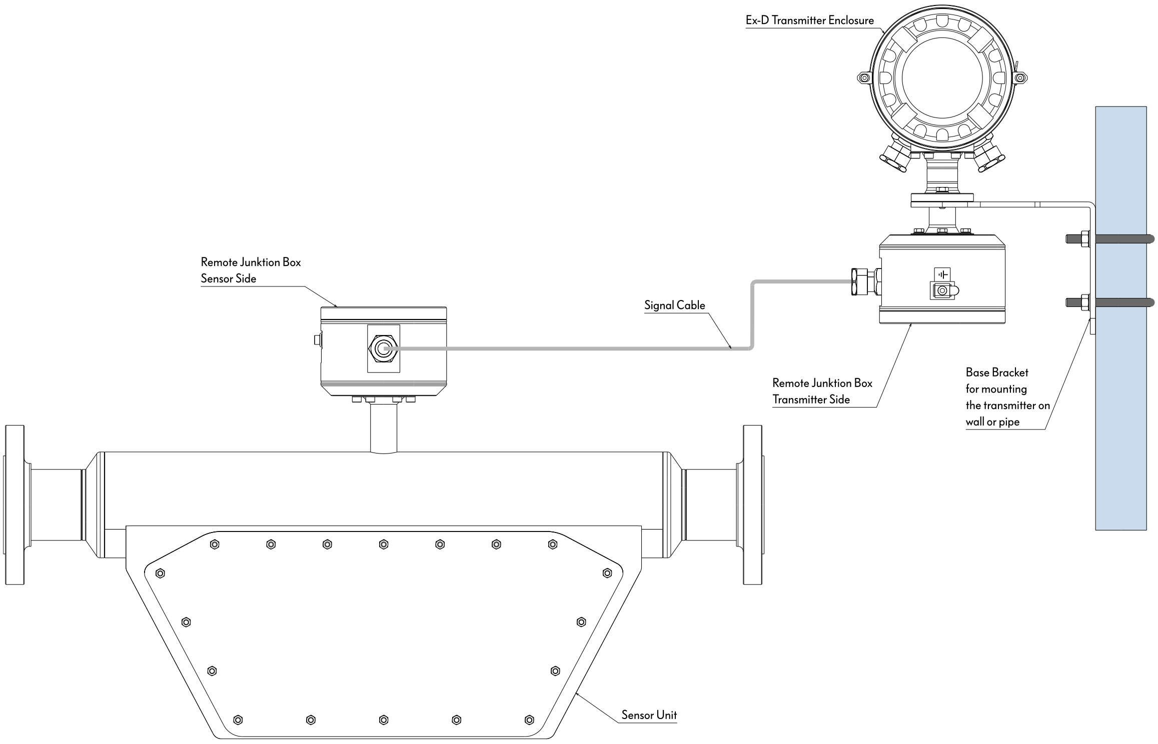
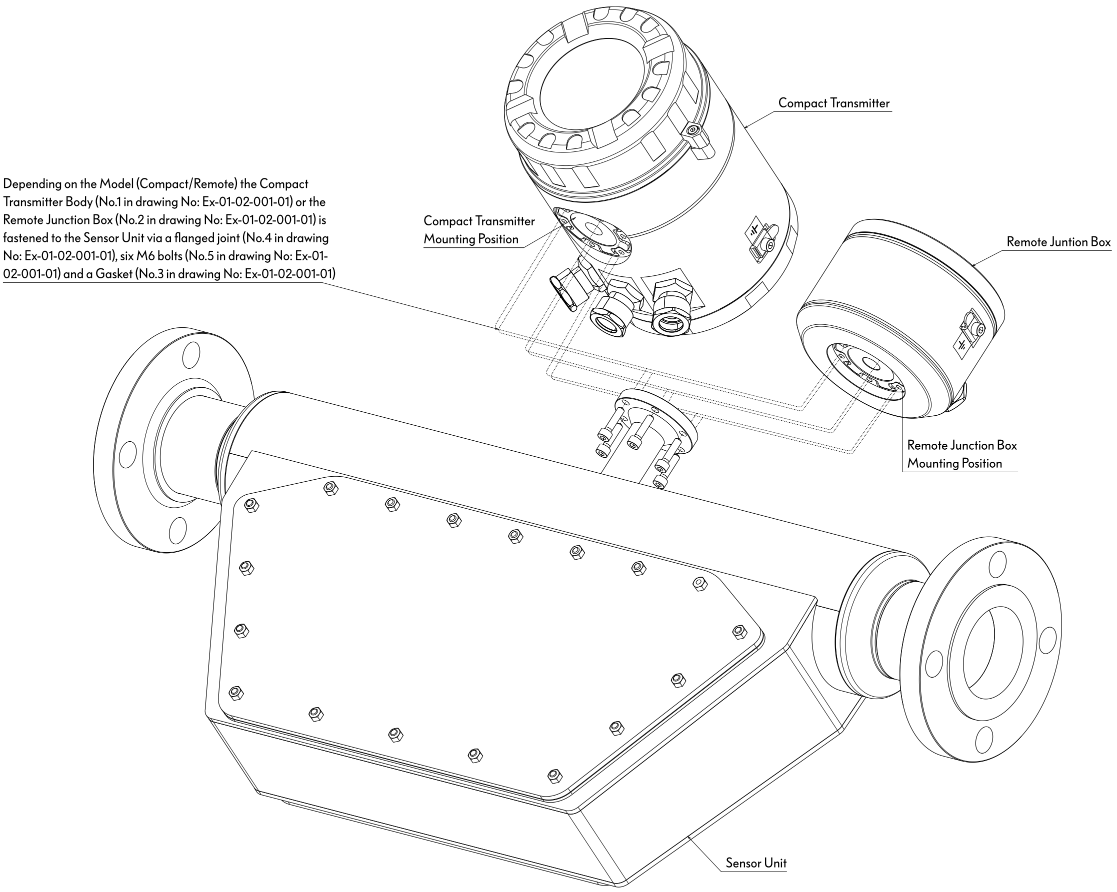


Figure 4-3 Overview of **PrismaTech®** Remote Coriolis Flowmeter

- **Split Architecture:** The flow sensor, along with an integrated barrier board, forms one part, which is connected via a dedicated cable to the remote transmitter unit.
- **Sensor Unit Installation:** The sensor unit, incorporating intrinsic safety (Ex ia) protection, is specifically designed and certified for installation in **Zone 0** or **Zone 1** hazardous areas, where an explosive atmosphere is continuously present or likely to occur.
- **Transmitter Unit Installation:** The transmitter unit, housing the main electronics and display, can be installed in **Zone 1**, **Zone 2**, or even in a non-hazardous (safe) area, depending on site requirements. This transmitter features flameproof (Ex db) protection for its internal circuitry and provides an intrinsically safe (Ex ia) output to power and communicate with the Zone 0/1 sensor.
- **Flexibility:** This setup allows for greater flexibility in system design, remote monitoring, and maintenance accessibility, especially when the sensor is located in an extremely hazardous or difficult-to-access area.

4.3 Key Components of the **PrismaTech®** Coriolis Flowmeter

This section provides an overview of the main components that constitute the [Product Name] Coriolis Flowmeter system, detailing their functions and significance. As illustrated in Figure 4-4, the system typically



comprises a Sensor Unit, a Transmitter Unit, and for remote configurations, a Junction Box.

Figure 4-4 different parts of **PrismaTech®** Coriolis Mass Flowmeter

4.3.1 Sensor Unit

The Sensor Unit is the primary measuring element of the Coriolis flowmeter. It directly interacts with the process fluid to measure mass flow rate, density, and temperature.

- **Function:** Utilizes the Coriolis principle to induce and measure the phase shift, frequency, and amplitude of vibrating tubes caused by the flowing fluid, thereby determining mass flow and density. Integrated RTDs measure process temperature.
- **Design:** Consists of one or more vibrating tubes, primary electronics for signal generation and detection, and process connections (flanges or threads) for inline installation.
- **Wetted Parts:** Typically constructed from materials like stainless steel (e.g., 316L) or more corrosion-resistant alloys (e.g., Hastelloy C22), suitable for a wide range of fluids.
- **Hazardous Area (Remote Version):** In remote configurations, the sensor unit (often with an integrated barrier board) is intrinsically safe (Ex ia certified) for direct installation in highly hazardous areas, including Zone 0.

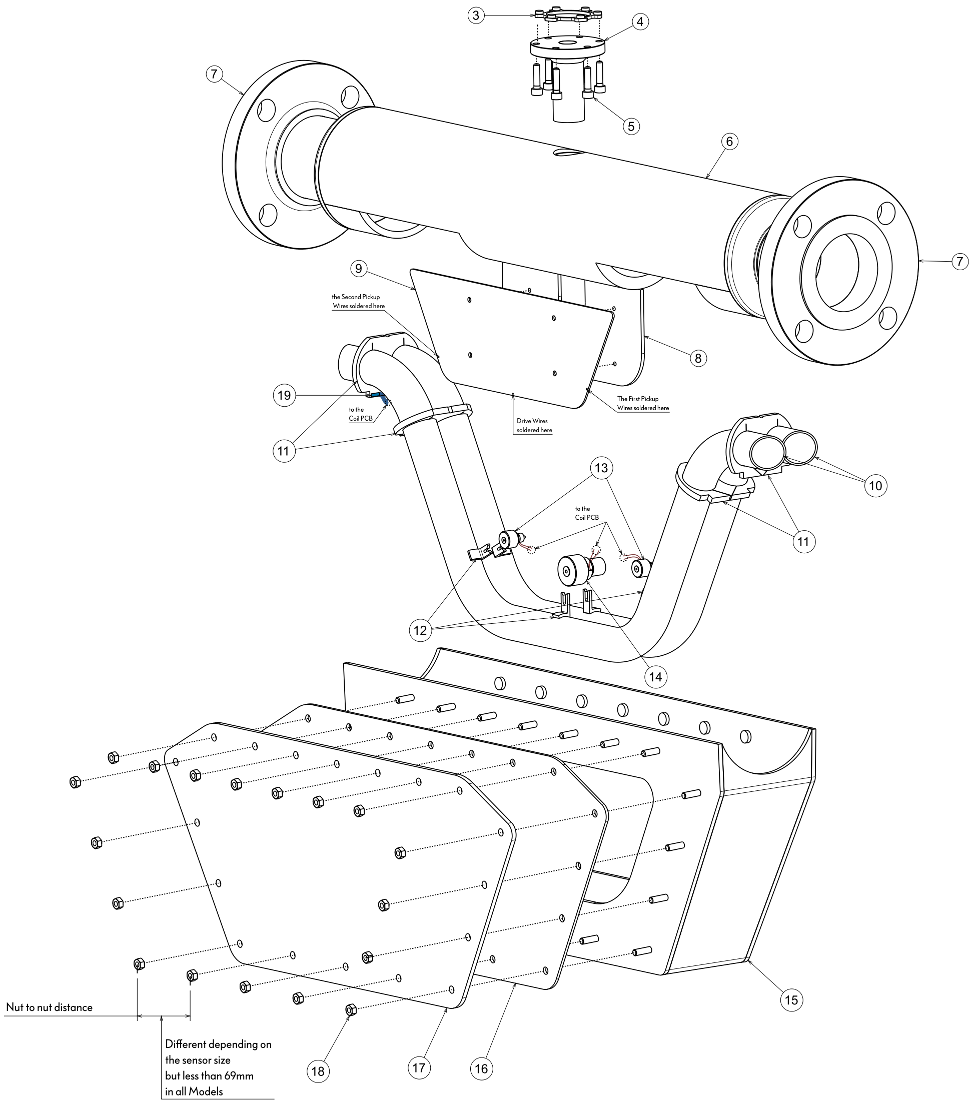


Figure 4-5 different parts of **PrismaTech®** Coriolis Mass Flowmeter sensor unit components

4.3.2 Transmitter Unit

The Transmitter Unit is the "brain" of the flowmeter, responsible for processing the raw signals from the sensor, performing calculations, displaying data, and facilitating communication with control systems.

- **Function:** Receives and processes signals from the sensor, calculates mass flow, volume flow, density, temperature, and totalized values. It provides a user interface for configuration, diagnostics, and data visualization.
- **Display & Interface:** Features a local display (e.g., LCD, graphical display) for real-time data visualization and an intuitive interface (e.g., push-buttons, touch screen) for parameter setup.
- **Outputs & Communication:** Offers various output options including analog (4–20 mA), digital (pulse, frequency), and advanced communication protocols (e.g., HART, Modbus RTU, Foundation Fieldbus, Profibus PA, Ethernet/IP) for seamless integration into control systems.
- **Hazardous Area:** The transmitter unit is typically flameproof (Ex db certified) for installation in Zone 1 or Zone 2 hazardous areas, or in safe areas. For remote versions, it provides an intrinsically safe (Ex ia) output to power and communicate with the Zone 0 sensor.

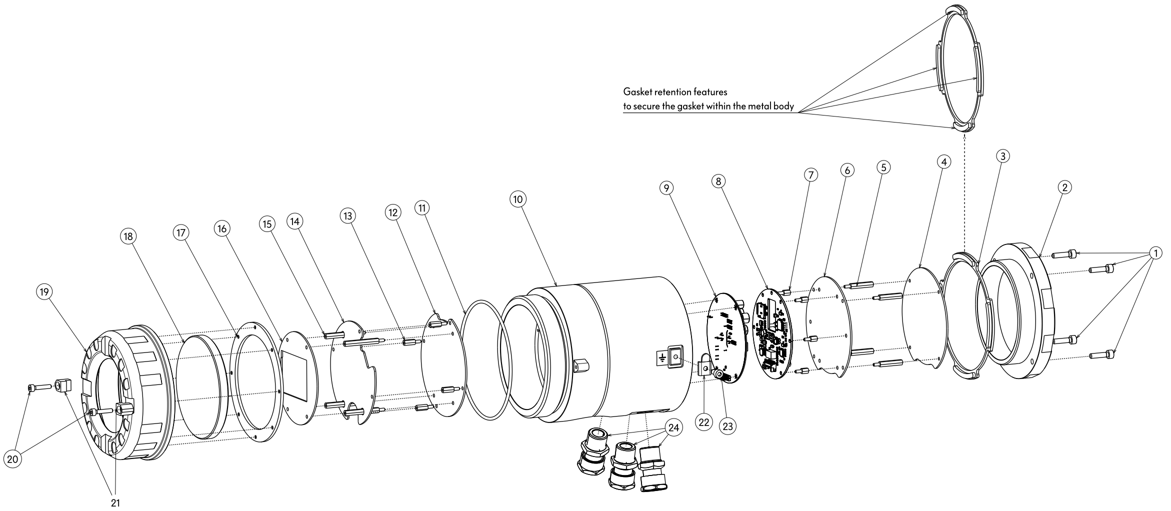


Figure 4-6 different parts of **Prisma**Tech® Coriolis Mass Flowmeter Integral transmitter unit components

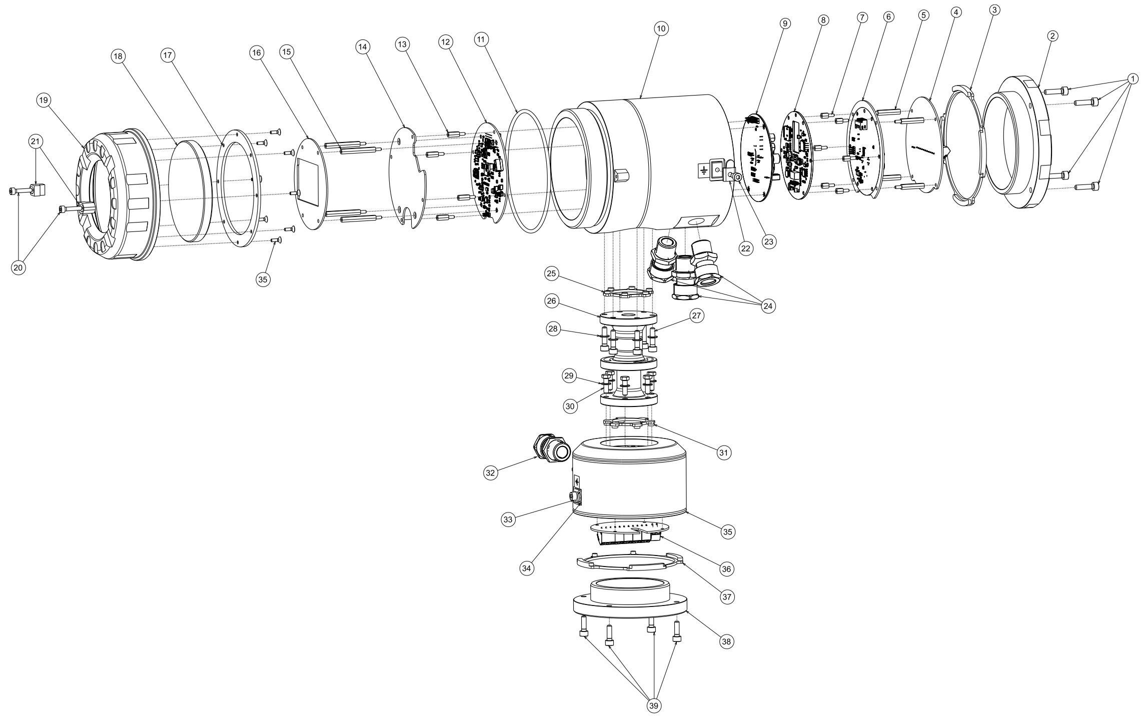


Figure 4-7 different parts of **Prisma**Tech® Coriolis Mass Flowmeter Remote transmitter unit components

4.3.3 Junction Box (for Remote Versions)

The Junction Box serves as a robust and safe intermediary connection point, primarily used in remote configurations to connect the sensor unit to the transmitter unit.

- **Function:** Provides secure
-
- re terminal connections for the sensor signal cables, power, and communication lines between the sensor and the remote transmitter. In some cases, it may house intrinsic safety barriers or additional electronics required for signal integrity over long cable runs.
- **Enclosure:** Designed for industrial environments, offering protection against dust and water ingress (e.g., IP66/67). Its robust construction ensures integrity in harsh conditions.
- **Hazardous Area:** Depending on its location, the junction box may also be certified for use in hazardous areas (e.g., Ex e, Ex d, or contain Ex ia barriers). It ensures the safe termination of intrinsically safe circuits from the sensor.

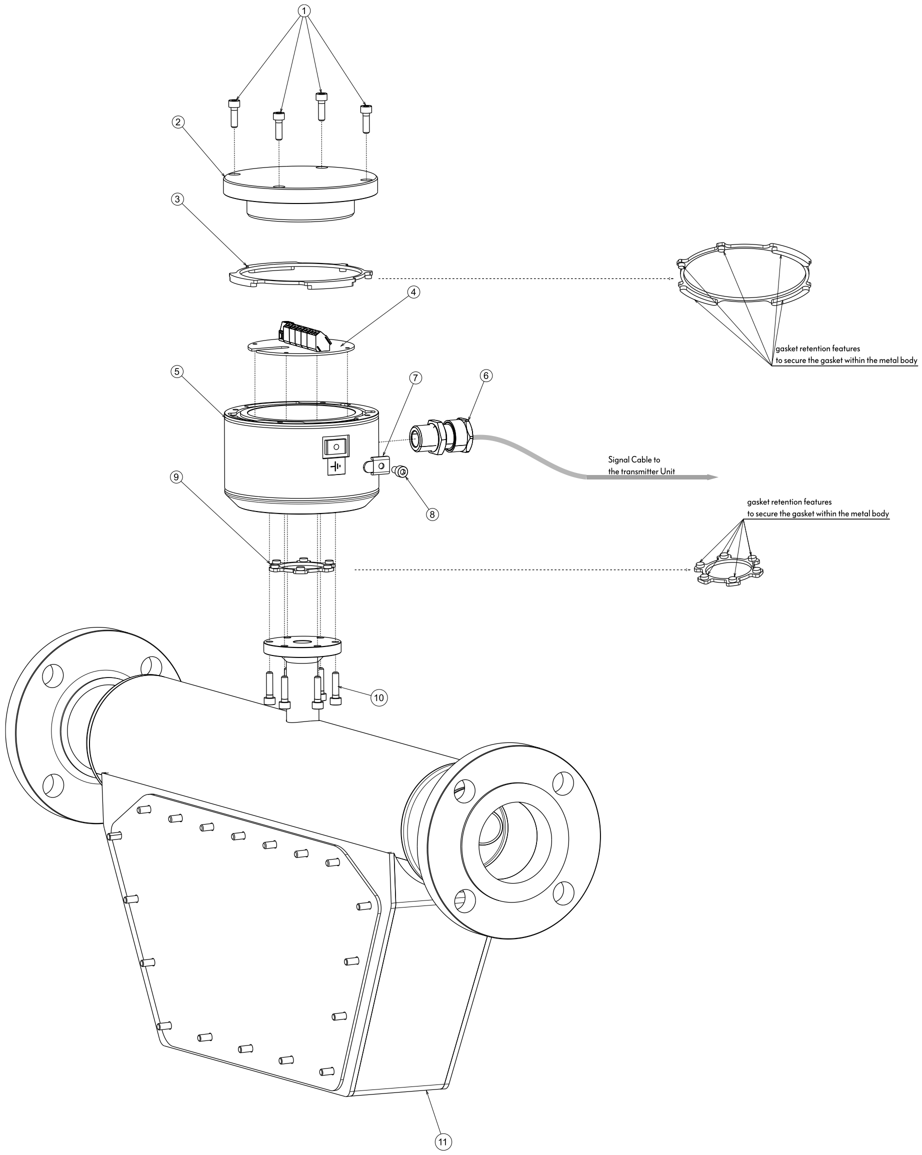
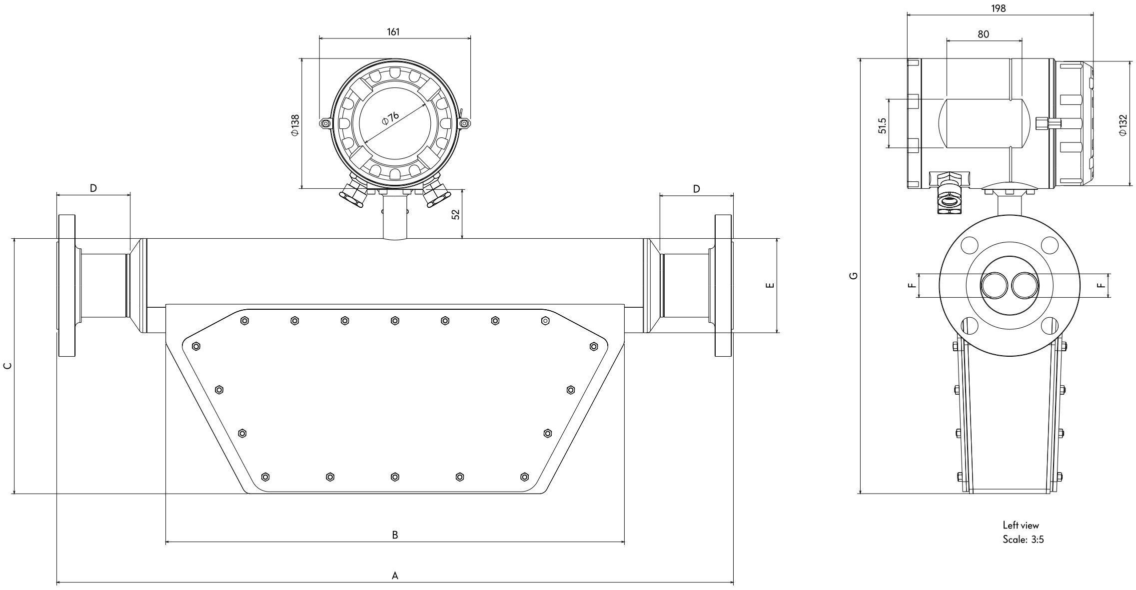


Figure 4-8 different parts of **PrismaTech®** Coriolis Mass Flowmeter Junction Box unit components

4.4 Dimensions

The dimensions and physical specifications of the **PrismaTech**® Coriolis Mass Flowmeters with a Flange installation connection are provided in the tables below.

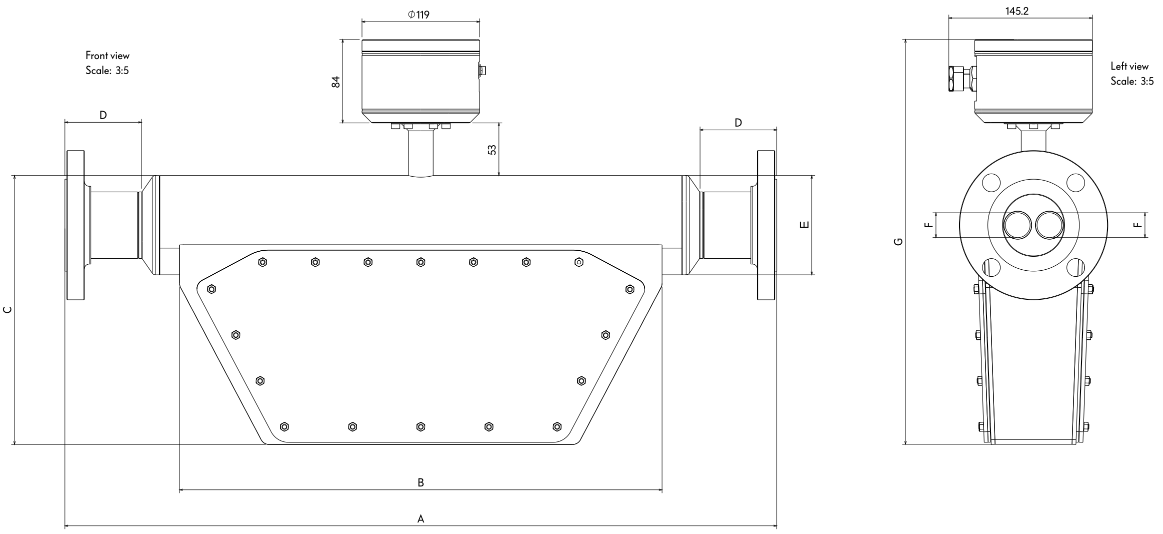
4.4.1 Integral Model Dimensions



Sensor Nominal Size	Dimension						
	A	B	C	D	E	F	G
DN08	387	240	120	39	41.5	5.7	311
DN15	418	245	146	49	47.5	8	337
DN25	454	276	148	48	59	12	339
DN40	560	372	207	61	71	18	398
DN50	720	488	271	78	100	25	462
DN80	900	598	331	96	140.5	39	522
DN100	1127	775	400	250	218	57.1	591

Figure 4-9 Dimensions of the **PrismaTech**® Coriolis Mass Flowmeter Sensor and Transmitter in Integral Model

4.4.2 Remote Model Dimensions



Sensor Nominal Size	Dimension						
	A	B	C	D	E	F	G
DN08	387	240	120	39	41.5	5.7	311
DN15	418	245	146	49	47.5	8	337
DN25	454	276	148	48	59	12	339
DN40	560	372	207	61	71	18	398
DN50	720	488	271	78	100	25	462
DN80	900	598	331	96	140.5	39	522
DN100	1127	775	400	250	218	57.1	591

Figure 4-10 Dimensions of the **Prisma**Tech® Coriolis Mass Flowmeter Sensor and Junction Box in Remote Model

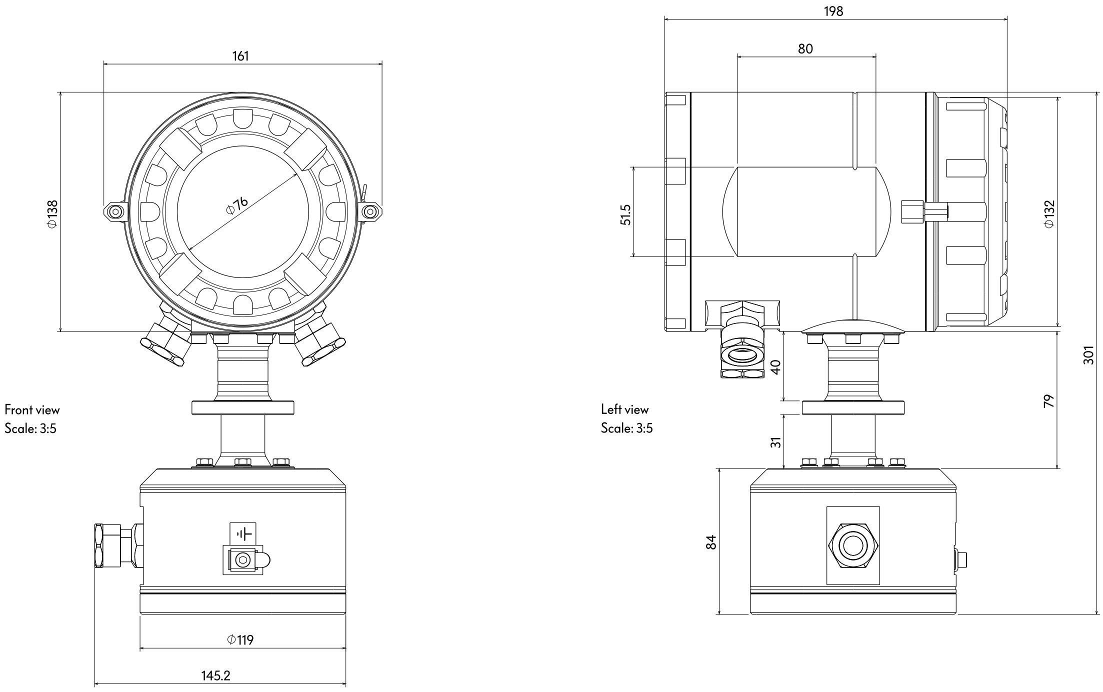


Figure 4-11 Overview of the **Prisma**Tech® Coriolis Mass Flowmeter Transmitter in Remote Model

4.5 Mechanical specifications

The **PrismaTech®** Coriolis Mass Flowmeter is engineered for robust performance in demanding industrial environments. Its mechanical design emphasizes durability, material compatibility, and ease of installation.

Fluid Temperature Range:

- Operable within a wide range of process fluid temperatures, from -20 ° C to 150 ° C. This broad compatibility allows for diverse application across various industries.

Ambient Temperature Range:

- Designed to function reliably in ambient conditions ranging from -20 ° C to 70 ° C, ensuring performance in typical industrial settings.

Maximum Fluid Pressure:

- Capable of withstanding process pressures up to 16 Bar, providing safe operation in medium-pressure applications.

Mounting Connections:

- Versatile connection options available to suit different installation requirements, including 3Aclamp, Flange, and Nut connections.

Protection Rating (Ingress Protection - IP):

- Sensor Unit: IP68 rated, providing complete protection against dust ingress and continuous immersion in water under specified conditions. Ideal for harsh outdoor or wash-down environments.

- Transmitter Unit: IP67 rated, ensuring full protection against dust and temporary immersion in water.

Material Construction:

- Measurement Tubes: Constructed from high-grade materials such as AISI 316L Stainless Steel, Titanium, or Hastelloy (available upon request), selected for excellent corrosion resistance and durability.

- Sensor Wetted Parts: All parts coming into direct contact with the process fluid are made from AISI 316L Stainless Steel, ensuring chemical compatibility and long-term reliability.

- Sensor Body: Encased in robust AISI 304 Stainless Steel for structural integrity and protection.

- Transmitter Body: Enclosed in AISI 304 Stainless Steel for durability and protection of internal electronics.

4.6 Transmitter specifications

The **PrismaTech®** Coriolis Flowmeter's transmitter unit is designed for intuitive operation, precise data processing, and seamless integration with control systems.

Power Supply:

- ❖ Requires a DC power input of 22-26 Vdc for stable and reliable operation.

Display:

- ❖ Features a 128×64128 \times 64128×64-pixel LCD STN Display, providing clear readability of measurement data, configurations, and diagnostic messages even in varying lighting conditions.

Measurement Units:

- ❖ **Mass Flow:** Supports a comprehensive range of units including gr/Min, gr/Sec, Kg/Hour, Kg/Min, Kg/Sec, Ton/Hour, ton/Min, with customizable decimal point positions for precision.
- ❖ **Density:** Offers versatility with units like gr/cm3, kg/cm3, gr/m3, gr/ml, gr/l, kg/l, kg/m3, with changeable dot points for specific application needs.
- ❖ **Volume Flow:** Measures in m3/h, m3/s, L/h, L/min, L/s, mL/min, mL/s, also with adjustable decimal point settings.
- ❖ **Concentration:** Capable of displaying concentration in Brix or Refractive Index (n), with customizable dot points, suitable for specific process monitoring.

Cable Glands:

- ❖ Equipped with three M20 Explosion-Proof Glands, ensuring secure and safe cable entry, especially crucial in hazardous area installations.

Accuracy:

- ❖ **Mass Flow:** Achieves high accuracy of ±0.15% for precise mass flow measurement.
- ❖ **Rate (Volume Flow):** Maintains an accuracy of ±0.15% for reliable volume flow rate indication.
- ❖ **Density:** Provides density measurement with an accuracy of ±1 kg/m3.

Outputs & Inputs:

- ❖ **Analog Outputs:** Two 4-20 mA outputs (maximum 1 Kohm load), fully configurable to represent mass flow, density, or other measured variables, for seamless integration with PLCs or DCS.
- ❖ **Digital Outputs:** Two selectable digital outputs that can be configured as Pulse, Frequency, or Alarm outputs, offering flexibility for counting, control, or status indication.
- ❖ **Digital Inputs:** One digital input supporting functions like Hold, Totalizer Reset, PID control enable, or Batch Filling Enable, enhancing process control capabilities.

Totalizer:

- ❖ Includes two independent totalizers with selectable units for Mass flow and Volume flow, allowing for cumulative tracking of process quantities.

Alarms:

- ❖ Comprehensive alarm capabilities including Empty Pipe detection, Analog Output Open Loop detection, and other customizable alarms for process upset conditions.

4.7 Transmitter Specifications Label

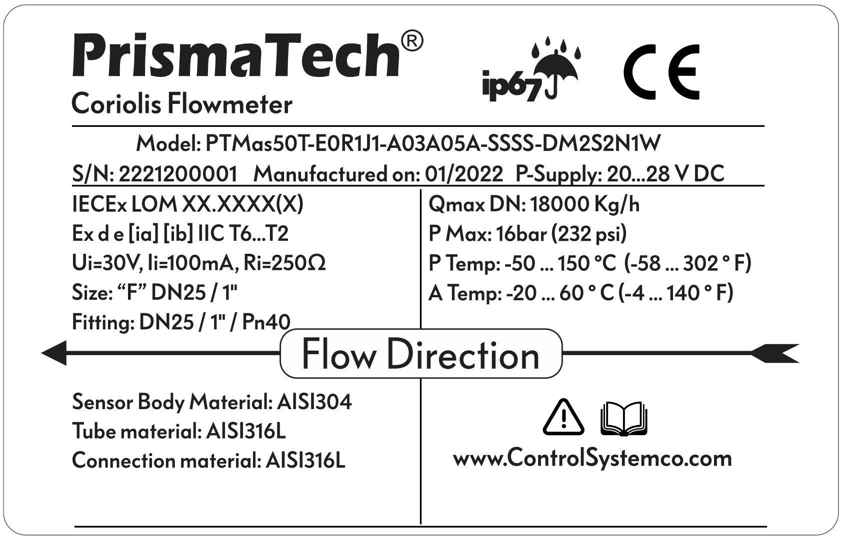


Figure 4-12 Sensor Specification Label

4.8 Terminal Board

In figure 2, the locations of input and output terminals on the transmitter unit board are shown. As seen, the name of each terminal is printed beside it, so attention should be paid when connecting wires to them.

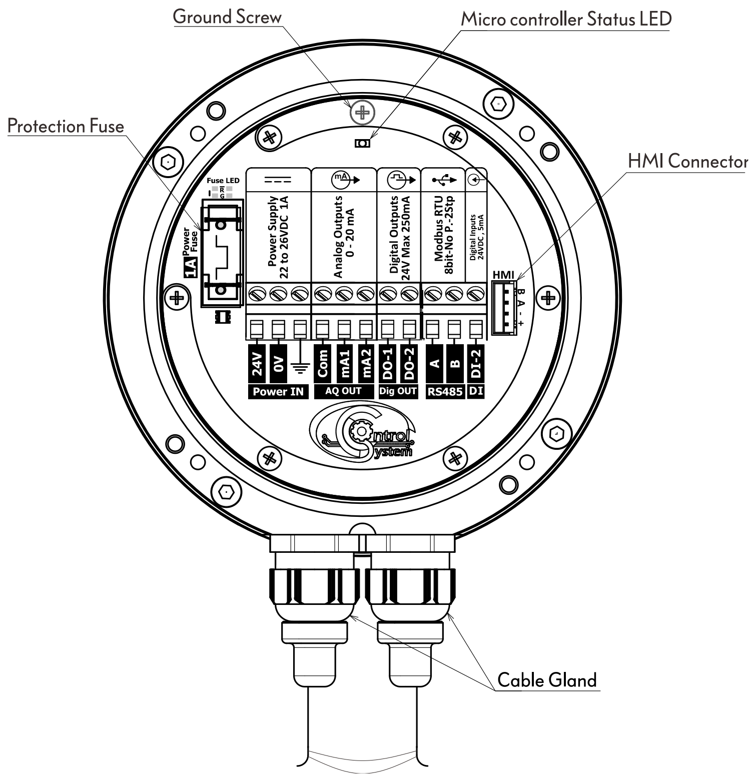


Figure 2-6 Inlet/Outlet Terminals for **PrismaTech®** Coriolis Mass FlowMeter.

Power IN	⏚	Connection point for ground wire	Ground Screw	Connecting screw of the terminal board to the device body.	
	0V	0 VDC power supply	AQ OUT	Com	Analog output terminals of active.
				mA1	
	24V	24 VDC power supply		mA2	
Dig. Out	DO-1	Digital Output	RS 485	A	RS485 Serial Communication Terminals
AI	AI1	Analog Input		B	
Dig. IN	DI-1	Digital Input	Power Fuse	Protective Fuse for Machine Power Supply (1A)	
			HMI Connector	Quick connect connector for HMI	
Microcontroller Status LED*	Indicator of the regular performance of the microcontroller of the device.				

*Being silent or irregularly blinking indicates a problem with the Microcontroller Status LED. In this case, please contact Prisma Tech's customer support and after-sales services unit.

5 Installation

5.1 Adjust the display according to how the sensor is installed

- Ensure Safety: Before any operation, make sure the device is powered off and disconnected from the mains.
- Opening the Display: Loosen and remove the locking screw(s) of the display or cover. Gently pull out the display unit.
- Rotating the Display: Rotate the display to your desired angle (usually 90 or 180 degrees) for optimal operator view.
- Re-tightening the Display: Set the display to the required position, then secure the screws firmly to ensure sealing and mechanical integrity.
- Opening the Terminal Cover: Use a suitable tool (typically a screwdriver) to loosen the terminal cover. Be careful not to damage any seals or gaskets.
- Accessing the Terminals: Connect or disconnect cables as required. Perform wiring as per the device wiring diagram.
- Closing the Terminal Cover: After finishing, close the cover and tighten the screws to ensure proper sealing.

Note: Always inspect gaskets or O-rings before final closure to ensure a tight seal against moisture and dust.

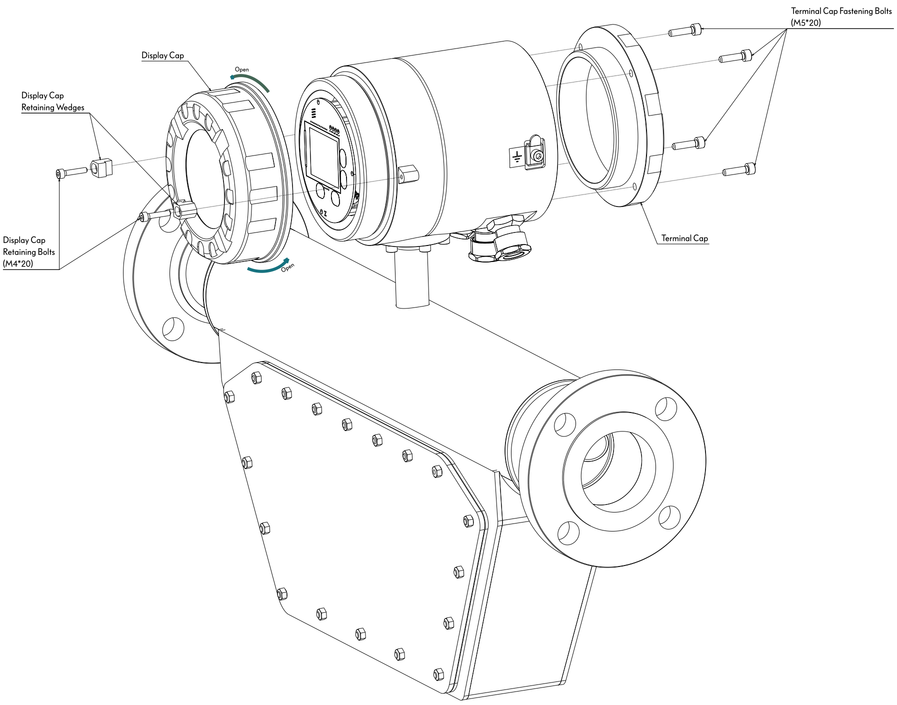


Figure 5-1 Setting the appropriate orientation for the display screen of the device

5.2 Parts used in sensor installation

Figure 5-2 shows the components used in installing the device.

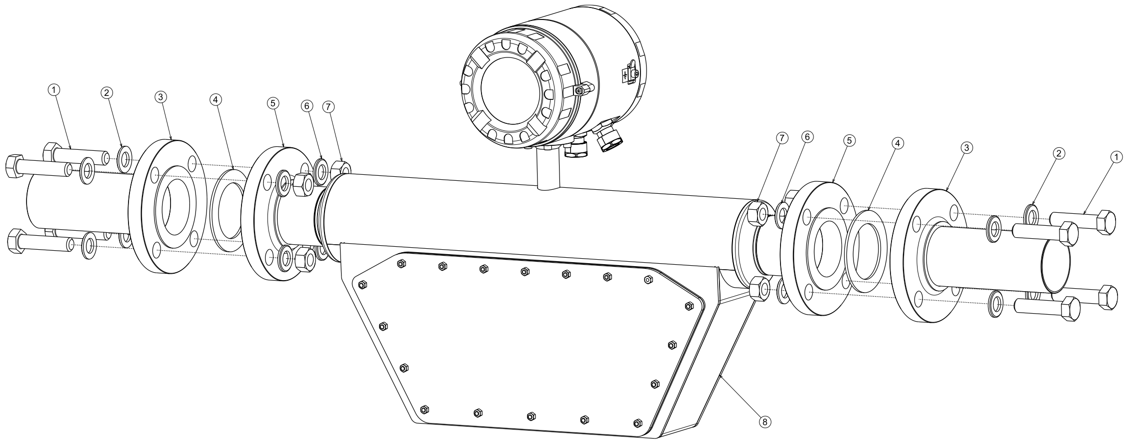


Figure 5-2 shows the components used in installing the sensor

1. Preparation of Flanges and Connections

- Ensure both pipe and device flanges are clean, flat, free from rust/scale, and matching in size/standard (ASME/EN).
- The device's flange type/size must be identical to the pipeline's flange.

2. Selection and Installation of Gasket/Seal

- Use a proper, compatible gasket (NBR, PTFE, or as recommended by manufacturer) resistant to process medium.
- Gasket thickness and type must comply with the device manufacturer's specifications to prevent leaks or mechanical damage.
- Place the gasket precisely between flanges, ensuring there is no folding or contamination.

3. Bolt and Nut Tightening

- Use standard-size and grade bolts/nuts, clean and undamaged.
- Tighten bolts gradually in a cross pattern (cross-tightening), applying the specified torque from the flange/pipe manufacturer's table.
- Use only approved lubricants (e.g., special flange grease); never use non-approved or corrosive substances.

4. Welding Requirements

- **Do not perform any welding after device installation.**
- If welding of nozzles or fittings is needed, **complete all welding and allow to cool fully before installing the sensor** to avoid thermal damage.
- Never weld directly to the device body!
- Ensure welding bead surfaces are smooth to prevent gasket damage and leakage.

5. Sealing and Leak Test

- Conduct a full leak test (hydrostatic or inert gas) before commissioning.
- Use the correct test pressure as per device standard, and fix all leaks before energizing or operating the unit.

6. Earthing

- For Ex or electrical protection requirements, attach the earth wire to the designated terminal of the device per manufacturer guidelines.

5.3 Remote Transmitter Wall/Panel Mounting Instructions

1. Sensor & Transmitter Separation

- In remote models, the flow sensor (installed directly on the pipeline) and the transmitter (electronics unit) are connected via a dedicated, shielded cable.
- This installation method is highly recommended in environments with high temperature, heavy vibration near the pipe, or hazardous areas such as Zone 0, to keep the electronics protected from damaging influences.

2. Preparing the Transmitter Mounting Location

- The installation point must be accessible and mounted on a solid, stable surface (such as a wall or panel).
- Avoid mounting the transmitter in direct sunlight, under high humidity, or in areas with high ambient temperature.

3. Mounting the Bracket or Holder

- Install the dedicated mounting bracket for the transmitter securely to the wall using appropriate fasteners.
- Make sure the bracket is perfectly leveled and firmly fixed.

4. Attaching the Transmitter to the Bracket

- Place the transmitter onto the mounting bracket and tightly secure it using the designated screws.
- Leave sufficient space to the front or sides of the transmitter for easy inspection and maintenance, if needed.

5. Cabling Between Sensor & Transmitter

- Use only the cable recommended by the manufacturer (shielded, anti-noise, and of adequate cross-section).
- Route the cable away from sources of strong electrical power, high voltage lines, or equipment generating electrical noise.
- At both ends (sensor and transmitter), use the recommended cable glands, at least rated IP68 or as per manufacturer specification.
- Do not exceed the maximum cable length stated in the technical datasheet—longer distances may compromise system accuracy and reliability.

6. Grounding (Earthing)

- Both the sensor and the transmitter must be separately and reliably grounded (earthed) to the plant's grounding system.

7. Final Check and Commissioning

- After completing the cabling and installation, power up the system and verify proper communication and signal transmission between the sensor and the transmitter.

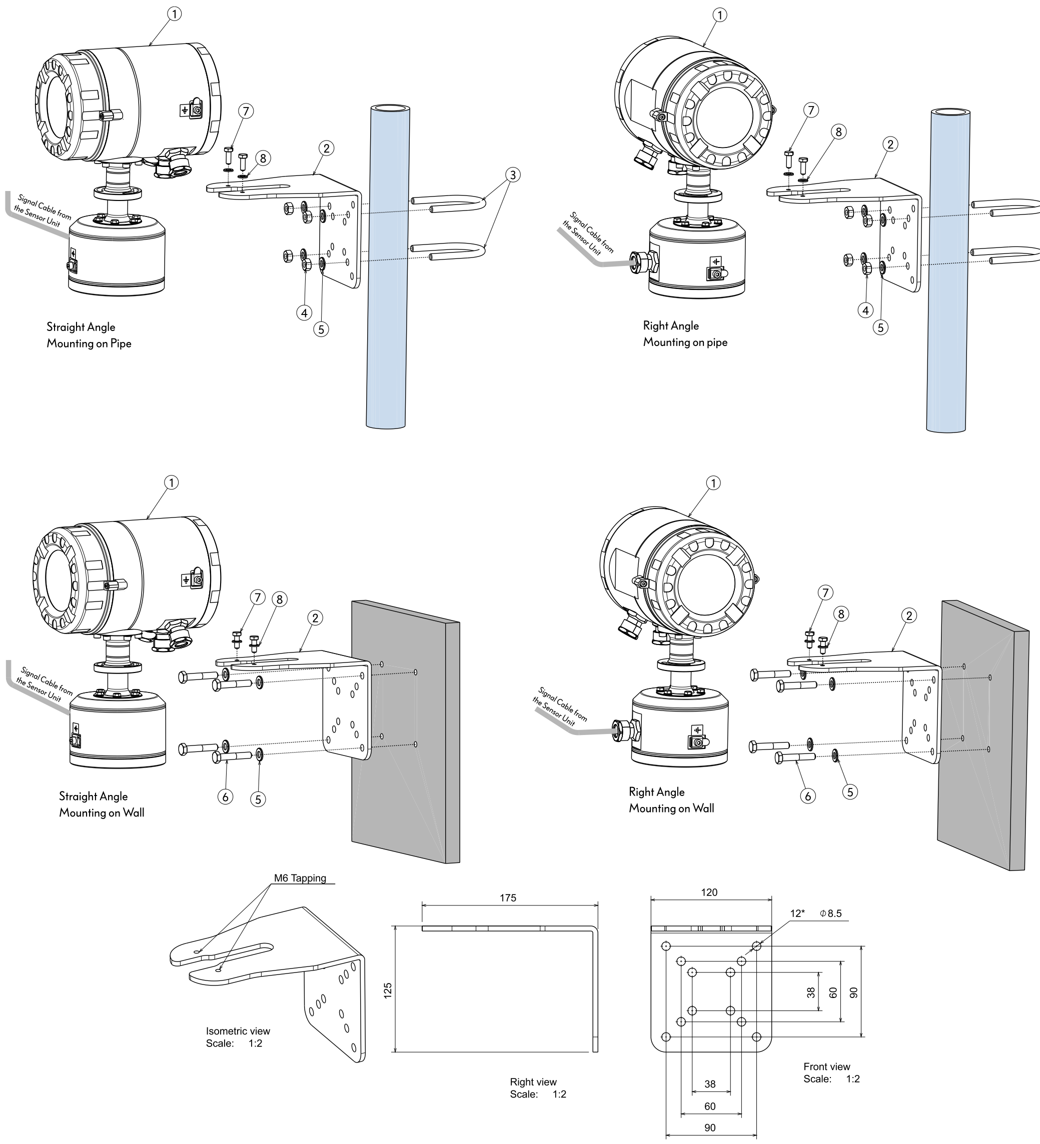


Figure 5-3 5.3 Remote Transmitter Wall/Panel Mounting Instructions

5.4 For fluid input and output

During installation, pay attention to the label on the device body. Ensure that the direction of the sensor matches the flow direction (direction of fluid flow inside the pipe) indicated on the label.

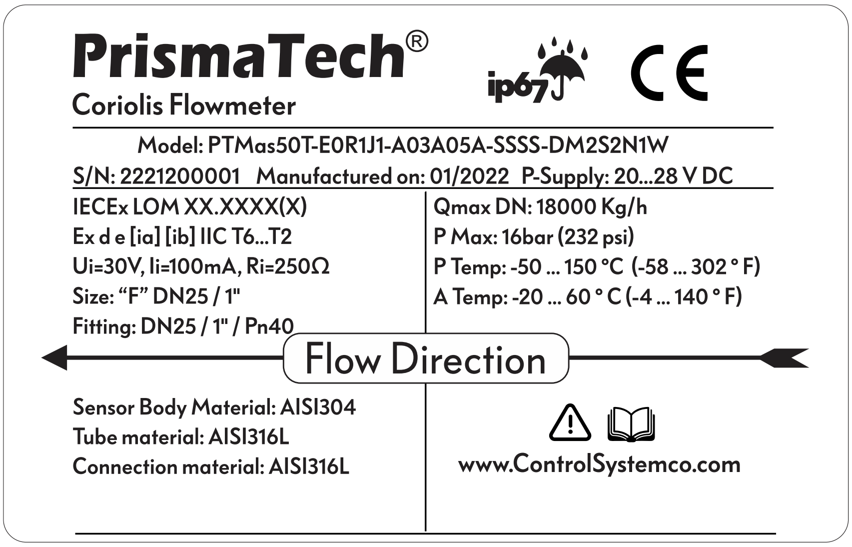


Figure 5-4 Label for the body of the device

5.5 Selecting the Flowmeter Size

In general, the diameter of the pipe along with the fluid flow velocity range determines the nominal size of the sensor. However, it is often the case that the flowmeter size is chosen to be equal to the pipe diameter, while sometimes a smaller sensor diameter is selected to increase fluid velocity and prevent sediment formation. The optimal speed for flow measurement is between 2m/s to 3m/s. Furthermore, the fluid flow velocity must be coordinated with the physical characteristics of the fluid:

- Speeds less than 2 meters per second (V<2m/s) are suitable for non-settling liquids such as slurry, lime slurry, mineral slurry, etc.
- Speeds greater than 2 meters per second (V>2m/s) are suitable for fluids that cause sedimentation in the pipe, such as viscous fluids, sewage, muddy waters, etc.
- Flow velocity can be increased by reducing the pipe diameter.

5.5.1 Measurable Flow Rate Range

When selecting a flowmeter size, the range of flow rates measurable by the device should also be considered. The table below shows the range of flow rates measurable by **PrismaTech®** Coriolis Mass Flowmeters.

Size		Minimum Flow Rate	Maximum Flow Rate	Unit
DN (mm)	Inch			
08	1/4	10	700	Kg/h
15	1/2	100	10000	Kg/h
25	1	300	40000	Kg/h
40	1 1/2	800	100000	Kg/h
50	2	1500	200000	Kg/h
100	4	10000	800000	Kg/h
150	6	30000	2000000	Kg/h
200	8	50000	3500000	Kg/h

ⓘ During installation, when choosing a model, make sure to note that the Coriolis flow meters' measuring mechanism is designed to have the highest accuracy near their maximum nominal flow rate. Therefore, it is advisable to select flow meters with smaller sizes whenever possible.

5.6 Appropriate Conditions and Location for Sensor Installation (in accordance with ISO 10790)

During the installation of a pipe sensor, the pipe must always be full, and no bubbles should form inside the pipe. The formation of gas or air bubbles inside the pipe reduces measurement accuracy. Avoid the following installation locations and positions:

- Measuring tubes as highest point in piping when measuring liquids
- Measuring tubes as lowest point in piping when measuring gases
- Immediately in front of a free pipe outlet in a downpipe
- Lateral positions
- The best place to install the device sensor is on vertical pipes with the flow direction facing upwards.

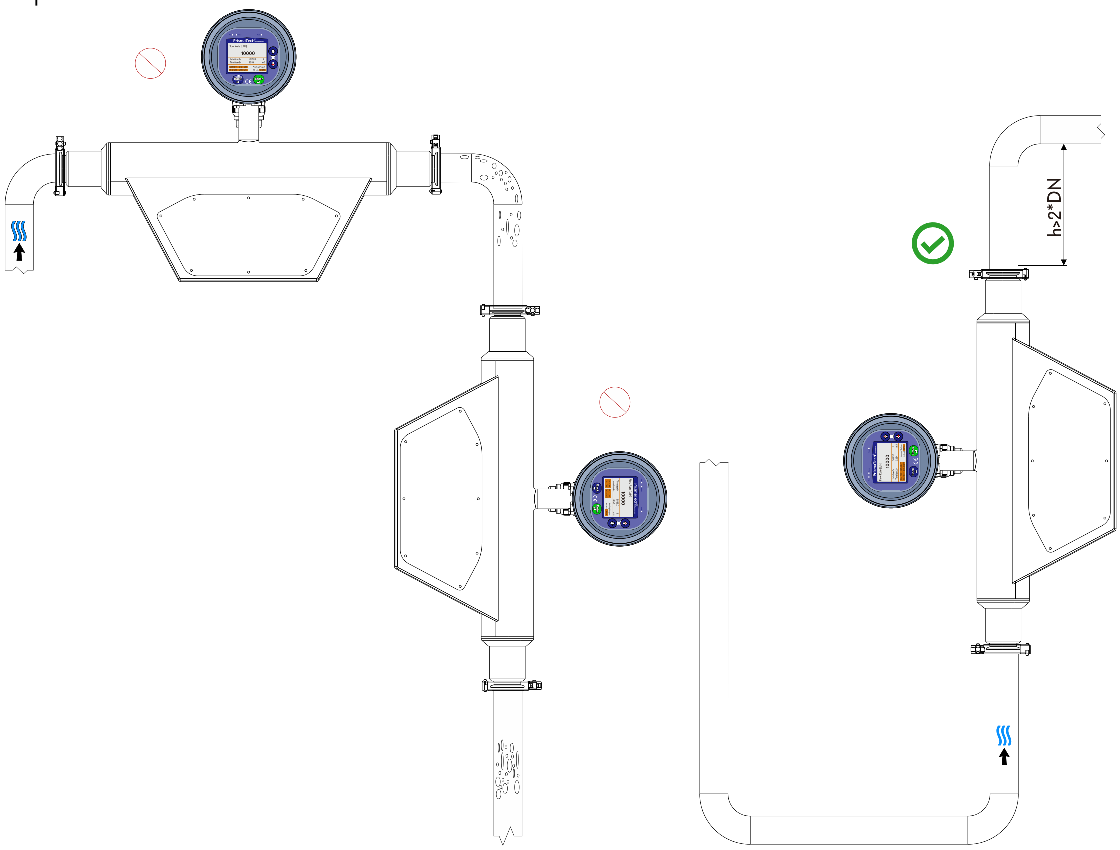


Figure 3-5 Different Installation Configurations of Sensors on the Line

5.6.1 Distance from high-conflict areas

Try to install the flowmeter as far away as possible from turbulent and disruptive elements such as pumps, orifices, bends, valve connections, three-ways, etc.

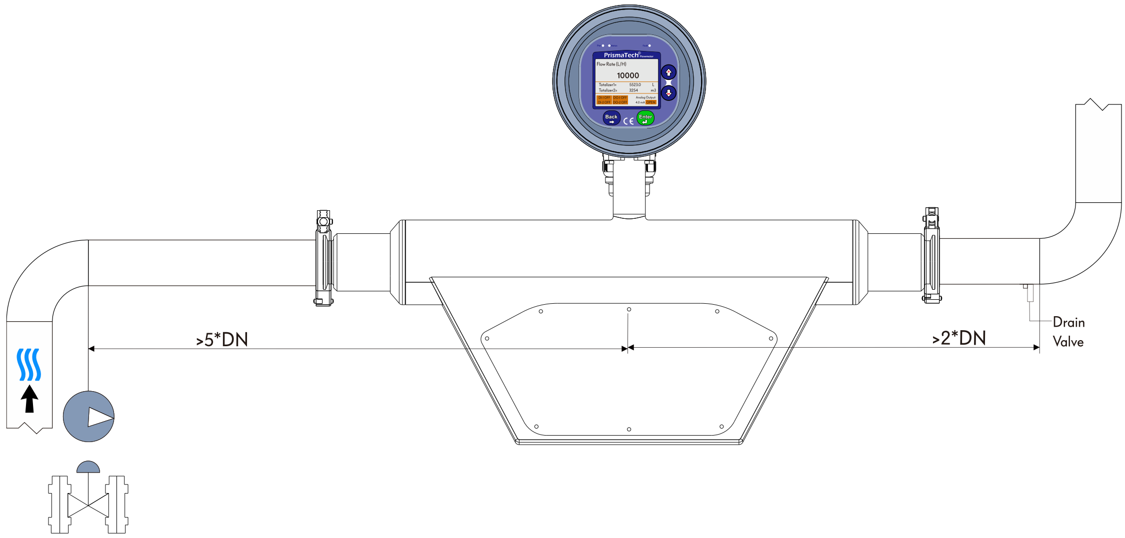


Figure 3-6 Appropriate distance of the sensor from the knees and connections

🛈 As seen in the figure, the distance of the knee, the three-way, etc., should be at least twice the diameter of the pipe from sensor. If the sensor is installed after these locations, it should be at least 5 times the diameter of the pipe away from it. If possible, install the sensor at a greater distance from these locations to increase measurement accuracy and stability.

5.6.2 Installation of sensor before the valve

If there is a sensor in place, the valve of the device must be installed before the valve and at the ideal distance (at least 5 times the diameter of the pipe).

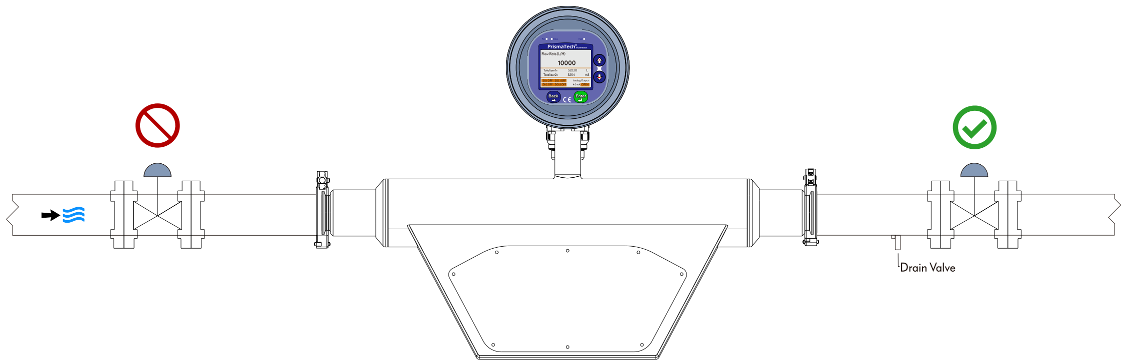


Figure 3-7 Installing a sensor in the presence of a valve.

5.6.3 Pump Output

Be sure to avoid installing a sensor at the pump inlet to prevent damage to the sensor lining due to low pressure areas, which could result in pressure drops.

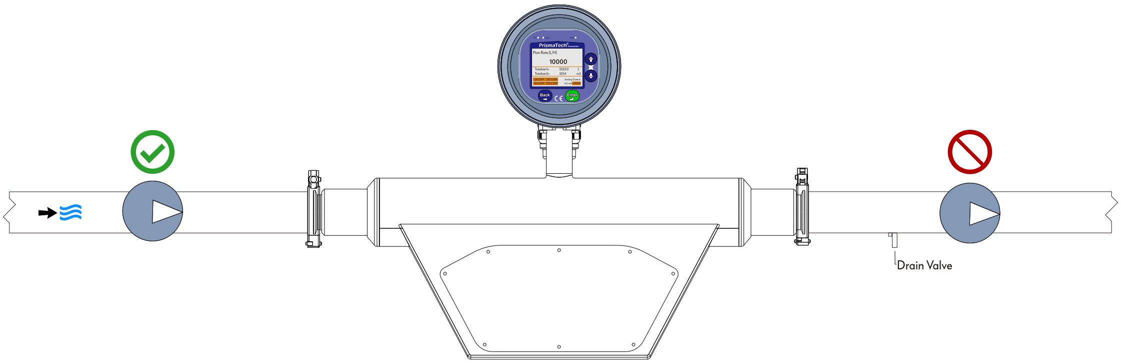


Figure 3-8 Suitable location for sensor installation in the presence of the pump.

5.6.4 Semi-filled pipes

Avoid installing sensors in parts of the pipe that may not be completely filled. Also, do not install the sensor at the lowest point of a drainage path as there is a higher risk of solid particle accumulation in these areas.

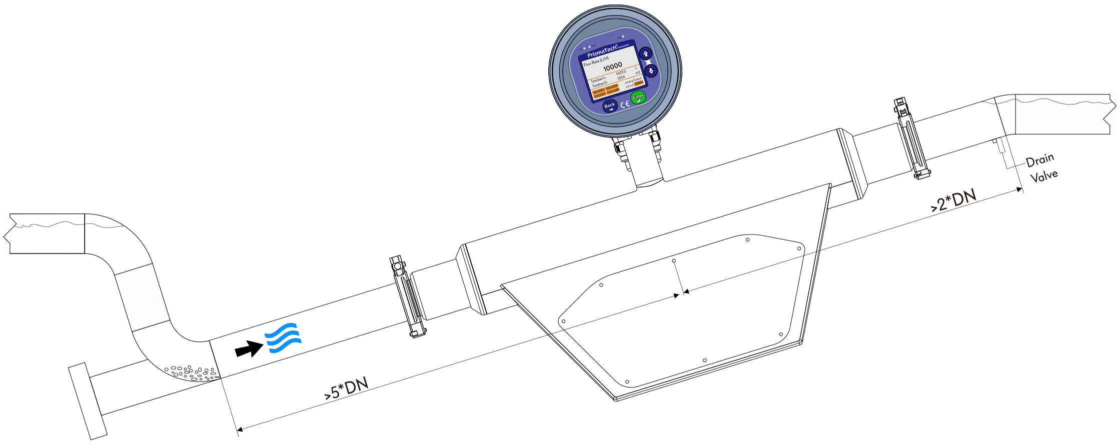


Figure 3-9 Installing sensors in partially filled pipes

5.6.5 Pipes Downward

If you are installing the sensor in a location where the flow will be downwards (h>5m), create a siphon with an air release valve before the vertical pipe. This is done to prevent the risk of pressure buildup damaging the sensor's internal lining. Additionally, this prevents the formation of air pockets at the sensor installation site.

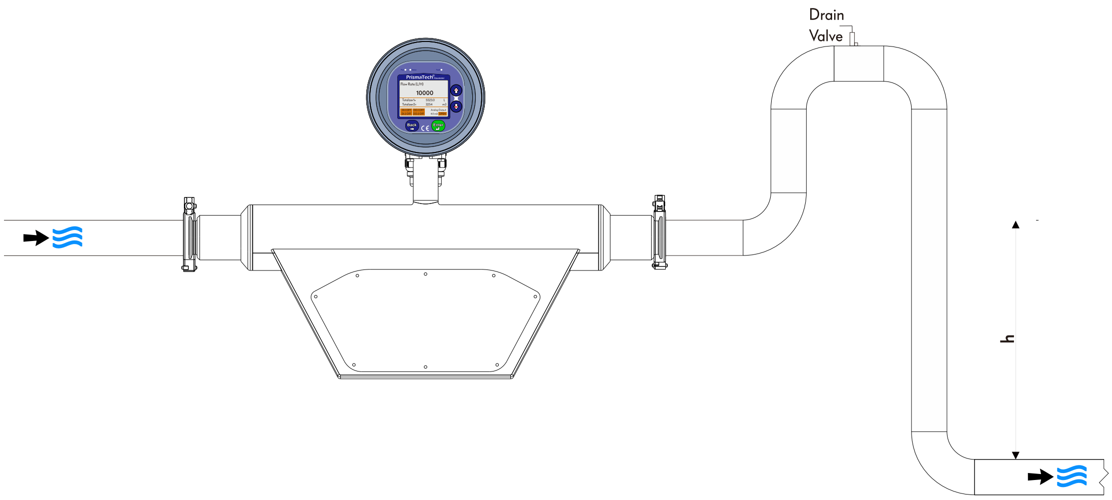


Figure 3-10 shows the installation of the sensor before the location where the fluid moves downwards in the pipe.

5.6.6 Various Orientations for Installing Sensors

An optimal method for installing a flow sensor prevents gas accumulation, air bubbles, and other particles at the sensor installation site. Generally, there are two methods for installing electromagnetic flowmeters: the horizontal method and the vertical method.

Horizontal Installation: In this method, the sensor is installed on the pipeline in a way that the common axis of the electrodes is completely horizontal.

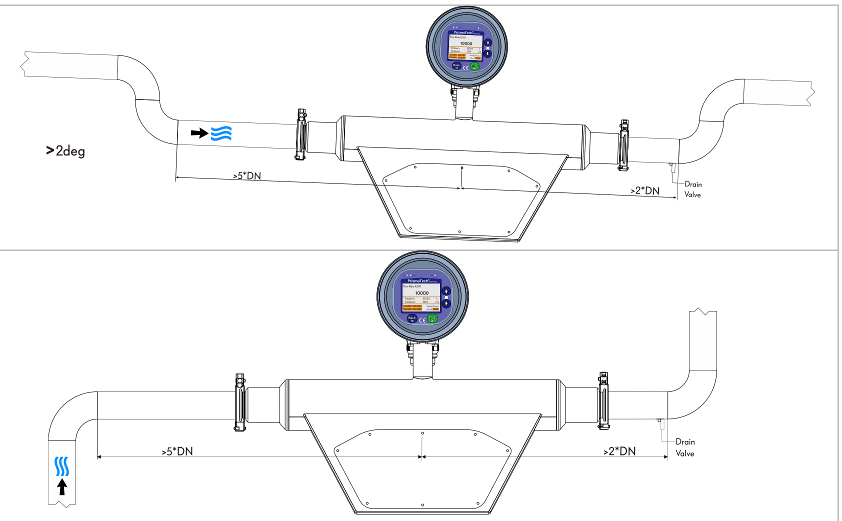


Figure 3-11 Installation of Horizontal Sensor

Vertical Installation: The best method for installing a flowmeter is when the flow moves from the bottom to the top inside the sensor. In this case, there is less chance of air bubbles, and solid materials remain at the bottom of the pipe at a lower cost.

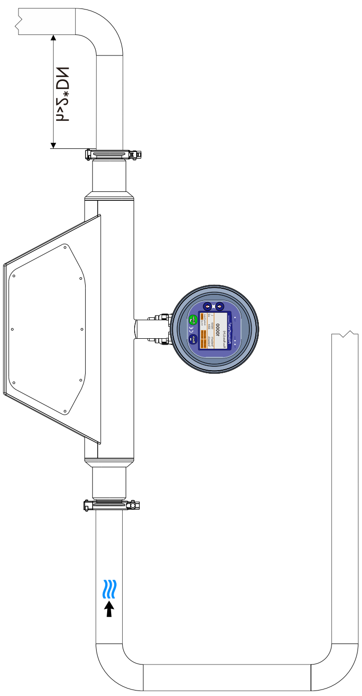


Figure 3-12 Vertical Sensor Installation

5.6.7 Additional Points in Installing the Sensor

1- Sensor installation location should be chosen to avoid any vibration. Therefore, if there is severe vibration in the pipeline, this vibration must be controlled.

2- Install the sensor in areas away from magnetic fields, such as high and medium voltage power cables.

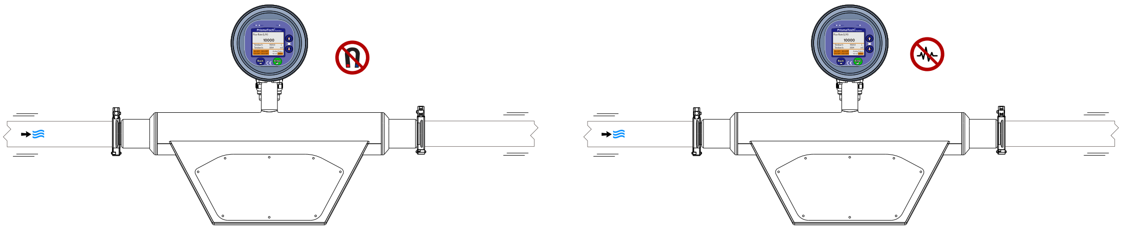


Figure 3-13 Failure to install sensors in highly vibrating areas

3- In pipelines with over 5 meters of level difference, an air release valve should be installed after the flowmeter at the highest point.

4- Both measurement pipes inside the sensor body are curved. Therefore, when the sensor is installed horizontally, its position should match the fluid characteristics.

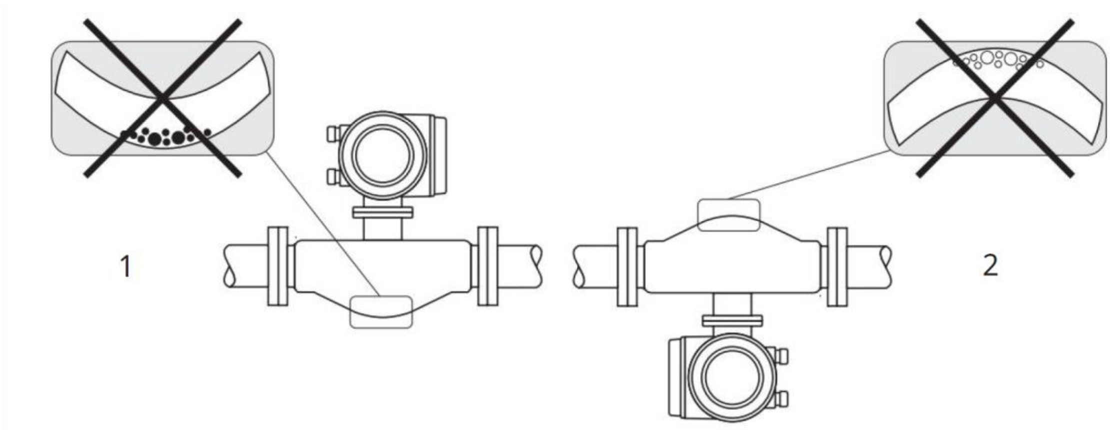


Figure 3-14 Installation pointers in fluids with solid materials and liquids

• Figure 1 is not suitable for fluids with solid materials due to the possibility of material accumulation at the bottom of the pipe.

• Figure 2 is not suitable for fluid drainage due to the possibility of air accumulation.

5- Install the device in a location away from sunlight and preferably in the shade.

6 User manual

Figure 4.1 on the main screen of the device displays the density, mass flow rate, density, volume flow rate, Brix, and temperature of the fluid along with the values of the Totalizers. Additionally, the user can adjust their desired settings using the touch keys and menus of the device.

Figure 4-1 Keys and Display of the Device

6.1 Keys and indicator lights

Four keys located next to and below the display screen are used for making changes and operating the device menus. The indicator lights at the top of the device screen are used to indicate the device's operation status and for troubleshooting. A brief description of the function of each key and indicator light is provided below:

Pwr LED	Indicates the power supply connection and device status	Enter	Confirm, enter the desired menu
Status LED	Sensor communication indicator	Back	back to before
Fault LED	Indicates faults in any section of the device		Increase values, go to top menu
			Decrease values, go to lower menu

On the main screen, you can enter the device settings by touching the Enter key. Then using the arrow keys and you can move between different tabs. Note that when a header is activated, its name is also displayed next to the number. In each tab, you can access its menus using the Enter key and return to the main menu using the Back key and move between the menus with the arrow keys and change the values of the parameters if needed.

6.2 Overview of device settings

In the table below, you can see how to access different settings of the device through. different

PrismaTech® PTMas Coriolis Flowmeter parameters diagram			
1- Main	**2- Setting**	**3- Diagnostics**	**4- Menu**
	1-Totalizer 1 Reset	1-Status	1- Flow Display Setting
	2-Totalizer 2 Reset	2-P1-2-SP-L	2- Density & Brix Disp. Setting
	3-Totalizer 1 Limit	3- Freq	3- Other Display Setting
	4-Totalizer 2 Limit	4-PPDT	4- Analog Output 1 Setting
	5-PID Setpoint	6-Tt, Tb, Tbt, TC	5- Analog Output 2 Setting
	6-Filling Setpoint	7- APC, Ps, WF, AF	6- Digital Outputs 1 Setting
	7- Home Main Value	8-IIR, BW, Hour	7- Digital Outputs 2 Setting
		9-Dp, FG, FT	8- Dig. Input Setting
		A-SS, SG, SA	9- Communication Setting
			10- Temperature Setting
			11- Totalizer Setting
			12- PID Controller Setting
			13- Batch Filling Setting
			14- Calibration & EPD Setting
			15- Mass Flow Field Calibration
			16- Factory Setting

submenus.

6.3 Main header or the main page of the display

In the Main header, the measured flow value as well as the status of inputs and outputs are observable

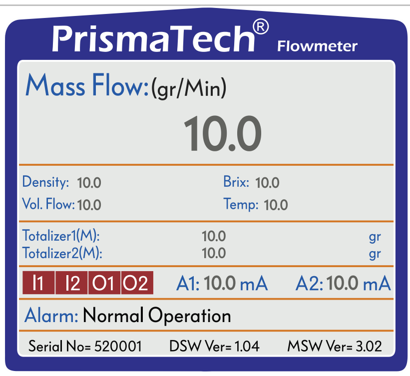


Figure 4-2 Main page of the device display.

Mass Flow		Mass flow rate value of the fluid passing through	
Density	Fluid density value passing through	Vol. Flow	Volume flow rate value of the fluid passing through
Brix	Brix value of the fluid passing through	Temp	Fluid temperature value passing through
Totalizer1	Totalizer 1 value	Totalizer2	Totalizer 2 value
DI1 DO1	Indicator of digital inputs and outputs being on/off	Analog Output 2	Current value of analog output 2
DI2 DO2		Analog Output 1	Current value of analog output 1
Alarm	Device warnings	Serial No	Device serial number
DSW Ver	Device hardware version	MSW Ver	Device software version

.

6.4 Setting header

On the second header, you can access the main settings of the device.

1	2- Setting	3	4

Parameter	Range	Description
1-Total1 Reset	Cancel	Resetting Totalizers
2-Total2 Reset	Reset	
3-Totalizer 1 Limit 4-Totalizer 2 Limit	0~99999999.9	Totalizers' limits in liters for the activation of digital outputs or resetting (sections 6.6.9)
5-PID Setpoint	0~999999.9	Setpoint for PID controller in liters per hour
6-Filling Setpoint	0~9999999.9	Setpoint for use in the filling system in milliliters
7-Home Main Value	0 = Mass Flow 1 = Density 2 = Brix or nD 3 = Volumetric Flow	Select the main parameter for display on the device screen.*

*If any of these parameters are selected, that parameter will be displayed as the main value on the main device page.

6.5 Diagnostics header

The performance parameters of the device for troubleshooting and evaluating its performance are displayed in the third header.

1	2	3- Diagnostics	4

Parameter	Nominal Range	Description	
1-Status	0 = Swp 1 = Boost 2 = Adj 3 = Stb	Status of reaching resonance	
2-P1-2-SP-L	Sampling voltage of coil samples		
3- Freq	Resonant Frequency	StdDiv	Deviation from resonance frequency criterion
4-PPDT	Phase difference of coil samples	StdDiv	Deviation from phase difference criterion
6-Tt, Tb, Tbt, TC	Tube temperature, body temperature, temperature difference between body and tube, CPU temperature		
7- APC, Ps, WF, AF	Automatic phase controller status, coil phase correction factor, water resonance frequency, air resonance frequency		
8-IIR, BW, Hour	Bandpass filter status, filter bandwidth determination, operating hours		
9-Dp, FG, FT	Number of ADC damping cycles, low-pass filter ADC factor, ADC damping time		
A-SS, SG, SA	Sweep settings		

6.6 Menu header

To access the fourth header, you must enter the password, which by default is "4000". In section 6.6.1, parameter 3-5- Change Password, you can change the default password to your preference.

	1	2	3	4
	4- Menu			

1- Flow Display Setting	2- Density & Brix Display Setting
3- Other Display Setting	4- Analog Output 1 Setting
5- Analog Output 2 Setting	6- Digital Output 1 Setting
7- Digital Output 2 Setting	8- Dig. Input Setting
9- Communication Setting	10- Temperature Setting
11- Totalizer Setting	12- PID Controller Setting
13- Batch Filling Setting	14- Calibration & EPD Setting
15-Mass Flow Field Calibration	16-Factory Setting

6.6.1 Flow Display Setting

The first sub-menu in the fourth header is related to the display settings of the device.

	1	2	3	4-Menu
	1- Flow Display Setting			

Parameter	Range	Description	
1-1-Home Mass Flow Unit	0= gr/Sec 1= gr/Min 2= oz/Sec 3= oz/Min 4= Kg/Sec 5= Kg/Min 6= Kg/Hour 7= Ton/Hour 8= Ton/Min 9= lb/Sec 10= lb/Min 11= lb/Hour 12= Ton(US)/Hour 13= Ton(US)/Min 14= Ton(UK)/Hour 15= Ton(UK)/Min	Unit display of mass flow	
1-2-Home Mass Flow Dot Points No.	0~3	Number of decimal places in mass flow display	
1-3-MassFlow Damping Time	1~800 Cycles	Number of averaging for mass flow to reduce momentary fluctuations	
1-4-MassFlow Direction	0= MassFlow Direction	Positive	For measuring mass flow
	1= Negative	Negative	
	2= Bi-Directional	Bi-Directional	
1-5-MassFlow Simulation	0= ON 1= OFF	Simulation of volumetric flow for troubleshooting	

1-6-Simmulated Mass Flow Value	0.0~999999.9 Kg/h	Amount of volumetric flow for simulation
1-7-Home Vol Flow Unit	0= ml/Min 1= ml/Sec 2= Liter/Hour 3= Liter/Min 4= Liter/Sec 5= m^3/Hour 6= m^3/min 7= gal(US)/Hour 8= gal(US)/Min 9= gal(US)/Sec 10= gal(Imp)/Hour 11= gal(Imp)/Min 12= gal(Imp)/Sec 13= in3/Sec 14= ft3/Sec 15= ft3/Min 16= ft3/Hour	Display unit of volumetric flow
1-8-Home Vol Flow Dot Points No.	0~3	Number of decimal places in volumetric flow display
1-9-VolFlow Damping Time	1~800 Cycles	Number of averaging for volumetric flow to reduce momentary fluctuations
1-A-Flow Low Cutoff Value	0.0~9999.9 Kg/h	Minimum mass flow rate value below which zero is displayed.
1-B-Fluid Type	0-Fluid is Liquid 1-Fluid is Gas	Fluid type
1-C-Gas Name	0=Air 1=Ammonia NH3 2=Argon Ar 3=Sulfur hexafluoride SF6 4=Oxygen O2 5=Ozone O3 6=Nitrogen oxide NOx 7=Nitrogen N2 8=Nitrous oxide N2O 9=Methane CH4 10=Hydrogen H2 11=Helium He 12=Hydrogen chloride HCl 13=Hydrogen sulfide H2S 14=Ethylene C2H4 15=Carbon dioxide CO2 16=Carbon monoxide CO 17=Chlorine Cl2 18=Butane C4H10 19=Propane C3H8 20=Propylene C3H6 21=Ethane C2H6 22= Custom Gas	Determining the type of gas

1-D-Custom Gas Density	0.001~9999.999 Kg/ m^3	Determining the Custom Gas Density

6.6.2 Density & Brix Display Setting

	1	2	3	4-Menu
	2- Density & Brix Display Setting			

Parameter	Range	Description
2-1-Home Density Unit	0= gr/cm3 1= gr/mL 2= gr/L 3= Kg/L 4= Kg/m3 5= lb/ft3 6= lb/in3 7= lb/gal(US) 8= lb/gal(Imp)	density display unit
2-2-Home Density Dot Points No.	0~5	Number of digits after the decimal point in density display
2-3-Density Damping Time	1~800 Cycles	Number of density averaging for reducing momentary fluctuations
2-4-Density Simulation	0= ON 1= OFF	Density simulation for troubleshooting
2-5-Simmulated Density Value	0.0~9999.999 Kg/m3	Density level for simulation
2-6-Home Concentrate Unit	0= Brix 1= Refractive Index(nD)	concentration display unit
2-7-Home Concentrate Dot Points No.	0~4	Number of digits after the decimal point in concentration display
2-8-Home Concentration Damping Time	1~800 Cycles	Number of concentrations averaging for reducing momentary fluctuations
2-9-Fluid Pressure	0.0~200.0 bar	Pressure of Fliud
2-A-Pressure Compensate Fac.	0.0000~1.000 $Kg/m^3 bar$	Pressure compensation coefficient for 1bar
2-B-Show Density At Ref. Temp.	0= DART OFF 1= DART ON	Density display at reference temperature
2-C-DART Ref. Temp. Value	0.0~90.0 °C	Density compensator reference temperature value
2-D-DART Compensate Factor	-9.000~9.000 $Kg/m^3 °C$	Density compensation factor for each degree Celsius

6.6.3 Other Display Setting

	1	2	3	4-Menu
	3- Other Display Setting			

Parameter	Range	Description	
3-1-Home Page Main Parameter	Mass Flow, Density, Brix or nD, Volumetric Flow	Main parameter for display on the Home page	
3-2- LCD go to Standby time	0000~9999 Minute	LCD standby time	
3-3-LCD Brightness Percent	0~100 %	Percentage of LCD brightness	
3-4-Status LED Mode	0 = Disable 1 = Flow Rate(0-35Hz), 2 = Modbus Communication 3 = Digital Output Status 4 = Digital Input Status	Selection of LED Status display mode	
3-5-Change Password	0000~9999	Changing the menu password	
3-6-Power Key Enable	Power Key Disabled	Deactivation	Settings for turning on and off the device using keys*
	Power Key Enabled	Activation	
3-7-Home Page Second Param.	0=Totalizer-2 Value 1=Density Low Limit DO1 2=Density Low Limit DO2	Second parameter for display on the Home page	

By enabling this option, you can turn the device on or off by simultaneously pressing the 

and 

keys for 2 seconds. Otherwise (if this option is disabled), the device will remain permanently on.

6.6.4 Analog Outputs Setting

1	2	3	4-Menu
4- Analog Output 1 Setting			

Parameter	Range	Description	
4-1-Analog Output Mode	Disable	Setting the analog output mode. In Disable mode, the output will always be 0mA.	
	Mass Flow4~20mA		
	Vol Flow 4~20mA		
	Density 4~20mA		
	Temperature 4~20mA		
	Brix 4~20mA		
	PID 4~20mA		
4-2- Analog Output Force	Not Force	Manually stimulating the analog output from 1 to 20mA with intervals of 1mA.	
	Force to 0,1,2, ~,20mA		
4-3-Analog Out Min Flow	0.0~999999.0 ---	Minimum value for the lower limit of the output current (4mA). The unit and value of this parameter are determined based on the selection of the analog output mode in the previous setting.	
4-4- Analog Out Max Flow	0.0~999999.0 ---	Maximum value for the upper limit of the output current (20mA). The unit and value of this parameter are determined based on the selection of the analog output mode in the previous setting.	
4-5- Analog Out Value	0~20mA	Current value of the analog output.	
4-6-Analog Out Offset	-20000~20000	Analog output offset (for each 327 units, the offset changes by 0.1mA in the analog output).	
4-7-Analog Out D.E.C.	0~99999	AD5420 Data Eror	
4-8-A.Out Open Loop Alarm	Alarm Disabled	Disable warning	Warning: Analog output connection is open
	Alarm Enabled	Enable warning	

ⓘ The settings for Analog Output 2 are also accessible under the menu of 5-Analog Output 2 Setting, just like Analog Output 1.

6.6.5 Digital Outputs Setting

When selecting one of these two modes, the Pump Control Mode parameter corresponding to that Totalizer must be set to Auto in the Totalizer Setting menu.

ⓘ The output voltage of the digital is 24VDC with a maximum allowable current of 500mA.

ⓘ The settings for the second digital output can also be performed under the 7-Digital Output 2 Setting submenus.

	1	2	3	4-Menu
	6-Digital Output 1 Setting			

Parameter	Range	Description	
6-1-Digital Out- Mode	Disable	In this state, the output is always inactive.	Setting or adjusting the digital output state or function is done in this section.
	0=Mass Flow Pulse	In this state, for a specific amount of liquid passing based on weight (parameter 6-4), a pulse with a length of parameter 6-3 is sent to the digital output.	
	1=Vol. Flow Pulse	In this state, for a specific amount of liquid passing based on volume (parameter 6-4), a pulse with a length of parameter 6-3 is sent to the digital output.	
	2=High M. Flow Alarm	When the mass flow exceeds the value of parameter 6-5, the output becomes active.	
	3=Low M. Flow Alarm	When the mass flow is less than the value of parameter 6-6, the output becomes active.	
	4=M.Flow Out of Range	When the mass flow is outside the range of parameters 6-6 and 6-5, the output becomes active.	
	5=High Density Alarm	When the density is greater than the value of parameter 6-5, the output becomes active.	
	6=Low Density Alarm	When the density is less than the value of parameter 6-6, the output becomes active.	
	7=Density Out of Range	When the density is outside the range of parameters 6-6 and 6-5, the output becomes active.	
	8=High V. Flow Alarm	When the volumetric flow exceeds the value of parameter 3-3, the output becomes active.	
	9=Low V. Flow Alarm	When the volumetric flow is less than the value of parameter 3-4, the output becomes active.	
	10=V.Flow Out of Range	When the volumetric flow is outside the range of parameters 3-3 and 3-4, the output becomes active.	
	11=High Brix Alarm	When the Brix value exceeds the value of parameter 3-3, the output becomes active.	
	12=Low Brix Alarm	When the Brix value is less than the value of parameter 3-4, the output becomes active.	
	13=Brix Out of Range	When the Brix value is outside the range of parameters 3-3 and 3-4, the output becomes active.	
	14=High Temp Alarm	When the temperature exceeds the value of parameter 3-3, the output becomes active.	
	15=Low Temp Alarm	When the temperature is less than the value of parameter 3-4, the output becomes active.	
	16=Temp Out of Range	When the temperature is outside the range of parameters 3-3 and 3-4, the output becomes active.	
	17=Empty Pipe Detected	When the sensor detects an empty pipe, the output becomes active indicating an empty pipe.	
	18=System is Ok	In a situation where the device has no errors, the output is active.	
	19=Pump Ctrl>T1 Limit	If the Totalizer1 value exceeds the set Total Limit1 value in the Setting header, the output becomes active.	
	20=Pump Ctrl>T2 Limit	If the Totalizer2 value exceeds the set Total Limit2 value in the Setting header, the output becomes active.	
	21=3State Fill Low Valve	The output has three states for the filling process.	
	22=Batch Filling Valve	The output acts for opening the control valve in automatic filling system.	
6-2- Digital Out Force	0=Not Forced	Manual intervention off (automatic intervention)	Manual stimulation of digital output
	1=Force to OFF	Manual shut down	
	2=Force to ON	Manual turn on	
6-3- Digital Out Pulse width	1~1300 [120µSec]	The duration or width of the pulse generated at the digital output	
6-4- Digital Out Volume/Pulse	0.01~100000.0 ---	Setting the passing volume for each pulse based on the selected mode of the digital output	
6-5- Digital Out High Limit	0.0~999999.0 ---	Upper limit for digital output performance	
6-6- Digital Out Low Limit	0.0~999999.0 ---	Lower limit for digital output performance	
6-7- Digital Out Hysteresis	10~6550.0 ---	Hysteresis delay value for digital output	

6.6.6 Digital Inputs Setting

Digital inputs are used to zero out the values of Totalizers, keep them constant, and enable or disable the PID controller and the filling system. These settings can be adjusted through the sub-menu Digital Inputs Setting.

	1	2	3	4-Menu
	8- Digital Input Setting			

Parameter	Range	Description
8-1-Digital Input-1 Mode	0=Disable	Digital input deactivated
	1=Totalzer 1 Reset	Reset Totalizer number one*
	2=Totalizer 2 Reset	Reset Totalizer number two**
	3=Totalizer 1&2 Reset	Simultaneous reset of Totalizer number one and two***
	4=Totalizer 1 Hold	Maintain Totalizer number one
	5=Totalizer 2 Hold	Maintain Totalizer number two
	6=Totalizer 1&2 Hold	Maintain both Totalizers
	7=PID Enable	Enable or disable PID controller (only for digital input number one)****
	8=Batch Filling Start	Batch Filling process starts upon digital input ON
	9=Batch Fill Start/Stop	When digital input is turned ON, the Batch Filling process is executed, and when digital input is turned OFF, the entire Batch Filling process stops.
	10=Flow Force to Zero	The measured flow rate value is displayed as zero.

* Totalizer can be reset through this method if parameter 10-2 allows it. (Section 6.6.9)

** Totalizer can be reset through this method if parameter 10-7 allows it. (Section 6.6.9)

*** Totalizers can be reset through this method if parameters 10-2 and 10-7 allow it. (Section 6.6.9)

**** Parameter 8-1 is used when set to Enable By Digital Input option. (Section 6.6.10)

• The minimum excitation voltage for the digital input is 18VDC with a minimum current of 5mA.

6.6.7 Communication Setting

	1	2	3	4-Menu
	9- Communication Setting			

Parameter	Range	Description
9-1- Modbus Baud Rate	0=9600 1=19200 2=38400 3=57600 4=115200 5=230400 6=460800 7=921600	Data transfer speed in Modbus communication
9-2- Modbus Data Mode	0= 8bit,Even,1Stop 1= 8bit,Even,2Stop 2= 8bit,Odd,1Stop 3= 8bit,Odd,2Stop 4= 8bit,No Parity,1Stop 5= 8bit,No Parity,2Stop	Modbus communication parameters
9-3- Modbus Node Address	0~200	Node number in serial communication using Modbus protocol
9-4-TCP IP Address	192.168.1.213	IP Address in TCP communication using TCP/IP protocol
9-5-TCP Subnet Mask	255.255.255.0	Subnet Mask in TCP communication using TCP/IP protocol
9-6=TCP Gateway Address	192.168.1.1	Gateway Address in TCP communication using TCP/IP protocol
9-7-Modbus TCP Port	0~65500	Modbus TCP Port in TCP communication using TCP/IP protocol
9-8-Modbus TCP Timeout	0.600~9.00 Sec	Waiting time for receive answer in TCP communication using TCP/IP protocol
9-9-Mac Address	00:00:00:00:00:00	Uniq MAC address

- The serial communication parameter addresses are provided in Section 10 (Appendix A).
- In TCP/IP mode, the values Modbus Baud Rate=38400bps and Modbus Data Mode=8bit,No Parity,2Stop are valid.

6.6.8 Temperature Setting

	1	2	3	4-Menu
	10- Temperature Setting			

Parameter	Range	Description
10-1- Tube Temp. Offset	-50~+50	Giving Offset to Pipe Temperature
10-2- Tube Temp. Damping	1~100 Cycles	Number of averaging for pipe temperature to reduce momentary fluctuations
10-3- Tube Temp. Unit	0 = Centigrade 1 = Fahrenheit	Display unit for pipe temperature
10-4- Tube Temp. Dot point	0~1	Number of decimal places in displaying pipe temperature
10-5- Tube Temp. Simulation	0 = OFF 1 = ON	Simulating pipe temperature for troubleshooting
10-6- Tube Temp. Sim. Value	0~120 Centigrade	Amount of pipe temperature for simulation
10-7- Body Temp. Offset	-50~+50	Giving Offset to Body Temperature
10-8- Body Temp. Damping	1~100 Cycles	Number of averaging for body temperature to reduce momentary fluctuations
10-9- Body Temp. Simulation	0 = OFF 1 = ON	Simulating body temperature for troubleshooting
10-A- Body Temp. Sim. Value	0~120 Centigrade	Amount of body temperature for simulation

6.6.9 Totalizers Setting

1	2	3	4-Menu
11- Totalizers Setting			

Parameter	Range	Description	
11-1- Totalizer 1 Unit	0=gr(1DP) 1=Kg(1DP) 2=Ton(3DP) 3=ml(1DP) 4=Liter(1DP) 5=m3(3DP) 6=Mix-1Kg(1DP) 7=Mix-2Kg(1DP)	Totalizer Unit: Milli Liters/ Liters/ Cubic Meters	
11-2- Total 1 Reset Mode	0=OFF (Cannot Reset)	In this mode, the totalizer never becomes zero.	Setting up how to zero out the totalizer
	1=Reset in Setting Page	The totalizer is reset to zero using the Reset Totalizer 1 parameter in the Setting header.	
	2=Reset With Digital In.	The totalizer is zeroed by using a digital input*.	
	3=Reset in Sett. & Dig. In.	In this case, the totalizer is reset with both of the previous conditions.	
	4=Reset on Limit	The totalizer is zeroed by reaching the set limit as the Totalizer Limit in the Setting header.	
11-3- Total 1 Pump Ctrl Mode	0=Manual Mode 1=Auto Mode	Determining the pump control mode through Totalizer 1.	
11-4- Total 1 Pump Ctrl Force	0= Force OFF 1= Force ON	Manual triggering of pump control by Totalizer 1.	
11-5- Total1 Hold Mode	0=No Hold	Totalizer 1 will not hold.	
	1=Hold With Digital IN	Totalizer 1 will hold with Digital input	
	2=Hold By Density Low Limit	Totalizer 1 will hold by Density low limit	
	3=Hold By Density High Limit	Totalizer 1 will hold by Density high limit	
	4=Hold By Brix Low Limit	Totalizer 1 will hold by Brix low limit	
	5=Hold By Brix High Limit	Totalizer 1 will hold by Brix high limit	
11-6-Total1 Hold Limit	0.000~9999.999	Totalizer 1 will hold by hold limit overflow	
11-7- Totalizer 2 Unit 11-8- Total 2 Reset Mode 11-9- Total 2 Pump Ctrl Mode 11-A- Total 2 Pump Ctrl Force 11-B- Total2 Hold Mode	These parameters are configured like Totalizer 1.		

11-C-Total2 Hold Limit		
11-D-Mixure 1 Density	0.000~9999.999 Kg/m3	Density value of substance 1 of the mixture **
11-E-Mixure 2 Density	0.000~9999.999 Kg/m3	Density value of substance 2 of the mixture
11-F-Mixure 1 MassFlow	Raed Only	Mass flow rate of the first mixed substance

*If the totalizer value becomes zero, it means that the Digital Input Mode parameter under the Digital Input Setting submenu located in the Menu header has been set to Totalizer Reset. (Section 6.6.9)

**When a mixture consisting of two substances with different densities passes through the flowmeter and the density of each substance is known, the flowmeter is able to calculate the amount of each substance passing through separately and display it in totalizer units (in this case, setting section 6.6.9 is required).

6.6.10 PID Controller Setting

1	2	3	4-Menu
12- PID Controller Setting			

Parameter	Range	Description	
12-1- PID Mode	0=PID Mode	Disable	Controller Operation Mode
	1=Always Enable	Always Enable	
	2=Enable By Digital Input	Enable By Digital Input	
12-2-Controlled Parameter	0=Mass Flow 1=Volumetric Flow 2=Density 3=Brix	Under Control Parameter	
12-3-PID Setpoint	0.00~99999.99	PID Controller Parameters	
12-4- PID Gain(P)	0.001~65.000		
12-5- PID Integral(i)	0.00~650.00 Sec		
12-6- PID Derivative(D)	0.00~650.00 Sec		
12-7- PID Sample Time	0.1~20.0 Sec	Controller Sampling Time	
12-8- PID Out Min Valve	0~100 %	Controller Output minimum limit	
12-9- PID Out Max Valve	1~100 %	Controller Output maximum limit	
12-A- PID Out Direction	Incremental/decremental	Direction of Controller Output (increasing/decreasing)	
12-B-PID Value	Read Only	Controller Output Value	
12-C-PID Manual Mode	0=Automatic	PID Controller Output value depending on automatic PID parameteres	
	1=Manual Output	PID Controller Output value set manually (12-D)	
12-D-PID Manual Value	0~100%	PID Controller Output manual value	

*The PID controller will be enabled in this mode only if the Digital Input Mode parameter within the Digital Input Setting submenu located in the Menu header is set to PID Enable. (Section 4.6.6)

• The PID controller setup guide is provided in Appendix B (Section 11) of this manual.

6.6.11 Batch Filling Setting

Coriolis mass flow meters can automatically control the filling operation using Batch Filling feature without the need for any other controller. The filling process can be done manually or triggered by a digital input signal (section 6.6.6), and in each filling cycle, the Batch Filling program automatically opens and closes the filling system valve. Parameters and settings related to the Batch Filling system are described in the table below.

	1	2	3	4-Menu
	13- **Batch Filling Setting**			

Parameter	Range	Description
13-1- Manual Force Filling	0=Filling not Forced	Automatic filling operation
	1=Manual Force Filling	Manual filling initiation
13-2- Auto SP. Correction	0=Auto Fill Setpoint OFF	Automatic correction system* off
	1=Auto Fill Setpoint ON	Automatic correction system on
13-3- Initial Diff. Value	-9999.9~9999.9 mLiter	This value is added to the Next Filling Setpoint parameter in the first working cycle of the filler.
13-4- Max Filling Time	0.0~50.0 Sec	Maximum allowable filling time per container**
13-5- Valve OFF Time	0.00~7.50 Sec	Controller sampling time
13-6- Last Filling Volume	Volume of the last filled container	
13-7- Last Difference	Difference between the last Next Filling Setpoint value and Last Filling Volume	
13-8- Next Filling Setpoint	Adjusted Setpoint value	
13-9- Last Filling Time	Time taken to fill the last container	
13-A-Auto Force Flow	0=Auto Zero Flow OFF	In this case, the flow rate is measured regardless of whether Batch Filling is enable.
	1=Auto Zero Flow ON	In this case, the flow rate is measured only if "Batch Filling is active"

*By enabling the "Automatic Correction System," the device compares the Next Filling Setpoint parameter with the Last Filling Volume parameter and compensates for any discrepancies that have occurred by adjusting the Next Filling Setpoint.

** If the filling time exceeds this limit, it indicates that the flow rate is lower than expected or the filling reservoir is empty. In this case, the filling process stops, and the Low Flow Alarm error is activated.

6.6.12 Density pressure compensation

Pressure compensation in **PrismaTech®** Coriolis Mass Flowmeter ensures high measurement accuracy by correcting for fluid pressure variations that affect the stiffness of the measuring tubes. By continuously monitoring the static pressure, the transmitter automatically adjusts the mass flow and density calculations in real-time. This feature is crucial for applications with significant pressure fluctuations, guaranteeing reliable and precise performance under varying process conditions.

	1	2	3	4-Menu
	14- Density Pressure Compensation			

Parameter	Range	Description
14-1- Pressure Input mode	0=Fix Pressure	Considering pressure with fixed value
	1=Pressure with Analog input	Considering pressure with analoge input
14-2- Fix Pressure Value	0.000~200.000 bar	Fixed pressure value
14-3- Analog In. Value	0.000~65000	Analog input value
14-4- Analog In. Min Value	0.000~65000	Analog input minimum value for scaling
14-5- Pressure Min Value	0.000~200.000 bar	Pressure minimum value for scaling
14-6- Analog In. Max Value	0.000~65000	Analog input maximum value for scaling
14-7- Pressure Max Value	0.000~200.000 bar	Pressure maximum value for scaling
14-8- Scaled Pressure Value	0.000~200.000 bar	Pressure value after scaling
14-9- Pressure Compensation Fac.	0.00000~1.00000 Kg/m^3 bar	Pressure compensation coefficient for 1bar

6.6.13 Calibration & EPD Setting

<table>
<tr><td rowspan="2"></td><td>1</td><td>2</td><td>3</td><td>4-Menu</td></tr>
<tr><td colspan="4">15- Calibration & EPD Setting</td></tr>
<tr><th>Parameter</th><th>Range</th><th colspan="3">Description</th></tr>
<tr><td>15-1-Mass Flow Zero Calibration</td><td>0~555</td><td colspan="3">Correction factor for volumetric flow (this factor is multiplied by the measured volumetric flow rate)</td></tr>
<tr><td>15-2- Mass Flow Cal.Factor</td><td>0.00000~9.99999</td><td colspan="3">Mass flow correction factor (this factor is multiplied by the measured mass flow number)</td></tr>
<tr><td>15-3-Mass Flow Offset</td><td>-9999.9~9999.9 Kg/h</td><td colspan="3">Mass flow rate offset</td></tr>
<tr><td>15-4- Low Cut-off Delta Teta</td><td>0~65.500 mDeg</td><td colspan="3">If the induced voltage on the electrodes is lower than this amount, the flow is considered zero. (Factory setting)</td></tr>
<tr><td>15-5- Density Cal. Gain</td><td>0.00000~9.99999</td><td colspan="3">Correction factor for density (this factor is multiplied by the measured density value)</td></tr>
<tr><td>15-6- Density Cal. Offset</td><td>-9999.999~9999.999 Kg/m3</td><td colspan="3">Density offset</td></tr>
<tr><td>15-7-Concentrate Cal. Gain</td><td>0.0001~6.5535</td><td colspan="3">Correction factor for Concentration (this factor is multiplied by the measured Brix value)</td></tr>
<tr><td>15-8-Concentrate Cal. Offset</td><td>-270~270 ‘B</td><td colspan="3">Concentration offset</td></tr>
<tr><td rowspan="2">15-9-Empty Pipe Det.Enable</td><td>0=EPD Disable</td><td>Deactivate</td><td colspan="2" rowspan="2">Empty pipe detection*</td></tr>
<tr><td>1=EPD Enable</td><td>Activate</td></tr>
<tr><td>15-A-Empty Pipe Det. Freq.</td><td>0~9999 Hz</td><td colspan="3">Frequency indicating empty pipe level (Factory setting)</td></tr>
<tr><td>15-B-ADC Damping (mA, Totalizers)</td><td>1~800 Cycles</td><td colspan="3">Number of ADC Damping cycles (for current output and totalizers)</td></tr>
<tr><td>15-C-ADC Gamma (mA, Totalizers)</td><td>0.1~99.9 %</td><td colspan="3">Low-pass filter coefficient for ADC</td></tr>
</table>

*When this option is enabled and there is nothing inside the pipe, the device will display an alert "Empty Pipe Detected" on the LCD, indicating an empty pipe, and the Totalizers will also stop.

6.6.14 Field Calibration

Calibration points can be used to correct and perform calibration on site; each calibration point is entered with a mass flow rate and a corresponding calibration correction factor.

	1	2	3	4-Menu
	16- Calibration & EPD Setting			

Parameter	Range	Description
16-1-M.Flow Field Cal.Point No.	0~9	Number of calibration point
16-2- Flow Rate1	0.0~999999.9 Kg/h	Mass flow rate of calibration point 1
16-3-Calibration Factor1	0.0000~99.0000	Correction factor of calibration point1
16-4- Flow Rate2	0.0~999999.9 Kg/h	The description of the parameters of calibration point 1 is correspondingly true for the other points.
16-5-Calibration Factor2	0.0000~99.0000	
. . .		
16-E- Flow Rate7	0.0~999999.9 Kg/h	
16-F-Calibration Factor7	0.0000~99.0000	

6.6.15 Factory Setting

	1	2	3	4-Menu
	17- Factory Setting			

Parameter	Range	Description
17-1-Pickup Setpoint	Read Only	Coil Settings
17-2-Pickup Low Limit	Read Only	Coil Settings
17-3-Sweep Freq. Step	Read Only	Sweep Frequency Drive Settings
17-4-Sweep Drive Amplitude	Read Only	Sweep Frequency Drive Settings
17-5-IIR Filter Range	Read Only	Bandpass Filter Status
17-6-PPDT Offset Value	Read Only	Phase Difference Offset
17-7-Drive Excitation Mode	Read Only	Coil Drive Excitation Mode
17-8-Test Timer Value	Read Only	Time Elapsed from Test
17-9-Test Timer Setpoint	Read Only	Time Set for Test
17-A-Test Timer Status	Read Only	Timer Activation Status
17-B-Copy Param to Fact Set	Read Only	Copy Device Parameters
17-C-Drive PID Gain	0.01~655.00	Drive Voltage PID Controller Parameters
17-D-Dirve PID Integral	0.01~655.00 Sec	
17-A-Reset All Settings	0~555	Reset Device Settings

※To reset all parameters, set the value of 16-A to 123.

7 Diagnostics and troubleshooting

7.1 General troubleshooting

Display

Error	Possible cause	Solution
The screen is off and the output signal is disconnected	The supply voltage does not match the rated voltage of the device	Apply a suitable supply voltage with the rated voltage
	The polarity of the supply voltage is not correct	Correct the positive and negative directions according to the device's power supply terminal.
	There is no proper connection between the power wires and the device terminal	Check the connection to the terminal and repair if necessary
	The power board and terminal are damaged	Order according to the spare parts list - refer to section 9
The screen is off or dim or bright, but the output signal is within the allowable range	Screen brightness not adjustable	Check and adjust the screen brightness - refer to section 6.6.3
The display is off but the output signal is within the allowable range	The display board socket is not connected	Check the display board socket connection and repair it if necessary
	The display board is damaged	Order according to the spare parts list - refer to section 9

Output Signals

Error	Possible cause	Solution
Output signals are outside the permissible range	Terminal board is damaged	Order according to the spare parts list - see section 9
The value on the display is displayed correctly, but the output signal sends the wrong value	Output analog signal parameters are not set	Check and adjust the settings of the analog output signal parameters – refer to section 6.6.4
The value on the display is not displayed correctly, and the output signal sends the wrong value	Error in measuring fluid values	Contact support

7.2 Troubleshooting from screen information

Alarm and Warning

Error	Possible cause	Solution
"Digital Output 1 Pulse Overlap"	Digital output1 signal pulse width not set correctly	Check and adjust the parameters of digital output signal 1 - refer to section 6.6.5
"Digital Output 2 Pulse Overlap"	Digital output2 signal pulse width not set correctly	Check and adjust the parameters of digital output signal 2 - refer to section 6.6.5
"Micro Controller HSE Error"	Main processor error	Turn the device off and on and if the error is not resolved, contact support
"Test Timer Timeout"	Temporary device usage time has expired	Contact support
"Totalizer 1 Reset Inhibited"	Totalizer 1 reset is prevented	Check and adjust the parameters of Totalizer 1 - refer to section 6.6.9
"Totalizer 2 Reset Inhibited"	Totalizer 2 reset is prevented	Check and adjust the parameters of Totalizer 2 - refer to section 6.6.9
"Low Filling Flow Rate"	The flow rate of the fluid passing through is lower than the minimum set in section 6.6.11	Check the fluid flow and increase the fluid flow rate
		Check and adjust the parameters related to the Batchfill section - refer to section 6.6.11
"High Filling Flow Rate"	The flow rate of the fluid passing through is lower than the minimum set in section 6.6.11	Check the fluid flow and reduce the fluid flow rate
		Check and adjust the parameters related to the Batchfill section - refer to section 6.6.11
"CPU Low Temperature"	The temperature of the main processor is low	Contact support
"CPU High Temperature"	The temperature of the main process is high	Contact support
"Filling Not Completed"	Filling operation is incomplete	Check and adjust the parameters related to Batchfill - refer to section 6.6.11
"Empty Pipe Detected"	There is no fluid inside the device pipes	Check the fluid flow path
"Flash Not Initialised"	The central controller program of the device is incomplete	Contact support
"Coil Current Error"	The electric current of the coil is out of the allowable range	Contact support

"LCD Controller HSE Error"	Display processor error	Turn the device off and on and if the error is not resolved, contact support
"Analog Out-1 Open Loop"	Analog output1 signal wire is disconnected	Check and correct the analog output 1 signal path
"Analog Out-2 Open Loop"	Analog output2 signal wire is disconnected	Check and correct the analog output 2 signal path
"EEPROM Write Error"	EEPROM write error	Contact support
"IIR Filter Range Error"	IIR filter range error	Contact support
"MCU Decryption Key Error"	The device controller program is locked	Contact support
"Tube Out Of Resonance"	The fluid concentration is higher than the allowable limit	Check the fluid flow
	The flow rate has air bubbles	Check the fluid flow
	A solid object is stuck inside the device pipes	Carefully check the inside of the device pipes
	The resonance coils are damaged	Contact support
"Fill SP is Less than Off-Fill"	The Setpoint value in the Batchfill section is less than the Off-Fill value	Check and adjust the parameters related to Batchfill - refer to section 6.6.11
"Zero Calibration Error!"	An error occurred while performing the Zero Calibration operation	Check the pipe routing and make sure there is no fluid flow
"Dig. Out. Not for Filling"	The digital output is not set for the Filling operation	Check and adjust the parameters related to the digital output - refer to section 6.6.5
"Mixture Totalizer Calc Error"	Totalizer calculations Error encountered for fluids with different densities	Check and correct the density parameters of fluids 1 and 2 - refer to section 6.6.9
"Totalizer 1 Overflow"	Totalizer 1 value overflowed	Reset the value of totalizer 1 - refer to section 6.6.9
"Totalizer 2 Overflow"	Totalizer 2 value overflowed	Reset the value of totalizer 2 - refer to section 6.6.9

8 Service and maintenance

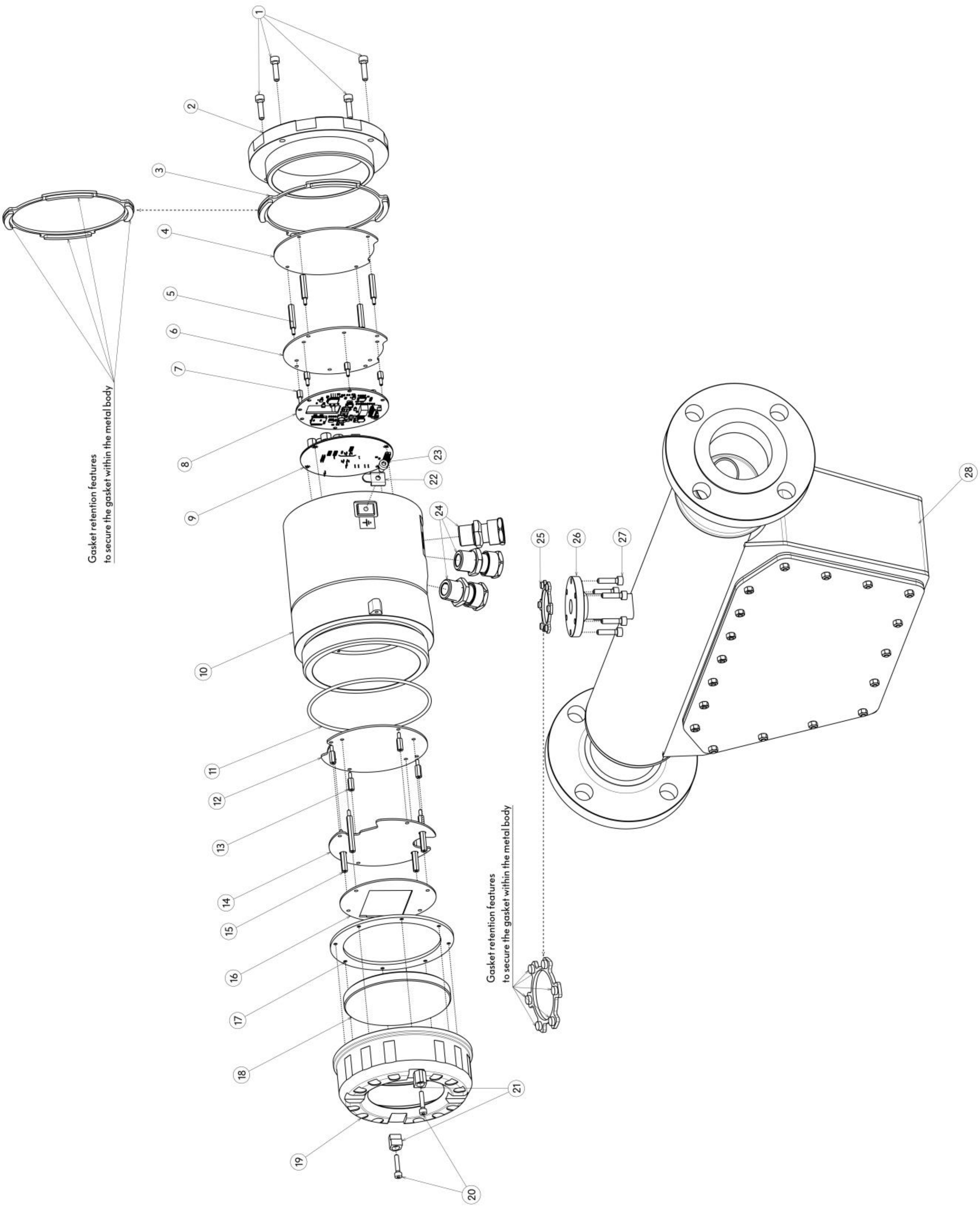
The **PrismaTech®** Coriolis flow meter is designed and built in a way that under normal operating conditions, it does not require constant maintenance and care. In case of any issues, refer to the troubleshooting parameters (section 7).

- Often, unstable measurement errors occur due to issues with the grounding wire. In such cases, verify the correctness of the grounding first.
- Use materials that do not damage the surface when cleaning the external surface of the device.

⚠ The clamp gaskets at both ends of the sensor should be periodically inspected and replaced if necessary. The intervals for replacement depend on the working temperature and the materials passing through the pipeline.

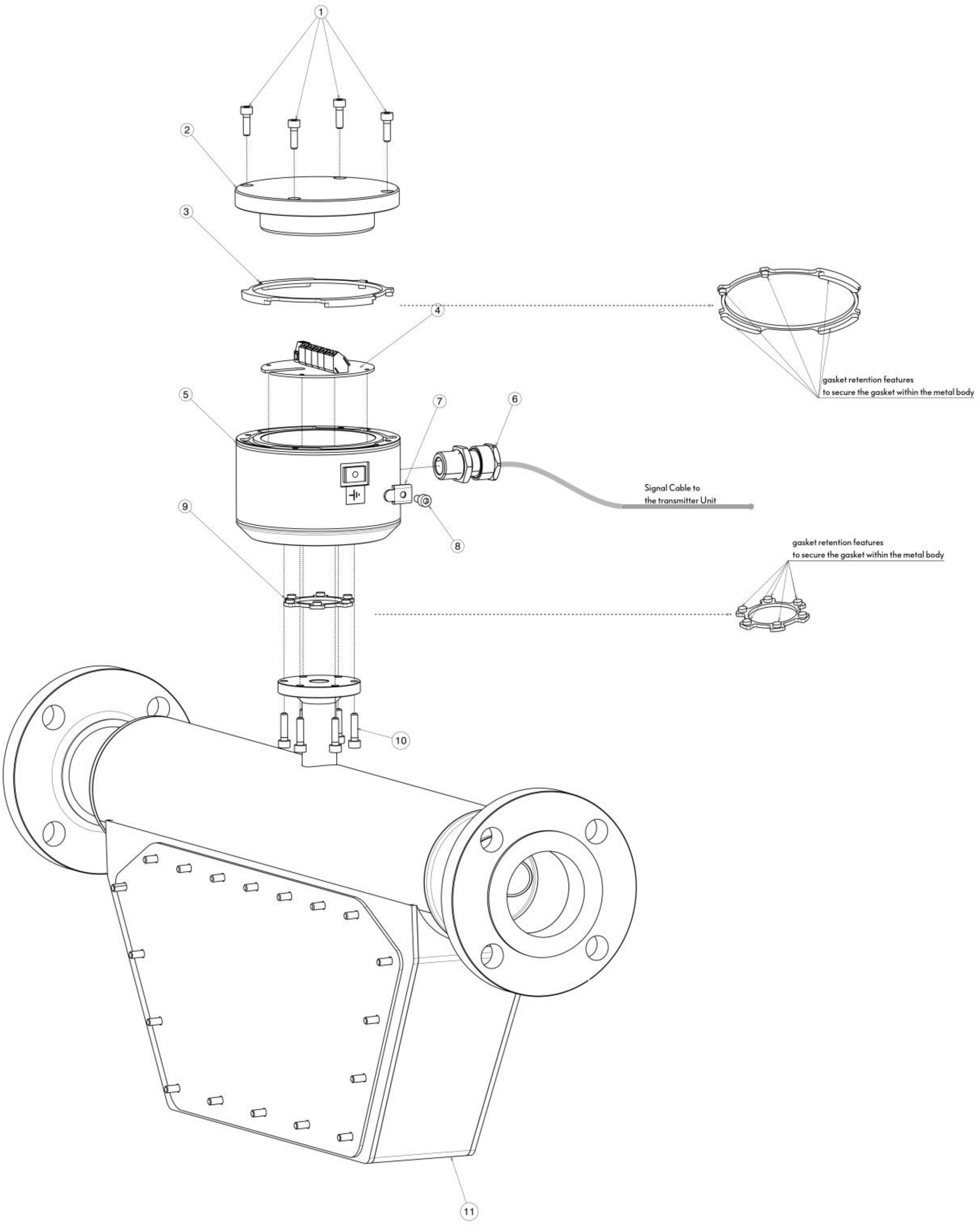
9 Spare Part List

9.1 With Integral Transmitter



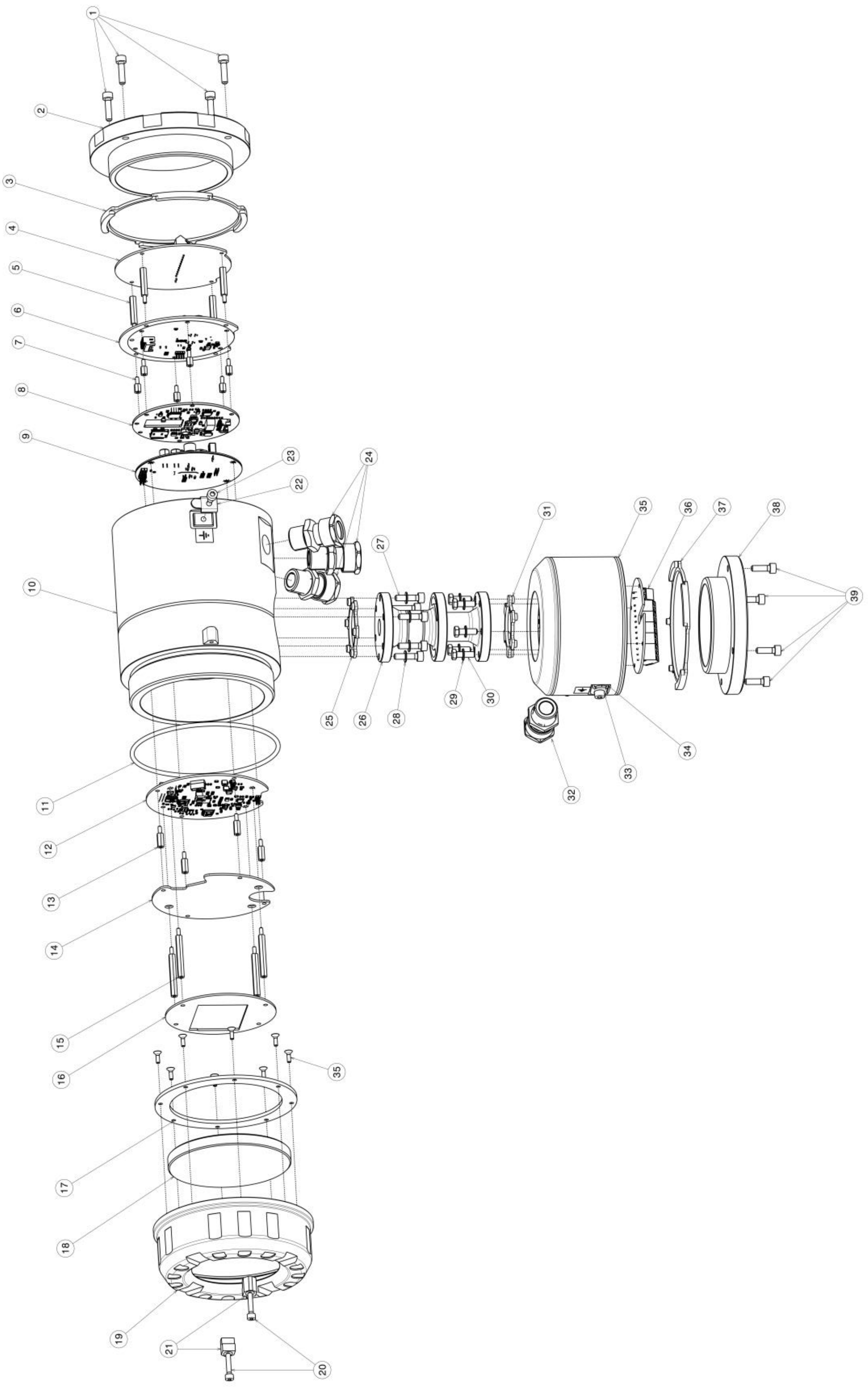
<table>
<tr><th>No</th><th>Component Name</th><th>Part Number</th><th>No</th><th colspan="2">Component Name</th><th>Part Number</th></tr>
<tr><td>1</td><td>Terminal Cap Fastening Bolts (M5*20 Socket Head)</td><td>1070306501</td><td>15</td><td colspan="2">Display PCB Spacers</td><td>1110101401</td></tr>
<tr><td>2</td><td>Integral-Terminal Cap</td><td>1110100301</td><td>16</td><td colspan="2">Display Board</td><td>210030601010</td></tr>
<tr><td>3</td><td>Integral-Terminal Cap Gasket</td><td>1110101101</td><td>17</td><td colspan="2">Glass Shield Backup Ring</td><td>1110100801</td></tr>
<tr><td>4</td><td>Terminal Board</td><td>210031901011</td><td>18</td><td colspan="2">Tempered Glass (10mm thickness)</td><td>1031100404</td></tr>
<tr><td>5</td><td>Terminal PCB Spacers</td><td>1110101501</td><td>19</td><td colspan="2">Display Cap</td><td>1110100201</td></tr>
<tr><td>6</td><td>Protection Board</td><td>210030201012</td><td>20</td><td colspan="2">Retaining bolts (M4*20 Socket Head)</td><td>1070303501</td></tr>
<tr><td>7</td><td>Communication PCB Spacers</td><td>1110101601</td><td>21</td><td colspan="2">Display Cap Retaining Wedges</td><td>1110100701</td></tr>
<tr><td>8</td><td>Communication Board</td><td>210031901012</td><td>22</td><td colspan="2">Earth Cable Bracket</td><td>1110100901</td></tr>
<tr><td>9</td><td>Power Board</td><td>210031801013</td><td>23</td><td colspan="2">Earth Cable Bolt (M5*10 Socket Head)</td><td>1070306201</td></tr>
<tr><td>10</td><td>Main Housing Body</td><td>1110100101</td><td>24</td><td colspan="2">M20 Explosion Proof Glands (Armoured/Non Armoured)</td><td>1110100501</td></tr>
<tr><td>11</td><td>Display Cap O-Ring (ID=120, CS=3.5)</td><td>1110101301</td><td>25</td><td colspan="2">Neck Silicon Gasket</td><td>1110101201</td></tr>
<tr><td>12</td><td>Sensor Board</td><td>210031704011</td><td>26</td><td colspan="2">Sensor Neck</td><td>1110100401</td></tr>
<tr><td>13</td><td>Barrier PCB Spacers</td><td>1110101701</td><td>27</td><td colspan="2">Neck-Transmitter Fastening Bolts (M5*20 Socket Head)</td><td>10703065501</td></tr>
<tr><td rowspan="7">14</td><td rowspan="7">Barrier Board</td><td rowspan="7">210031704012</td><td rowspan="7">28</td><td rowspan="7">Sensor Unit</td><td>DN8</td><td>1046300201</td></tr>
<tr><td>DN15</td><td>1046301201</td></tr>
<tr><td>DN25</td><td>1046302201</td></tr>
<tr><td>DN40</td><td>1046303201</td></tr>
<tr><td>DN50</td><td>1046304201</td></tr>
<tr><td>DN80</td><td>1046305001</td></tr>
<tr><td>DN100</td><td>1046305401</td></tr>
</table>

9.2 With Remote Transmitter



<table>
<tr><th>No.</th><th colspan="2">Component Name</th><th>Part Number</th></tr>
<tr><td>1</td><td colspan="2">Terminal Cap Bolts (M5*20 Socket Head)</td><td>1070306501</td></tr>
<tr><td>2</td><td colspan="2">Junction Box Terminal Cap</td><td>1110200201</td></tr>
<tr><td>3</td><td colspan="2">Junction Box_Cap Gasket</td><td>1070601101</td></tr>
<tr><td>4</td><td colspan="2">Sensor Junction Board</td><td>210031901013</td></tr>
<tr><td>5</td><td colspan="2">Junction Box Body</td><td>1110200101</td></tr>
<tr><td>6</td><td colspan="2">M20_Explosion Proof Glands (Armoured/Non Armoured)</td><td>1110100501</td></tr>
<tr><td>7</td><td colspan="2">Earth Cable Bracket</td><td>1110100901</td></tr>
<tr><td>8</td><td colspan="2">Earth Cable Bolt (M5*10 Socket Head)</td><td>11070306201</td></tr>
<tr><td>9</td><td colspan="2">Neck Silicon Gasket</td><td>1110101201</td></tr>
<tr><td>10</td><td colspan="2">Neck Junction Box Fastening Bolts (M5*15 Socket Head)</td><td>1070306402</td></tr>
<tr><td rowspan="7">11</td><td rowspan="7">Sensor Unit</td><td>DN8</td><td>1046300201</td></tr>
<tr><td>DN15</td><td>1046301201</td></tr>
<tr><td>DN25</td><td>1046302201</td></tr>
<tr><td>DN40</td><td>1046303201</td></tr>
<tr><td>DN50</td><td>1046304201</td></tr>
<tr><td>DN80</td><td>1046305001</td></tr>
<tr><td>DN100</td><td>1046305401</td></tr>
</table>

9.3 Remote Transmitter



No	Component Name	Part Number
1	Terminal Cap Fastening Bolts (M5*20 Socket Head)	1070306501
2	Compact-Terminal Cap	1110100301
3	Compact-Terminal Cap Gasket	1110101101
4	Terminal Board	210031901011
5	Terminal PCB Spacers	1110101501
6	Protection Board	210030201012
7	Communication PCB Spacers	1110101601
8	Communication Board	210031901012
9	Power Board	210031801013
10	Transmitter Main Housing	1110100101
11	Display Cap O-Ring (ID=120, CS=3.5)	1110101301
12	Sensor Board	210031704011
13	Barrier PCB Spacers	1110101701
14	Barrier Board	210031704012
15	Display PCB Spacers	1110101401
16	Display Board	210030601010
17	Glass Shield Backup Ring	1110100801
18	10mm Tempered Glass	1110100601
19	Transmitter Display Cap	1110100201
20	Retaining Bolts (M4*20 Socket Head)	1070303501
21	Display Cap Retaining Wedges	1110100701
22	Earth Cable Bracket	1110100901
23	Earth Cable Bolt (M5*10 Socket Head)	1070306201
24	M20 Explosion Proof Glands (Armoured/Non Armoured)	1110100501
25	Neck Silicon Gasket	1110101201
26	Interconnecting Neck	1110200301
27	Neck-Transmitter Fastening Bolts	1070306501
28	Neck-Transmitter Fastening Washer	1070500203
29	Neck-JunctionBox Fastening Washer	1070500202
30	Neck-JunctionBox Fastening Bolts (M5*15 Hexagon Head)	1070306402
31	Neck Silicon Gasket	1110101201
32	M20 Explosion Proof Glands (Armoured/Non Armoured)	1110100501
33	Earth Cable Bolt (M5*10 Socket Head)	1070306201
34	Earth Cable Bracket	1110100901
35	JunctionBox Body	1110200101
36	Transmitter Junction Board	210031901014
37	JunctionBox Gasket	1070601101
38	JunctionBox Terminal Cap	1110200201
39	JunctionBox Cap Fastening Bolts (M5*20 Socket Head)	1070306501

10 Attachment A: RS485 Modbus RTU Address

Home Page				
Parameter Name	Modbus Address	Format	Type	Range
Mas. Flow	776	Int-32bit	R	---
Vol. Flow	920	Int-32bit	R	---
Density	904	Uint-32bit	R	---
Brix/nD	906	Uint-32bit	R	---
Temp	908	Uint-32bit	R	---
Totalizer 1(M)	772	Uint-32bit	R	---
Totalizer 2(M)	774	Uint-32bit	R	---
Digital Input 1	203.4	Bit	R	0 = Off 1 = On
Digital Output 1	203.6	Bit	R	0 = Off 1 = On
Digital Output 2	203.7	Bit	R	0 = Off 1 = On
Analog Output 1	231	Uint-16bit	R	--- (Gain = 0.0305175)
Analog Output 2	282	Uint-16bit	R	--- (Gain = 0.0305175)
Alarms	227	Uint-16bit	R	Bit 0 to 16
Serial Nomber	352	Uint-32bit	R	---
Device Software	200	Uint-16bit	R	---
Main Software	200	Uint-16bit	R	---

1- Flow Display Setting				
Parameter Name	Modbus Address	Format	Type	Range
1-1- Home Mass Flow Unit	7	Uint-16bit	R/W	0= gr/Sec 1= gr/Min 2= oz/Sec 3= oz/Min 4= Kg/Sec 5= Kg/Min 6= Kg/Hour 7= Ton/Hour 8= Ton/Min 9= lb/Sec 10= lb/Min 11= lb/Hour 12= Ton(US)/Hour 13= Ton(US)/Min 14= Ton(UK)/Hour 15= Ton(UK)/Min
1-2- Home Mass Flow Dot Points	8	Uint-16bit	R/W	0 to 3
1-3- Mass Flow Damping Time	22	Uint-16bit	R/W	1 to 800 Cycles
1-4- Mass Flow Direction	9	Uint-16bit	R/W	0 = Positive 1 = Negative 2 = Bi-Directional
1-5- Mass Flow Simulation	203.9	Bit	R/W	0 =Off 1 = On

1-6- Simulated Mass Flow Value	780	Int-32bit	R/W	0.0 to 999999.9 Kg/h
1-7- Home Vol.Flow Unit	155	Uint-16bit	R/W	0= ml/Min 1= ml/Sec 2= Liter/Hour 3= Liter/Min 4= Liter/Sec 5= m^3/Hour 6= m^3/min 7= gal(US)/Hour 8= gal(US)/Min 9= gal(US)/Sec 10= gal(Imp)/Hour 11= gal(Imp)/Min 12= gal(Imp)/Sec 13= in3/Sec 14= ft3/Sec 15= ft3/Min 16= ft3/Hour
1-8- Home Vol.Flow Dot points	156	Uint-16bit	R/W	0 to 3
1-9- Vol. Flow Damping Time	157	Uint-16bit	R/W	1 to 800 Cycles
1-A-Flow Low Cutoff Value	378	Uint-32bit	R/W	0.0~9999.9 Kg/h
1-B-Fluid Type	2.1	Bit	R/W	0=Liquid 1=Gas

1-C-Gas Name	183	Uint-16bit	R/W	0= Air 1= Ammonia NH3 2= Argon Ar 3= Sulfur hexafluoride SF6 4= Oxygen O2 5= Ozone O3 6= Nitrogen oxide NOx 7= Nitrogen N2 8= Nitrous oxide N2O 9= Methane CH4 10= Hydrogen H2 11= Helium He 12= Hydrogen chloride HCl 13= Hydrogen sulfide H2S 14= Ethylene C2H4 15= Carbon dioxide CO2 16= Carbon monoxide CO 17= Chlorine Cl2 18= Butane C4H10 19= Propane C3H8 20= Propylene C3H6 21= Ethane C2H6 22= Custom Gas
1-D-Custom Gas Density	560	Uint-32bit	R/W	0.0 to 999999.9 Kg/m^3

2- Density & Brix Display Setting				
Parameter Name	Modbus Address	Format	Type	Range
2-1- Home Density Unit	152	Uint-16bit	R/W	0 = Gram/cm3 1 = Kg/cm3 2 = Gram/m3 3 = Gram/mL 4 = Gram /Liter 5 = Kg/Liter 6 = Kg/m3
2-2- Home Density Dot Points	153	Uint-16bit	R/W	0 to 5
2-3- Density Damping Time	154	Uint-16bit	R/W	1 to 800 Cycles
2-4- Density Simulation	288.F	Bit	R/W	0 =Off 1 = On
2-5- Simulated Density Value	912	UInt-32bit	R/W	0.0 to 9999.999 Kg/m3
2-6- Home Concentrate Unit	158	Uint-16bit	R/W	0 = Brix 1 = Refractive Index
2-7- Home Concentrate Dot Points	159	Uint-16bit	R/W	0 to 4
2-8- Concentrate Damping Time	160	Uint-16bit	R/W	1 to 800 Cycles
2-9-Fluid Pressure	152	Uint-16bit	R/W	0.0~300.0 bar
2-A-Pressure Compensate Fac.	97	Uint-16bit	R/W	0.000~1.000 Kg/m^3 bar
2-B-Show Density At Ref. Temp.	3.8	Bit	R/W	0= DART OFF 1= DART ON
2-C-DART Ref. Temp. Value	95	Uint-16bit	R/W	0.0~90.0 °C
2-D-DART Compensate Factor	96	Int-16bit	R/W	-9.000~9.000 Kg/m^3 °C

3- Other Display Setting				
Parameter Name	Modbus Address	Format	Type	Range
3-1- Home Page Main Parameter	151	Uint-16bit	R/W	0 = Mass Flow 1 = Density 2 = Brix or nD 3 = Volumetric Flow
3-2- LCD go to Standby Time	153	Uint-16bit	R/W	0 to 5
3-3- LCD Brightness Percent	154	Uint-16bit	R/W	1 to 800 Cycles
3-4- Status LED Mode	288.F	Bit	R/W	0 =Off 1 = On
3-5- Change Password	912	UInt-32bit	R/W	0.0 to 9999.999 Kg/m3
3-6- Power Key Enable	158	Uint-16bit	R/W	0 = Brix 1 = Refractive Index
3-7-Home Page Second Param.	45	Uint-16bit	R/W	1= Totalizer-2 Value 2= Density Low Limit DO1 3= Density Low Limit DO2

4- Analog Output 1 Setting				
Parameter Name	Modbus Address	Format	Type	Range
4-1- Anal. Out1. Mode	25	Uint-16bit	R/W	0= Disable 1= Mass Flow 4-20 mA *2= Vol. Flow 4-20 mA* 3= Density 4-20 mA 4= Temperature 4-20 mA 5= Brix 4-20 mA 6= PID 4-20 mA
4-2- Anal. Out1. Force	26	Uint-16bit	R/W	0= No Force 1= Force to 0 mA 2= Force to 1 mA 20= Force to 19 mA 21= Force to 20mA
4-3- An. Out.1 Min Flow	354	Uint-32bit	R/W	0.0 to 999999.0 L/h
4-4- An. Out.1 Max Flow	356	Uint-32bit	R/W	0.0 to 999999.0 L/h
4-5- An. Out.1 Value	231	Uint-16bit	R	0.000 to 20.000 mA 0=0mA, 65535=20mA
4-6-Analog Out.1 Offset	89	Int-16bit	R/W	-20000 to +20000 Each 327 Offset Value = 0.1 mA
4-7-Analog Out.1 D.E.C.	209	Uint-16bit	R	0 to 99999
4-8-A. Out.1 Open Loop Alarm	230.2	Bit	R	0= Alarm Disabled 1= Alarm Enabled

5- Analog Output 2 Setting				
Parameter Name	Modbus Address	Format	Type	Range
5-1- Anal. Out2. Mode	55	Uint-16bit	R/W	0= Disable 1= Mass Flow 4-20 mA 2= Vol. Flow 4-20 mA 3= Density 4-20 mA 4= Temperature 4-20 mA 5= Brix 4-20 mA 6= PID 4-20 mA
5-2- Anal. Out2. Force	56	Uint-16bit	R/W	0= No Force 1= Force to 0 mA 2= Force to 1 mA 20= Force to 19 mA 21= Force to 20mA
5-3- An. Out.2 Min Flow	440	Uint-32bit	R/W	0.0 to 999999.0 L/h
5-4- An. Out.2 Max Flow	442	Uint-32bit	R/W	0.0 to 999999.0 L/h
5-5- An. Out.2 Value	282	Uint-16bit	R	0.000 to 20.000 mA 0=0mA, 65535=20mA
5-6-Analog Out.2 Offset	131	Int-16bit	R/W	-20000 to +20000 Each 327 Offset Value = 0.1 mA
5-7-Analog Out.2 D.E.C.	280	Uint-16bit	R	0 to 99999
5-8-A. Out.2 Open Loop Alarm	281.2	Bit	R	0= Alarm Disabled 1= Alarm Enabled

6- Digital Output 1 Setting				
Parameter Name	Modbus Address	Format	Type	Range
6-1- Dig. Out1 Mode	41	Uint-16bit	R/W	0= OFF 1= Mass flow Pulse 2= Vol Flow Pulse 3= High Mass Flow Alarm 4= Low Mass Flow Alarm 5= Mass Flow Out of Range 6= Hight Density Alarm 7= Low Density Alarm 8= Density Out of Range 9= High V. Flow Alarm 10= Low V. Flow Alarm 11= V. Flow Out of Range 12= High Brix Alarm 13= Low Brix Alarm 14= Brix Out of Range 15= High Temp Alarm 16= Low Temp Alarm 17= Temp Out of Range 18= Empty Pipe Detected 19= System is OK 20= Pump Ctrl>Total 1 Limit 21= Pump Ctrl>Total 2 Limit 22= 3State Fill Low Valve 23= Batch Filling Valve

6-2- Dig. Out1 Force	42	Uint-16bit	R/W	0= Not Forced 1= Force to OFF 2= Force to ON
6-3- D.O.1 Pulse Width	44	Uint-16bit	R/W	1 to 1300 *720uSec
6-4-D.O.1 Volume/Pulse	366	Uint-32bit	R/W	0.01 to 999999.99
6-5- Dig Out1 Hi Limit	358	Uint-32bit	R/W	0.0 to 999999.0
6-6- Dig Out1 Lo Limit	360	Uint-32bit	R/W	0.0 to 999999.0
6-7- Dig Out1 Hysters.	43	Uint-16bit	R/W	1.0 to 6550.0

7- Digital Output 2 Setting				
Parameter Name	Modbus Address	Format	Type	Range
7-1- Dig. Out2 Mode	47	Uint-16bit	R/W	0= OFF 1= Mass flow Pulse 2= Vol Flow Pulse 3= High Mass Flow Alarm 4= Low Mass Flow Alarm 5= Mass Flow Out of Range 6= Hight Density Alarm 7= Low Density Alarm 8= Density Out of Range 9= High V. Flow Alarm 10= Low V. Flow Alarm 11= V. Flow Out of Range 12= High Brix Alarm 13= Low Brix Alarm 14= Brix Out of Range 15= High Temp Alarm 16= Low Temp Alarm 17= Temp Out of Range 18= Empty Pipe Detected 19= System is OK 20= Pump Ctrl>Total 1 Limit 21= Pump Ctrl>Total 2 Limit 22= 3State Fill Low Valve 23= Batch Filling Valve

7-2- Dig. Out2 Force	48	Uint-16bit	R/W	0= Not Forced 1= Force to OFF 2= Force to ON
7-3- D.O.2 Pulse Width	50	Uint-16bit	R/W	1 to 1300 *720uSec
7-4-D.O.2 Volume/Pulse	368	Uint-32bit	R/W	0.01 to 999999.99 ---
7-5- Dig Out2 Hi Limit	362	Uint-32bit	R/W	0.0 to 999999.0 ---
7-6- Dig Out2 Low Limit	364	Uint-32bit	R/W	0.0 to 999999.0 ---
7-7- Dig Out2 Hysters.	49	Uint-16bit	R/W	1.0 to 6550.0 ---

8- Digital Inputs Setting				
Parameter Name	Modbus Address	Format	Type	Range
8-1- Dig. In Mode	53	Uint-16bit	R/W	0= Disable 1= Total1 Reset 2= Total2 Reset 3= Total1&2 Reset 4= Total1 Hold 5= Total2 Hold 6= Total 1&2 Hold 7= PID Enable 8= Batch Filling Start 9=batch filling start/stop 10=Flow force to zero

9- Communication Setting				
Parameter Name	Modbus Address	Format	Type	Range
9-1- Modbus Baud Rate	29	Uint-16bit	R/W	0= 9600 bps 1= 19200 bps 2= 38400 bps 3= 57600 bps 4= 115200 bps 5= 230400 bps 6= 460800 bps 7= 921600 bps
9-2- Modbus Data Mode	30	Uint-16bit	R	0= 8bit, Even,1Stop 1= 8bit, Even,2Stop 2= 8bit, Odd,1Stop 3= 8bit, Odd,2Stop 4= 8bit, None,1Stop 5= 8bit, None,2Stop
9-3- Modbus Node Add.	31	Uint-16bit	R/W	0 to 31
9-4-TCP IP Address	103: 1st part 104: 2st part 105: 3st part 106: 4st part	Uint-16bit	R/W	192.168.1.222
9-5-TCP Subnet Mask	107: 1st part 108: 2st part 109: 3st part 110: 4st part	Uint-16bit	R/W	255.255.255.0

9-6=TCP Gateway Address	111: 1st part 112: 2st part 113: 3st part 114: 4st part	Uint-16bit	R/W	192.168.1.1
9-7-Modbus TCP Port	102	Uint-16bit	R/W	0~65500
9-8-Modbus TCP Timeout	115	Uint-16bit	R/W	0.600~9.00 Sec
9-9-Mac Address	333: 1st part 334: 2st part 335: 3st part 336: 4st part 337: 5st part 338: 6st part	Uint-16bit	R	00:00:00:00:00:00

10- Temperature Setting				
Parameter Name	Modbus Address	Format	Type	Range
10-1- Tube Temp. Offset	11	int-16bit	R/W	-50 to 50 °C
10-2- Tube Temp. Damping	12	Uint-16bit	R/W	1 to 100 Cycles
10-3- Tube Temp. Unit	161	Uint-16bit	R/W	0= Centigrade 1= Fahrenheit
10-4- Tube Temp. Dot Points	162	Uint-16bit	R/W	0 to 1
10-5- Tube Temp. Simulation	2.A	Bit	R/W	0= Off 1= On
10-6-Tube Temp. Simulated Value	10	Uint-16bit	R/W	0.0 to 120 °C
10-7- Body Temp. Offset	163	Int-16bit	R/W	-50 to 50 °C
10-8- Body Temp. Damping	164	Uint-16bit	R/W	1 to 100 Cycles
10-9- Body Temp. Simulation	3.1	Bit	R/W	0= Off 1= On
10-A-Body Temp. Simulated Value	165	Uint-16bit	R/W	0.0 to 120 °C

11- Totalizers Setting				
Parameter Name	Modbus Address	Format	Type	Range
11-1- Totalizer1 Unit	57	Uint-16bit	R/W	0= Gram (1 DP) 1= Kg (1 DP) 2= Ton (3 DP) 3 = mL (1 DP) 4 = Liter (1 DP) 5 = m3 (3DP) 6= Mix-1Kg(1DP) 7= Mix-2Kg(1DP)
11-2- Total1 Reset Mode	59	Uint-16bit	R/W	0= OFF 1= Setting Page 2= Digital Input 3= Sett. & Dig. In 4= Reset on Limit
11-3- Total 1 Pump Ctrl Mode	261.0	Bit	R/W	0 = Manual Mode 1 = Auto Mode
11-4- Total 1 Pump Ctrl Force	261.1	Bit	R/W	0 = Force Off 1 = Force On
11-5- Reset Total 1 Value	203.A	Bit	W	1= Totalizer 1 Reset
11-6- Total1 Hold Mode	179	Uint-16bit	R/W	0=No Hold 1=Hold With Digital IN 2=Hold By Density Low Limit 3=Hold By Density High Limit 4=Hold By Brix Low Limit 5=Hold By Brix High Limit
11-7- Total1 Hold limit	370	Uint-32bit	R/W	0.000~99999999.9

11-8- Totalizer2 Unit	60	Uint-16bit	R/W	0= Gram (1 DP) 1= Kg (1 DP) 2= Ton (3 DP) 3 = mL (1 DP) 4 = Liter (1 DP) 5 = m3 (3 DP)
11-9- Total2 Reset Mode	62	Uint-16bit	R/W	0= OFF 1= Setting Page 2= Digital Input 3= Sett. & Dig. In 4= Reset on Limit
11-10- Total2 Pump Ctrl Mode	261.2	Bit	R/W	0 = Manual Mode 1 = Auto Mode
11-11- Total2 Pump Ctrl Force	261.3	Bit	R/W	0 = Force Off 1 = Force On
11-12- Reset Total2 Value	203.B	Bit	W	1= Totalizer 2 Reset
11-13- Total2 Hold Mode	180	Uint-16bit	R/W	0=No Hold 1=Hold With Digital IN 2=Hold By Density Low Limit 3=Hold By Density High Limit 4=Hold By Brix Low Limit 5=Hold By Brix High Limit
11-14- Total2 Hold limit	372	Uint-32bit	R/W	0.000~99999999.9
11-15-Mixure 1 Density	456	Uint-32bit	R/W	0.000~9999.999 Kg/m^3
11-16-Mixure 2 Density	456	Uint-32bit	R/W	0.000~9999.999 Kg/m^3
11-17-Mixure 1 MassFlow	832	Uint-32bit	R	0.000~9999.999 Kg/m^3

12- PID Controller Setting				
Parameter Name	Modbus Address	Format	Type	Range
12-1-PID Enable Mode	33	Uint-16bit	R/W	Disable Always Enable Enable By Digital Input
12-2-Controlled Parameter	99	Uint-16bit	R/W	Mass Flow Volumetric Flow Density Brix
12-3-PID Setpoint	388	Uint-32bit	R/W	0.00~99999.99
12-4- PID Gain(P)	34	Uint-16bit	R/W	0.001~65.000
12-5- PID Integral(i)	35	Uint-16bit	R/W	0.00~650.00 Sec
12-6- PID Derivative(D)	36	Uint-16bit	R/W	0.00~650.00 Sec
12-7- PID Sample Time	37	Uint-16bit	R/W	0.1~20.0 Sec
12-8- PID Out Min Valve	38	Uint-16bit	R/W	0~100 %
12-9- PID Out Max Valve	39	Uint-16bit	R/W	1~100 %
12-A- PID Out Direction	2.2	Bit	R/W	Incremental/decremental
12-B-PID Value	223	Uint-16bit	R/W	Read Only
12-C-PID Manual Mode	203.3	Bit	R/W	0= Automatic 1= Manual Output
12-D-PID Manual Value	40	Uint-16bit	R/W	0~100%

13- Batch Filling Setting				
Parameter Name	Modbus Address	Format	Type	Range
13-1-Manual Force Filling	245.0	Bit	R/W	0= Filling not Forced 1= Manual Force Filling
13-2-Auto SP. Correction	5.0	Bit	R/W	0= Auto Fill Setpoint OFF 1= Auto Fill Setpoint ON
13-3-Initial Diff.Value	402	Int-32bit	R/W	-9999.9 to 9999.9 mLiter(cc)
12-4-Max Filling Time	400	Uint-32bit	R/W	0 to 99.9 Sec
13-5-Valve Off Time	66	Uint-16bit	R/W	0 to 9.99 Sec
13-6-Last Filling Volume	592	Uint-32bit	R	0 to 9999999.9 mLiter(cc)
13-7-Last Difference	594	Int-32bit	R	-999999.9 to 999999.9
13-8-Next Filling Setpoint	596	Uint-32bit	R	0 to 9999999.9 mLiter(cc)
13-9-Last Filling Time	600	Uint-32bit	R	0 to 999.99 Sec
13-10-Auto Force Flow	2.7	Bit	R/W	0= Auto Zero Flow OFF 1= Auto Zero Flow ON

14- Calibration & EPD Setting				
Parameter Name	**Modbus Address**	**Format**	**Type**	**Range**
14-1- Mass Flow Zero Calibration	330	Uint-16bit	R/W	0~555
14-2-MassFlow Cal. Factor	374	Uint-32bit	R/W	0 to 99.9999
14-3-Mass Flow Offset	376	Int-32bit	R/W	-9999.9~9999.9 Kg/h
14-4-Low Cut-off Delta Teta	16	Uint-16bit	R/W	0 to 65.500
14-5-Density Cal. Gain	518	Uint-32bit	R/W	0.00000 to 9.99999
14-6-Density Cal. Offset	520	Int-32bit	R/W	-9999.999 to 9999.999 Kg/m3
14-7-Concentrate Cal. Gain	166	Uint-16bit	R/W	0.0001 to 6.5535
14-8-Concentrate Cal. Offset	167	Int-16bit	R/W	-270.00 to 270.00 Brix
14-9-Empty Pipe Det.Enable	23.0	Bit	R/W	0= EPD Disable 1= EPD Enable
14-10-Empty Pipe Det.Freq.	18	Uint-16bit	R/W	0 to 9999
14-10-ADC Damping (mA, Totalizers)	21	Uint-16bit	R/W	1 to 500 Cycles
14-11-ADC Gamma (mA, Totalizers)	6	Uint-16bit	R/W	0.1 to 99.9 %

15- Calibration & EPD Setting				
Parameter Name	Modbus Address	Format	Type	Range
15-1- M.Flow Field Cal.Point No.	122	Uint-16bit	R/W	0~9
15-2-Flow Rate1	562	Uint-32bit	R/W	0.0~999999.9 Kg/h
15-3-Calibration Factor1	564	Uint-32bit	R/W	0.0000~99.0000
15-4-Flow Rate2	566	Uint-32bit	R/W	0.0~999999.9 Kg/h
15-5-Calibration Factor2	568	Uint-32bit	R/W	0.0~999999.9 Kg/h
15-7-Flow Rate3	570	Uint-32bit	R/W	0.0~999999.9 Kg/h
15-8-Calibration Factor3	572	Uint-32bit	R/W	0.0000~99.0000
15-10-Flow Rate4	574	Uint-32bit	R/W	0.0~999999.9 Kg/h
15-11-Calibration Factor4	576	Uint-32bit	R/W	0.0000~99.0000
15-12-Flow Rate5	578	Uint-32bit	R/W	0.0~999999.9 Kg/h
15-13-Calibration Factor5	580	Uint-32bit	R/W	0.0000~99.0000
15-14-Flow Rate6	582	Uint-32bit	R/W	0.0~999999.9 Kg/h
15-15-Calibration Factor6	584	Uint-32bit	R/W	0.0000~99.0000
15-16-Flow Rate7	586	Uint-32bit	R/W	0.0~999999.9 Kg/h
15-17-Calibration Factor7	588	Uint-32bit	R/W	0.0000~99.0000

16-Factory Setting				
Parameter Name	Modbus Address	Format	Type	Range
16-1-Pickup2 Setpoint	137	Uint-16bit	R	0~999.99 mV
16-2-Pickup Low Limit	454	Uint-32bit	R	0~99.99 mV
16-3-Sweep Freq. Step	133	Uint-16bit	R	0~999.9 mHz
16-4-Sweep Drive Amplitude	78	Uint-16bit	R	0~9.999
16-5-IIR Filter Range	144	Uint-16bit	R	0 to 16
16-6-PPDT Offset Value	448	Int-16bit	R	-999.999~999.999
16-7-Drive Excitation Mode	2.D	Bit	R/W	0= Direct 1=Reverce
6-8-Test Timer Value	808	Uint-32bit	R	0 to 9999.9Sec
16-9-Test Timer Setpoint	4	Uint-16bit	R	1 to 65000Sec
16-A-Test Timer Status	2.0	Bit	R	0= Test Counter Off 1= Test Counter ON
16-B-Copy Param to Fact Set	275	Uint-16bit	R/W	0~9999
16-C-Drive PID Gain	138	Uint-16bit	R/W	0.01~655.00
16-D-Dirve PID Integral	139	Uint-16bit	R/W	0.01~655.00 Sec
16-E-Reset All Settings	275	Uint-16bit	R/W	0~9999

HART Setting					
No.	Name	Modbus Address	Format	Type	Range
1	HART Baud Rate	32	Uint-16bit	R/W	0= 9600 bps 1= 19200 bps 2= 38400 bps 3= 57600 bps 4= 115200 bps 5= 230400 bps 6= 460800 bps 7= 921600 bps
2	HART Data Mode	27	Uint-16bit	R/W	0= 8bit, Even,1Stop 1= 8bit, Even,2Stop 2= 8bit, Odd,1Stop 3= 8bit, Odd,2Stop 4= 8bit, None,1Stop 5= 8bit, None,2Stop
3	HART Node Add.	28	Uint-16bit	R/W	0 to 31

Alarm List & Addresses (Bit)

No.	Name	Address	Type	Solution
1	Digital Output 1 Pulse Overlap	227.0	R	Increase “3-6-D.O.1 Volume/Pulse” and/or decrease “3-5- D.O.1 Pulse Width”
2	Digital Output 2 Pulse Overlap	227.1	R	Increase “4-6-D.O.1 Volume/Pulse” and/or decrease “4-5- D.O.1 Pulse Width”
3	Micro Controller 2 Read Error	227.2	R	
4	Test Timer Timeout!!!	227.3	R	Call to Control System Co.
5	Totalizer 1 Reset Inhibited	227.4	R	Change “7-1-Total1 Reset Mod” Parameter
6	Totalizer 2 Reset Inhibited	227.5	R	Change “7-3-Total2 Reset Mod “Parameter

11 Attachment B: Setting up PID Controllers

11.1 PID Theory

Proportional-Integral-Derivative (PID) control is the most common controller used in industry today. The popularity of PID controllers stems from their suitable performance under a wide range of operating conditions as well as their simplicity, allowing engineers to work with them easily.

The PID controller, as its name suggests, consists of three coefficients: proportional, integral, and derivative, which can be adjusted by the user to achieve optimal performance. This article discusses closed-loop systems, classical PID controller theory, various methods of tuning PID controllers, and the effect of controller tuning on the response of a closed-loop system.

11.2 The Effect of Integral and Derivative Control Operations on System Performance

In this section, we examine the effects of integral and derivative control operations on system performance. Here, we only consider simple systems to clearly observe these effects on system performance.

11.2.1 Integral Control Operation

In proportional control, where the transfer function lacks an integral term, there exists a steady-state error or offset in response to a step input. By incorporating integral control operation in the controller, this offset can be eliminated.

In integral control, the control signal, which is the controller output signal, is equal to the area under the error signal curve up to that moment. In this case, the control signal u(t) can have a non-zero value even when the error signal e(t) is zero. Such behavior is not possible in a proportional controller since a non-zero control signal requires a non-zero error signal. (The presence of a non-zero error signal in steady-state indicates the existence of an offset).

Note that while integral control eliminates offset or steady-state error, it can lead to oscillatory responses with a decreasing or even increasing amplitude, both of which are usually undesirable.

11.2.2 Derivative Control Action

Adding a derivative controller to a proportional controller is a method to achieve a controller with high sensitivity. One advantage of the derivative controller is that it responds to the rate of change of the error signal and can make significant corrections before the error grows excessively. Therefore, the derivative controller predicts the error, acts promptly to correct it, and thereby enhances system stability.

While derivative control does not directly affect steady-state error, it allows for a larger selection of Kp value by adding damping to the system, improving the accuracy of steady-state error. Since derivative control operates based on the rate of change of the error signal rather than the error signal itself, it is never used alone. Derivative control is always accompanied by proportional control or proportional-integral control.

11.2.3 Proportional-Integral-Derivative Control Action

The combination of proportional, integral, and derivative control actions creates the PID controller. This composite action incorporates the benefits of all three controllers at once. The equation of the PID controller is expressed as:

Relationship 1)

$$u(t) = k_p\left(e(t) + \frac{1}{T_i}\int_0^t e(\tau)d\tau + T_d\frac{de(t)}{dt}\right)$$

11.3 Methods of Setting PID Controller

The process of optimizing coefficients for P, I, and D to achieve an ideal response from a control system is called tuning a PID controller. Various methods exist for this purpose, and in this article, the trial and error method, the error method, and the Ziegler-Nichols method are explained.

11.3.1 Trial and Error Method

PID controller coefficients can be obtained through trial and error. When an engineer understands the effect of controller coefficients on the final system response, controller tuning becomes relatively simple. In this method, the integral and derivative coefficients are initially set to zero, and the proportional coefficient "P" is gradually increased until the system output begins to oscillate. As the proportional coefficient increases, the system performance becomes faster, but care must be taken to prevent system instability. Once P is determined to achieve the desired response at the desired speed, the integral coefficient I is increased to stop the oscillations. The integral term reduces the steady-state error but increases overshoot. It is essential to have a certain amount of overshoot to achieve a fast response. The integral term is used to minimize the steady-state error. When the P and I coefficients are tuned to achieve the desired response accurately and promptly, the derivative coefficient D is increased to increase the system's rate of reaching the specified Setpoint. Increasing the derivative coefficient reduces overshoot, allows a higher proportional coefficient to be selected without instability, but can make the system very sensitive to unwanted noise. To prevent the impact of unwanted noise resulting from measuring the control variable on the derivative term, in many cases, a filter is used along with the derivative term. However, most of the time, engineers need to compromise between one characteristic and another in order to better achieve the desired aspects.

Table (1) shows the effect of each of the PID controller coefficients on system performance.

Gain Increase	Rise Time	OverShoot	Settling Time	Steady-State Error
K_p	▼	▲	Small Change	▼
K_i	▼	▲	▲	Great Reduce
K_d	Small Change	▼	▼	Small Change

Table 1) The effect of changing PID coefficients on control system performance (in this table, Ki=Kp/Ti)

The graphs in Figure (1) display the effects of coefficient changes on the control system response.

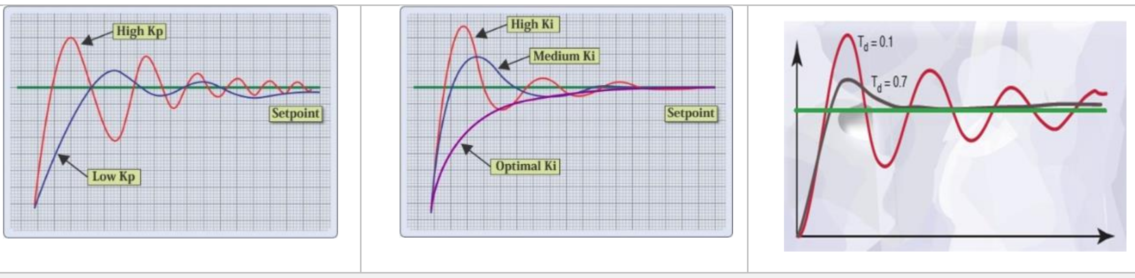


Figure 1) Graph showing the effect of changing PID coefficients on control system performance (in these graphs, Ki=Kp/Ti)

11.3.2 Zigler-Nichols Method

In this method, the response of the system to a unit step input is experimentally determined, as shown in Figure (2). In many industrial systems (systems that do not have dominant integral or complex conjugate pole) the step response will be in the form of an S-shaped curve, similar to the curve shown in Figure (2). If the response is not in the form of an S-shaped curve, this method cannot be applied. The step response curve can be obtained experimentally or through system simulation.

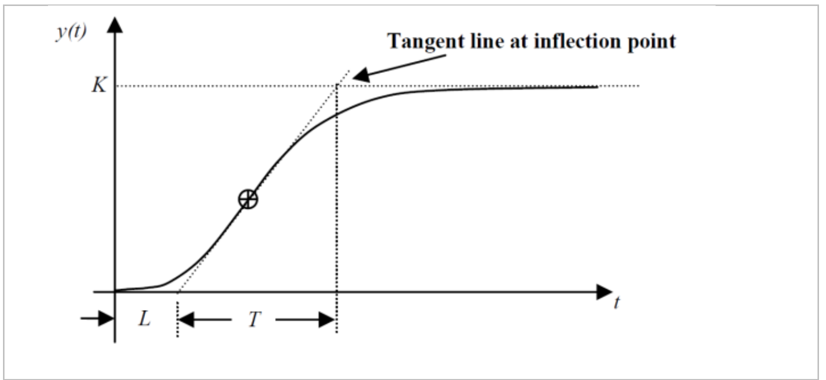


Figure 2) Ziegler-Nichols method

The S-curve can be defined by two parameters, the time delay L, and the time constant T. The time delay and time constant are determined by drawing a tangent line at the inflection point of the S-curve, finding its intersection with the time axis and the line C(t)=K as shown in Figure (2). Ziegler and Nichols suggest that the values of Kp, Ti, and Td be selected based on the formulas in Table (2).

T_d	T_i	K_p	Controller Type
0	∞	T/L	P
0	L/0.3	0.9T/L	PI
0.5L	2L	1.2T/L	PID

Table 2) Tuning P, PI, and PID controllers using the Ziegler-Nichols first tune method

11.3.3 Ziegler-Nichols Second Method

The Ziegler-Nichols second method of tuning is another popular approach for tuning PID controllers. This method is similar to the trial-and-error method where the coefficients I and D are set to zero, and the coefficient P is gradually increased until the system starts oscillating. Once the oscillations start, the critical gain Ku and the oscillation periods Pu are measured. Then, the coefficients P, I, and D are adjusted based on the guidelines in Table (3).

Control	P	T_i	T_d
P	$0.5K_u$	-	-
PI	$0.45K_u$	$P_u/1.2$	-
PID	$0.6K_u$	$P_u/2$	$P_u/8$

Table 3) Tuning P, PI, and PID controllers using the Ziegler-Nichols second tune method

Automatic tuning method Relay based is a simple method for tuning PID controllers that prevents trial and error and minimizes system operation within stability limits.

Challenges of tuning: When discussing PID controller tuning with control engineers, you come across the Ziegler-Nichols rules and the Ultimate Oscillation Method. Engineers will say: "Yes, the Ziegler-Nichols tuning method, we have used this method and the system started oscillating in an unclear manner, it is an inappropriate strategy. Furthermore, when tuning is done using this method, the system response is generally oscillatory."

Given that the Ziegler-Nichols tuning method is tiresome and sometimes risky, and often the system oscillation slows down significantly, the question arises as to why this method is often recognized as the only method known to instrument engineers, or whether using this method has definite advantages or not?

In fact, the Ziegler-Nichols tuning method, in which the controller Gain is determined empirically to just remove the system from instability, is a form of specifying the mathematical model of the system empirically. All tuning methods include a model identification component, but the more popular methods are those that approximate this part with simplicity and greater accuracy. After years of using PID controllers, engineers thought of devising an automated method to obtain PID controller coefficients. This method is called Relay Feedback and is used in many equipment.