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PD340 / PD386 Flow Transmitter with PROFINET, Modbus TCP/IP and P-NET IP

Manual GB

PROCES-DATA A/S
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Contents

1 General information

1.1 Introduction

The PD340 Flow Transmitter is a precision meter for the volumetric measurement of liquids that are electrically conducting.

The rugged construction of the transmitter makes it suitable for installations where solid particulates make up part of the liquid for measurement.
By using the PD386 terminal box instead of the standard terminal box, the transmitter gets a communication interface supporting PROFINET, Modbus TCP/IP and P-NET IP. It supports all 3 protocols without any configuration.

This manual is only applicable to PD340 Flow Transmitter with PD386 terminal box and extended electronic module.

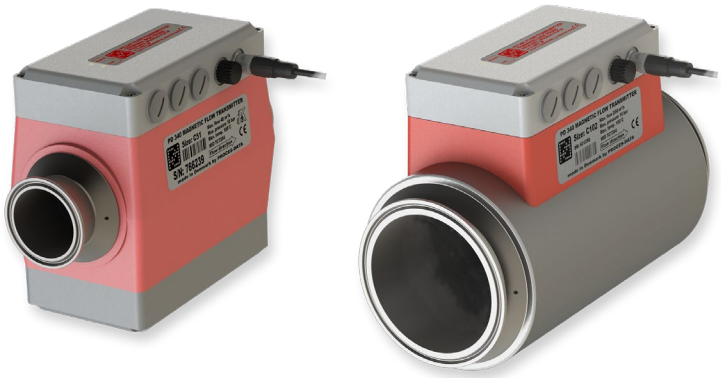
1.2 Features

- Sanitary design
- Maintenance-free, no moving parts
- Automatic zero point correction
- High accuracy, even at very low flow rates
- Bi-directional flow
- A PD210 display unit can be simply connected. The PD210 unit can display accumulated volume, flow rate, temperature, etc.
- Temperature measurement using an external temperature sensor
- Continuous Self-test
- Communication interface for PROFINET, Modbus TCP/IP and P-NET IP

1.3 Construction

The PD340 Flow Transmitter consists of three parts:
The meter head, the Electronic Module, and the Terminal Box. [1]
The Electronic Module and the Terminal Box are the same for all sizes of transmitter.

The Terminal Box is completely separated from the electronic module. All terminals inside the terminal box are clearly marked with both number and function.



PD340: C25, C38, C51, C63, C76, and C102

The Terminal Box is equipped with three cable glands, type PG 11 and two M12 connectors, one for IP and one for power connection

[1] For meter size C102: The Electronic Module is an integrated part of the meter head.

2 Specifications

All electrical characteristics are valid at an ambient temperature from -10 °C to +50 °C, unless otherwise stated.

All specifications apply within approved EMI conditions. EMC test specifications for the PD340 Flow Transmitter are found in a separate document, available at the PROCES-DATA homepage.

2.1 Flow measurement

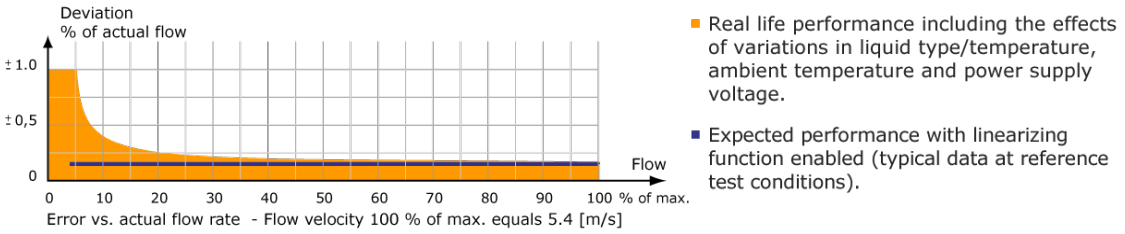


Figure 1: Max. error vs. actual flow rate

With the linearization function enabled, the accuracy at very low flow rates is improved considerably. See details in chapter 10, Linearizing function.

- Flow measurement
  - Accuracy: see Figure 1
  - Linearity: see Figure 1
  - Repeatability: max. (0.5 x error)
- Ambient temperature effect: max. 0.004 % / °C
- Voltage supply effect: max. 0.005 % / V
- Liquid
  - Minimum conductivity: (5 µS/cm) 500 µS/m
  - Temperature: -30 °C to +100 °C
  - Pressure: max.10 bar
- Ambient temperature: -10 °C to +50 °C
- Temperature measurement
  - Range: -30 °C to +100 °C
  - Error, exclude the accuracy of the Pt100: max. ±0.9 °C
- Power supply DC:
  - nom.: 24.0 V
  - min.: 20.0 V
  - max.: 28.0 V
  - Current at power up: max. 650mA
  - Current @ 24V: max. 250mA
  - Power consumption: max. 6W

- Protection: IP 67

2.2 Approvals

Compliance with EMC-directive no.:	89/336/ECC
Generic standards for emission:	
Residential, commercial and light industry	DS/EN 61000-6-3
Industry	DS/EN 61000-6-4
Generic standards for immunity:	
Residential, commercial and light industry	DS/EN 61000-6-1
Industry	DS/EN 61000-6-2

2.3 Operating principles

The meter head consists of a metering pipe and two magnetic coils. When a current is applied to the coils a magnetic field is produced at right angles to the metering pipe.

With a conductive liquid flowing through the metering pipe an electrical voltage is induced and measured by two electrodes mounted in the metering pipe. This voltage is proportional to the average velocity of the flow and therefore to the volume flowing.

The PD340 Flow Transmitter utilizes a square measurement chamber. The shape of the measurement chamber significantly reduces the influence of viscosity, type of liquid, and flow profiles (see details in chapter 11, Advantage of a square measuring chamber.

Practical tests with the PD340 Flow Transmitter confirm that it is not necessary to recalibrate the meter when changing product, such as from water to milk. This would normally be necessary when using magnetic flowmeters that have traditional round measuring chambers.

- Ue = K x B x V x D
- Ue = voltage across electrodes
- K = system constant
- B = magnetic field
- V = average velocity
- D = distance between electrodes

The microprocessor in the transmitter controls the current generator, keeping the magnetic field constant. The voltage across the electrodes is amplified and converted to a digital value from which the microprocessor calculates the liquid flow.

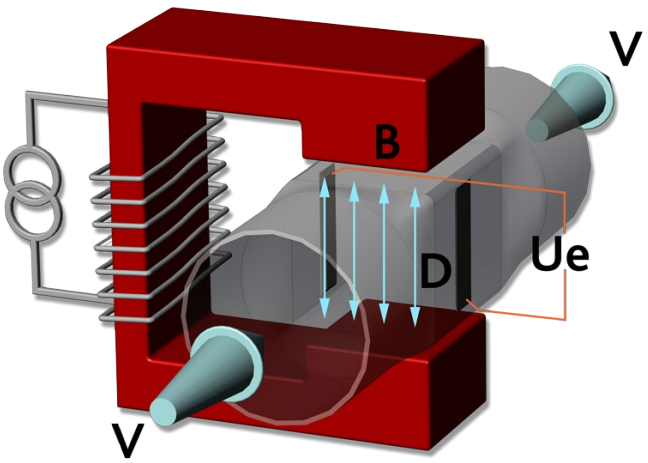


Figure 2: Operating principles

2.4 Selecting the correct meter size

The complete PD340 Flow Transmitter family has a very large measuring range. It is normally recommended that a particular transmitter size is selected so that it will operate in the upper half of its measuring range. This is due to the fact that the influence of zero point error is relatively higher at low flow rates. This applies to any flow transmitter on the market. However, it is possible to use the PD340 Flow Transmitter even at very low flow rates, whilst still obtaining high accuracy. Flow measurement down to 1 % of maximum flow rate for the Flow Transmitter is now possible (100:1 turndown), when the linearizing function is enabled (refer to Linearizing function in Chapter 10.

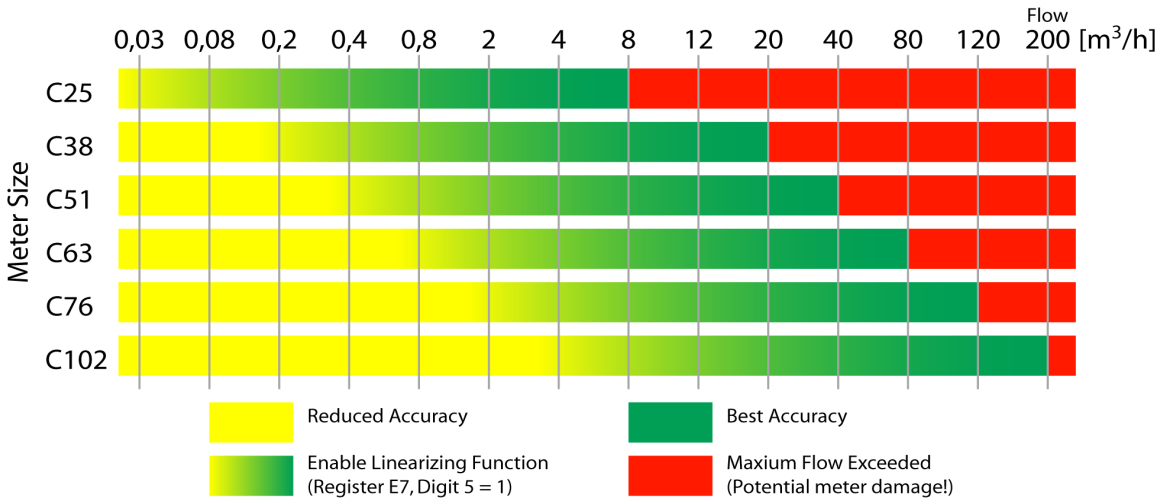
A PD340 Flow Transmitter should not be installed in a pipe construction where the PD340 is smaller than the pipes in the connections.

If two products are mixed before measuring, the mixed product must be a homogenous liquid before entering the Flow Transmitter to ensure maximum accuracy.

The PD340 Flow Transmitter is available in six different sizes as shown in the table below.

Use the following diagram as a guideline for selection of the meter size, and then take the following precautions:

- Never exceed the maximum flow rate of the PD340 Flow Transmitter.
- If optimum measurement accuracy is of primary concern, the smallest possible transmitter should be chosen, while still observing that the maximum flow rate must not, under any circumstances, be exceeded.
- To further improve accuracy, especially at very low flow rates, the Linearizing function should be enabled.



Note:
The max. flow rate for the PD340 Flow Transmitter must NEVER be exceeded, otherwise the meter head may be damaged.

2.5 Installation of the PD340 Flow Transmitter

The PD340 Flow Transmitter should be installed within the pipe system in such a way that the metering pipe is always filled with liquid, because the PD340 Flow Transmitter can register some flow when the PD340 Flow Transmitter is empty (this will be registered as too low conductivity of the “liquid” in the transmitter).

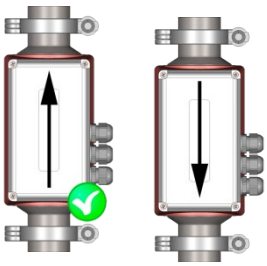
The PD340 Flow Transmitter can be mounted both horizontally, vertically and tilted, as long as no air is trapped in the meter.

When mounted in a horizontal pipeline, the orientation shown is recommended.
This orientation also helps keeping water out the Terminal Box in case of leakage between cable and glands, as the cables are going vertically down from the transmitter.

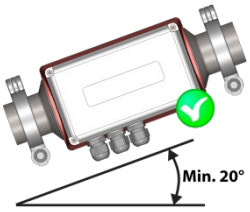
When mounted as not recommended, the electrodes will be positioned horizontally and any air bubbles might cause the upper electrode to lose contact with the liquid.

When mounted in a vertical pipeline, it is recommended that the flow direction is up. The reason for this is that any air within the liquid will easily follow the liquid in its upward direction.

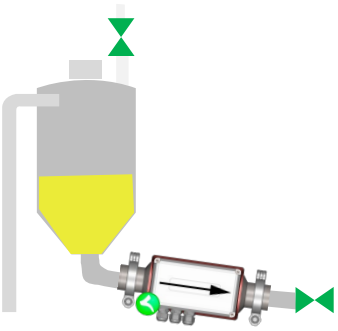
With flow direction down, especially with very low flow, any air within the liquid will have problem to follow the liquid downward. That can result in fluctuating flow reading.



Mounting in an angle of minimum 20° to horizontal as shown in the figure to the right will ensure the correct self-draining property in hygienic applications. This mounting is recommended for a system with air eliminator where the PD340 Flow Transmitter must be filled before the measurement can be started.



If the liquid contains air, an air eliminator should be mounted before the PD340 Flow Transmitter.
Before starting a flow measurement in an empty system, the transmitter must be filled.
——Here is an example with an air eliminator, where the PD340 Flow Transmitter is tilted and followed by an outlet valve.
When filling the air eliminator, the liquid also fills the PD340 Flow Transmitter, as the air in the PD340 Flow Transmitter goes up in the air eliminator.
After the PD340 Flow Transmitter is filled, counters are cleared and the valve is opened. This will also make the system self-draining.



The positive flow direction is indicated by an arrow on the meter head.
To create the best conditions for precise metering, a straight pipe run of at least three times the pipe diameter should be mounted upstream and downstream of the PD340 Flow Transmitter.

When selecting the location of the PD340 Flow Transmitter, it must be ensured that the ambient temperature is within the specified limits.

Note: The clamp connections **must** be loosened completely before the PD340 Flow Transmitter is rotated. Otherwise the meter head may be fatally damaged.

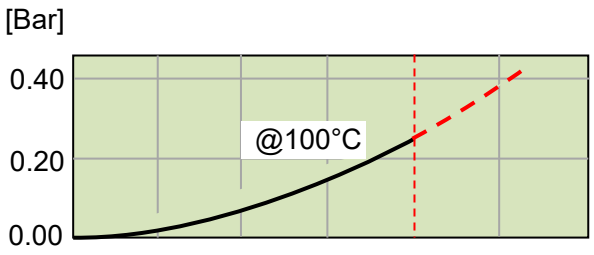
Precautions must be taken to ensure that the Electronic Module, the meter head and the Terminal Box are not exposed to moisture, when the PD340 Flow Transmitter is dismantled. To prevent moisture, the cables must be mounted correctly in the glands. The Electronic Module and the Terminal Box must be carefully mounted with all screws tightened.

With the PD340 Flow Transmitter connected to 24 V supply, heat developed in the Terminal Box and Electronic Module will prevent condensation.

2.5.1 Pressure

As the PD340 Flow Transmitter will measure any air in the liquid as a part of the total volume, the volume of the air must be reduced to an absolute minimum. To help achieve this, the transmitter should be located in the pipe work system at the point of the highest pressure. Here the volume of the air will be at a minimum and thus the influence of air on the measurement will also be at a minimum. It is therefore recommended that control valves, or other restrictions that might create a pressure drop, are mounted after the PD340 Flow Transmitter. Even when there is no air in the liquid it is important to ensure that the pressure is sufficiently high, otherwise cavitation may occur in the PD340 Flow Transmitter. Not only will this influence the accuracy, but could also be destructive to the PD340 Flow Transmitter.

The graph to the right shows the required minimum gauge pressure (measured in the pipeline after the transmitter) as a function of flow at 100 °C, for water.
Always ensure that the gauge pressure is well above the curve defined by the relevant operational temperature. Please observe that the dotted parts of curves fall outside the allowable operational specifications and are only shown as extrapolations from permitted values.
Using the transmitter under these conditions may cause damage, which will not be covered under the product guarantee.



Flow	0	25	50	75	100	125	150	%
C25	0	2	4	6	8	10	12	m^3/h
C38	0	5	10	15	20	25	30	m^3/h
C51	0	10	20	30	40	50	60	m^3/h
C63	0	20	40	60	80	100	120	m^3/h
C76	0	30	60	90	120	150	180	m^3/h
C102	0	50	100	150	200	250	300	m^3/h

3 Function description

The PD340 Flow Transmitter with PD386 Terminal Box with PROFINET, Modbus TCP/IP and P-NET IP interface is measuring flow, volume and temperature. Temperature measurement requires that an external Pt100 sensor is connected.
The PLC has access to read the following registers and is allowed to write to the Available registers with the corresponding Write enable bit true (refer to 4.8, Write enable). The GSD/ML file and Modbus address list are available on the PROCES-DATA home page under PD386.
A COPP assembly type, with the PD386 COPP device and a COPP component type, will be available on the PROCES-DATA COPP server.

3.1 Flow rate

Data type: 4-byte real. The flow rate is a read only value. The unit for flow is defined in the configuration parameters. Flow is measured in both directions with positive flow in the direction of the arrow on the meter head.

Activating the hardware input will set the Flow rate =0 and the volume counting is stopped.
Flow rates below 0.2 % of full scale can be configured to be ignored. This may be useful to avoid totalizing the volume during long periods with no flow.

3.2 Volume1 / Volume2

Data type: 4-byte real. The Flow Transmitter utilizes two independent totalizers, Volume1 and Volume2, which indicate the measured volume since the counters were cleared. Each volume counter may be independently cleared or preset to a specific value. This allows one volume counter to be used for e.g. batch measurements, while the other one is used for the total volume. The unit is default m^3 but can be changed by the Volume conversion factor.

3.3 Temperature

Data type: 4-byte real. The PD340 Flow Transmitter measures temperature when an external Pt100 temperature sensor is connected. The unit can be configured to Celsius or Fahrenheit.

3.4 Available registers

All available registers are of data type: 4-byte real. These registers have no influence on the flow measurement. They can be used to exchange values between the operator and the PLC. An example: The operator near the flow meter can key in a set point value on the PD210, which is used by the PLC. The PLC has read and write access to the four registers, and the registers can be read from the PD210 and can be changed from the PD210 if the corresponding write enable bits are true.

3.4.1 A

3.4.2 B

3.4.3 SETP

3.4.4 C

3.5 Error codes

The PD340 Flow Transmitter generates the following error codes. After the error is removed, the error code is automatically changed to: No error, but will be present for a minimum of 10 seconds.

0	No error
2	Input activated
3	Flow > max.
4	Flow >> max. or empty pipe
5	Temperature > max.
6	Internal error or empty pipe
7	Pt100 wrong connected
8	No connection from PD386 to PD340
9	PD386 Reset by power fail
10	Internal error
11	PD340 Reset caused by power fail
12	Reset caused by internal error
13	Reset ordered from external bus

3.6 Command – Response

The PLC master sends a command byte (8 bit) to the PD340 Flow Transmitter and receives a response byte (8 bit) from the PD340 Flow Transmitter.

Command byte (from PLC to PD340 Flow Transmitter):

		Bit value
Bit 0	Clear volume1 counter	LSB
Bit 1	Clear volume2 counter	
Bit 2		
Bit 3		
Bit 4		
Bit 5		
Bit 6		
Bit 7		MSB

Response byte (from PD340 Flow Transmitter to PLC):

		Bit value
Bit 0	Volume1 counter cleared	LSB
Bit 1	Volume2 counter cleared	
Bit 2		
Bit 3		
Bit 4		
Bit 5		
Bit 6	Input1 (stop flow counter) is active	
Bit 7	Error	MSB

The functions defined in the command are activated when the bit changes from 0 to 1. When the function is finished, the corresponding bit in the response is set. This signals to the PLC that the action has been accomplished. Now, the PLC should clear the command bit. This will clear the corresponding bit in the response.

3.7 Simulation flow rate

The simulation flow rate is of data type: 4-byte Real. It holds volume in the same unit as the flow rate is configured.

3.8 Input

The PD340 Flow Transmitter has a logic input. It stops the counters when activated. The signal may be derived from an air detector, and is then used to make the PD340 Flow Transmitter stop counting, when there is air in the liquid. The signal may also be set in cases where counting is not desired.

4 Configuration

The PD340 Flow Transmitter is configured in this **record** with the following fields. In PROFINET the record can automatically be sent from the PLC during initialization.

4.1 Full scale

Full scale is a byte, holding the meter size in SI units [m^3/h]. The size can be read from the type plate on the meter head. Full-scales for the different meter heads are listed here. Only these 6 sizes are accepted, - all other values will be rejected.
From the factory it is set to 8 m^3/h, so please insert the value that corresponds the actual size.

- C25: 8 m^3/h
- C38: 20 m^3/h
- C51: 40 m^3/h
- C63: 80 m^3/h
- C76: 120 m^3/h
- C102: 200 m^3/h

4.2 Volume conversion factor

The Volume conversion factor is a 4-byte real.
The volume is multiplied with this conversion factor and can in this way be converted to another unit. With a factor equal to e.g. 1000, the volume will be in [litres].
Default it is set to 1.

4.3 Disable flow < 0.2 %

Flow rates below 0.2 % of full scale can be configured to be ignored. This may be useful to avoid totalizing the volume during long periods with no flow.

Data type Boolean

0: Normal
1: Flow less than 0.2 % of full scale is set to zero

Default it is set to 0 (Normal).

4.4 Flow rate filter

This setting is controlling the time constant for the flow rate filter. Data type: Byte

1: 0.15 s
3: 1.0 s
5: 5.0 s
7: 10.0 s

All other values are illegal, and will be rejected.
Default it is set to 1 (0.15 s).

4.5 Flow conversion factor

The flow conversion factor is a 4-byte real.
The flow is multiplied with this conversion factor and can in this way be converted to another unit, e.g. with a factor equal to 1000, the flow will be in [l/h].

Default it is set to 1.

4.6 Temperature unit

The temperature selector is of data type byte. It must be set to one of these values:

0: Celsius
1: Fahrenheit

From the factory it is set to 0 (Celsius).

4.7 Simulation

The PD340 Flow Transmitter can be set in simulation mode which can be used to simulate that liquid is flowing in the pipe system. The simulated flow is written in to the simulation flow rate register.

Data type: Boolean

0: Normal
1: Simulation

In simulation mode the PD340 Flow Transmitter is skipping the measurement of the flow, and uses the flow simulation value. The volume counters are following the flow simulation value.
Default it is set to 0 (Normal).

4.8 Write enable

Write enable is a byte, where 4 bits are used.
The 4 registers A, B, SETP and C can only be changed from the PD210 if the corresponding write enable bit is 1.
Default all bits are set to 0.

Bit 0	A	LSB
Bit 1	B	
Bit 2	SETP	
Bit 3	C	
Bit 4		
Bit 5		
Bit 6		
Bit 7		MSB

4.9 Enable linearization

Data type: Boolean

0: Normal
1: With linearization

Linearization is used to improve accuracy, especially at very low flow rates. This function is by default disabled. It will only be optimal when the **meter head and the Electronic Module were factory calibrated together.**
Default it is set to 0 (Normal).

4.10 Calibration factor

Data type: 4-byte Real. The calibration factor is used for recalibrating the PD340 Flow Transmitter. From the factory it is set to 1.000. This calibration factor cannot be used to recalibrate

from PROFINET and Modbus TCP/IP. Flow and volume are multiplied with the calibration factor. This value has limited range from 0.8 to 1.2.

5 Read only registers

5.1 Device Type PD340

Data type: 2-byte Integer.

5.2 SerialNo PD340 electronics

Data type: String.

5.3 Program Version PD340

Data type: 2-byte Integer.

5.4 DeviceType PD386

Data type: 2-byte Integer.

5.5 SerialNo PD386

Data type: String.

5.6 Program Version PD386

Data type: 2-byte Integer.

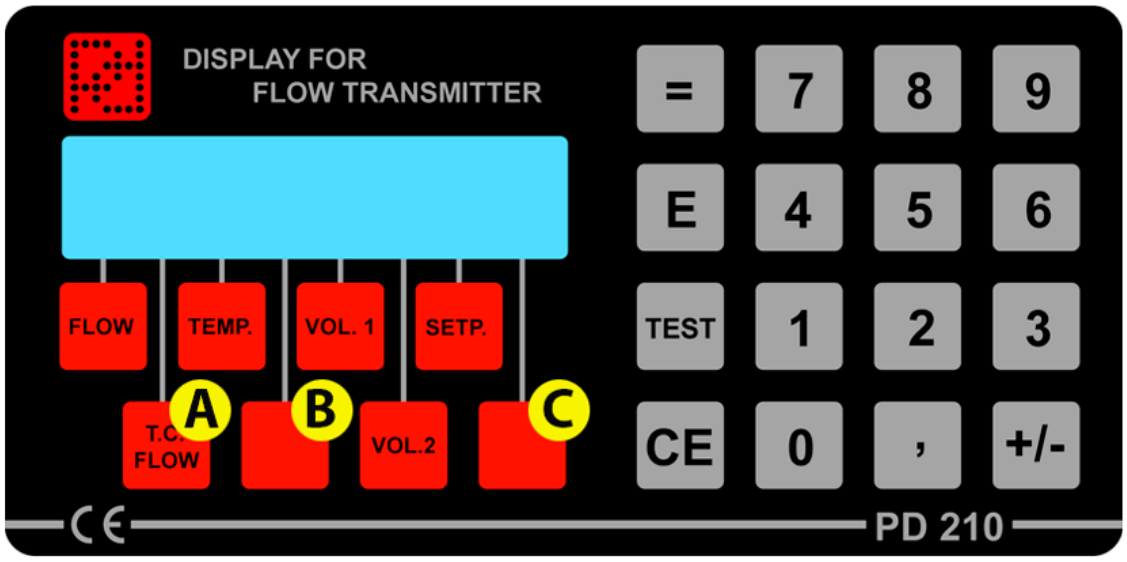
6 Status LEDs

The PD386 has two LEDs for Link and Status.
They are visible from the outside.

- Link colour: Yellow.
- Status indicates the status of the flow metering. This LED is normally green. With flow the LED is flashing, with a frequency proportional to the flow. In case of error the LED becomes red.

7 Local display unit PD210

The PD210 Display unit can be directly connected to the transmitter. The value of the 8 different registers can be displayed on the PD210. A touch on one of the 8 buttons under the display selects whichever register to be shown.



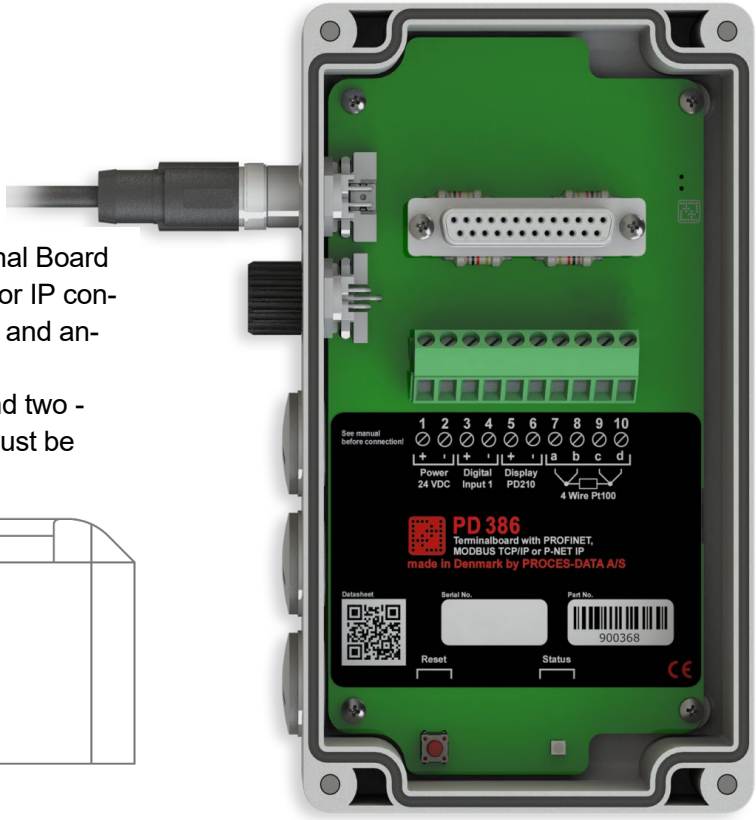
The registers Flow, Volume 1, Volume 2, and Temperature are controlled by the PD340 Flow Transmitter.
The four available registers: A, B, SETP and C can be controlled by the connected PLC. These registers can also be modified from the keyboard, depending on whether they are individually write-enabled.

The PD210 is a general display. Keys to show the A, B and C registers are not labelled correctly, here these keys are shown marked with A, B, C.
A version of the PD210 can be delivered without front foil, for adding another layout.

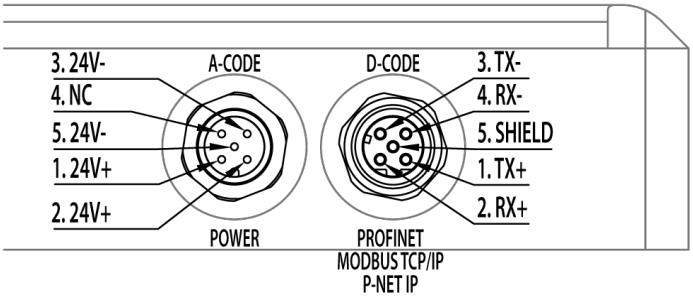
The user is informed of an error by an "A" for ALARM appearing in the first digit of the display. By pressing the "TEST" button, the display will show an error code of two digits, indicating the actual error. Additional details may be found in 3.5, Error codes.

The PD210 is not used to configure the PD340 Flow Transmitter. Configuration is done automatically by the PD386.

8 Electrical connections

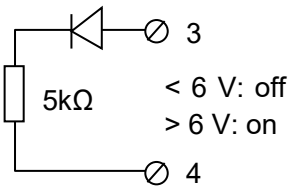


On the figure to the right, the PD386 Terminal Board is shown. It has two M12 connectors: One for IP connection, following the PROFINET standard, and another for connecting power.
The power connector has two +24V pins and two -24V pins. Only one 24V and one 24V pin must be connected.



The terminal board also has screw terminals used for connecting digital input, PD210, Pt100 temperature sensor, as well as an alternative 24V supply.

8.1 Digital Input 1



The input signal is galvanically isolated. To activate the input, a voltage of minimum 18 V must be connected to the terminals with the right polarization. This voltage may be supplied from either the internal voltage supply or an external power supply.

8.2 Temperature signal, Pt100

A standard Pt100 temperature sensor (IEC 751, DIN 43760) may be connected to the PD340 Flow Transmitter. The temperature sensor must be connected with a 4-wire cable all the way from the sensor to the Terminal Box. This must be done to avoid errors introduced by the cable length, junctions and connections. The length of the cable that connects the Pt100 temperature sensor to the PD340 Flow Transmitter must not exceed 25 m.

The sensor wires must not be connected to the sensor housing (grounded). If a temperature sensor is not used, the terminals 7-8-9-10 must be connected together in order to avoid errors in the flow measurement.

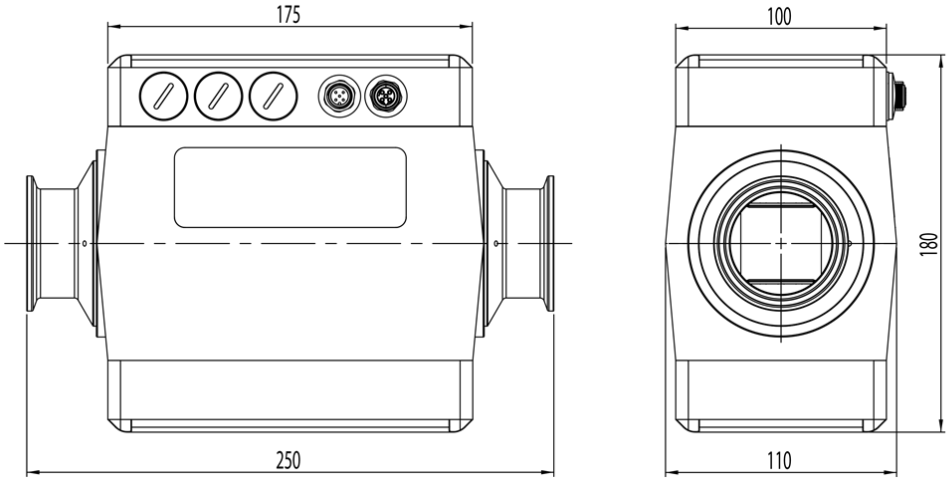
8.3 Connecting the display unit PD210

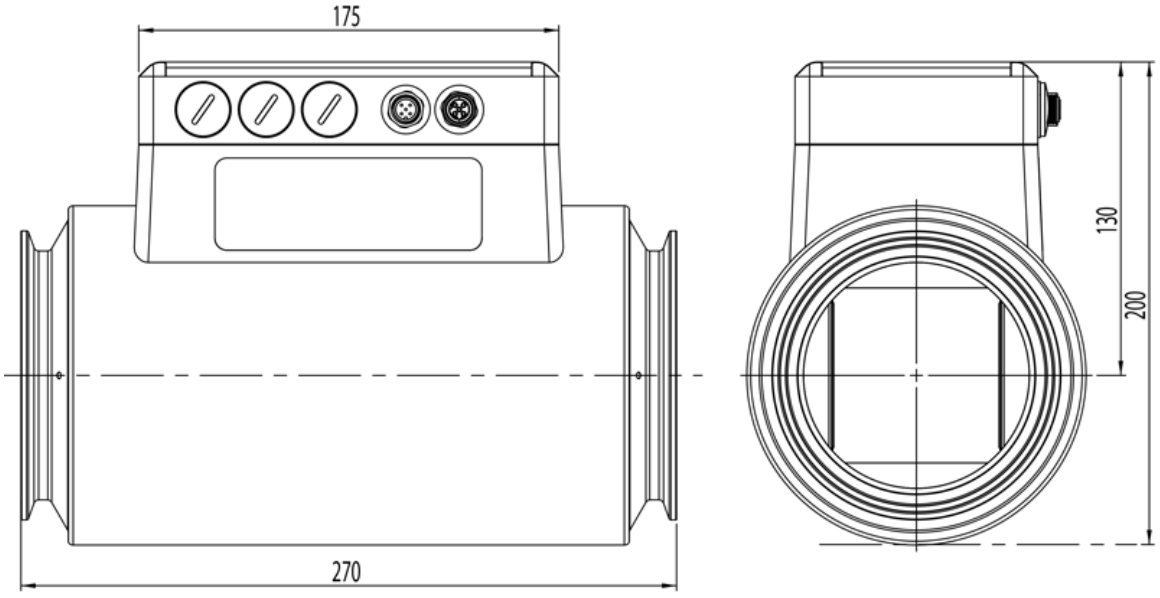
The PD210 Display unit is connected to the PD340 Flow Transmitter with a two-wire twisted cable, up to a length of 100 m. The display unit is supplied with power via this cable. It also carries the exchange of data between the PD340 Flow Transmitter and the display unit.

To improve the electrical noise immunity with long cables, a shielded cable is recommended. In this case the shield should be connected to terminal 7 at the Terminal Box, but not at the PD210.

9 Dimensions and materials

9.1 Dimensions





9.2 Maximum flow rates and weight

Meter size	Nom. size D i mm	Max. flow rate m^3/h	Weight in kg
C25	25	8	5
C38	38	20	5
C51	51	40	5
C63	63.5	80	5
C76	76	120	5
C102	102	200	10.5

9.3 Materials

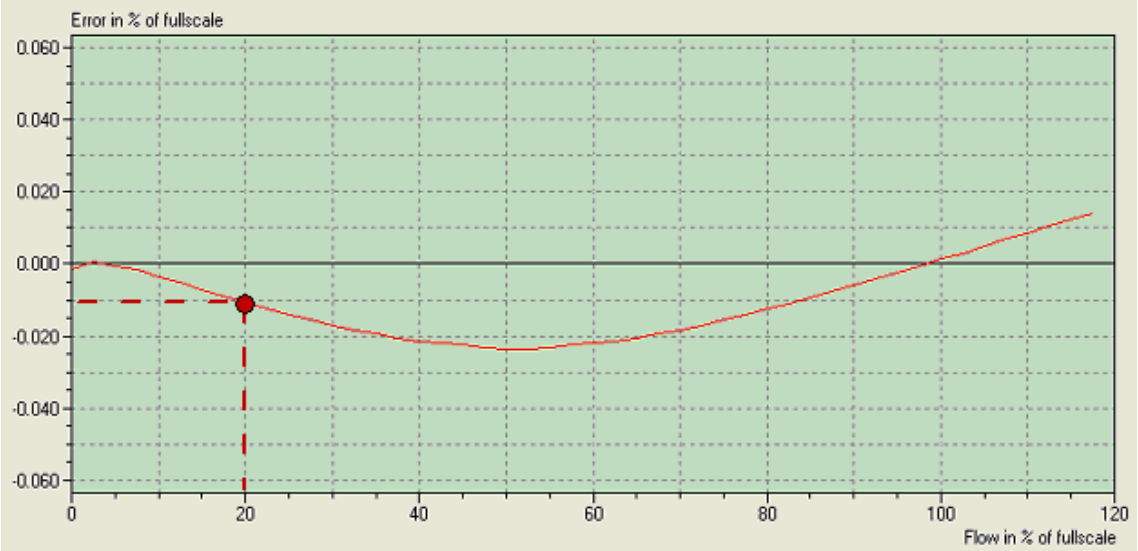
Electrodes: Stainless steel AISI 316.
Metering pipe: Stainless steel AISI 316.
Coating inside metering pipe: PFA.
Housing:
C25 – C76: PPO Noryle.
C102: Stainless steel AISI 316.

10 Linearizing function

Because of its construction (as described in chapter 2.3, Operating principles), the PD340 Flow Transmitter is by its nature very linear, even without any electronic compensation.

However, when using the PD340 Flow Transmitter at very low flow rates, the linearity can be improved by enabling the linearizing function. The PD340 Flow Transmitter can then be used even at very low flow rates, still offering the same well-known high accuracy measurement as experienced with higher flow rates.

During the flow calibration at the factory, the linearizing curve is calculated and downloaded to the electronic module. For this reason, all new PD340 Flow Transmitters will hold the data needed by the linearizing function, when they are delivered as complete meters, i.e. meter head and electronic module.
If one of the new Electronic Modules needs to be mounted on a meter head with which it was not originally tested, the linearizing function will not be working.
The graph below shows the linearizing curve for a specific PD340 Flow Transmitter. If this PD340 Flow Transmitter measures the flow rate at 20 % of full scale, it will be compensated by +0.01% of full scale.

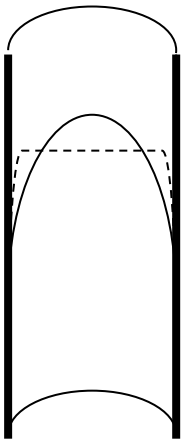


11 Advantage of a square measuring chamber.

When a liquid is flowing through a pipe, its velocity tends to vary from zero along the pipe wall up to its maximum at the centre of the pipe.

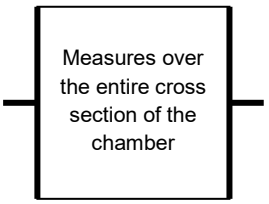
The velocity profile depends on the actual flow velocity together with the viscosity of the liquid.

When the flow rate is low, the velocity profile takes the shape of a parabola. This is called laminar flow. When the flow rate is gradually increased, the flow profile also changes gradually, still maintaining the laminar flow profile, until it reaches the critical velocity. At this flow rate, the flow profile will, via a transition phase, change from laminar to turbulent flow with the formation of eddies and chaotic motion, which do not contribute to the volume flow rate. The two types of flow profiles are illustrated on the figure to the right. Precisely when the liquid reaches the critical velocity and changes to turbulent flow, depends on the diameter of the pipe, and on the viscosity and density of the liquid. For cream, for example, the viscosity strongly depends on the temperature and the percentage of fat, and it is therefore not possible to predict the flow profile at any given flow rates.



The technique used to avoid an unknown flow profile from affecting the accuracy of a measurement, essentially consists of measuring the average velocity of the liquid throughout the **full cross section of the pipe,** hence registering all the liquid passing through it.

The average measurement is achieved in a PD340 Flow Transmitter by using a square measurement chamber, where each of the two electrodes are designed to measure across the complete cross section of flow.



This is in contrast to flow meters having a circular cross section and point-type electrodes. Here the ‘field of view’ between the electrodes is limited to only involving the liquid passing between the electrodes. Its calibration is therefore conditional on a particular known flow profile.