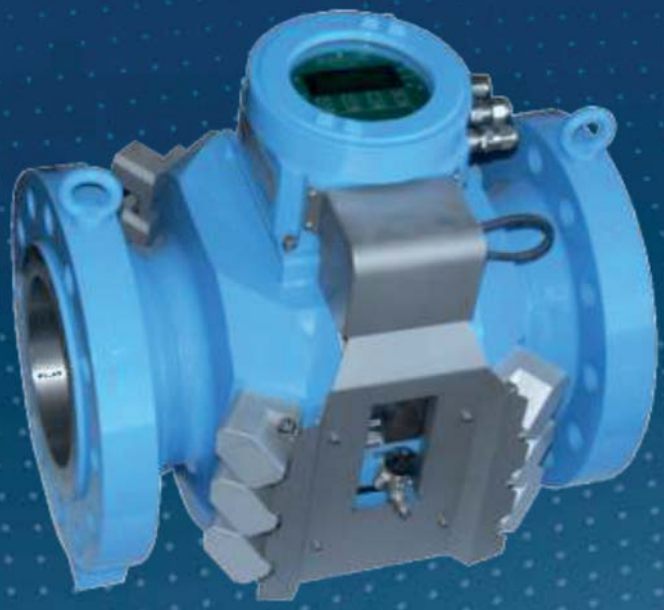
Ultrasonic Gas Flow Rate Meter USZ 08



OPERATING INSTRUCTIONS

Reliable Measurement of Gas

RMG

STATUS: 2017 NOVEMBER, 10th
Version: 06

Manufacturer

Our customer service is available for technical queries

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Original document

The **USZ08_manual_en_06** from 2017 November, 10th for the ultrasonic gas flow rate meter USZ08 is the document translated first from the German original version. Anyhow, this document may serve as reference for translations into other languages. Please use in case of any uncertainties the German version as main reference.

Note

Unfortunately, paper is not updated automatically, whereas technical development continuously advances. Therefore, we reserve the right to make technical changes regarding the representations and specifications of these operating instructions. The latest version of this manual (and other devices) can be downloaded at your convenience from our Internet home-page:

www.rmg.com.

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Contents

1 About this manual

1.1 Structure of the manual

The introduction of this manual, the first chapter consists mainly of three parts. The first part of the introduction introduces general guidelines, presenting the symbols used and the structure of notes as well as a risk assessment. Since the USZ 08 may be operated in an explosion-proof area, the second part provides information on explosion protection. The third part outlines general control and maintenance work.

The second chapter describes the physics of the ultrasonic gas meter, its realization in principle and the necessary mathematical basics. In the third chapter, the mechanical installation and the electronic connection of the USZ 08 are presented. The PC software RMGView^{USM} is used to support the operation of the USZ 08 and to visualize the results. This software is described in a separate manual, the information given here is of a general nature and is mainly used to connect the USZ 08 to a PC.

Chapter 5 explains the operation of the USZ 08, Chapter 6 the associated alarm and warning messages. The USZ 08 can be connected via Modbus, the corresponding settings are described in chapter 7.

See chapter 8 for technical data and chapter 9 for seal plans. This manual ends with the approval documents of the type approvals of the USZ 08.

1.2 Objective of the manual

The manual provides you with the information that is designed for trouble-free and safe operation. The ultrasonic gas meter USZ08 is state of the art and manufactured according to recognized safety standards and guidelines.

However, risks may arise during use that can be easily avoided by observing this manual. For this reason, you may only use the device as intended and in technically sound condition.

⚠ Warning

If the ultrasonic gas meter is not used for its intended purpose, warranty claims will be void.

1.2.1 Abbreviations

The following abbreviations are used:

MessEG	Mess- und Eichgesetz Law on placing and providing of measurement devices into the market, their usage and verification; valid from 1.1.2015
MessEV	Mess- und Eichverordnung Regulation on placing and providing of measurement devices into the market, their usage and verification; valid from 11.12.2014
MID	Measurement Instruments Directive
PTB	Physikalisch-Technische Bundesanstalt
DSfG	Digital Interface for gas measurement devices
TCP/IP	Transmission Control Protocol/Internet Protocol “Family“ of network protocols (Internet protocol suite)
IP (-Address)	Device assigned, based on the Internet Protocol (IP) address. That way the devices are individually addressable and reachable.
LAN	LAN (Local Area Network)
SNR	Signal to Noise Ratio
SoS (VoS)	Speed (Velocity) of Sound
TD	Transducer (Ultrasonic transmitter and receiver)
USM (USZ)	Ultrasonic Flowmeter
HART	Highway Addressable Remote Transducer Protocol Standardized digital Communication superimposed on the 4..20 mA analog signal for data exchange with transmitters.

1.2.2 Symbols

The following abbreviations are used:

1, 2, …	Marks steps within a work operation
..	

1.2.3 Layout of instructions

The following instructions are used:

Danger

This warning instruction informs you of potentially hazardous situations that can occur as a result of incorrect operation or human error. If these situations are not avoided, they can lead to fatal or severest injuries.

Warning

This warning instruction informs you of possible hazardous situations that can occur as a result of incorrect operation or human error. If these situations are not avoided, they can lead to slight or minor injuries.

Caution

This message informs you of potentially dangerous situations that may occur as a result of incorrect operation or misconduct. If these situations are not avoided, damage to the equipment or its surroundings may result.

Notice

This notice may also give to you tips on how to simplify your work. With this screen, you additionally receive further information on the device or the work process.

1.2.4 Using the flowmeter

1.2.4.1 Safety Instructions, Danger, Warning, Caution and Notice

Danger

Observe the following safety instructions!

Non-observance of these safety instructions can lead to a risk of life and limb and health of the person as well as damage to the environment or property damage.

Note that the safety instructions in this operating instruction and on the device, cannot cover all possible hazardous situations as the combination of different circumstances is impossible to predict. To simply follow the instructions specified may not normally be sufficient enough to ensure for correct operation. Always be observant and also consider the following:

- Before working with the device for the first time, read through this operating instruction and, in particular, follow the safety instructions carefully.
- The operating instruction warns against the residual risks for users, third parties, devices or other material assets. The safety instructions used refer to residual risks that cannot be avoided due to the design.
- Operate the device only in a sound state and when observing the operating instruction.
- Also observe the local legal accident prevention, installation and assembly guidelines.

Caution

Please observe and follow all the instructions of the manual.

The usage of the flowmeter USZ 08 is only permissible according to the specification of the operating instructions.

RMG as manufacturer is not responsible for any damage that result as a consequence of not observing the operating instruction.

Danger

Service and maintenance work or repairs that are not described in the operating instruction must not be carried out without previous consultation with the manufacturer.

Changes and modifications at the device are forbidden.

For safe operation, the technical specifications must be observed and followed. Performance limits must not be exceeded (*chapter 8 Technical specifications*).

For a safe operation, the device must only be used in the scope of its intended use. (*chapter 3.2 Electronic connections*)

Only use the listed set screws, bolts, nuts and gaskets or parts with similar characteristics for the installation of the meter in the pipeline (*chapter 3.1.5 Sealings* and *3.1.6 Screws*)

The device should only be used under the intended use for safe operation.

1.2.4.2 Hazards during commissioning

Initial start up	Initial start-up must only be carried out by specially trained personal (training by RMG) or by service personal from RMG.

Notice

In accordance with §15 BetrSichV "Betriebssicherheitsverordung", §5 DGUV VORSCHRIFT 3 "Elektrische Anlagen und Betriebsmittel" and the generally acknowledged rules of technology, especially the VDE-Normen VDE 0100-100 "Errichten von Niederspannungsanlagen" and VDE 0165 "elektrischer Explosionsschutz" prior to the commissioning of the device a check of the measuring system has to be carried out.

If these German rules are not valid please check and apply similar local rules.

For the commissioning an acceptance test certificate and test reports have to be created. Those, as well as the manual and the die CE-declaration of conformity are constantly to be kept at hand at any time. The complete documentation and the conformity declaration have to be checked for completeness.

Danger

This symbol warns you of an explosion hazard.
Please follow the instructions given next to this symbol.

Danger

Install the device in accordance with operating instructions. If the device is not installed according to the manual, there is possibly an insufficient explosion protection.

The explosion protection expires!

Please take care during the installation to the flow direction marked on the housing by an arrow.

When staff carry out work without sufficient qualification, risks remain understated when working. Explosion or fire may happen. Perform the work only if you have the appropriate qualifications and you are an expert.

If you do not use the appropriate tools and materials, components may be damaged. Use tools that are recommended to you for the job in the operating instructions.

Mechanical installation	Mechanical installation must only be carried out by the respectively qualified specialist personnel.
Electrical installation	Installation on components must only be carried out by qualified electricians.
Mechanical and/or electrical installation	The specialist personnel require a training especially for working in potentially explosive environment. Specialist personnel are persons that can verify a training / further education according to **DIN VDE 0105**, **IEC 364** or **similar national standards**.

Danger

The assembly of pressurized pipelines must be carried out by trained and authorized people only.

The installation and removal of the USZ08 may only be carried out in an explosion-free, de-pressurized atmosphere. It is important to pay attention to the descriptions of the operation manual during the installation process.

It is generally recommended to ask the RMG Service for any installation or removal.

After working on pressurized components, a control of leaks must be carried out.

All points above have to be considered for any repair and maintenance and in general, when an opening of the meter (convertor) is required.

Parts to lock the flanges, locking screws, fittings and check valves, oil supply and the pressure tap fittings, valves, HF pulse device, protecting pipe and rotating adapter may not be opened during operation.

1.2.4.3 Danger when using, servicing and maintaining the device USZ08

Operating personnel	The operating personnel are to use and operate the device within the scope of the intended purpose.
Maintenance personnel	Work on the device must only be carried out by specialist personnel that can carry out the respective work assigned to them as a result of their training, knowledge and experience as well as the applicable regulations. These specialist personnel are familiar with the legal guidelines for accident prevention and can evaluate and avoid possible risks by themselves.
Maintaining and cleaning	Maintenance and cleaning must only be carried out by the respectively qualified specialist personnel.

Danger

If staff carry out work without sufficient qualification, risks may be underestimated when working. Explosion or fire may happen. If work is carried out in hazardous areas on voltage supporting equipment, resulting sparks may cause an explosion.

Only proceed the work, if you are appropriately qualified and a well trained professional worker.

Caution

If the unit is not cleaned in accordance with the operating instructions, the device may be damaged. Clean the unit only in accordance with the operating instructions.

- **Clean with a damp cloth!**

Danger

The flowmeter USZ 08 may only be used as intended!
(*Chapter 2 Ultrasonic flow rate meter USZ 08*).

Avoid any use of the USZ08 as possible climbing aid or as possible handholds!

1.2.4.4 Specialized knowledge required

In general we recommend that persons working with or on the device must have the following knowledge:

- Training / education for working in potentially explosive environments
- Having the ability to correctly assess dangers and risks in handling the ultrasonic gas meter USZ 08 and all connected devices. Possible hazards are, for example, components under pressure or the consequences of incorrect installation.
- To know the hazards that may be caused by the medium being used.
- Training / education by RMG for working with gas measuring instruments.
- Education / instruction in all country-specific standards and directives to be observed for work that is to be carried out on the device.

1.2.5 Risk assessment and mitigation

The flowmeter USZ08 subjects to risks in its use, which were judged by qualified staff of the company RMG. Risks may arise due to high pressures, more rarely by too low. Even work outside the permissible temperature range can lead to danger. Invalid current and voltage values can trigger explosions in hazardous areas. The risk assessment assumes that when installing or removing a turbine a draining and venting of the pipeline takes place. Thus, and only then no explosive gas mixture is in the pipeline.

Of course (*chapter 1.2.4.4 Specialized knowledge required*) only work by trained personnel are permitted, which is also trained to know proper tools and use only this. These risks have been considered during the development phase and action were taken to minimize these risks.

Danger

Working in an explosive atmosphere (all areas)

For work in potentially explosive atmospheres (all zones) you have to apply:

- For maintenance and repair work only tool must be used, which is approved for Ex zone. 1. If you do not use the appropriate tool, components may be damaged.
  - **The explosion protection expires!**
- Otherwise, work must be carried out only if there is no explosive atmosphere.
- Danger of ignition caused by impact or friction must be avoided.
- In hazardous areas, the wiring / installation must be performed by trained personnel in accordance to EN 60079-14 and according to national regulations.
- Skilled persons are in accordance to DIN VDE 0105 or IEC 364, or comparable standards
- Use only trained and qualified personnel. Work on the measuring system may only be carried out by qualified personnel and must be checked by a specialist supervisor
- All pressure-retaining parts are designed in accordance to rules of AD 2000 (German literature: AD-Regelwerk, DGRL Anhang 1; see translations and / or similar English literature)
- The complete design being pressurized is verified by the notified body “TÜV Hessen”

- All pressurized parts are made with material certificate; there is a traceability to the batch tracking of all pressurized parts
- The mechanical properties of all relevant pressurized components are checked by tensile testing, impact testing and hardness testing
- In addition, non-destructive testing was applied: X-ray and ultrasonic testing of the meter housing for defects in material, surface crack detection by magnetic particle and dye-penetration
- With pressure tests 1.5 times of the intended operating pressure the strength of the components was verified; leak test was carried out at 1.1 times of the intended operating pressure. Successful tests were marked.
- The maximum operating pressure is stated on the nameplate of the device, as well as the temperature range. Operation of the device is only permitted within the indicated ranges.

1.2.6 Validity of the manual

This manual describes the flowmeter USZ08. The USZ08 is only a part of a complete on-site system. Observe also the instructions of other components of the site system. If you find contradicting instructions, please contact RMG and/or the manufacturer of the other components.

⚠ Caution

Make sure that the performance of the power connector corresponds to the data on the nameplate. Additionally, observe any existing national regulations in the country. Use cable suitable for the cable glands. (Chapter *3.2 Electronic connections*)

1.2.6.1 Hazards during Operation

Please take care of the information provided by the plant manufacturer and/or plant manager.

1.2.6.2 Danger during operation in hazardous areas

Danger

- **Use the device only in the original condition.**
- **The USZ 08 may be operated in explosion zone 1, but only within the permitted temperatures *(Chapter 1.3.1 General information)***

- Operate the device in perfect and complete condition. When you perform technical modifications to the instrument, a safe operation can no longer be guaranteed.
- Take care that with connecting other measuring components or additional devices in hazardous areas, these components have the appropriate explosion protection.
- If the device is intrinsically safe, a galvanic isolation is scheduled for the connection of the devise.

1.2.6.3 Responsibility of the operator

Take care as plant manager that only sufficiently skilled personnel will work on the device. Ensure that all employees who handle the equipment have read and understood these instructions. Additionally, you are obliged to train staff on a regular basis and to inform them about any dangers. Ensure that any work carried out on the device is done by qualified personnel and checked by responsible specialists. You must establish clearly the responsibilities for installation, operation, troubleshooting, maintenance and cleaning.

Point out to your staff any risks involved when using the device.

Gefahr

Risk of destruction due to body electricity, which can occur, for example, as a result of friction in the clothing - wear appropriate protective clothing.

For all works at the USZ 08 appropriate personal protective equipment must be used. As the operator you have to make them available. This applies, although as far as possible all sharp edges have been removed.

1.2.7 Transport

The device is packaged customized according to the transport requirements, usually on an EUR-P palette. When transporting the product, ensure that it is safely packed in such a way that it absorbs shocks and vibrations. However, inform the carrier of this fact, to avoid possible shocks and shocks during transport.

⚠ Warning

Risk of injury during transport

Any foot screws must be fitted, if they are used as transport protection against rolling and tipping. Take care that a rolling and tilting is safely prevented.

To lift the meter only the special lifting eyes / eye bolts may be used. Pay attention to the maximal loads for the lifting devices. Make sure that the load is fastened securely before lifting. Do not stand under lifted loads. During lifting and/or depositing the device may slip, tip over or fall. Disregarding the maximum load capacity of the lifting device, the device may fall down. For any people standing nearby, there is a significant risk of serious injury.

If the unit is supplied on a Euro pallet, the unit can be transported using a lift truck or a forklift.

During the transport the meter has to be protected against shock or vibration. The meter or additionally mounted spool pieces are equipped with flanges that are protected with a sticker foil or blind plugs made of plastic. These must be removed completely before installation in the pipeline. Remaining rests of these protections may change the flow pattern and may result in a measurement error!

For any transport e.g. for recalibration we ask you to use these protections.

This applies particularly for transport:

- In case of suspected improper transportation or damage during transport immediately contact the service at RMG!

1.2.8 Delivery

Supplied number of parts may differ depending on the optional customer order. "Usually" is following in the delivery:

Part	Quantity
Flow meter USZ 08	1
Ultrasonic electronic [1]	1
Connection box [2]	1
Inlet pipe [3]	1
Outlet pipe [3]	1
Special tool for opening the ultrasonic electronic	2
Manual	1
Calibration certificate	1
Material test report	1
Certificate strength 3.1.	1 optional
Software RMGView[USM]	1
Screw connection and blind plug set for sealing	1

[1] Already mounted on the ultrasonic flowmeter.
[2] Already mounted electrically on to the ultrasonic electronic.
[3] The inlet and outlet pipes are only scope of supply and mounted if the pipes have been ordered optional.

1.2.9 Dispose of packaging material

Dispose the packing material in an environmentally friendly way in accordance to the national standards.

1.2.10 Storage

Avoid long periods of storage. Check the device after any storage for damage and functionality. Ask for a check from the RMG service after a storage period for the device of over one year. In this case please send back the device to RMG.

If storage is still necessary, the following must be taken into account:

Notice

For storage, a dry and protected space has to be provided.
It is important to ensure that all open pipe pieces must be protected via a sticker foil.

1.3 Explosion-proof version

1.3.1 General information

Danger

The USZ 08 may be installed in areas of potentially explosive atmospheres of zone 1.

ATEX – Approval number: BVS 07 ATEX E 035

Marking:  **II 2G Ex de IIC T5/T6 GB**

The device meets the regulations of guideline 94/9/EG.

For installation and operation, the appropriate laws and regulations must always be observed. The acceptable electrical data can be found in *chapter 8 Technical specifications.*

Notice

When mounting the meter, ensure that the protection class of the device is maintained. An exposure to direct sunlight must be avoided.

The ultrasonic flowmeter corresponds to protection class IP65 according to EN 60529.

Temperature range

According to MID:

-20°C to +55°C (ambient temperature, for fiscal metering)

According to ATEX:

-40°C to +80°C (T5/T6)

Notice

In case of doubt the limited range of the MID applies: -20°C to +55°C (optional -40° to +55°C)

1.3.2 Connector housing for increased safety protection

Danger

For the electrical connection of the device, make sure that the correct voltage is supplied (see information on the type plate).

1.4 Inspection and maintenance work

1.4.1 General information

The maintenance plan defines intervals of the maintenance tasks, to ensure the functionality of the device.

Intervals	Action
Weekly	Check all seals for damage
As required	Cleaning the device. Check all plug-in connections and screw joints for leakage and tightness, if necessary replace seals.
After 8 years	Check device for leaks.
In consultation with RMG	Check device for leaks. The seal tightness may be restricted, if improper types of gas are used. In that case please contact RMG.

Danger

In areas subject to explosion hazards, work is generally prohibited on voltage-carrying electrical apparatus (except for intrinsically safe circuits).

In special cases, work can also be carried out on live electrical equipment in potentially explosive atmospheres if it is ensured that there is no potentially explosive atmosphere. This may only be done with explosion-proof, approved measuring instruments.

Gefahr

If there is unlocked access to the electrical assemblies needed, the following safety precautions must be followed:

- **The complete unit must be disconnected from the power supply.**
- **Personnel and instruments should be grounded when working on electrostatic sensitive modules.**

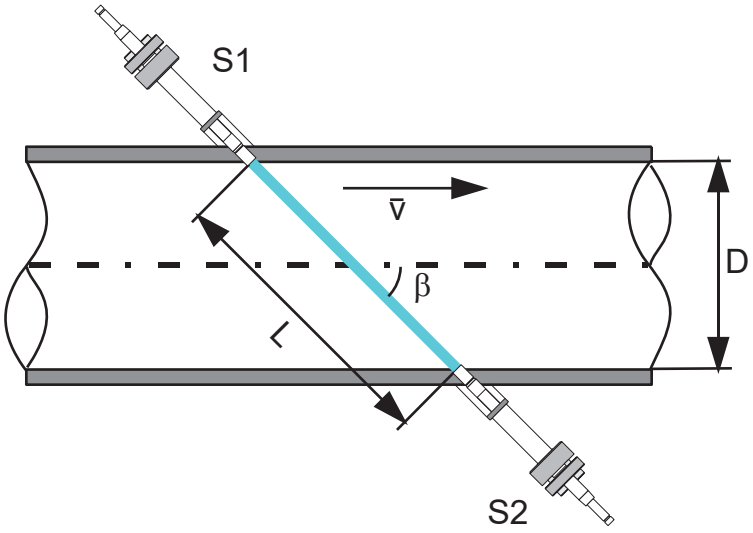
If the device is repaired regarding a part on which the explosion protection depends, it must not be put back into operation until it has been inspected by an accepted expert (*chapter 1.2.4.4 Specialized knowledge required*).

If repairs are carried out by the manufacturer, no acceptance by an expert is required.

2 Ultrasonic flow rate meter USZ 08

2.1 Introduction

By means of the transit times of ultrasonic pulses, the USZ 08 ultrasonic flowmeter measures the flow velocity of the gas from which it calculates the flow rate at measurement conditions. Here use is made of the fact that ultrasonic pulses move faster in the direction of flow than in the opposite direction.



The transit times from S1 to S2 and from S2 to S1 are calculated as follows:

$$t_{S12} = \frac{L}{c_0 + \bar{v} \cdot \cos\beta} \qquad t_{S21} = \frac{L}{c_0 - \bar{v} \cdot \cos\beta}$$

where: $\bar{v}$: mean flow velocity
c_0: velocity of sound
ß: path angle to the pipe
L: path length

If measurements are taken alternatively in both directions, the velocity of sound depending on the type of gas is no longer included in the calculation of the flow velocity:

$$\bar{v} = \frac{L}{2 \cdot \cos\beta} \cdot \left(\frac{1}{t_{S12}} - \frac{1}{t_{S21}} \right)$$

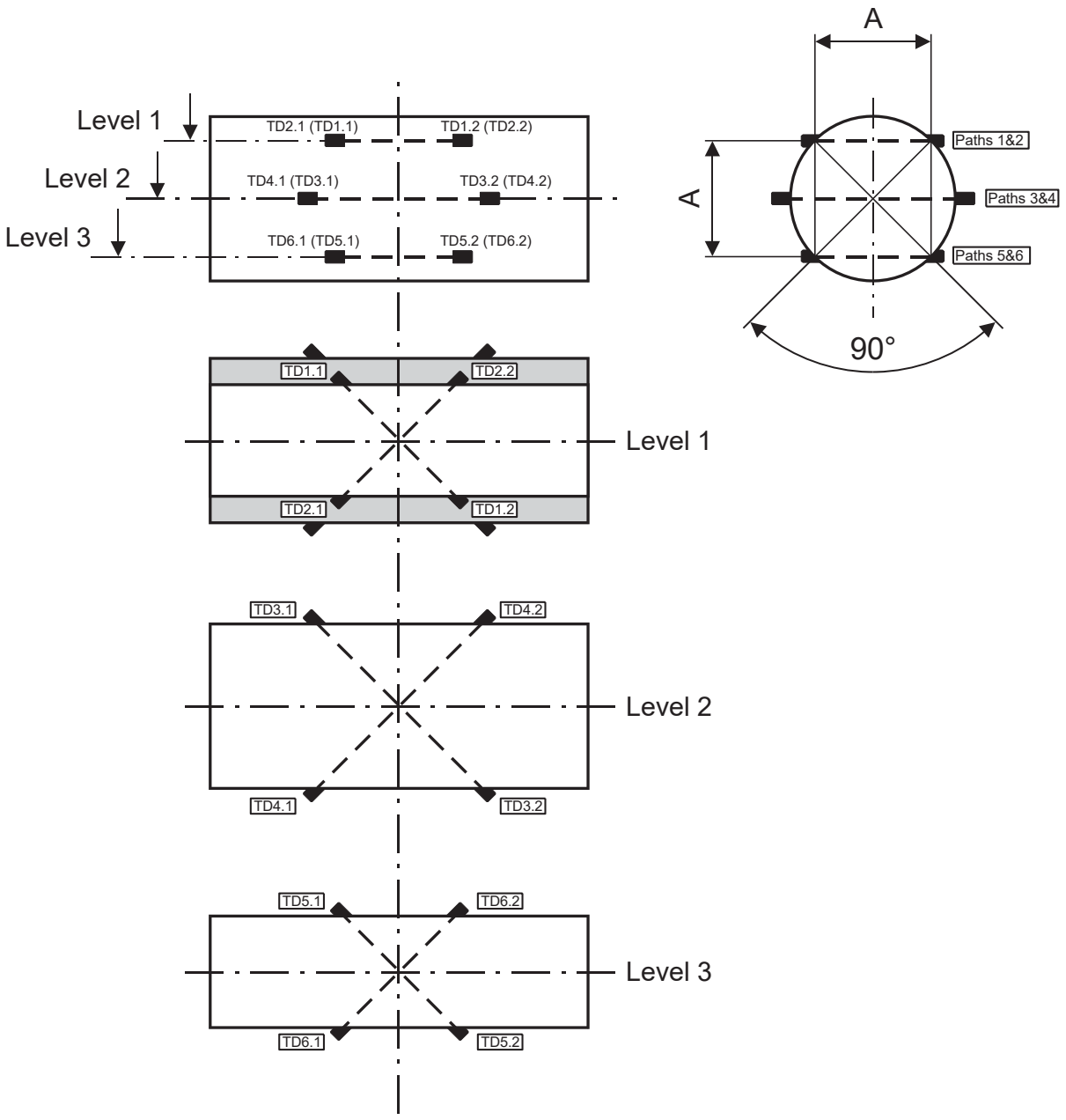
In order to take the flow profile into account, the USZ 08-6P takes measurements with a total of six acoustic paths in three planes. In the case of the 3-path design of type USZ 08-3P, the two paths of each plane crossing each other are replaced by one V-path with single reflection. The following ultrasonic system is available:

USE 09-C

- Meter with electronic totalizers
- MID-approved
- Full version of the USE 09 with integrated controller function
  With this configuration, it is possible to evaluate even flow rate and totalizer readings without an ERZ 2000 USC; other types of correctors can be connected via pulse outputs.

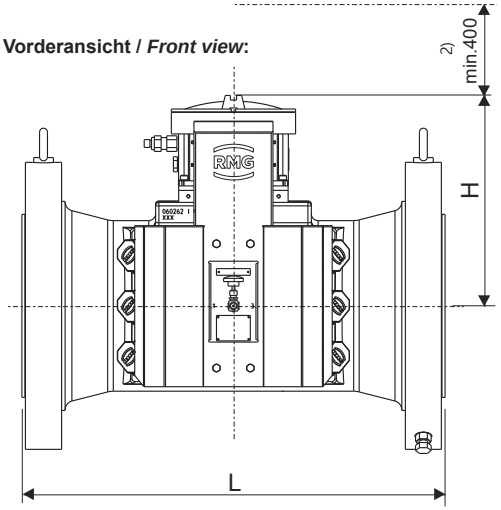
Using a PC, you can access the USE 09(-C) data via a service interface. To do this, you can use the RMGView^{USM} diagnostic software. The RMGView^{USM} has got its own manual.

2.2 Geometric arrangement of the paths USZ 08-6P

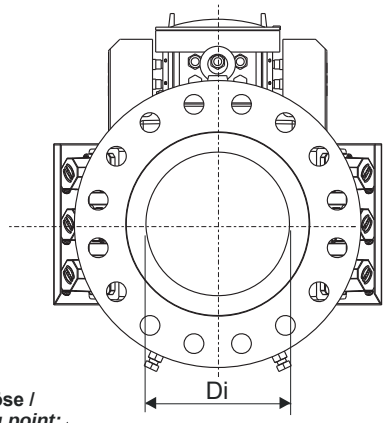


In each of the three planes, there are two paths crossing each other. The ultrasonic flowmeter has been designed symmetrically regarding the middle plane and axially with regard to the center of the meter.

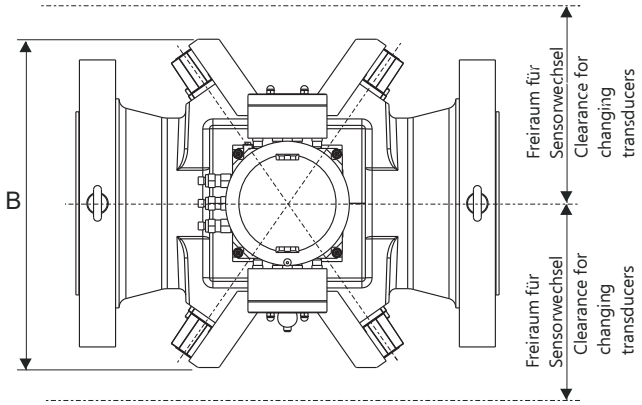
Vorderansicht / *Front view*:



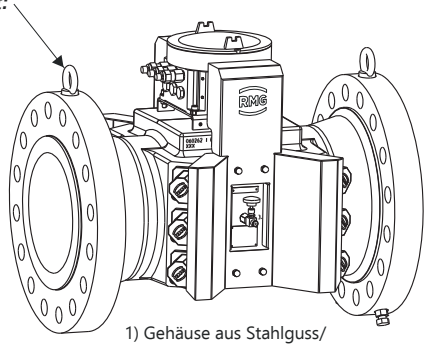
Seitenansicht / *Side view*:



Draufsicht / *Top view*:



Hebeöse / *Lifting point:*



1) Gehäuse aus Stahlguss/
Meter body to cast steel

2) Freiraum für das Anschließen der Elektronik / Elektronikwechsel
clearance for connecting electronic / changing electronic

DN/Size	PN	L	H	B	Di	Freiraum für Sensorwechsel/ clearance for changing transducers		1) Gewicht/ Weight
						Zähler mit Sensorenwechsel unter Druck./ Meter with pressurized changing of transducers	Zähler mit Sensorenwechsel ohne Druck./ Meter without pressurized changing of transducers	
200/8″	ANSI 600	600	360	530	202,7	1500	800	ca. 260kg
250/10″	ANSI 600	750	390	590	254,5	1550	850	ca. 400kg
300/12″	ANSI 600	900	420	640	303,2	1550	880	ca. 530kg
400/16″	ANSI 600	1200	450	710	378	1600	950	ca. 885kg
500/20″	ANSI 600	1500	530	820	476	1650	1000	ca. 1465kg
600/24″	ANSI 600	1200	510	940	570	1700	1070	ca. 1480kg
700/28″	ANSI 600	1200	540	1030	660	1800	1100	ca. 1600kg

Tabellenwerte sind Richtwerte (Abmessungen in mm).

Z.-Nr.: 061413.4

Stand: 19.03.2014

2.2.1 Equations for the ERZ 2000 USC / USE 09-C

Path velocity

v_i = Flow velocity, measured in path i (m/s)

$$v_i = \frac{L^2}{2 \cdot d} \cdot \frac{\Delta t_i}{t_{i1} \cdot t_{i2}}$$

t_{i1} = Transit time in direction 1 (path i) (s)

t_{i2} = Transit time in direction 2 (path i) (s)

$$\Delta t_i = t_{i1} - t_{i2}$$

L = Path length (cm)

d = Axial distance (cm)

Corrected path velocity

v_{ci} = Corrected path velocity (m/s)

$$v_{ci} = k_i \cdot v_i$$

k_i = Correction factor for path i

Weighted flow velocity

v_w = Weighted flow velocity (m/s)

$$v_w = \sum_{i=1}^{6} w_i \cdot v_{ci}$$

w_i = Weighting factor regarding the flow profile

Corrected weighted flow velocity

v_{wc} = Corrected weighted flow velocity (m/s)

$$v_{wc} = v_w \cdot K_R \cdot K_V \cdot \left(1 + \frac{F}{100}\right)$$

K_V = Meter factor

K_R = Correction factor, Reynolds number

$$K_R = A - B \cdot (\log Re)^C$$

F = Error from error curve linearization

Re = Reynolds number

A, B, C = Parameters for Reynolds number correction function

Flow rate at measurement conditions

Q_m = Flow rate at measurement conditions

$$Q_m = v_w \cdot \pi \cdot \frac{D_i^2}{4} \cdot 3600 \cdot \frac{s}{h}$$

v_w = Weighted flow velocity

D_i = Inside pipe diameter

Corrected flow rate at measurement conditions

Q_{mc} = Corrected flow rate at measurement conditions

$$Q_{mc} = k_c \cdot v_{wc} \cdot \pi \cdot \frac{D_i^2}{4} \cdot 3600 \cdot \frac{s}{h}$$

v_{wc} = Corrected weighted flow velocity

D_i = Inside pipe diameter

k_c = Correction factor, error curve linearization

2.3 Base correction of the gas meter

Polynomial
The base correction of the meter is performed via a quartic polynomial which reproduces the error curve.

Error equation: $F_1 = A_{-2} \cdot v_{wr}^{-2} + A_{-1} \cdot v_{wr}^{-1} + A_0 + A_1 \cdot v_{wr} + A_2 \cdot v_{wr}^2$

F_1	=	Deviation of the error curve	(%)
v_{wr}	=	Weighted flow velocity corrected by Reynolds number	(m/s)
A_n	=	Constants	

The constants A_n (n = -2 to n = 2) are calculated from the measured value pairs Error F_{1i} and flow velocity v_{wr}. Instead of the constant meter factor K_V, the corrected meter factor K_{Vc} is used for further calculation.

$$K_{Vc} = K_V \cdot (1+F_1/100)$$

2.4 Error curve linearization of the gas meter

Polynomial
The error curve linearization is also performed via a quartic polynomial which represents the error curve of the gas meter.

Error equation: $F_2 = B_{-2} \cdot Q_m^{-2} + B_{-1} \cdot Q_m^{-1} + B_0 + B_1 \cdot Q_m + B_2 \cdot Q_m^2$

F_2	=	Deviation of the error curve	(%)
Q_m	=	Flow rate at measurement conditions	(m^3/h)
B_n	=	Constants	

The constants B_n (n = -2 to n = 2) are calculated from the measured value pairs Error F_{2i} and flow rate Q_{mi}. In order to further calculate the corrected flow rate at measurement conditions, the correction factor of error curve linearization K_c is used.

$$K_c = (1+F_2/100)$$

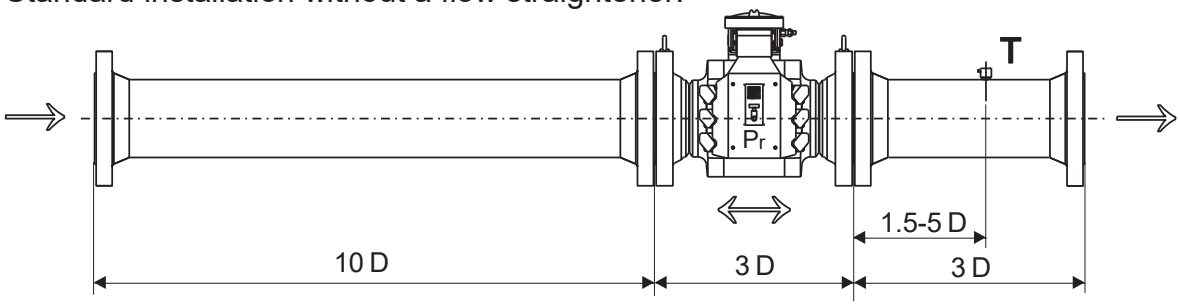
3 Installation and commissioning

3.1 Installation of the meter

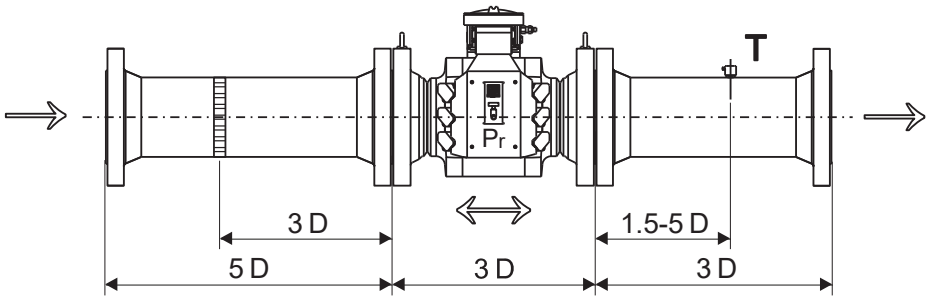
The USZ 08 ultrasonic flowmeter is to be operated with an inlet pipe and an outlet pipe. The following details are identical to the requirements of the PTB approval certificate and are therefore binding for custody transfer metering. These specifications are also recommended for secondary metering; if they are not observed, it is likely that the accuracy of measurement will be lower.

3.1.1 Unidirectional operation

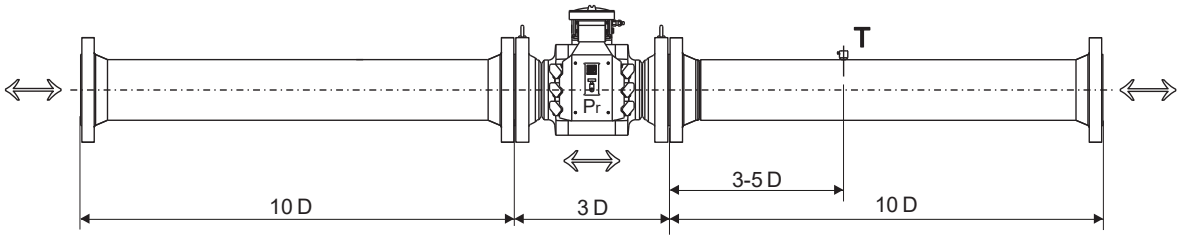
Standard installation without a flow straightener:



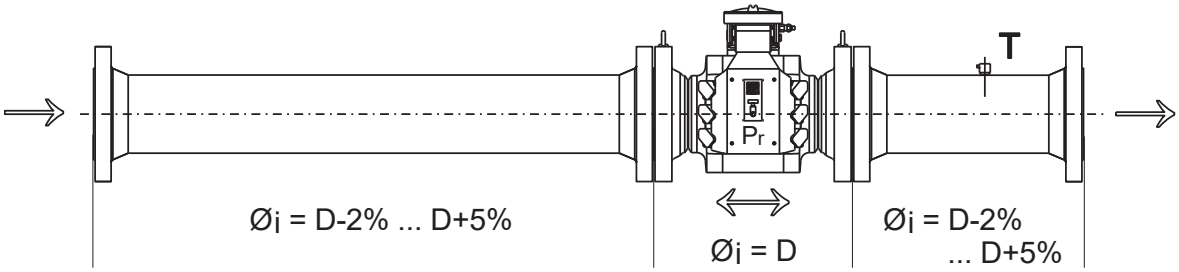
Compact installation with a flow straightener:



3.1.2 Bidirectional operation



3.1.3 Pipe diameter



The inside diameters of the inlet and outlet pipes may be up to 2% smaller or up to 5% larger than the inside diameter of the meter.

3.1.4 Outdoor installation

In case of outdoor installation of an USZ 08 with viewing window and electronic display, a cover for the electronics case is required.

The display must definitely not be exposed to direct solar radiation, since otherwise it will be destroyed by UV radiation!

Ultrasonic flowmeters can be equipped with a cover in the factory. Also retrofitting on site is possible.

3.1.5 Sealings

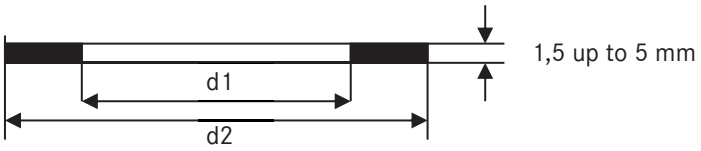
It must be guaranteed that flange seals of RMG turbine meters do not protrude from the flange into the gas line.

All seals approved as per DVGW can be used depending on the requirements for stability and reliability.

We recommend seals with the following maximum material characteristic values according to the AD2000 rules:

- gaskets: $k_0 \times K_D = 20 \times b_D \mid k_1 = 1.3 \times b_D$ [N/mm]
- grooved seals: $k_0 \times K_D = 15 \times b_D \mid k_1 = 1.1 \times b_D$ [N/mm]
- spiral seals: $k_0 \times K_D = 50 \times b_D \mid k_1 = 1.4 \times b_D$ [N/mm]
- octagonal ring joint seal: $K_D = 480$ N/mm²

For recommended dimensions, see the tables below.



Gaskets			PN 10	PN 16	ANSI 150	PN 25	PN 40
DN		d1	d2				
100	4"	115	162	162	175	168	168
150	6"	169	218	218	222	225	225
200	8"	220	273	273	279	285	292
250	10"	274	328	330	340	342	353
300	12"	325	378	385	410	402	418
400	16"	420	490	497	514	515	547
500	20"	520	595	618	607	625	628
600	24"	620	695	735	718	730	745

Grooved seals	ANSI 300 / ANSI 600		PN 64	
DN (“)	d1	d2	d1	d2
100 (4)	123,8	154,0	118	144
150 (6)	177,8	212,7	170	204
200 (8)	228,6	266,7	220	258
250 (10)	282.6	320.7	270	315
300 (12)	339.7	377.8	320	365
400 (16)	422.3	466.7	426	474
500 (20)	530.2	581.0	530	578
600 (24)	631.8	682.6	630	680

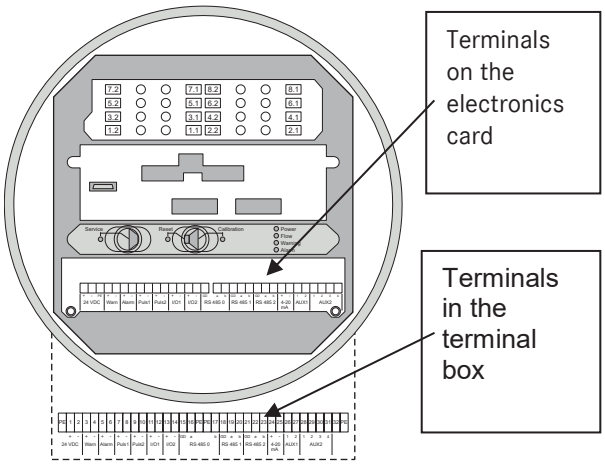
Spiral seals		ANSI 300		PN 64		ANSI 600	
DN		d1	d2	D1	d2	d1	d2
50	2"	69,9	85,9	66	84	69,9	85,9
80	3"	101,6	120,7	95	119	101,6	120,7
100	4"	127,0	149,4	120	144	120,7	149,4
150	6"	182,6	209,6	174	200	174,8	209,6
200	8"	233,4	263,7	225	257	225,6	263,7
250	10"	287,3	317,5	279	315	274,6	317,5
300	12"	339,9	374,7	330	366	327,2	374,7
400	16"	422,4	463,6	426	466	412,8	463,6
500	20"	525,5	577,9	530	574	520,7	577,9
600	24"	628,7	685,8	630	674	628,7	685,8

3.1.6 Screws

	Temperature ranges for screws and nuts			
	-10°C to +80°C	-40°C to +80°C		
Pressure		Variant 1	Variant 2	Variant 3
up to and including 40 bar	Screws complying with DIN EN ISO 4014 made of material 5.6, Nuts complying with DIN EN ISO 4032 made of material 5-2	Screws complying with DIN EN ISO 4014 made of material 25CrMo4, Nuts complying with DIN EN ISO 4032 made of material 25CrMo4		
from 40 bar	Screw bolts complying with ANSI B1.1 made of material ASTM A193 Grade B7, Nuts complying with ANSI B1.1 made of material ASTM A194 Grade 2H	Screw bolts complying with ANSI B1.1 made of material ASTM A320 Grade L7, Nuts complying with ANSI B1.1 made of material ASTM A320 Grade L7	Screw bolts complying with ANSI B1.1 made of material 42CrMo4, Nuts complying with ANSI B1.1 made of material 42CrMo4	Anti-fatigue bolts complying with DIN 2510 made of material 25CrMo4, Nuts complying with DIN 2510 made of material 25CrMo4

3.2 Electronic connections

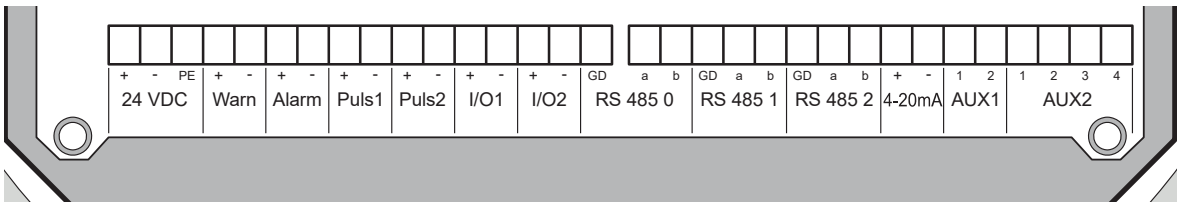
3.2.1 Terminal assignments of the measuring element



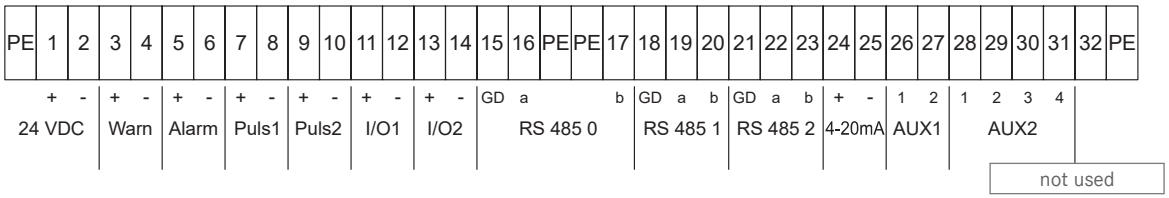
The USZ 08 ultrasonic flowmeter with the USE 09 ultrasonic electronic system is supplied with two case variants:

- with the mere electronics case: here connection is to be made directly at the electronics card (standard with the USE 09);
- with an additional terminal box: in the case of this version, connection is basically to be made in the terminal box (standard with the USE 09-C, optional with the USE 09).

Terminal assignments on the electronics card



Terminal assignments in the terminal box (in the case of the USE 09-C)



If the meter is operated in conjunction with a Flow Computer/ultrasonic computer of the ERZ 2000 USC series, the computer is to be connected to the **RS 485 1** interface. Due to the fact that the parameters of the meter are stored in the ERZ 2000 USC, you have to make sure that the correct computer is connected to the measuring element (compare the serial numbers of the measuring element on both data plates).

The **RS 485 0** interface is used for servicing. The **RMGView^{USM} service and diagnostic software** which is required for this purpose is described from page 31 onwards.

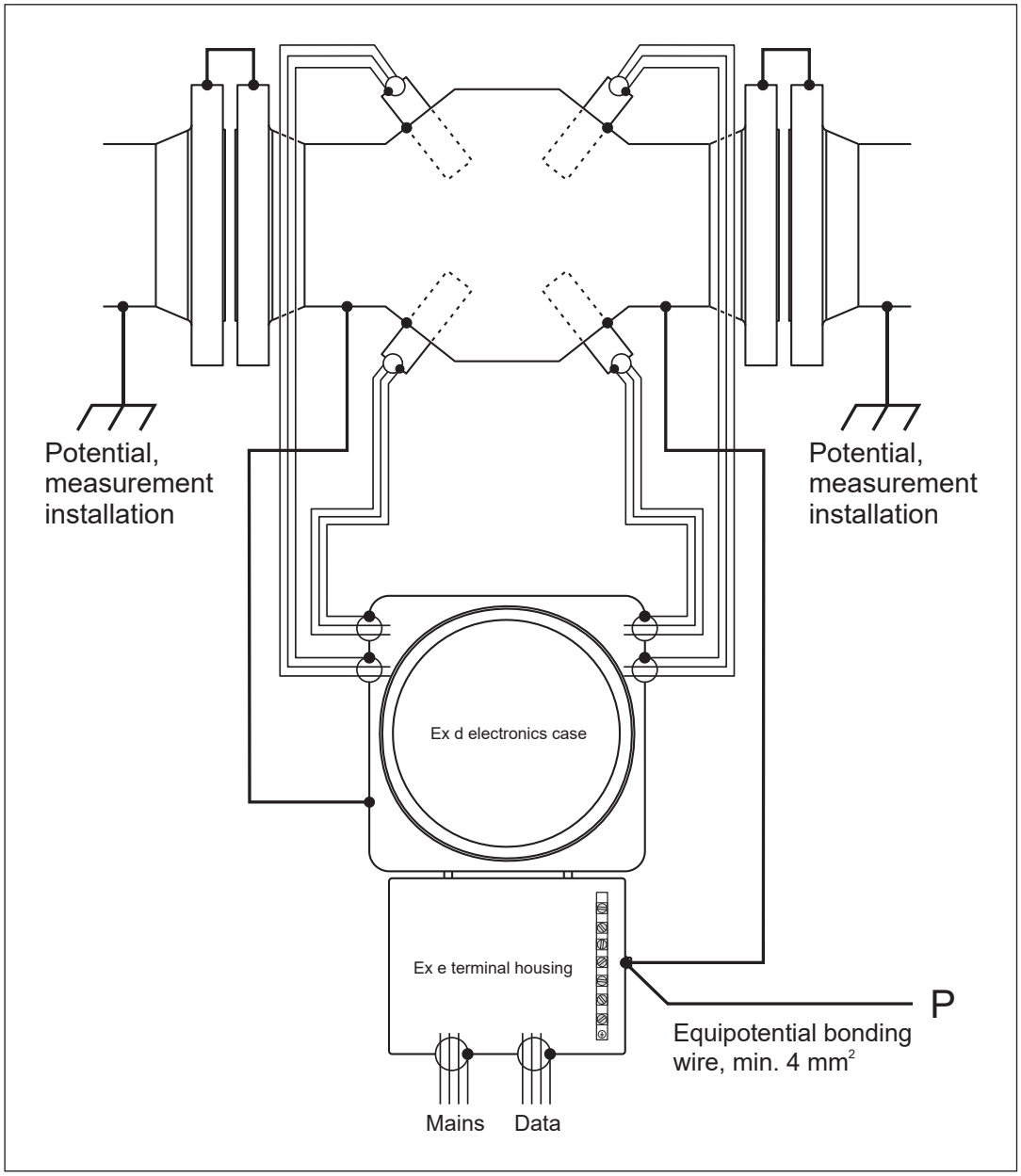
A second Flow Computer can optionally be connected to the **RS 485 2** interface if an appropriate optional USE 09 card is used. However, this interface can also be used as a Modbus (ASCII or RTU) interface for other purposes.

On the USE 09-**C**, there are 2 pulse outputs (terminals 7/8 and 9/10) and a current output (4-20 mA) available. The pulse outputs are set in such a way that a frequency of approx. 2 kHz is outputted at maximum flow rate. The direction of flow can be outputted through the contact outputs I/O1 and I/O2.

Use shielded cables from a length of 1 m (this also applies to power cords). Apply the shields to the cable glands. Use cables which are twisted together in pairs of the type LiYCY 2x2x0.75 mm² for the data line!

The maximal permissible cable length between USZ 08 and ERZ 2000(-NG) is 500 m.

3.2.2 Earthing and screening



Use shielded cables from a length of 1 m (this also applies to power cords). Apply the shields to the cable glands. Use cables which are twisted together in pairs of the type LiYCY 2x2x0.75 mm² for the data line!

The sensors are in metal-to-metal contact with the meter case and need not be separately earthed when they are replaced. However, a conductive connection has to be established with the piping of the measurement installation.

In the case of devices without an Ex e terminal housing, the equipotential bonding wire is to be connected to the earthing screw of the Ex d electronics case.

3.3 Start-up

Usually, all parameters are programmed into the ultrasonic electronics on the test bench and no control is necessary. Therefore, this chapter is usually omitted.

The following information is for the installation of a meter and connection to an ERZ 2000 USC. After the meter has been installed and the ERZ 2000 USC has been connected, the parameters of the meter have to be checked on the computer. They are listed on the verification certificate of the meter together with the coordinates. Parameters from the verification certificate without any coordinate stated are directly stored in the ultrasonic electronic system of the measuring element (IGM/USE 09). They can be found on the inspection certificate of the measuring element and can be checked using the RMGView^{USM} diagnostic software. In the case of a meter without an ERZ 2000 USC, all parameters are programmed into the ultrasonic electronic system on the test facility and it is not necessary to check them.

As soon as the meter is pressurized, it is possible to check its function. To do this, check the velocities of sound measured for each path (lines 9 to 14) in column FH (Ultrasonic diagnosis) on the ERZ 2000 USC. The velocity of sound varies with the gas composition, pressure and temperature. The values of the individual paths should differ only slightly. However, a comparison with the velocity of sound of the fluid can be made only to a limited extent, since such velocity of sound can be determined only in a very inaccurate way under operating conditions.

If there is no flow rate available during start-up, thermal layering may occur in the piping, so that the velocities of sound of the paths of different measuring planes may differ considerably from each other.

If there is no ERZ 2000 USC available (model with totalizer on the meter case), the velocities of sound (columns L to Q) can be read out using the RMGView^{USM} software.

If the velocity of sound of a device with an ERZ 2000 USC should not be plausible, it is necessary to perform troubleshooting using RMGView^{USM}.

If the velocities of sound of the measuring element are OK, but not on the ERZ 2000, this is in most cases due to the connection between the measuring element and the computer. In such a case, check not only the cable but also the screening and earthing as well as the terminating resistor on the ERZ 2000 USC. If only a single path has failed, it is likely that the fault is to be found in the wiring of the path.

4 Diagnostic software RMGView^{USM}

4.1 Functions

The RMGView^{USM} diagnostic software allows the USE 09 measuring electronic system to be directly accessed with a PC. The program enables to read out all available data from an ultrasonic flowmeter using the USE 09. It is described in a separate user-manual.

You can find all necessary information about usage and conditions of this software in the manual.

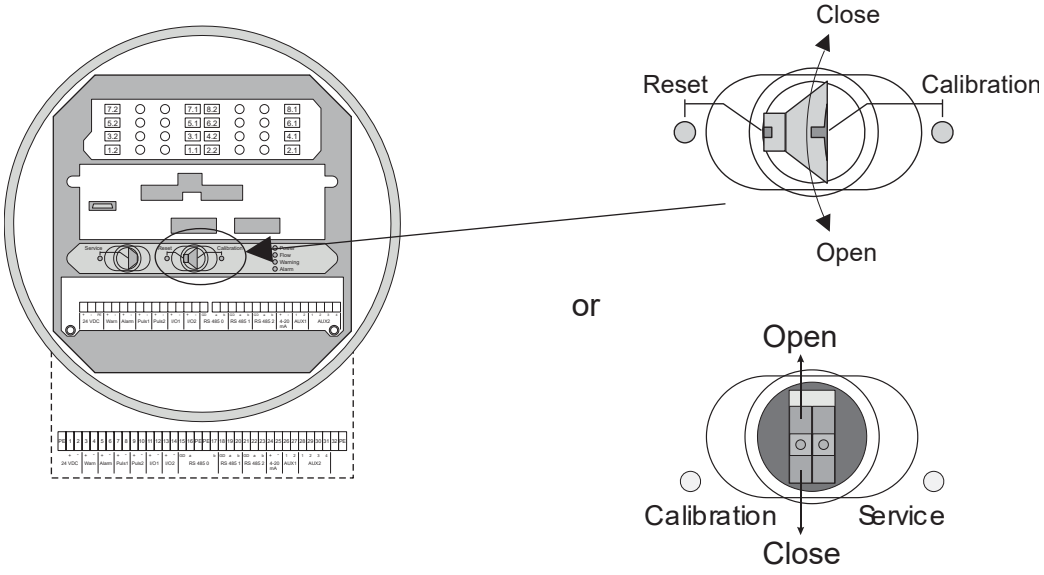
4.3 Connecting a PC

Use the RS 485-0 interface to connect a PC to the measuring element of the USZ 08. To do this, you need an interface converter for RS 485 to RS 232 or USB. If available, you can also use a 9-pin sub D connector in the control cabinet to connect the PC to the service interface. Pin assignments will be as follows:

USE 09 (RS 485 0)	Control cabinet connection	Assignments
GD	5	GND
a	3	Tx
b	8	Rx

4.4 Calibration switch of the USE 09

Open the calibration switch to parameterize the ultrasonic electronic system. This switch is located above the electrical connections.



4.5 Operating the program

For the RMGView[USM] diagnostic software a separate manual is available which can be found as a pdf document on the data storage medium with the software. Please take all information needed from this document.

5 USE 09 measured values and parameters

5.1 Access

Using the RMGView[USM] diagnostic software, you can display and, if necessary, also edit all measured values and parameters of the USE 09 ultrasonic electronic system. All the parameters listed below will be visible on the display of the USE 09-C and will be used to calculate the flow rate.

5.2 List of measured values and parameters

The following tables show the parameters which can be displayed or edited using the RMGView[USM] diagnostic software. The coordinate shown in the left column corresponds to that displayed in RMGView[USM]. In the case of different device software versions, individual parameters may have different coordinates.

The second column shows how the individual values are protected:

A: Display values which cannot be changed.

C: User data which can be changed via the user code.

E: Custody transfer metering data which can only be changed if the calibration switch is open.

F: Free parameters without protection.

S: Specially protected parameters which can only be changed via the user code and the calibration switch.

In the case of some values the units are variable depending on the setting in the Mode column (Y). These values are identified by "&":

&v: m/s or ft/s (flow velocity)

&Q: m³/h or acfh (flow rate)

&P: P/m³ or P/cf (pulse factor)

&Z: m³ or acf (totalizers)

The column to the right of the Modbus address shows the data type. For further information, see chapter "Brief description of the USE09 Modbus".

5.2.1 Pressure (option)

		Value	Unit	Modbus		Description
A-01	A	pressure	bar_a	6252	F	Indication of the pressure at measurement conditions
A-03	A	current input	mA	6254	F	Indication of the input value in mA
A-05	E	p min value	bar_a	1392	F	Pressure at measurement conditions, min. value
A-06	E	p max value	bar_a	1394	F	Pressure at measurement conditions, max. value
A-09	E	p set value	bar_a	1396	F	Pressure at measurement conditions, set value
A-11	E	p at base cond.	bar_a	1398	F	Pressure at base conditions
A-12	E	curr. inp. gradient		1400	F	Gradient (correction of the mA value)
A-13	E	curr. inp. offset		1402	F	Offset (correction of the mA value)
A-14	E	p err. min	bar_a	1404	F	Pressure at measuring conditions, lower error limit
A-15	E	p err. max	bar_a	1406	F	Pressure at measuring conditions, upper error limit
A-17	E	p mode		4078	M	Pressure at measurement conditions, operating mode (**OFF**, SET VALUE, 4-20mA, 4-20mA_ERR)

Notice

If a pressure transmitter is connected to the USE 09 ultrasonic electronic system, the measured value displayed here is not identical to that of the associated volume corrector!

5.2.2 Temperature (Option)

		Value	Unit	Modbus		Description
B-01	A	temperature	°C	6256	F	PT100 input, indication of the temperature
B-03	A	PT100 resistance	Ohm	6258	F	PT100 input, indication in ohm
B-09	E	T set value	°C	1408	F	PT100 input, set value for temperature
B-11	E	T at base cond.	K	1410	F	Temperature at base conditions
B-12	E	T gradient		1412	F	Gradient (correction of the ohm value)
B-13	E	T offset		1414	F	Offset (correction of the ohm value)
B-14	E	T err. min	°C	1416	F	PT100 input, temperature, lower error limit
B-15	E	T err. max	°C	1418	F	PT100 input, temperature, upper error limit
B-17	E	T mode		4079	M	PT100 input, operating mode (**OFF**, SET VALUE, PT100, PT100_ERR)

Notice

If a temperature transmitter is connected to the USE 09 ultrasonic electronic system, the measured value displayed here is not identical to that of the associated volume corrector!

5.2.3 USE09-C measured values

		Value	Unit	Modbus		Description
C-01	A	vw	&v	6220	F	Indication of Vw
C-02	A	vwc	&v	6222	F	Indication of Vwc
C-03	A	Qm	&Q	6224	F	Intermediate result for Qm (with preceding sign)
C-04	A	Qmb	&Q	6238	F	Intermediate result for Qmb (with preceding sign)
C-05	A	Qmc	&Q	6226	F	Intermediate result for Qmc (with preceding sign)

5.2.4 USE09-C flow rate Qm

		Value	Unit	Modbus		Description
D-01	A	vol. flow rate Qm	&Q	730	T	Volumetric flow rate Qm after all corrections (as amount) with upstream/downstream identification
D-02	A	vol. flow rate Qm	&Q	6230	F	Volumetric flow rate Qm after all corrections (Qm lower limit will be observed)
D-03	A	Qm damped	&Q	6264	F	Volumetric flow rate Qm damped (Qm lower limit will be observed)
D-04	E	Qm min.	&Q	1320	F	Qm min. limit
D-05	E	Qm max.	&Q	1322	F	Qm max. limit
D-06	E	vw factor d1	[1]	1324	F	Constant Kv direction 1
D-07	E	vw factor d2	[1]	1436	F	Constant Kv direction 2
D-08	E	vw lower limit	&v	1326	F	vw lower limit (creeping quantity before apply. polynomial)
D-09	E	Qm lower limit	&Q	1328	F	Qm lower limit (creeping quantity)
D-10	E	Qm-min time	sek	2120	I	Time below Qm min
D-15	C	Qm damping		1446	F	Damping for Qmc-D (0.0=off, 1.0=max)
D-16	E	pipe diameter	mm	1334	F	Pipe diameter
D-17	E	geometry correcting		2258	M	Correction of the effects of press. and temp. (**OFF**, ON)
D-18	E	temp. coefficient		1450	F	Temperature coefficient
D-19	E	pressure coeff.		1452	F	Pressure coefficient
D-20	E	Qm-max value	&Q	1330	F	Qm max. value of direction 1
D-21	E	Qm-max time		2580	U	Time of Qm max. value
D-22	E	Qm-max value	&Q	1332	F	Qm max. value of direction 2
D-23	E	Qm-max time		2582	U	Time of Qm max. value

5.2.5 USE09 parameters

		Value	Unit	Modbus		Description
E-01	E	USE09 working mode		2090	M	USE09 operating mode (**IGM**, USE09C, SIMU)
E-02	E	path select		690	T	Select activated paths (path 1.1, path 1.2 to path 4.2)
E-03	E	max. path RV		2121	I	Max. number of replacement values used
E-04	E	fault time	s	2122	I	Time limit for IGM timeout
E-05	E	error per cent	%	2123	I	A measurement quality below this level will cause a path error
E-09	E	moving average cent		2125	I	Number of measured values for the moving average, V, VOS
E-15	C	VOS mode		2240	M	VOS mode (**STANDARD**, EXTENDED, CALIBRATION)
E-16	C	delta VOS mode		2091	M	Delta C monitoring (OFF, **ON**)
E-17	C	delta VOS limit	%	1344	F	Limit for delta C
E-18	E	c-corr factor	[1]	1370	F	Factor for C correction
E-19	E	v-corr factor	[1]	1372	F	Factor for V correction
E-20	C	delta AGC limits	dB	1438	F	Max. deviation between path-AGC and AGC-mean
E-21	E	tw correct		2281	M	Correct TWs (**OFF**, SET)
E-22	C	tw damping		1518	F	Damping for TW adjustment

5.2.6 USE09-C polynomials

		Value	Unit	Modbus		Description
G-01	E	err. curve lin.		2093	M	Error curve linearization mode (OFF, POLYNOMIAL)
G-02	E	const m2 d.1	[1]	1276	F	Error polynomial for direction 1
G-03	E	const m1 d.1	[1]	1278	F	Error polynomial for direction 1
G-04	E	const 0 d.1	[1]	1280	F	Error polynomial for direction 1
G-05	E	const 1 d.1	[1]	1282	F	Error polynomial for direction 1
G-06	E	const 2 d.1	[1]	1284	F	Error polynomial for direction 1
G-10	E	const m2 d.2	[1]	1306	F	Error polynomial for direction 2
G-11	E	const m1 d.2	[1]	1308	F	Error polynomial for direction 2
G-12	E	const 0 d.2	[1]	1310	F	Error polynomial for direction 2
G-13	E	const 1 d.2	[1]	1312	F	Error polynomial for direction 2
G-14	E	const 2 d.2	[1]	1314	F	Error polynomial for direction 2

5.2.7 Frequency, pulse outputs

		Value	Unit	Modbus		Description
H-01	A	fo base value	&Q	6248	F	Measured value of the frequency output
H-02	A	frequency value	Hz	6250	F	Frequency value of the frequency output (in Hz)
H-03	E	fo corr. factor		1386	F	Correction factor of the frequency output

H-04	A	corr. frequency	Hz	6266	F	Correction of the frequency value of the frequency output (in Hz)
H-05	E	fo base max.	&Q	1388	F	Upper range value of the frequency output (physical value)
H-06	E	fo freq. max.	Hz	1444	F	Maximum value of the frequency output (in Hz)
H-07	A	pulse value	&P	6262	F	Indication of the calculated pulse value of the frequency output
H-08	E	fo set value	Hz	1390	F	Calibration frequency
H-09	C	fo select		2161	M	Selection of the measured value for the frequency output (**QMC**, QMCD)
H-10	E	fo mode		2162	M	Operating mode of the frequency output (OFF, SET VALUE, **ON**, TEST)
H-11	E	fo2 error mode		2163	M	Frequency-2 mode if a fault occurs (**F2 STOP**, F2 ACTIVE, CRYSTAL TEST)
H-12	A	ferr waveform gen.	Hz	6260	F	Frequency delta (FOut: waveform generator)
H-15	C	IO-1 mode		2165	M	Mode for IO-1 (OFF, **DIRECTION**, DIRECTION INV., INPUT, TEST, WARN-INPUT HIGH, WARN-INPUT LOW)
H-16	C	IO-2 mode		2166	M	Mode for IO-2 (OFF, **DIRECTION**, DIRECTION INV., INPUT, TEST, CPU)
H-17	C	mode ext. warning		2186	M	Mode in the case of external warning (**OFF**, LOW_POWER)
H-20	C	test alarm a. warn		4081	M	Tests the warning and alarm contacts (**OFF**, TEST)

5.2.8 Current output

		Value	Unit	Modbus		Description
I-01	A	c-out physical val.		6244	F	Current output, physical value
I-02	A	c-out value	mA	6246	F	Current output in mA
I-03	C	c-out min.		1374	F	Current output, physical minimum value
I-04	C	c-out max.		1376	F	Current output, physical maximum value
I-05	C	c-out set value	mA	1378	F	Current output, set value
I-06	C	c-out select		2158	I	Current output, selection of the measured value (Modbus reg.)
I-07	C	c-out mode		2159	M	Current output, operating mode (**OFF**, SET VALUE, 0-20mA, 4-20mA)
I-08	C	c-out err mode		2160	M	Current output, operating mode if a fault occurs (**OFF**, MIN, MAX)
I-09	C	c-out damping		1380	F	Current output, damping (0.0=OFF, 1.0=max)
I-10	E	c-out gradient		1382	F	Current output, gradient
I-11	E	c-out offset		1384	F	Current output, offset

5.2.9 Serial ports

		Value	Unit	Modbus		Description
J-12	N	DZU-0 address		2283	I	Serial interface -0 DZU slave ID (ASCII: 00-99)
J-13	A	serial-0 status		760	T	Serial interface -0, status
J-14	N	serial-1 mode		2107	M	Serial interface -1, mode (OFF, **IGM**, USE09, DZU, DZU-DIAG, DZU X-FRAME, VO)
J-15	N	serial-1 baud rate	baud	2108	M	Serial interface -1, baud rate (2400, 4800, 9600, 19200, **38400**, 57600)
J-16	N	serial-1 bits		2109	M	Serial interface -1, number of bits (7, **8**)
J-17	N	serial-1 parity		2110	M	Serial interface -1, parity (**NONE**, EVEN, ODD)
J-18	N	not available		2286	M	Serial interface -1 Modbus operating mode (not yet available)
J-19	N	not available		2287	M	Serial interface -1 Modbus hardware (not yet available)
J-20	N	not available		2288	I	Serial interface -1 Modbus address (not yet available)
J-21	N	not available		2289	I	Serial interface -1 Modbus register offset (not yet available)
J-22	N	not available		2290	I	Serial interface -1 Modbus turn-off time (not yet available)
J-23	N	DZU-1 address		2284	I	Serial interface -1 DZU slave ID (ASCII: 00-99)
J-24	A	serial-1 status		770	T	Serial interface -1, status
J-25	N	opt. ser2 mode		2112	M	Optional serial interface -2, mode (**OFF**, IGM, USE09, MODBUS, DZU-SLAVE)
J-26	N	opt. ser2 baud rate	baud	2113	M	Optional serial interface -2, baud rate (2400, 4800, 9600, 19200, **38400**, 57600)
J-27	N	opt. ser2 bits		2114	M	Optional serial interface -2, number of bits (7, **8**)
J-28	N	opt. ser2 parity		2115	M	Optional serial interface -2, parity (**NONE**, EVEN, ODD)
J-29	N	Modbus-2 protocol		2178	M	Optional serial interface -2, Modbus operating mode (OFF, **RTU**, ASCII)
J-30	N	Modbus-2 hw-mode		2179	M	Optional serial interface -2, Modbus hardware (RS232, **RS485**)
J-31	N	Modbus-2 address		2180	I	Optional serial interface -2, Modbus address (ID)
J-32	N	Modbus-2 reg.offset		2181	I	Optional serial interface -2, Modbus register offset
J-33	N	Modbus-2 gap time		2182	I	Optional serial interface -2, Modbus gap time
J-34	N	long byte order		2251	M	Ser-2 Modbus byte order with long: (1,0)(3,2) or (3,2)(1,0) (**Normal**, SWAPPED)
J-35	N	float byte order		2252	M	Ser-2 Modbus byte order with float: (1,0)(3,2) or (3,2)(1,0) (**Normal**, SWAPPED)
J-36	N	double byte order		2253	M	Ser-2 Modbus byte order with double: (1,0)(3,2)(5,4)(7,6) or (7,6)(5,4)(3,2)(1,0) (**Normal**, SWAPPED)
J-37	N	DZU-2 address		2285	I	Serial interface -2 DZU slave ID (ASCII: 00-99)
J-38	A	serial-2 status		780	T	Optional serial interface -2, status
J-39	E	DZU interval	tics	2111	I	Serial interface -1, DZU interval
J-40	N	DZU checksum preset		2255	M	Serial interface -1, initial DZU checksum value (**0x00**, 0x7F)

5.2.10 DSP, FPGA values

		Value	Unit	Modbus		Description
K-20	A	DSP status	hex	4004	I	DSP status (bit-coded)
K-21	A	DSP error	hex	4003	I	DSP error (bit-coded)
K-22	A	DSP bytes received		7034	I	Counts the telegrams received from the DSP
K-23	A	FPGA status	hex	4006	I	FPGA status (bit-coded)
K-24	A	FPGA error	hex	4005	I	FPGA error (bit-coded)

5.2.11 Path# measured values

		Value	Unit	Modbus		Description
L (…S)-1	A	p#.1 time of flight	us	6100	F	Path#.1 time of flight
L (…S)-2	A	p#.2 time of flight	us	6120	F	Path#.2 time of flight
L (…S)-3	A	path-# delta-t	us	6140	F	Path# time difference
L (…S)-4	A	p# delta-t corr.	us	6540	F	Path# time difference corrected
L (...S)-6	A	Valid samples G#	%	7000	I	Path# valid measured values in %
L (...S)-7	A	path-# velocity	&v	6000	F	Path# path velocity
L (...S)-8	A	velocity vc#	&v	6200	F	Path# corrected path velocity vc
L (...S)-9	A	c#	&v	6020	F	Path# velocity of sound
L (...S)-10	A	path-# delta c	%	6080	F	Path# path-VOS / total-VOS
L (...S)-12	A	path-# fault	hex	4030	I	Path# path fault
L (...S)-13	A	path-# status	hex	4040	I	Path# path status
L (...S)-14	A	p#.1 amplitude	%	7010	I	Path#.1 amplitude in percent
L (...S)-15	A	p#.2 amplitude	%	7020	I	Path#.2 amplitude in percent
L (...S)-16	A	p#.1 AGC-level	dB	6040	F	Path#.1 AGC
L (...S)-17	A	p#.2 AGC-level	dB	6060	F	Path#.2 AGC
L (…S)-18	A	p#.1 snr	dB	6640	F	Path#.1 signal-to-noise ratio
L (…S)-19	A	p#.2 snr	dB	6660	F	Path#.2 signal-to-noise ratio
L (…S)-20	A	path-# fault (X)	hex	2270	I	Path# path fault (3X measurement)
L (…S)-21	A	p#.1 AGC-level (X)	dB	6680	F	Path#.1 AGC (3X measurement)
L (…S)-22	A	p#.2 AGC-level (X)	dB	6700	F	Path#.2 AGC (3X measurement)
L (…S)-23	A	p#.1 snr (X)	dB	6720	F	Path#.1 signal-to-noise ratio (3X measurement)
L (…S)-24	A	p#.2 snr (X)	dB	6740	F	Path#.2 signal-to-noise ratio (3X measurement)

Notice

The Modbus addresses stated are for path 1! To determine the Modbus addresses for the other paths, see chapter "Brief description of the USE09 Modbus".

5.2.12 Path# signal analysis

		Value	Unit	Modbus		Description
T (…AA)-1	A	p#.1 tw offset	us	6600	F	Path#.1 corrected delay time
T (…AA)-2	A	p#.2 tw offset	us	6620	F	Path#.2 corrected delay time
T (…AA)-3	A	p# tw damped	us	6830	F	Path# delay time twd

5.2.13 USE09 measured values

		Value	Unit	Modbus		Description
AB-01	A	VOS average	&v	6228	F	Average velocity of sound through all paths
AB-02	A	p.1 AGC average	dB	6056	F	Path x.1 average AGC through all paths
AB-03	A	p.2 AGC average	dB	6076	F	Path x.2 average AGC through all paths

5.2.14 USE09 diagnosis

		Value	Unit	Modbus		Description
AC-01	A	Vz plane-1	&v	6560	F	Vz velocity of plane 1
AC-02	A	Vz plane-2	&v	6562	F	Vz velocity of plane 2
AC-03	A	Vz plane-3	&v	6564	F	Vz velocity of plane 3
AC-04	A	Vz plane-4	&v	6566	F	Vz velocity of plane 4
AC-05	A	Vx plane-1	&v	6568	F	Vx velocity of plane 1
AC-06	A	Vx plane-2	&v	6570	F	Vx velocity of plane 2
AC-07	A	Vx plane-3	&v	6572	F	Vx velocity of plane 3
AC-08	A	Vx plane-4	&v	6574	F	Vx velocity of plane 4
AC-09	A	Ve plane-1	&v	6576	F	Ve velocity of plane 1
AC-10	A	Ve plane-2	&v	6578	F	Ve velocity of plane 2
AC-11	A	Ve plane-3	&v	6580	F	Ve velocity of plane 3
AC-12	A	Ve plane-4	&v	6582	F	Ve velocity of plane 4
AC-15	A	swirl angle plane -1	°	6584	F	Swirl angle of plane 1
AC-16	A	swirl angle plane -2	°	6586	F	Swirl angle of plane 2
AC-17	A	swirl angle plane -3	°	6588	F	Swirl angle of plane 3
AC-18	A	swirl angle plane -4	°	6590	F	Swirl angle of plane 4
AC-20	A	profile PFY1		6800	F	Profile factor PFY1
AC-21	A	profile PFY2		6802	F	Profile factor PFY2
AC-22	A	profile PFY		6804	F	Profile factor PFY
AC-23	A	profile PFY31		6806	F	Profile factor PFY31
AC-24	A	profile PFY35		6808	F	Profile factor PFY35
AC-25	A	profile PFY42		6810	F	Profile factor PFY42
AC-26	A	profile PFY46		6812	F	Profile factor PFY46
AC-27	A	profile PFX		6814	F	Profile factor PFX
AC-28	A	profile PFX12		6816	F	profile PFX12

AC-29	A	profile PFX56		6818	F	Profile PFX56
AC-30	A	profile factor		6820	F	Diagnosis: profile factor
AC-31	A	symmetry X		6822	F	Symmetry X
AC-32	A	symmetry Y		6824	F	Symmetry Y
AC-33	A	symmetry		6826	F	Symmetry

5.2.15 Time and date

		Value	Unit	Modbus		Description
AD-01	N	Time		2560	U	Date and time

5.2.16 USE09-C totalizers

		Value	Unit	Modbus		Description
AE-01	Z	Tot. Volume d.1	&Z	3000	D	Totalizer for volume at measurement conditions, direction 1
AE-02	Z	Tot. Volume d.2	&Z	3004	D	Totalizer for volume at measurement conditions, direction 2
AE-04	Z	Tot. VolumeErr d.1	&Z	3008	D	Disturbing quantity totalizer for volume at measurement conditions, direction 1
AE-05	Z	Tot. VolumeErr d.2	&Z	3012	D	Disturbing quantity totalizer for volume at measurement conditions, direction 2
AE-07	Z	Tot. VolumeSum d.1	&Z	3016	D	Total volume totalizer (Vm + VmD), direction 1
AE-08	Z	Tot. VolumeSum d.2	&Z	3020	D	Total volume totalizer (Vm + VmD), direction 2
AE-09	Z	Total Volume	&Z	3024	D	Total volume totalizer for volume at measurement conditions, direction 2
AE-10	E	tot. Error-mode		2096	M	Error mode of Vm and test totalizers (**STOP**, RUN)
AE-11	E	Total Volume mode		2098	M	Mode of the total volume totalizer (VO) (**D1-D2**, DIRECTION_1, DIRECTION_2)
AE-20	N	test-tot. mode		2097	M	Start/stop of the Vm test totalizers (**STOP**, RUN)
AE-21	A	Vm-dir.1 test sum	&Z	3040	D	Test totalizer for volume at measurement conditions, direction 1
AE-22	A	Vm-dir.2 test sum	&Z	3044	D	Test totalizer for volume at measurement conditions, direction 2
AE-23	A	time for test sum	s	6242	F	Duration of on-the-fly calibration
AE-30	N	Unit LF-Volumes		2217	M	Unit (factor) for totalizers of type LONG (**x 1**, x 0.1, x 0.01)
AE-31	A	L: Tot. Volume d.1	&EinheitLVB	2600	L	Copy of Vm totalizer, direction 1 (with factor in Long format)
AE-32	A	L: Tot. Volume d.2	&EinheitLVB	2602	L	Copy of Vm totalizer, direction 2 (with factor in Long format)
AE-34	A	L: Tot. Vol.Err d.1	&Einheit LVB	2604	L	Copy of disturbing Vm totalizer, direction 1 (with factor in Long format)
AE-35	A	L: Tot. Vol.Err d.2	&EinheitLVB	2606	L	Copy of disturbing Vm totalizer, direction 2 (with factor in Long format)
AE-37	A	L: Tot. Vol.Sum d.1	&EinheitLVB	2608	L	Copy of total volume totalizer (Vm+VmD), direction 1 (with factor in Long format)
AE-38	A	L: Tot. Vol.Sum d.2	&EinheitLVB	2610	L	Copy of total volume totalizer (Vm+VmD), direction 2 (with factor in Long format)
AE-39	A	L: Total Volume	&EinheitLVB	2612	L	Copy of Vm total volume totalizer (with factor in Long format)

5.2.17 ID (type plate)

		Value	Unit	Modbus		Description
AF-01	E	electronic type		500	T	ID: Device type
AF-02	E	electronic no		2564	L	ID: Device No.
AF-03	E	unit no		510	T	ID: Type of measuring element
AF-04	E	unit no		2562	L	ID: Measuring element No.
AF-05	E	manufacturer		2151	M	ID: Manufacturer of the USE09 (**RMG**)
AF-06	E	model (year)		2152	I	ID: Year of construction of the USE09 (DZU interface)
AF-07	E	meter size		520	T	ID: Meter size
AF-08	E	nominal diameter DN	mm	2210	I	ID: Nominal diameter DN
AF-09	E	Pressure rating		740	T	ID: Pressure rating
AF-10	E	pipe flange type		2211	M	ID: Flange standard (**PN**, ANSI)
AF-11	E	pipe flange value	mm	2212	I	ID: Flange value
AF-12	E	Qmin	&Q	1346	F	ID: q-min
AF-13	E	Qmax	&Q	1348	F	ID: q-max
AF-14	E	pmin	bar_g	1350	F	ID: Calibration pressure min
AF-15	E	pmax	bar_g	1352	F	ID: Calibration pressure max
AF-16	E	meas.press. min	bar_a	1520	F	ID: Measuring pressure min
AF-17	E	meas.press. max	bar_a	1522	F	ID: Measuring pressure max
AF-18	E	Tmin	°C	1354	F	ID: T-min
AF-21	E	Tmax	°C	1356	F	ID: T-max
AF-22	E	error curve lin.		2153	M	ID: Error curve linearization (**OFF**, ON)
AF-23	E	gas type		2154	M	ID: Gas type (**NATURAL GAS**)
AF-24	E	p type		2155	M	ID: P-type (**3051CA**, G1151Ap, G1151, 2088A)
AF-25	E	p no.		2566	L	ID: P-No.
AF-26	E	T type		2156	M	ID: T-type (**AGG-EX**, Q-4407, PT100, F-56, F-57)
AF-27	E	T no		2568	L	ID: T-No.
AF-28	E	sensor 1.1 no.		530	T	ID: Sensor 1/1 No.
AF-29	E	sensor 1.1 length	mm	1524	F	ID: Sensor 1/1 length
AF-30	E	sensor 1.1 built		2291	I	ID: Sensor 1/1 year of construction
AF-31	E	sensor 1.2 no.		540	T	ID: Sensor 1/2 No.
AF-32	E	sensor 1.2 length	mm	1526	F	ID: Sensor 1/2 length
AF-33	E	sensor 1.2 built		2292	I	ID: Sensor 1/2 year of construction
AF-34	E	Sensor 2.1 no.		550	T	ID: Sensor 2/1 No.
AF-35	E	sensor 2.1 length	mm	1528	F	ID: Sensor 2/1 length
AF-36	E	sensor 2.1 built		2293	I	ID: Sensor 2/1 year of construction
AF-37	E	Sensor 2.2 no.		560	T	ID: Sensor 2/2 No.
AF-38	E	sensor 2.2 length	mm	1530	F	ID: Sensor 2/2 length
AF-39	E	sensor 2.2 built		2294	I	ID: Sensor 2/2 year of construction
AF-40	E	sensor 3.1 no.		570	T	ID: Sensor 3/1 No.
AF-41	E	sensor 3.1 length	mm	1532	F	ID: Sensor 3/1 length
AF-42	E	sensor 3.1 built		2295	I	ID: Sensor 3/1 year of construction
AF-43	E	sensor 3.2 no.		580	T	ID: Sensor 3/2 No.
AF-44	E	sensor 3.2 length	mm	1534	F	ID: Sensor 3/2 length
AF-45	E	sensor 3.2 built		2296	I	ID: Sensor 3/2 year of construction

AF-46	E	sensor 4.1 no.		590	T	ID: Sensor 4/1 No.
AF-47	E	sensor 4.1 length	mm	1536	F	ID: Sensor 4/1 length
AF-48	E	sensor 4.1 built		2297	I	ID: Sensor 4/1 year of construction
AF-49	E	sensor 4.2 no.		600	T	ID: Sensor 4/2 No.
AF-50	E	sensor 4.2 length	mm	1538	F	ID: Sensor 4/2 length
AF-51	E	sensor 4.2 built		2298	I	ID: Sensor 4/2 year of construction
AF-52	E	sensor 5.1 no.		610	T	ID: Sensor 5/1 No.
AF-53	E	sensor 5.1 length	mm	1540	F	ID: Sensor 5/1 length
AF-54	E	sensor 5.1 built		2299	I	ID: Sensor 5/1 year of construction
AF-55	E	sensor 5.2 no.		620	T	ID: Sensor 5/2 No.
AF-56	E	sensor 5.2 length	mm	1542	F	ID: Sensor 5/2 length
AF-57	E	sensor 5.2 built		2300	I	ID: Sensor 5/2 year of construction
AF-58	E	sensor 6.1 no.		630	T	ID: Sensor 6/1 No.
AF-59	E	sensor 6.1 length	mm	1544	F	ID: Sensor 6/1 length
AF-60	E	sensor 6.1 built		2301	I	ID: Sensor 6/1 year of construction
AF-61	E	sensor 6.2 no.		640	T	ID: Sensor 6/2 No.
AF-62	E	sensor 6.2 length	mm	1546	F	ID: Sensor 6/2 length
AF-63	E	sensor 6.2 built		2302	I	ID: Sensor 6/2 year of construction
AF-64	E	sensor 7.1 no.		650	T	ID: Sensor 7/1 No.
AF-65	E	sensor 7.1 length	mm	1548	F	ID: Sensor 7/1 length
AF-66	E	sensor 7.1 built		2303	I	ID: Sensor 7/1 year of construction
AF-67	E	sensor 7.2 no.		660	T	ID: Sensor 7/2 No.
AF-68	E	sensor 7.2 length	mm	1550	F	ID: Sensor 7/2 length
AF-69	E	sensor 7.2 built		2304	I	ID: Sensor 7/2 year of construction
AF-70	E	sensor 8.1 no.		670	T	ID: Sensor 8/1 No.
AF-71	E	sensor 8.1 length	mm	1552	F	ID: Sensor 8/1 length
AF-72	E	sensor 8.1 built		2305	I	ID: Sensor 8/1 year of construction
AF-73	E	sensor 8.2 no.		680	T	ID: Sensor 8/2 No.
AF-74	E	sensor 8.2 length	mm	1554	F	ID: Sensor 8/2 length
AF-75	E	sensor 8.2 built		2306	I	ID: Sensor 8/2 year of construction
AF-76	E	serial number USE09		790	T	ID: Serial number USE09
AF-77	A	Version		100	F	ID: M32C software version
AF-78	A	CPU CRC	hex	201	I	ID: M32C CRC-16
AF-79	A	Matrix version		200	I	ID: M32C matrix version
AF-80	A	DSP version		102	F	ID: DSP software version
AF-81	A	DSP CRC	hex	202	I	ID: DSP CRC-16
AF-82	A	FPGA version		104	F	ID: FPGA software version
AF-83	A	FPGA CRC	hex	203	I	ID: FPGA CRC-16

5.2.18 Mode

		Value	Unit	Modbus		Description
AG-04	N	codeword		750	C	Entry of codeword
AG-26	E	test working mode		2185	M	Test mode for debugging the DSP (**OFF**, DEBUG, WD)

AG-27	A	Display, LED test		-----	T	Display test, bottom
AG-28	C	Test LEDs		4080	M	Tests the LEDs on the front panel (**OFF**, TEST)
AG-30	C	language		2094	M	Selection of language (**GERMAN**, ENGLISH)
AG-31	Z	units		2095	M	Selection of units (**METRICAL-UNITS**, IMPERIAL-UNITS)
AG-32	A	velocity unit		7030	M	Unit: Velocities (m/s, ft/s)
AG-33	A	flow unit		7031	M	Unit: Flow rate (m^3/h, acfh)
AG-34	A	volume unit		7032	M	Unit: Totalizers (m^3, acf)
AG-35	A	pulse unit		7033	M	Unit: Pulse value (P/m^3, P/cf)

5.2.19 Faults

		Value	Unit	Modbus		Description
AH-01	A	fault message		710	T	Fault message as rolling text
AH-02	A	fault time		7500	U	Date and time of the fault
AH-03	N	clear fault		2126	M	Clear fault (**NO**, YES)
AH-04	E	fault mode		2127	M	Fault mode below Qm-min (**NORMAL**, ALL)
AH-05	E	fault display mode		2128	M	Fault display mode active: Shows all currently active faults (**NORMAL**, ACTIVE)
AH-06	E	path error mode		2129	M	Error mode in the case of a path failure (**WARNING**, ALARM)
AH-07	N	fault,warn contact		2254	M	Mode for alarm and warning contact (NORMAL, 5_SECONDS, HOLD)
AH-09	A	path ok		700	T	Indication of the path status (path monitoring is considered)
AH-10	A	hint status		4008	M	Current hint status (OFF, ON, QUIT)
AH-11	A	warning status		4001	M	Current warning status (OFF, ON, QUIT)
AH-12	A	warn contact		4120	M	Current warning contact (OFF, ON)
AH-13	A	fault status		4000	M	Current alarm status (OFF, ON, QUITI
AH-14	A	fault contact		4121	M	Current alarm contact (OFF, ON)
AH-15	A	USE09 device status	hex	4002	I	USE09 device status
AH-16	A	Fault bit 0-15	hex	4010	I	Active faults (bit-coded) 0-15
AH-17	A	Fault bit 16-31	hex	4011	I	Active faults (bit-coded) 16-31
AH-18	A	Fault bit 32-47	hex	4012	I	Active faults (bit-coded) 32-47
AH-19	A	Fault bit 48-63	hex	4013	I	Active faults (bit-coded) 48-63
AH-20	A	Fault bit 64-79	hex	4014	I	Active faults (bit-coded) 64-79
AH-21	A	Fault bit 80-95	hex	4015	I	Active faults (bit-coded) 80-95
AH-22	A	Fault bit 96-111	hex	4016	I	Active faults (bit-coded) 96-111
AH-23	A	Fault bit 112-127	hex	4017	I	Active faults (bit-coded) 112-127
AH-24	A	Fault bit 128-143	hex	4018	I	Active faults (bit-coded) 128-143
AH-25	A	Fault bit 144-159	hex	4019	I	Active faults (bit-coded) 144-159
AH-26	A	Fault bit 160-175	hex	4020	I	Active faults (bit-coded) 160-175
AH-27	A	Fault bit 176-191	hex	4021	I	Active faults (bit-coded) 176-191
AH-28	A	Fault bit 192-207	hex	4022	I	Active faults (bit-coded) 192-207

5.2.20 DSP parameters

		Value	Unit	Modbus		Description
AI-09	C	number of batches		2136	I	Number of batches
AI-10	E	Relay delay time	ms	2137	I	Relay delay time (RDT)
AI-11	E	sample frequency	MHz	2138	M	Sample frequency in MHz (1.00, 1.25, 1.67, 2.0, 2.5, 3.33, 4.0, **5.0**, 6.67, 10.0)
AI-12	E	fifo size		2139	M	Size of the receiving memory (512, 1024, **2048**)
AI-13	N	FPGA testpin ctrl.	hex	2214	I	Hexadecimal control word for the FPGA test pins
AI-14	E	transmission level	%	2140	I	Transmission level control in %
AI-15	E	send mux time	ms	1364	F	Response time of transmit multiplexer in ms
AI-16	E	receive mux time	ms	1366	F	Response time of receive multiplexer in ms
AI-17	E	Attenuator mode		2141	M	Operating mode of the attenuator (**OFF**, ON, TEST, AUTO_SEPARATE)
AI-18	E	Attenuator on	dB	2142	I	Limit for the attenuator ON
AI-19	E	Attenuator off	dB	2143	I	Limit for the attenuator OFF
AI-20	E	Attenuator HV	dB	2144	I	Limit for the attenuator HV mode
AI-21	C	amp. regulator mode		2145	M	Operating mode of amplitude control (SET VALUE, **ON**, STOP)
AI-22	C	amp. regulator min	%	2146	I	Min. range for amplitude control
AI-23	C	amp. regulator max	%	2147	I	Max. range for amplitude control
AI-24	C	amp. damping		1448	F	Damping for amplitude control
AI-25	E	theoretical VOS	m/s	1368	F	Theoretical velocity of sound of the fluid
AI-26	E	ADC gain		2164	M	FPGA AD gain 0 dB, +6 dB, -6 dB (**1**, 2, 0.5)
AI-27	C	signal tracking		2169	M	Switches signal tracking ON or OFF (ON, **OFF**)
AI-28	C	max. track. offset	Tics	2187	I	Max. size of the tracking window
AI-37	E	corr. mode		2256	M	Correlation mode (OFF, FADE_IN)
AI-38	E	corr. length		2189	I	Length of the correlation window
AI-39	E	Batch: amp. min.	%	2279	I	Batch: Minimum amplitude

5.2.21 DSP parameters 3X

		Value	Unit	Modbus		Description
AJ-07	E	corr. mode (X)		2257	M	Correlation mode (3X measurement) (**OFF**, FADE_IN)
AJ-09	E	Batch: amp. min.	%	2280	I	Batch: Minimum amplitude (3X measurement)

5.2.22 Path# parameters

		Value	Unit	Modbus		Description
AK (...AR)-1	E	p#.1 amp. min limit	%	2000	I	Path#.1 limit of the input signal (LOW)
AK (...AR)-2	E	p#.1 amp. max limit	%	2010	I	Path#.1 limit of the input signal (HIGH)
AK (...AR)-3	E	p#.2 amp. min limit	%	2020	I	Path#.2 limit of the input signal (LOW)

AK (...AR)-4	E	p#.2 amp. max limit	%	2030	I	Path#.2 limit of the input signal (HIGH)
AK (...AR)-5	E	path-# v-min	&v	1000	F	Path# lower limit of the flow velocity
AK (...AR)-6	E	path-# v-max	&v	1020	F	Path# upper limit of the flow velocity
AK (...AR)-7	E	path-# vos-min	&v	1040	F	Path# lower limit of the velocity of sound
AK (...AR)-8	E	path-# vos-max	&v	1060	F	Path# upper limit of the velocity of sound
AK (...AR)-9	E	p# f-trans set val	Hz	2500	L	Path# transmission frequency, set value in Hz
AK (...AR)-10	A	path-# trans. freq.	Hz	2520	L	Path# transmission frequency, actual value in Hz
AK (...AR)-11	E	path-# band limits	%	2190	I	Path# limits which are being monitored
AK (...AR)-12	E	path-# trans.pulses		2040	I	Path# number of transmission pulses
AK (...AR)-13	E	p# filter selection	kHz	2170	M	Path# DSP filter selection (50, 75, **100**, 125, 150, 175, 200, 225, 250, 275, 300, 325)
AK (...AR)-14	E	path-# tw	us	1080	F	Path# delay time
AK (...AR)-16	E	path-# DAC-G1 cmd		2050	I	Path# DAC-G1 instruction register
AK (...AR)-17	E	path-# DAC-G1 val		2060	I	Path# DAC-G1 data register
AK (...AR)-18	E	path-# DAC-G2 cmd		2070	I	Path# DAC-G2 instruction register
AK (...AR)-19	E	path-# DAC-G2 val		2080	I	Path# DAC-G2 data register
AK (...AR)-20	A	p# blanking delay	us	1100	F	Path# blanking delay
AK (...AR)-21	A	p# blanking count	tic	2540	L	Path# blanking count
AK (...AR)-22	E	path-# decay time	ms	1120	F	Path# decay time at the end of measurement
AK (...AR)-23	E	path-# path length	mm	1140	F	Path# length of path
AK (...AR)-24	E	path-# axial dist.	mm	1160	F	Path# min. axial distance of path
AK (...AR)-25	E	p# assembly angle	°	1500	F	Path# assembly angle of the sensor
AK (...AR)-26	E	p# delta-t offset	us	1420	F	Path# time difference offset
AK (...AR)-27	E	const-K# d.1	[1]	1200	F	Path# constant K# direction 1
AK (...AR)-28	E	const-K# d.2	[1]	1220	F	Path# constant K# direction 2
AK (...AR)-29	E	const w#	[1]	1240	F	Path# constant w#
AK (...AR)-30	E	p# tic offset	tic	2200	I	Path# Tic offset
AK (...AR)-31	E	p# tic offset (X)	tic	2260	I	Path# Tic offset (3X measurement)
AK (...AR)-32	E	p# AGC-limit	dB	2220	I	Path# AGC error limit
AK (...AR)-34	C	P# no. of f-batches		2312	I	Path# number of measurements (FBatches)

Attention:

Notice

The Modbus addresses stated are for path 1!

To determine the Modbus addresses for the other paths, see chapter "Brief description of the USE09 Modbus".

5.2.23 Service

		Value	Unit	Modbus		Description
AS-01	E	CPU speed	Hz	2574	L	Actual M32 clock speed
AS-02	E	DSP speed	Hz	2576	L	Actual DSP clock speed
AS-04	E	FPGA speed	Hz	2578	L	Actual FPGA clock speed
AS-05	E	ext. card s.no.		2584	L	IO card s. No.
AS-06	E	ext. ADC s.no.		2586	L	IO-ADC card s. No.
AS-07	E	write opt.EEProm		2167	M	(Service key!) Writes paramet. in the OPT-EEP (**NO**, YES)
AS-08	E	write ADC EEProm		2168	M	(Service key!) Writes paramet. in the OPT-ADC-EEP (**NO**, YES)
AS-09	N	LCD lighting		2183	M	Display lighting if key is pressed or steady light (**KEY**, ALWAYS)
AS-10	Z	parameter reset		2148	M	Load new parameters (**NO**, YES)
AS-12	C	def. val. reset		2149	M	Reset default values (**NO**, YES)
AS-13	C	RV: number		2150	I	No of mean values used to calcul. the replacement values
AS-14	A	RV status		720	T	Indication of the replacement value status
AS-15	C	def. val. mode		2213	M	Operating mode of default values (OFF, **ON**)
AS-16	N	Raw data path no.		2124	I	Raw data: Path selection (0=OFF)
AS-17	N	Raw data type		2184	M	Raw data: Type selection (TEST, **RAW**, FILTER, RAW_ERR, FILTER_ERR, FFG, ROH_FFT, FILTER_FFT)
AS-18	N	Raw data function		2215	I	Raw data: Trigger function (subselection)
AS-20	A	M32 temperature	°C	5000	F	Temperature of the M32 board
AS-21	A	transmit level	%	5002	F	Transmission level HV analog board
AS-22	A	+-5V symmetry	V	5004	F	Symmetry +-5V, analog board
AS-23	A	system temperature	°C	5006	F	Temperature, baseboard
AS-24	A	+-12V symmetry	V	5008	F	Symmetry +-12V, analog board
AS-25	A	1V2 voltage	V	5010	F	Voltage 1V2 DSP board
AS-26	A	1V5 voltage	V	5012	F	Voltage 1V5 DSP board
AS-27	A	3V3 voltage	V	5014	F	Voltage 3V3 M32 board
AS-28	A	adc-p binary val.		7502	L	Pressure input, transmitter value
AS-29	A	adc-t binary val.		7504	L	PT100 input, transmitter value
AS-30	E	max. sys. temp.	°C	1440	F	System temperature, max. value
AS-31	E	time max. sys. temp		2588	U	Time of max. system temperature
AS-32	E	min. sys. temp.	°C	1442	F	System temperature, min. value
AS-33	E	time min. sys. temp		2590	U	Time of min. system temperature

5.2.24 Data logger

		Value	Unit	Modbus		Description
AT-01	A	Log-data date		800	T	Data logger, date of last change
AT-02	A	Log-data coordinate		810	T	Data logger, coordinate of last change
AT-03	A	Log-data old value		820	T	Data logger (old value)
AT-04	A	Log-data new value		830	T	Data logger (new value)
AT-10	A	Log-data fill level	%	4007	I	Data logger, fill level
AT-11	E	clear par-log		2157	M	Clear parameter logging list (**NO**, YES)
AT-12	N	clear event-log		2216	M	Clear event logging list (**NO**, YES)

5.2.25 Site information

		Value	Unit	Modbus		Description
AU-01	N	User Text-1		840	T	User-programmable text line 1
AU-02	N	User Text-2		850	T	User-programmable text line 2
AU-03	N	User Text-3		860	T	User-programmable text line 3
AU-04	N	User Text-4		870	T	User-programmable text line 4
AU-05	N	User Text-5		880	T	User-programmable text line 5

6 Alarm- and warning messages

6.1 Alarm messages

No.	Message	Explanation
0	No Error	Error-free operation
1	Power Off	Power failure in the meantime
2	FPGA Timeout	FPGA communication: no response from FPGA
3	FPGA CRC	FPGA communication: incorrect checksum
4	DSP-SPI Timeout	DSP communication: no response from the **s**erial **p**eripheral **i**nterface (data bus) of the **d**igital **s**ignal **p**rocessor
5	DSP-SPI CRC	DSP communication: incorrect checksum at the SPI
6	DSP no Data	No DSP measuring data available
7	DSP R-length	DSP communication: invalid telegram length
8	DSP	Critical DSP fault. Fault bits are to be read off separately in DSP fault
9	FPGA	Critical FPGA fault. Fault bits are to be read off separately in FPGA fault
10	COM-0	Error in data transmission via interface COM-0
11	COM-1	Error in data transmission via interface COM-1
12	COM-2	Error in data transmission via interface COM-2
13	COM-3	Error in data transmission via interface COM-3
14	AD-Converter	Fault in the analog-digital converter of the option card 2
15	extension card	Fault in the option card 1
16	Tot. not valid	Totalizers invalid
17	RV.not valid	Replacement value of the path reconstruction invalid
18	F-Ram not valid	Checksum of the F-RAM telegram invalid
19	F-Ram size	Length of the F-RAM telegram invalid
20	opt. data crc	Checksum of the data from the option card invalid
21	ADCdata crc	Checksum of the data from the AD converter invalid
22	c-out min/max	Min/max limits of the current output violated
23	trans.level min	Transmission level too low
24	DSPversion	DSP SW version not compatible to M32 SW version
25	FPGA version	FPGA version not compatible to M32 SW version
26	LOGP not valid	Parameter in data logger invalid
30	Path1 Failure	Failure of measuring path 1
31	Path2 Failure	Failure of measuring path 2
32	Path3 Failure	Failure of measuring path 3
33	Path4 Failure	Failure of measuring path 4
34	Path5 Failure	Failure of measuring path 5
35	Path6 Failure	Failure of measuring path 6
36	Path7 Failure	Failure of measuring path 7 (reserve)
37	Path8 Failure	Failure of measuring path 8 (reserve)
38	max. Path	Maximum permissible number of path failures exceeded
40	RV not calc.	Replacement value for failed path could not be calculated
41	USE09 Timeout	No valid measurement, all measuring paths have failed
42	ADC temperature	ADC fault temperature input
43	ADC pressure	ADC fault pressure input
45	I1 out min/max	Current output outside of the min./max. limits
47	temp.min/max	Temperature outside of the min./max. limits

48	press. min/max	Pressure outside of the min./max. limits
50	DSP path1	Critical path fault. Fault bits are to be read off separately in Path1 Failure
51	DSP path2	Critical path fault. Fault bits are to be read off separately in Path2 Failure
52	DSP path3	Critical path fault. Fault bits are to be read off separately in Path3 Failure
53	DSP path4	Critical path fault. Fault bits are to be read off separately in Path4 Failure
54	DSP path5	Critical path fault. Fault bits are to be read off separately in Path5 Failure
55	DSP path6	Critical path fault. Fault bits are to be read off separately in Path6 Failure
56	DSP path7	Critical path fault. Fault bits are to be read off separately in Path7 Failure (reserve)
57	DSP path8	Critical path fault. Fault bits are to be read off separately in Path8 Failure (reserve)
60	p1 AGC limit	Amplification factor for path 1 outside of the permissible limits
61	p2 AGC limit	Amplification factor for path 2 outside of the permissible limits
62	p3 AGC limit	Amplification factor for path 3 outside of the permissible limits
63	p4 AGC limit	Amplification factor for path 4 outside of the permissible limits
64	p5 AGC limit	Amplification factor for path 5 outside of the permissible limits
65	p6 AGC limit	Amplification factor for path 6 outside of the permissible limits
66	p7 AGC limit	Amplification factor for path 7 outside of the permissible limits (reserve)
67	p8 AGC limit	Amplification factor for path 8 outside of the permissible limits (reserve)
77	QVm min. Limit	Volumetric flow rate at measurement conditions below Qmin
78	QVm max. Limit	Volumetric flow rate at measurement conditions exceeds Qmax
99	wrong parameter	Entered parameter invalid

6.2 Warning messages

No.	Message	Explanation
100	Path1 Warn.	Fraction of invalid measurements for path 1 too high
101	Path2 Warn.	Fraction of invalid measurements for path 2 too high
102	Path3 Warn.	Fraction of invalid measurements for path 3 too high
103	Path4 Warn.	Fraction of invalid measurements for path 4 too high
104	Path5 Warn.	Fraction of invalid measurements for path 5 too high
105	Path6 Warn.	Fraction of invalid measurements for path 6 too high
106	Path7 Warn.	Fraction of invalid measurements for path 7 too high (reserve)
107	Path8 Warn.	Fraction of invalid measurements for path 8 too high (reserve)
108	RTC Hardware	Hardware fault of real time clock
109	ext. Warning	External warning
110	P1 v min/max	Flow velocity from path 1 outside of the min./max. limits
111	P2 v min/max	Flow velocity from path 2 outside of the min./max. limits
112	P3 v min/max	Flow velocity from path 3 outside of the min./max. limits
113	P4 v min/max	Flow velocity from path 4 outside of the min./max. limits
114	P5 v min/max	Flow velocity from path 5 outside of the min./max. limits
115	P6 v min/max	Flow velocity from path 6 outside of the min./max. limits
116	P7 v min/max	Flow velocity from path 7 outside of the min./max. limits (reserve)
117	P8 v min/max	Flow velocity from path 8 outside of the min./max. limits (reserve)

118	work.mode test	Meter is running in test mode
120	P1 c min/max	Velocity of sound from path 1 outside of the min./max. limits
121	P2 c min/max	Velocity of sound from path 2 outside of the min./max. limits
122	P3 c min/max	Velocity of sound from path 3 outside of the min./max. limits
123	P4 c min/max	Velocity of sound from path 4 outside of the min./max. limits
124	P5 c min/max	Velocity of sound from path 5 outside of the min./max. limits
125	P6 c min/max	Velocity of sound from path 6 outside of the min./max. limits
126	P7 c min/max	Velocity of sound from path 7 outside of the min./max. limits (reserve)
127	P8 c min/max	Velocity of sound from path 8 outside of the min./max. limits (reserve)
130	p1.1 amplitude	Amplitude of the signal from sensor 1.1 too small
131	p2.1 amplitude	Amplitude of the signal from sensor 2.1 too small
132	p3.1 amplitude	Amplitude of the signal from sensor 3.1 too small
133	p4.1 amplitude	Amplitude of the signal from sensor 4.1 too small
134	p5.1 amplitude	Amplitude of the signal from sensor 5.1 too small
135	p6.1 amplitude	Amplitude of the signal from sensor 6.1 too small
136	p7.1 amplitude	Amplitude of the signal from sensor 7.1 too small (reserve)
137	p8.1 amplitude	Amplitude of the signal from sensor 8.1 too small (reserve)
140	p1.2 amplitude	Amplitude of the signal from sensor 1.2 too small
141	p2.2 amplitude	Amplitude of the signal from sensor 2.2 too small
142	p3.2 amplitude	Amplitude of the signal from sensor 3.2 too small
143	p4.2 amplitude	Amplitude of the signal from sensor 4.2 too small
144	p5.2 amplitude	Amplitude of the signal from sensor 5.2 too small
145	p6.2 amplitude	Amplitude of the signal from sensor 6.2 too small
146	p7.2 amplitude	Amplitude of the signal from sensor 7.2 too small (reserve)
147	p8.2 amplitude	Amplitude of the signal from sensor 8.2 too small (reserve)
150	Path1 delta c	Deviation of velocity of sound in path 1 from the average velocity of sound too big
151	Path2 delta c	Deviation of velocity of sound in path 2 from the average velocity of sound too big
152	Path3 delta c	Deviation of velocity of sound in path 3 from the average velocity of sound too big
153	Path4 delta c	Deviation of velocity of sound in path 4 from the average velocity of sound too big
154	Path5 delta c	Deviation of velocity of sound in path 5 from the average velocity of sound too big
155	Path6 delta c	Deviation of velocity of sound in path 6 from the average velocity of sound too big
156	Path7 delta c	Deviation of velocity of sound in path 7 from the average velocity of sound too big (reserve)
157	Path8 delta c	Deviation of velocity of sound in path 8 from the average velocity of sound too big (reserve)
170	p1 AGC delta	Deviation of the amplification factor in path 1 from the average gain too big
171	p2 AGC delta	Deviation of the amplification factor in path 2 from the average gain too big
172	p3 AGC delta	Deviation of the amplification factor in path 3 from the average gain too big
173	p4 AGC delta	Deviation of the amplification factor in path 4 from the average gain too big
174	p5 AGC delta	Deviation of the amplification factor in path 5 from the average gain too big
175	p6 AGC delta	Deviation of the amplification factor in path 6 from the average gain too big
176	p7 AGC delta	Deviation of the amplification factor in path 7 from the average gain too big (reserve)
177	p8 AGC delta	Deviation of the amplification factor in path 8 from the average gain too big (reserve)

6.3 Hints

No.	Message	Explanation
181	sys. temp min	System temperature too low
182	sys. temp max	System temperature too high
183	Rawdata len	Length of raw data telegram incorrect
184	Rawdata crc	Checksum of raw data telegram incorrect
185	P-LOG full	Parameter data logger full
186	DSP info len	Length of DSP info-telegram incorrect
187	DSP info crc	Checksum of DSP info.telegram incorrect

7 Brief description USE09 Modbus

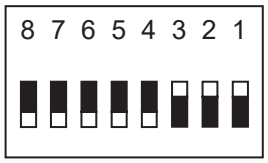
7.1 Parameterizing Modbus

The USE09 has three serial interfaces:
- interface – 0 is reserved for servicing (RMGView[USM]).
- interface – 1 has been designed for exchanging data with volume correctors.
- interface – 2 (optional) is intended for communications with a Modbus master.

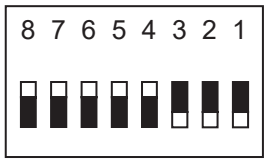
The interface and Modbus parameters can be set in the "Serial ports" column.

Interface – 2 can be configured as RS232 or RS485. Such configuration is to be made via the software and the hardware.

DIP switch
RS232 configuration



DIP switch
RS485 configuration



This DIP switch is located on the optional card.

USE09 Modbus commands

The USE09 knows the following Modbus commands:

(03 Hex) Read Holding Registers
(06 Hex) Read Single Register
(10 Hex) Preset Multiple Register
(08 Hex) Diagnostic
(00 Hex) Return Query Data

USE09 Exception Codes

01 Illegal Function
02 Illegal Data Address (register not available)
03 Illegal Data Value (register not writeable or wrong value)

Example (Modbus query / response):

Query:	**Modbus - ASCII**	**Modbus - RTU**	
Start Char	**:**		
Slave Address	**01**	**01**	
Function	**03**	**03**	

Starting Address Hi	**0F**	**0F**	
Starting Address Lo	**A2**	**A2**	Register = 4002 (0FA2)
No. of Points Hi	**00**	**00**	
No. of Points Lo	**01**	**01**	Number = 0001 (0001)
LRC / CRC	**42**	**26**	
carriage return	**CR**	**FC**	
line feed	**LF**		
Response:			
Start Char	**:**		
Slave Address	**01**	**01**	
Function	**03**	**03**	
Byte Count	**02**	**02**	
Data Hi (Reg 2000)	**A8**	**A8**	
Data Lo (Reg 2000)	**01**	**01**	Value = A801
LRC	**51**	**06**	
carriage return	**CR**	**44**	
line feed	**LF**		
	Values in ASCII	**Values in HEX**	

Read Holding Register 4002, value is A801 (Hex)

Example (Modbus number formats):

Data type	Register	Value	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
float	2	273.15	0x93	0x33	0x43	0x88				
Text	10	USZ08-6P	0x53	0x55	0x30	0x5A	0x2D	0x38	0x50	0x36
			0x00	0x00	0x00	0x00	0x00	0x00	0x00	0x00
			0x00	0x00	0x00	0x00				
int	1	44067	0xAC	0x23						
double	4	14.2740	0x13	0x58	0x8A	0xCF	0x8C	0x4C	0x40	0x2C
long	2	100000	0x86	0xA0	0x00	0x01				

Please see the Modbus specification for further information.

Special features of the USE09 Modbus:

- All data types comprising more than one register can only be written completely.

  float (F) : 2 registers
  double (D) : 4 registers
  long integer (L) : 2 registers
  integer (I) : 1 register
  Text (T) : 10 registers

The data types are to be found in the tables of the "USE 09 measured values and parameters" chapter in the column standing to the right of the Modbus address.

- Text fields must at least have one final null (0x00). Max. text length is 19 characters.
- Modbus registers are the registers transmitted through the bus – therefore, no registers +- 1!
  In any case, a register offset can be set in the USE09.
- In the tables with the measured values and parameters for the individual paths, there are the Modbus addresses for path 1; the addresses for paths 2 to 8 follow directly afterwards.
  Example: The velocity of sound for path 1 has address 6020. Since it is a quantity in the float format, the address for path 2 is 6022 and the velocity of sound for path 6 is to be found under address 6020 + 5 * 2 = 6030.

Please contact the service from RMG Messtechnik (see contact on the 2nd page) to obtain the complete Modbus register assignments for the USE09.

8 Technical specifications

Power supply:
Measuring element: 24 VDC
ERZ 2000 USC: 24 VDC or 230 VAC

Power input:
Measuring element: USE 09: 5 W USE 09C: 15 W
ERZ 2000 USC: 24 W

Protection class: IP 65

Interfaces:
RS 485 0 (RMGView^{USM}): 9600 / 19200 / 38400 / 57600 baud
RS 485 1: 9600 / 19200 / 38400 / 57600 baud
RS 485 2 (with USE 09C): 9600 / 19200 / 38400 / 57600 baud
(optional for the USE 09)

Current output: U_{max}= 16 V Load resistance: max. 400 Ω

Pulse outputs: U_{max}= 30 V f_{max}= 5 kHz

Sensor frequency: 120 kHz or 200 kHz

Flow velocity: -40 to + 40 m/s

Temperature range: -20° to +55°C (optional: -40°C to +55°C)

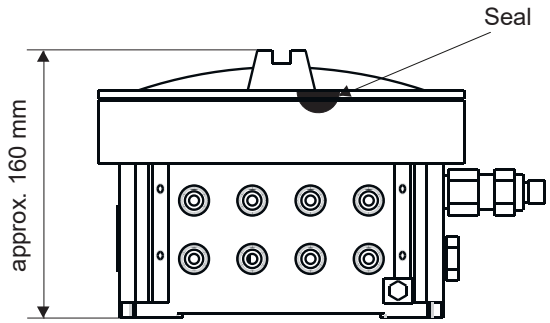
Measuring ranges: for custody transfer metering

Nominal diameter		Measuring range (m³/h)		Acoustic paths
mm	inches	Qmin	Qmax	
100	4	13	1000	6
150	6	20	2500	6
200	8	40	4000	6
250	10	65	6500	6
300	12	80	10000	6
400	16	130	16000	6
500	20	200	25000	6
600	24	320	40000	6

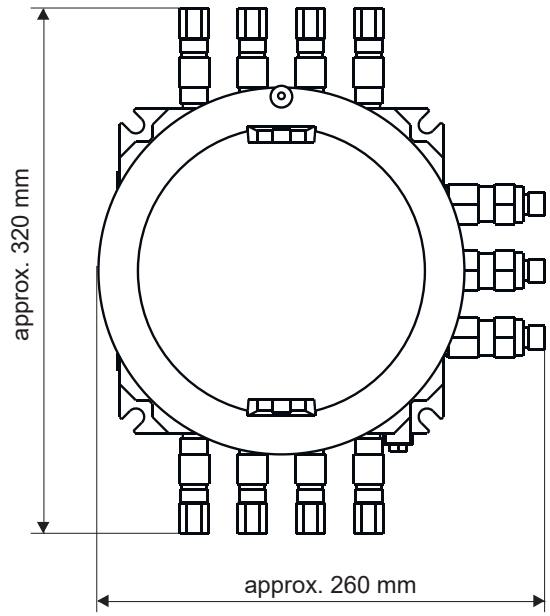
9 Seal diagrams

9.1 Seals of the USE 09 ultrasonic electronic system

Side view:



Top view:

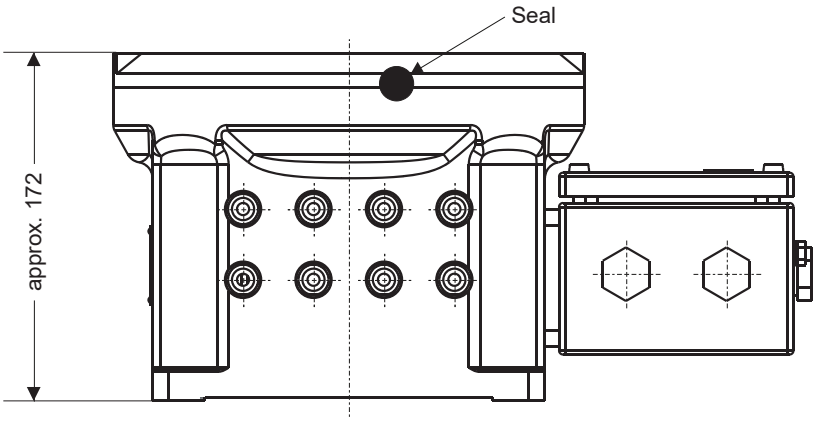


Drw. No.: 059504.4

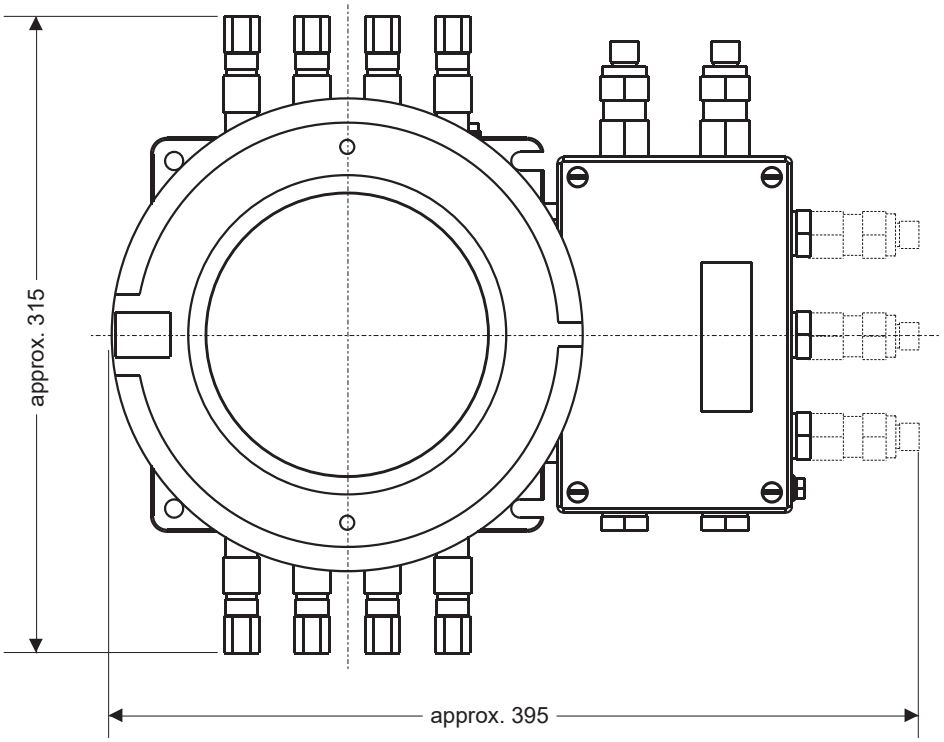
Status: 14.03.2007

9.2 Seals of the USE 09-C-LT

Side view



Top view

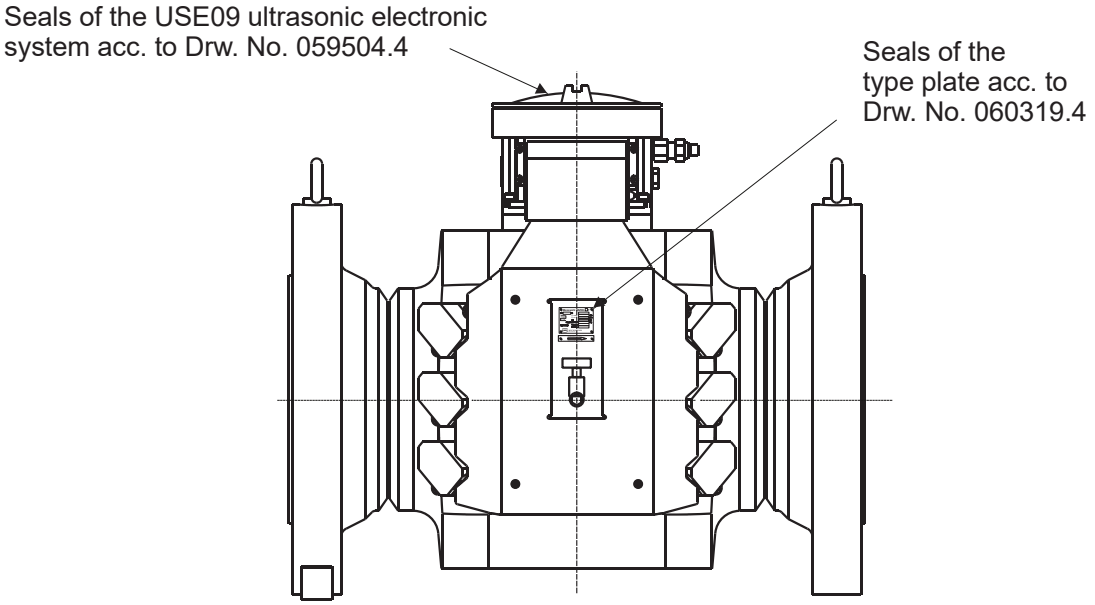


Drw. No.: 060377.4

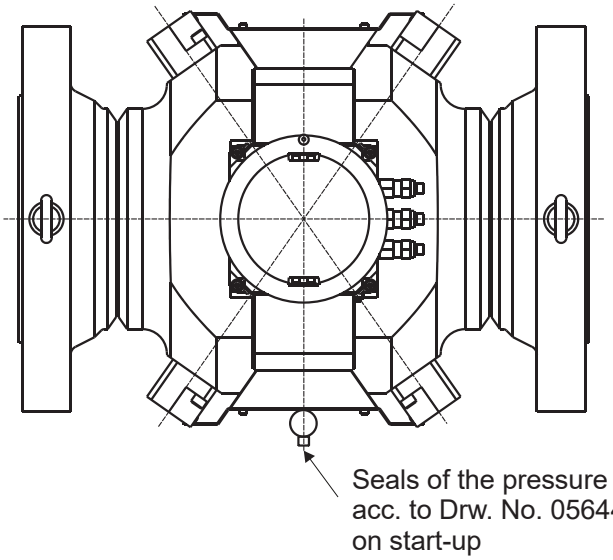
Status: 04.05.2009

9.3 Seals of USZ 08-6P (with USE 09)

Front view:



Top view:

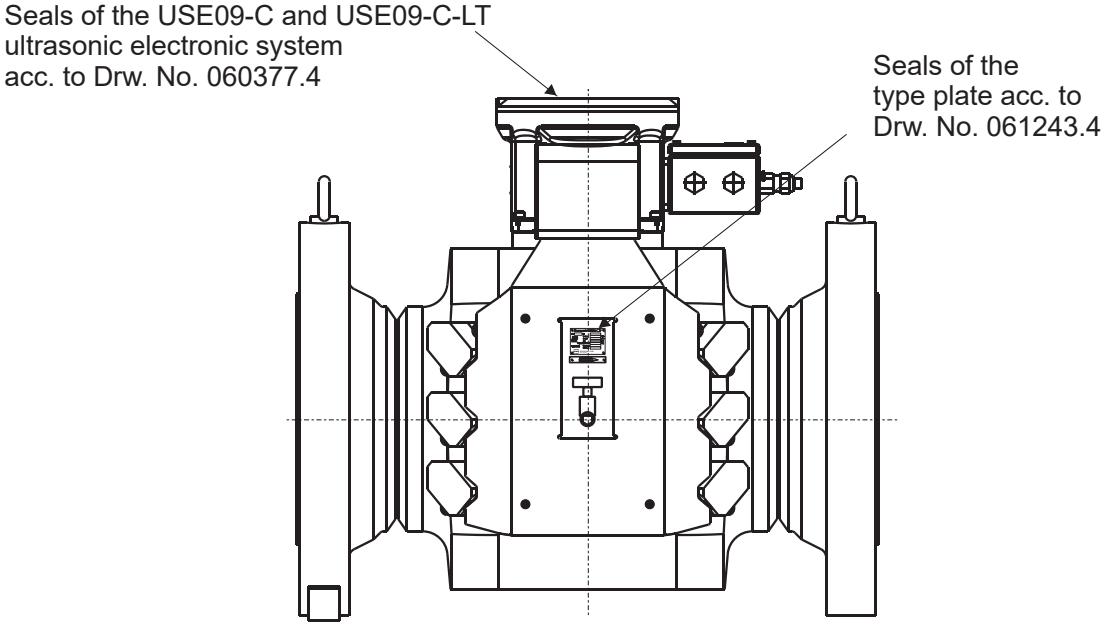


Drw. No.: 060318.4

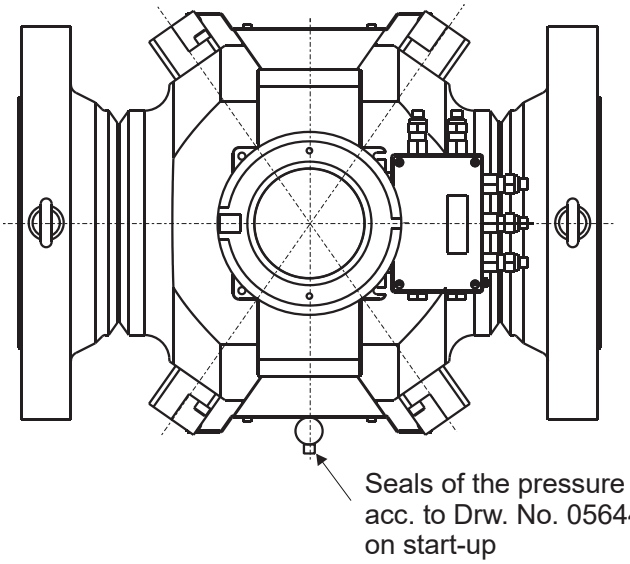
Status: 27.03.2008

9.4 Seals of USZ 08-6P (with USE 09-C))

Front view:



Top view:

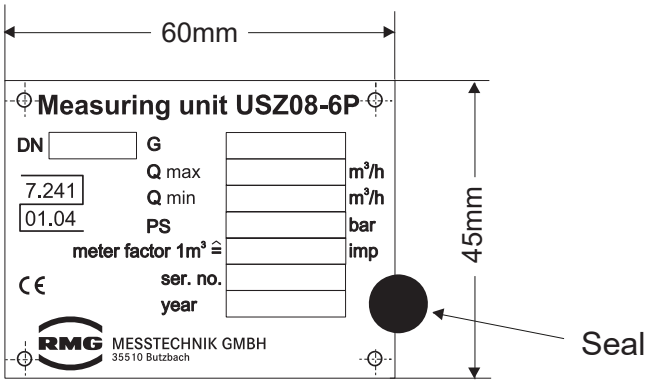


Drw. No.: 061246.4

Status: 04.05.2009

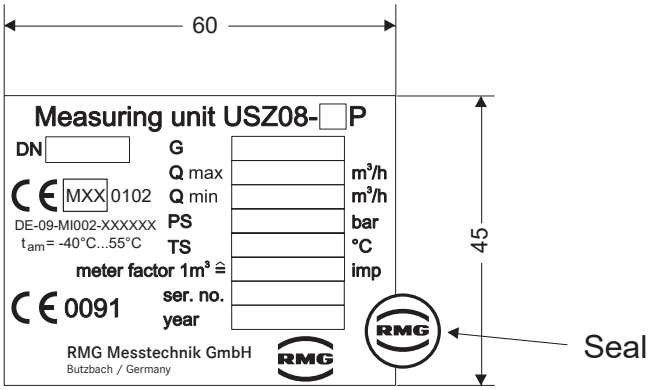
9.5 Seals on type plate USZ 08 measuring element

Device with PTB approval



Drw. No.: 060319.4 Status: 27.03.2008

Device with MID approval



Drw.-No.: 061243.4 Status: 04.05.2009

Subject to technical modification

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