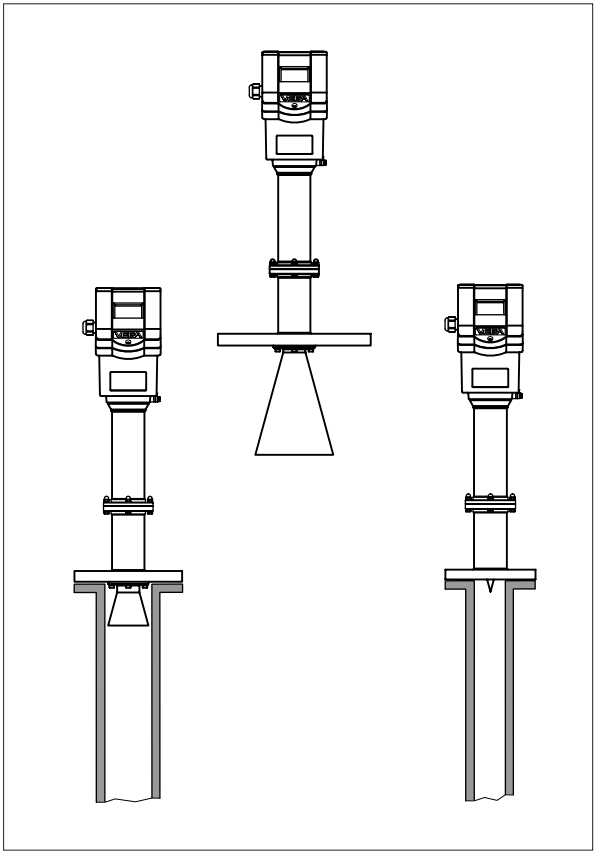
Operating Instructions

VEGAPULS 56K



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Safety information

Please read this manual carefully, and also take note of country-specific installation standards (e.g. the VDE regulations in Germany) as well as all prevailing safety regulations and accident prevention rules.
For safety and warranty reasons, any internal work on the instruments, apart from that involved in normal installation and electrical connection, must be carried out only by VEGA personnel.

Note Ex area

Please note the attached safety instructions containing important information on installation and operation in Ex areas.
These safety instructions are part of the operating instructions manual and come with the Ex approved instruments.

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1 Product description

Level measurement in high temperature processes or of products with high temperatures was formerly very difficult or even impossible. And if the measurement had to be made under high pressure, as well, there was practically no measuring system available. Not to mention a non-contacting system with high measurement accuracy.

In distillation and stripper columns, levels (e.g. of sump, plate and head products) were usually measured indirectly up to now via pressure transmitters or differential pressure measurements. The installation required for such pressure measuring systems (pressure lines, pressure transmitters…) is considerable and expensive, often amounting to several times the value of the sensor itself. Due to the lack of suitable alternatives, instrumentation departments have not only had to live with this but also accept high maintenance costs (cleaning of measuring pipes, errors by condensation, buildup on the diaphragm) as well as inadequate accuracy (temperature errors, density fluctuations, installation faults…).

The requirements of the petrochemical industry on a non-contact level sensor are the following:

- independent of temperature and pressure
- process temperature up to 350°C
- process pressure up to 64 bar
- high resistance wetted parts, materials for universal use
- accuracy 0.1 %
- rugged metal housing
- Ex-approved (available in EEx d and EEx ia)
- loop-powered as well as digitally connectable

This state of affairs defines the development goals for a high-temperature radar level measuring system, the VEGAPULS 56 series. The new series represents an innovation in high temperature radar sensors for level measurement, in temperatures up to 350°C and pressures up to 64 bar.

The sensors would not have been possible without the new developments in materials science and production technology. A specially developed ceramic is used as coupling material. It has high frequency characteristics similar to those of plastic materials, which are normally used. But it demonstrates incredibly high chemical and thermal resistance.

The sensor is connected to the process only via high-grade, expensive materials. This refers not so much to the flange of high-alloy stainless steel (1.4571 or better), as to the specially developed ceramic (Al_2O_3) and its connecting elements. The ceramic rod receives from the high frequency module (from the intelligent Fuzzy-Logic processing electronics) the radar signals and its cone-shaped end operates as emitter and receiver. The seal between stainless steel flange and ceramic rod is an expensively produced tantalum seal ring.

1.1 Function

Radio **d**etecting **a**nd **r**anging: Radar. VEGAPULS radar sensors are used for non-contact and continuous distance measurement. The measured distance corresponds to a filling height and is outputted as level.

Measuring principle:

emission – reflection – reception

Extremely small 5.8 GHz radar signals are emitted from the antenna of the radar sensor as short pulses. The radar pulses reflected by the sensor environment and the product are received by the antenna as radar echoes. The running period of the radar pulses from emission to reception is proportional to the distance and hence to the level.

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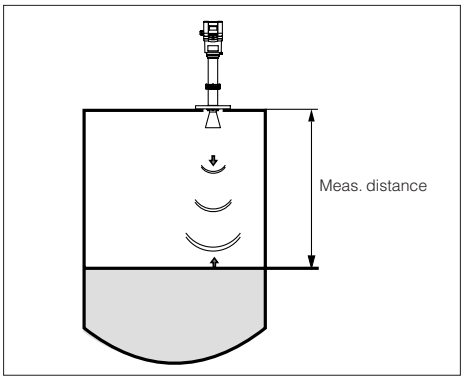
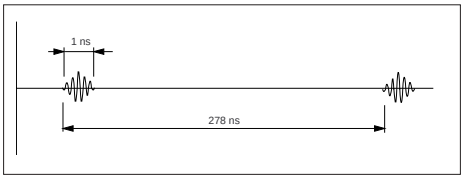


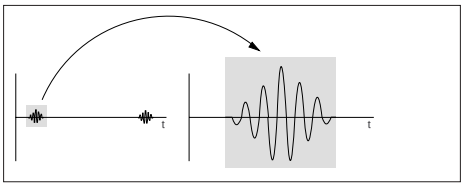
emission - reflection - reception

The radar pulses are emitted by the antenna system as pulse packets with a pulse duration of 1 ns and pulse intervals of 278 ns; this corresponds to a pulse package frequency of 3.6 MHz. In the pulse intervals, the antenna system operates as a receiver. Signal running periods of less than one billionth of a second must be processed and the echo image evaluated in a fraction of a second.



Pulse sequence

VEGAPULS can achieve this through a special time transformation procedure which spreads out the more than 3.6 million echo images per second in a slow-motion picture, then freezes and processes them.



Time transformation

Hence, it is possible for the VEGAPULS 56 radar sensors to process the slow-motion pictures of the sensor environment precisely and in detail in cycles of 0.5 to 1 second without using time-consuming frequency analysis (e.g. FMCW, required by other radar techniques).

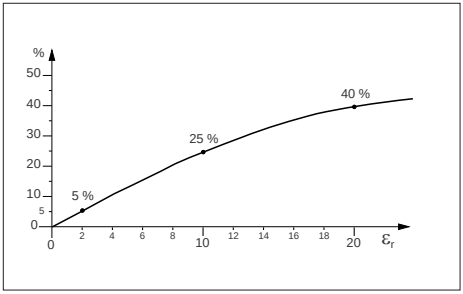
Nearly all products can be measured

Radar signals display physical properties similar to those of visible light. According to the quantum theory, they propagate through empty space. Hence, they are not dependent on a conductive medium (air), and they spread out like light at the speed of light. Radar signals react to two basic electrical properties:

- the electrical conductivity of a substance
- the dielectric constant of a substance.

All products which are electrically conductive reflect radar signals very well. Even slightly conductive products provide a sufficiently strong reflection for a reliable measurement.

All products with a dielectric constant ε_r greater than 2.0 reflect radar pulses sufficiently (note: air has a dielectric constant ε_r of 1).



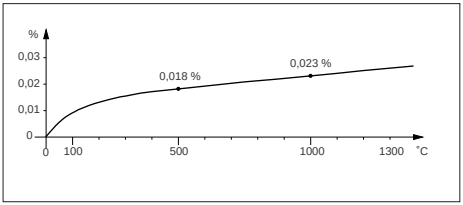
Reflected radar power dependent on the dielectric constant of the measured product

Signal reflectivity grows stronger with increasing conductivity or increasing dielectric constant of the product. Hence, nearly all substances can be measured.

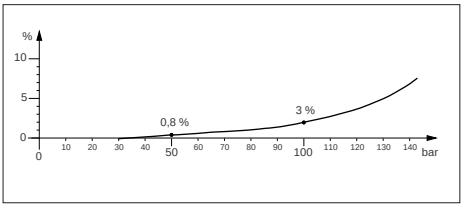
With standard flanges from DN 50 up to DN 250, ANSI 2“ up to ANSI 10“ the sensor antenna systems are adapted to the various products and process environments. The high-quality materials withstand extreme chemical and physical conditions. The sensors deliver stable, reproducible analogue or digital level signals with reliability and precision, and have a long useful life.

Continuous and accurate

Unaffected by temperature, pressure and atmosphere content, VEGAPULS radar sensors measure quickly and accurately the levels of widely varying products.



Temperature influence: Temperature error absolutely zero (e.g. at 500°C 0.018 %)



Pressure influence: Error with pressure increase very low (e.g. at 50 bar 0.8 %)

VEGAPULS 56 sensors now make radar level measurement possible in plants where it was hitherto unthinkable.

1.2 Application features

Applications

- level measurement of liquids and solids
- measurement also in vacuum
- all slightly conductive materials and all substances with a dielectric constant > 2.0 can be measured
- measuring range 0 … 20 m

Two-wire technology

- power supply and output signal on one two-wire cable
- 4 … 20 mA output signal or digital output signal

Rugged and abrasionproof

- non-contact
- high-resistance materials

Exact and reliable

- accuracy 1 mm
- unaffected by noise, vapours, dusts, gas compositions and inert gas stratification
- unaffected by varying density and temperature of the medium
- measurement in pressures up to 64 bar and product temperatures up to 350°C

Communicative

- individual connection, with 15 sensors on one two-wire cable (digital output signal)
- integrated measured value display
- optional display module separate from sensor
- connection to all BUS systems: Interbus S, Modbus, Siemens 3964R, Profibus DP, Profibus FMS, ASCII
- adjustment from the PLC level

Ex approvals

- CENELEC, FM, CSA, ABS, LRS, GL, LR, ATEX, PTB

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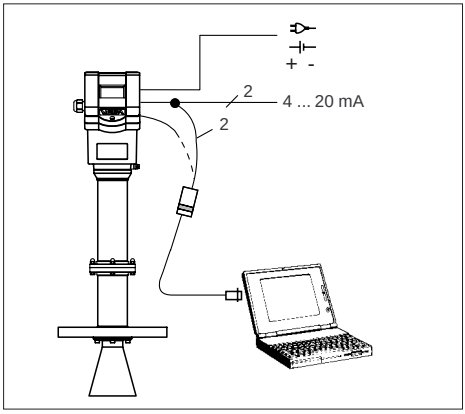
1.3 Adjustment

Every measurement set-up is unique. For that reason, every radar sensor needs some basic information on the application and the environment, e.g. which level means "empty" and which level "full". Beside this "empty and full adjustment", many other settings and adjustments are possible with VEGAPULS radar sensors.

The adjustment and parameter setting of radar sensors is carried out with
- the PC
- the detachable adjustment module MINICOM
- the HART® handheld

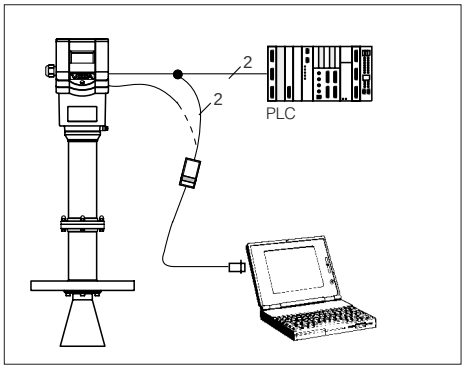
Adjustment with the PC

The set-up and adjustment of the radar sensors is generally done on the PC with the adjustment software PACT*ware*™. The program leads quickly through the adjustment and parameter setting by means of pictures, graphics and process visualisations.
The PC can be connected at any measuring site in the system or directly to the signal cable. It is connected by means of the two-wire PC interface converter VEGACONNECT 3 to the sensor or the signal cable.



Adjustment with the PC on the 4 … 20 mA signal and supply cable to the PLC or directly on the sensor

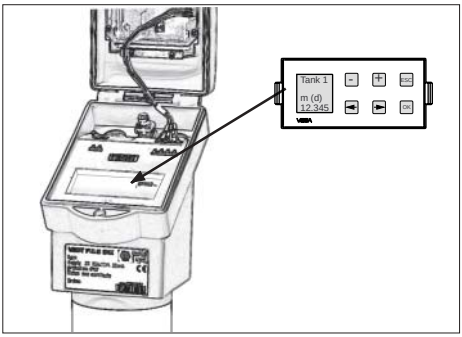
The adjustment and parameter data can be saved with the adjustment software on the PC and can be protected by passwords. On request, the adjustments can be quickly transferred to other sensors.



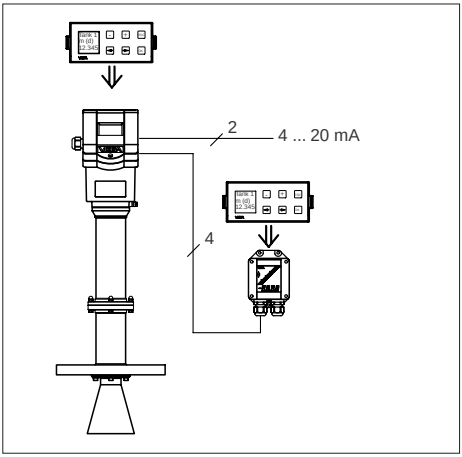
Adjustment with the PC on the 4 … 20 mA signal and supply cable to the PLC or directly on the sensor

Adjustment with the adjustment module MINICOM

With the small (3.2 cm x 6.7 cm) 6-key adjustment module with display, the adjustment can be carried out in clear text dialogue. The adjustment module can be plugged into the radar sensor or into the optional, external indicating instrument.



Detachable adjustment module MINICOM



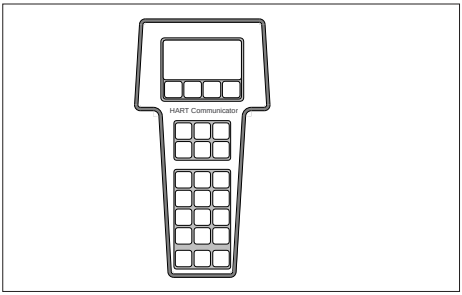
Adjustment with detachable adjustment module on the radar sensor or on the external indicating instrument VEGADIS 50

Unauthorised sensor adjustments can be prevented by removing the adjustment module.

Adjustment with the HART® handheld

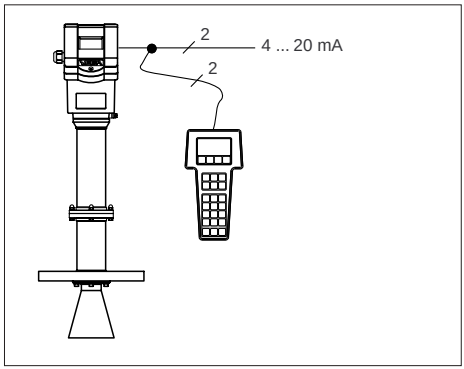
VEGAPULS series 50 sensors with 4 … 20 mA output signal can also be adjusted with the HART® handheld. A special DDD (Data Device Description) is not necessary - the sensors can be adjusted with the HART® standard menus of the handheld.

To make adjustments, simply connect the



HART® handheld

HART® handheld to the 4 … 20 mA output signal cable or insert the two communication cables of the HART® handheld into the adjustment jacks on the sensor.



HART® handheld on the 4 … 20 mA signal cable

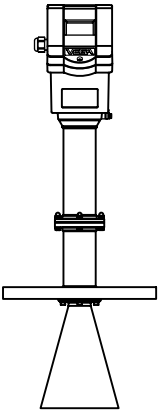
1.4 Antennas

The antenna is the eye of the radar sensor. The shape of the antenna, however, doesn't give a casual observer the slightest clue on how carefully the antenna geometry must be adapted to the physical properties of electromagnetic waves. The geometrical form determines focal properties and sensitivity - the same way it determines the sensitivity of a unidirectional microphone.

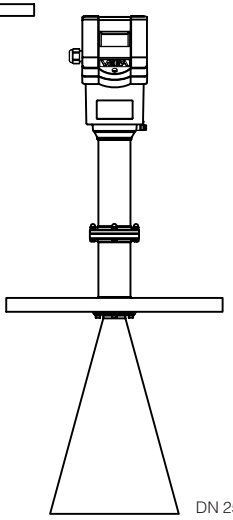
Various antenna configurations are available for different applications and process conditions. Beside the focussing properties, each is characterised by special chemical and physical features.

Horn antennas

Horn antennas focus the radar signals very well. Manufactured of 1.4571 (StSt) or Hastelloy C22 they are very rugged and physically as well as chemically resistant.
Horn antennas are used for measurement in closed or open vessels.

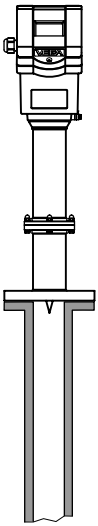


DN 150



DN 250

Pipe antenna

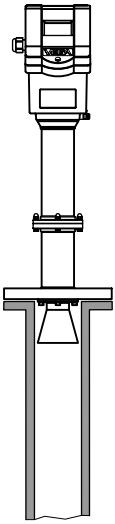


DN 50

Pipe antennas on surge or bypass tubes form a complete antenna system in conjunction with a measuring pipe (which can also be bent). Pipe antennas are best suited for products with extreme turbulence or products with low dielectric constant.

The antenna can be configured with or without horn. Antennas with horn are characterized by very high antenna gain - reliable measurement results are achieved even in case of products with very bad reflection properties.

The measuring pipe constitutes a conductor for radar signals. The running period of the radar signals changes in the pipe and depends on the pipe diameter. The pipe inner diameter must be programmed into the electronics so that the running period can be compensated.

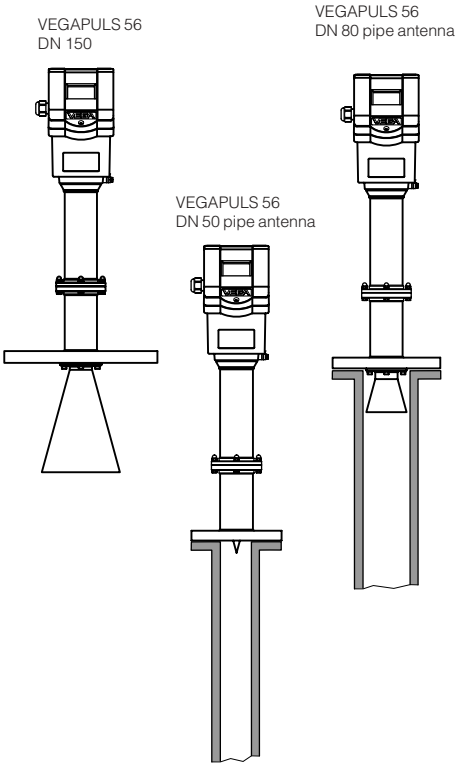


DN 80

2 Types and versions

VEGAPULS 56 are a newly developed generation of very compact high temperature radar sensors. For the first time it is now possible to carry out a non-contact level measurement under high temperatures and pressures. They bring the benefits of radar level measurement to applications where previously, due to extreme process conditions, the special special advantages of radar had to be forgone.

VEGAPULS 56 radar sensors are perfectly adapted to two-wire technology. They transmit the supply voltage and the output signal via one two-wire cable. An analogue 4 ... 20 mA output signal is available as output or measuring signal.



2.1 Type survey

General features

- level measurement on processes and products under high temperatures and high pressures
- measuring range 0 ... 20 m
- Ex-approved in Zone 1 and Zone 10 (IEC) or Zone 0 and Zone 20 (ATEX) classification mark EEx ia IIC T6 or EEx d ia IIC T6
- integrated measured value display
- external measured value display which can be mounted up to 25 m away in Ex-area

Survey of features

Signal output
- 4 ... 20 mA active (four-wire sensor)
- 4 ... 20 mA passive (two-wire sensor)

Power supply
- two-wire technology (power supply and signal output via one two-wire cable)
- four-wire technology (power supply separated from the signal cable)

Process fitting
- DN 50; ANSI 2“
- DN 80; ANSI 3“
- DN 100; ANSI 4“
- DN 150; ANSI 6“
- DN 200; ANSI 8“
- DN 250; ANSI 10“

Adjustment
- PC
- adjustment module in the sensor
- adjustment module in the external indicating instrument
- HART® handheld

Antennas
- horn antenna with stainless steel horn and ceramic tip
- standpipe antenna with ceramic tip

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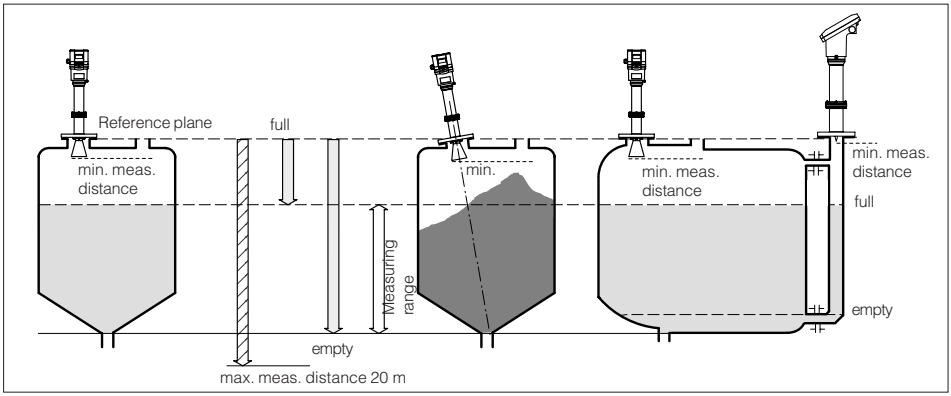
3 Mounting and installation

3.1 General installation instructions

Measuring range

The reference plane for the measuring range of the sensors is the lower edge of the flange. The measuring range is 0 … 20 m. With measurements in surge or bypass tubes (pipe antenna) the max. measuring distance decreases (see „Technical data - Measuring range“).

Keep in mind that in measuring environments where the medium can reach the sensor flange, buildup may form on the antenna and later cause measurement errors.

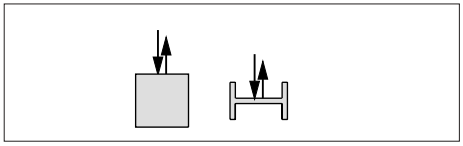


Measuring range (operating range) and max. measuring distance
Note: Use of the sensors for applications with solids is limited.

False echoes

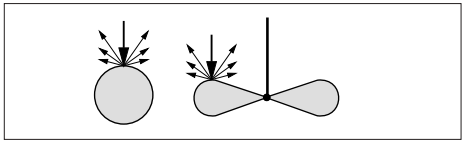
Flat obstructions and struts cause strong false echoes. They reflect the radar signal with high energy density.

Interfering surfaces with rounded profiles scatter the radar signals into the surrounding space more diffusely and thus generate false echoes with a lower energy density. Hence, those reflections are less critical than those from a flat surface.

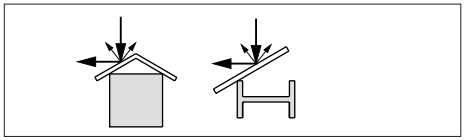


Profiles with smooth interfering surfaces cause large false signals

If flat obstructions in the range of the radar signals cannot be avoided, we recommend diverting the interfering signals with a deflector. The deflector prevents the interfering signals from being directly received by the radar sensor. The signals are then so low-energy and diffuse that they can be filtered out by the sensor.



Round profiles diffuse radar signals



Cover smooth interfering surfaces with deflectors

Emission cone and false echoes

The radar signals are focused by the antenna system. The signals leave the antenna in a conical path similar to the beam pattern of a spotlight. This emission cone depends on the antenna used.

Any object in this beam cone will reflect the radar signals. Within the first few meters of the beam cone, tubes, struts or other installations can interfere with the measurement. At a distance of 6 m, the false echo of a strut has an amplitude nine times greater than at a distance of 18 m.

At greater distances, the energy of the radar signal distributes itself over a larger area, thus causing weaker echoes from obstructing surfaces. The interfering signals are therefore less critical than those at close range.

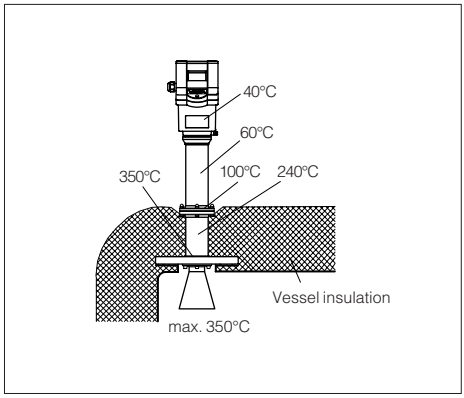
If possible, orient the sensor axis perpendicularly to the product surface and avoid vessel installations (e.g. pipes and struts) within the 100% emission cone. If possible, provide a "clear view“ to the product inside the emission cone and avoid vessel installations in the first third of the emission cone.

Optimum measuring conditions exist when the emission cone reaches the measured product perpendicularly and when the emission cone is free from obstructions.

Heat insulation

In case of process temperature of more than 200°C an insulation on the rear of the flange is necessary to keep radiated heat away from the sensor electronics.

The best would be to incorporate the sensor insulation into the vessel insulation and insulate up to approx. the first pipe segment.

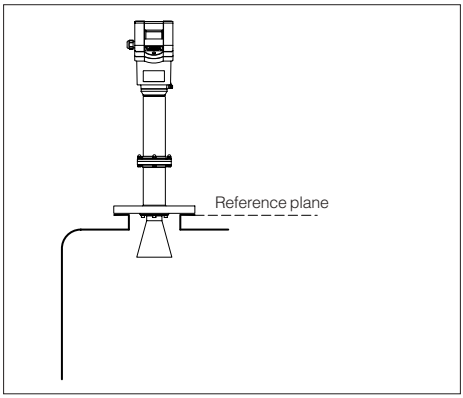


Heat insulation

3.2 Measurement of liquids

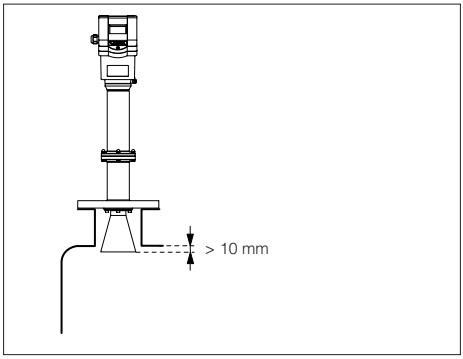
Sensor on DIN socket piece

Radar sensors are usually mounted on short DIN socket pieces. The lower side of the instrument flange is the reference plane for the measuring range. The antenna must always protrude out of the flange pipe.



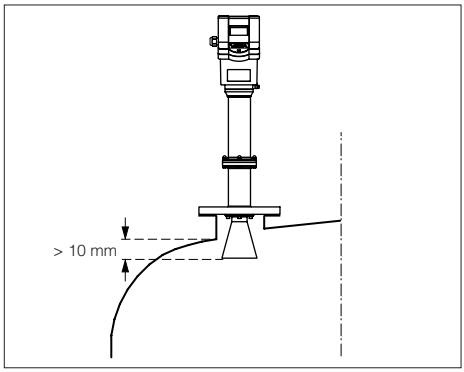
Mounting on short DIN socket piece

If the DIN socket piece is longer, please make sure that the horn antenna protrudes at least 10 mm out of the socket.



Mounting on longer DIN socket pieces

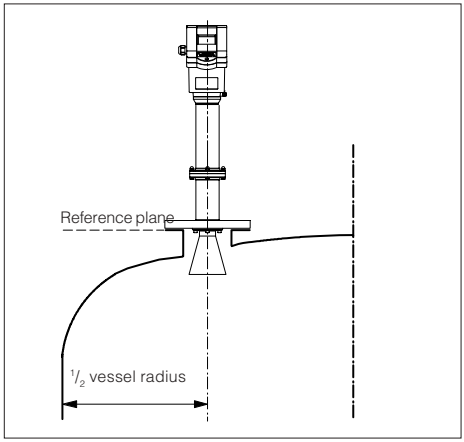
When mounting on dished or rounded vessel tops, the antenna must also protrude at least 10 mm (long socket side).



Mounting on round vessel tops

On dished vessel tops, please do not mount the instrument in the centre or close to the vessel wall, but approx.½ vessel radius from the centre or from the vessel wall.

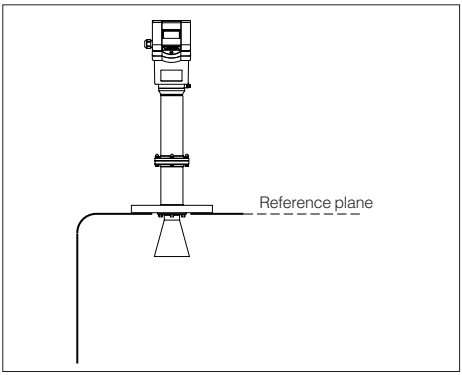
Dished tank tops can act as paraboloidal reflectors. If the radar sensor is placed in the focal point of the parabolic tank top, the radar sensor receives amplified false echoes. The radar sensor should be mounted outside the focal point. Parabolically amplified echoes are thereby avoided.



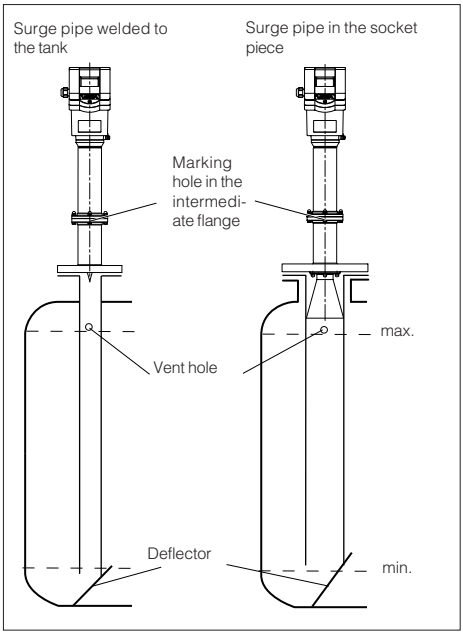
Mounting on round vessel tops

Sensor directly on the vessel top

If the stability of the vessel will allow it (sensor weight), flat mounting directly on the vessel top is a good and cost-effective solution. The top side of the vessel is the reference plane.



Mounting directly on flat vessel top



Pipe antenna system in the tank

3.3 Measurement in standpipe (surge or bypass tube)

General instructions

Measurement in a standpipe is preferred in vessels which contain many installations, e.g. heating tubes, heat exchangers or fast-running agitators. Measurement is then possible when the product surface is very turbulent, and vessel installations can cause no false echoes.

Due to the concentration of the radar signals within the measuring tube, even products with small dielectric constants (ε_r= 1.6 up to 3) can be reliably measured in surge or bypass tubes. Note the following instructions.

Surge pipes which are open at the bottom must extend over the full measuring range (i.e. down to 0% level), as measurement is only possible within the tube.

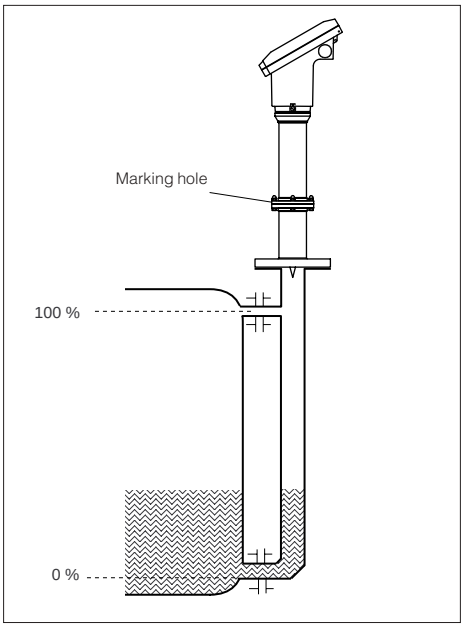
It is advantageous to mount a deflector at the tube end. This enables the minimum level of the product to be reliably detected. This is particularly important for products with a dielectric figure < 5.

Make sure the required upper vent hole in the surge pipe is aligned with the marking hole in the intermediate flange (polarisation direction of the radar signals).

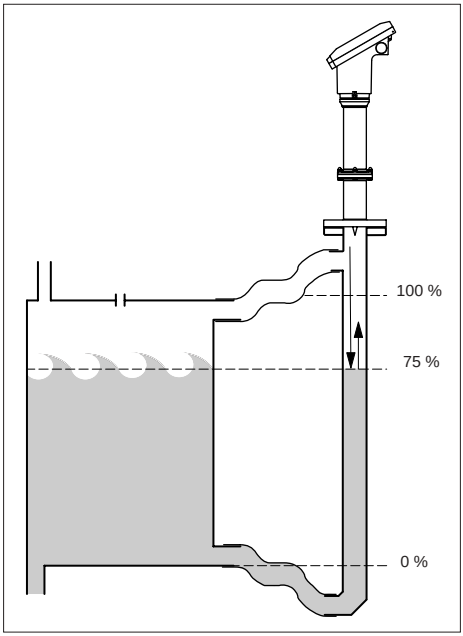
As an alternative to a surge pipe in the vessel, a pipe antenna system outside the vessel in a bypass tube is also possible.

Please note that when measuring in a surge or bypass tube, the max. measuring range is reduced by 5 ... 20 % (e.g. DN 50: 16 m instead of 20 m and DN 100 only 19 m instead of 20 m).

Align the sensor such that the type label lies on one axis with the tube holes or the tube connection openings. The polarisation of the radar signals enables a considerably stabler measurement with this alignment.



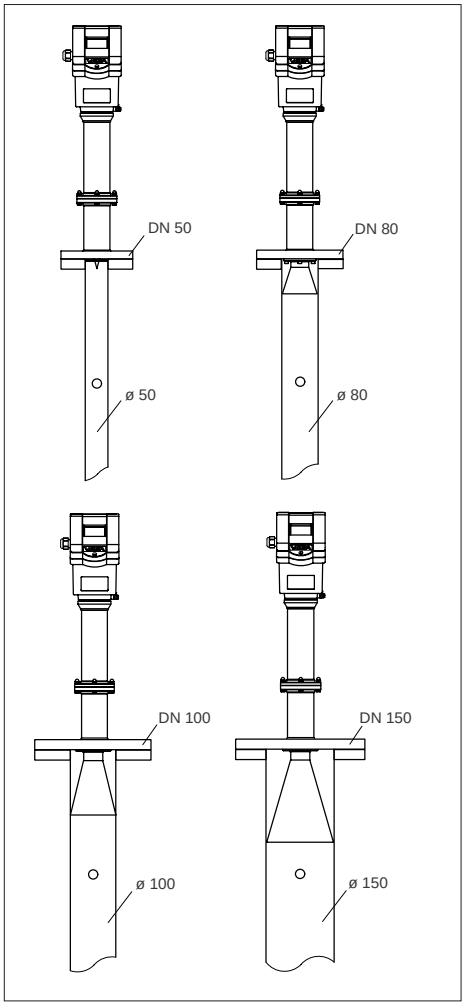
Tube flange system as bypass tube



Extended bypass tube on a vessel with turbulent product movements

Adhesive products

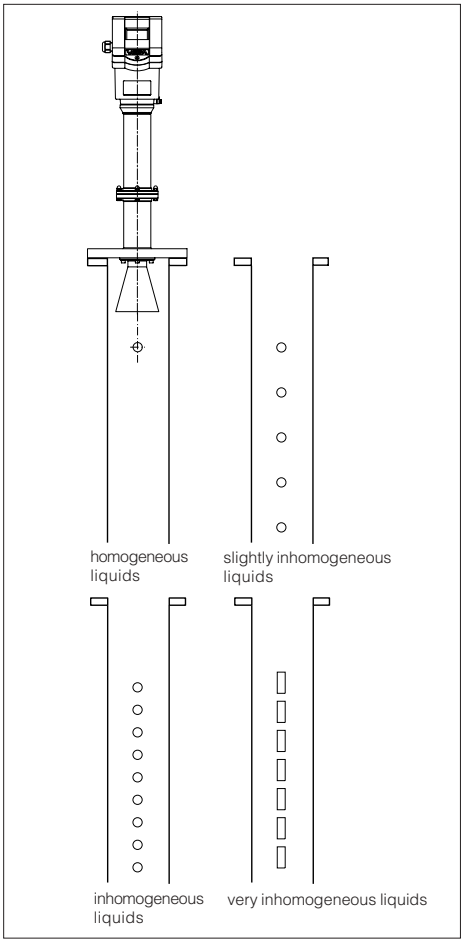
When measuring adhesive products, the the surge pipe must have a larger diameter. For non-adhesive products, a 50 mm measuring tube is a good and cost-effective solution. In slightly adhesive products, use preferably a surge pipe with a nominal width of 100 mm or 150 mm so that buildup cannot cause measurement errors. The measurement of extremely adhesive products in a standpipe is not possible at all.



Pipe antenna with DN 50, DN 80, DN 100 and DN 150

Standpipe measurement of inhomogeneous products

If you want to measure inhomogeneous or stratified products in a surge pipe, it must have holes, elongated holes or slots. These openings ensure that the liquid is mixed and corresponds to the liquid in the vessel.

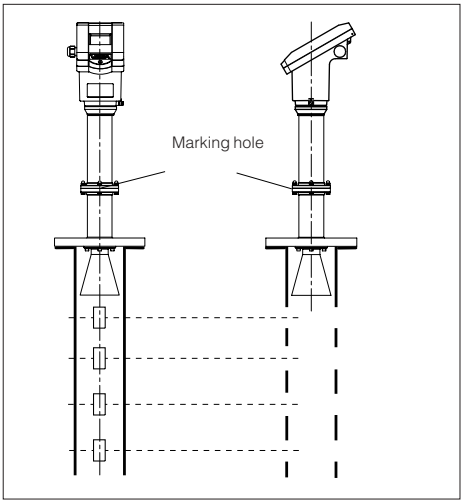


Openings in a surge pipe for mixing of inhomogeneous products

The more inhomogeneous the measured product, the closer the openings should be spaced.

Polarisation direction

Due to radar signal polarisation, the holes or slots must be positioned in two rows offset by 180°. The radar sensor must then be mounted so that the type label of the sensor is aligned with the rows of holes.



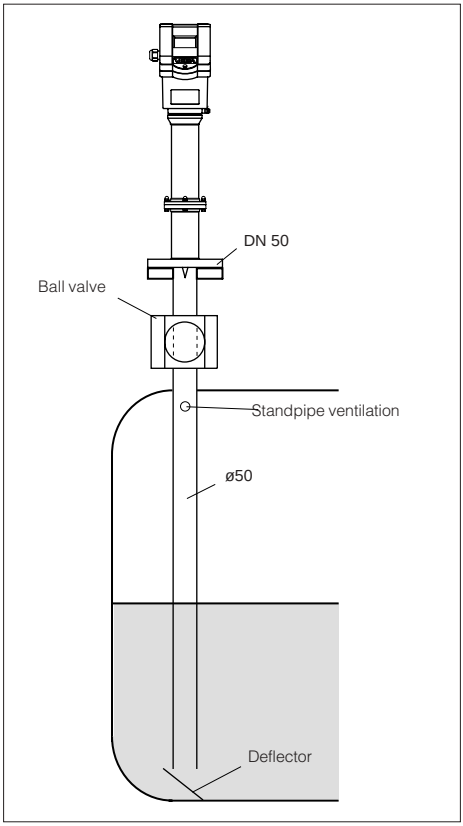
Row of holes in one axis with the marking hole

Surge pipe with ball valve

If a ball valve is mounted in the surge pipe, maintenance and servicing can be carried out without opening the vessel (e.g. if it contains liquid gas or toxic products).

A prerequisite for trouble-free operation is a ball valve throat that corresponds to the pipe diameter. The valve must not have rough edges or constructions in its channel.

Make sure that standpipe ventilation is provided.

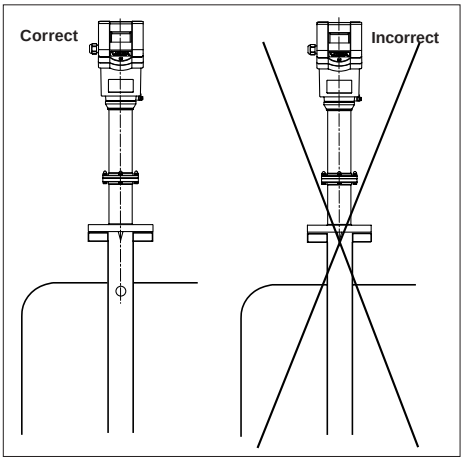


Lockable measuring pipe on a pipe antenna system

Installation errors in standpipe

Missing ventilation hole

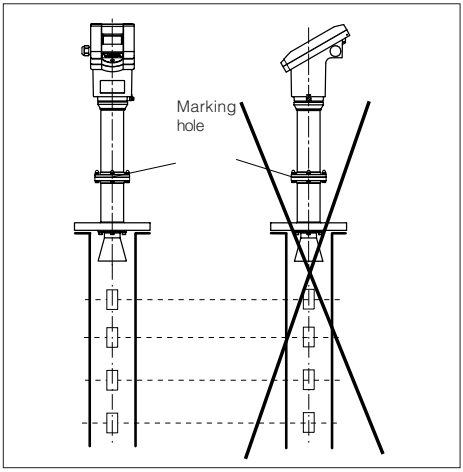
Pipe antenna systems must be provided with a vent hole at the upper end of the surge pipe. A missing hole causes wrong measurements.



Pipe antenna: The surge pipe open to the bottom must have a ventilation or compensation hole on top

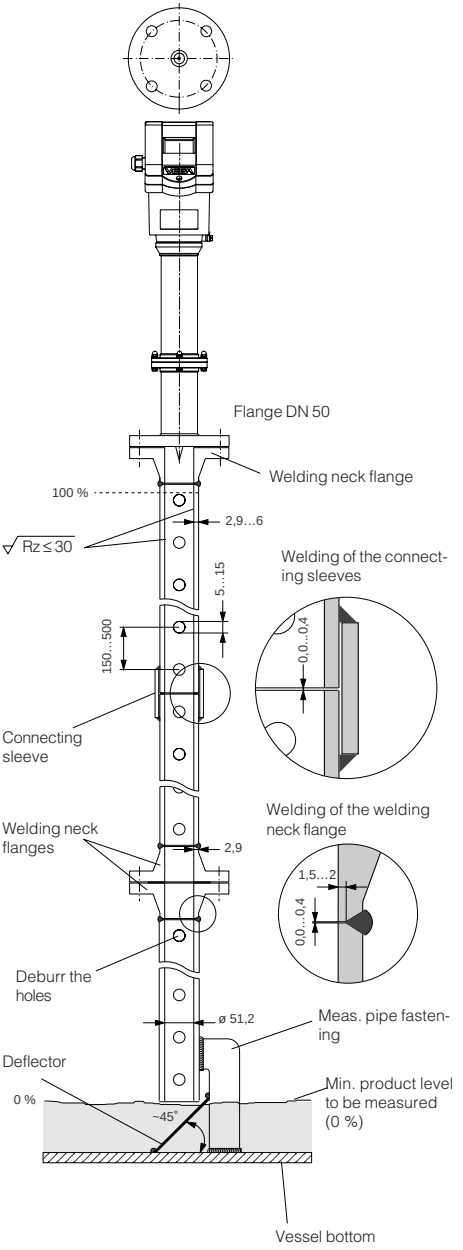
Wrong polarisation direction

When measuring in a surge pipe, especially when there are holes for mixing, it is important that the radar sensor is aligned with the rows of holes. The rows of holes of the surge pipe (displaced by 180°) must be in one plane with the polarisation direction of the radar signals. The polarisation direction is the same plane as the marking hole.



The polarisation direction is in the same plane as the marking hole. The sensor must be aligned with the marking hole to the rows of holes or the openings.

Guidelines for standpipe construction



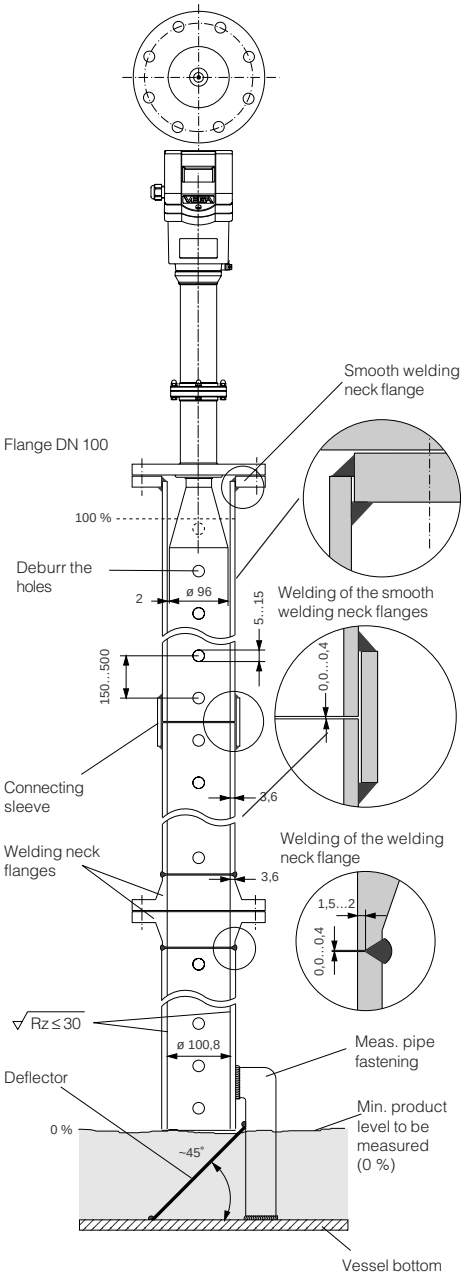
Radar sensors for measurement on surge or bypass tubes are used in the flange sizes DN 50, DN 80, DN 100 and DN 150.

On the left you see the constructional features of a measuring pipe (surge or bypass tube) as exemplified by a radar sensor with a DN 50 flange.

The radar sensor with DN 50 flange forms a functioning measuring system only in conjunction with a measuring pipe.

The measuring pipe must be smooth inside (average roughness Rz ≤ 30). Use stainless steel tubing (drawn or welded lengthwise) for construction of the measuring pipe. Extend the measuring pipe to the required length with weld-on flanges or with connecting sleeves. Make sure that no shoulders or projections are created during welding. Before welding, join pipe and flange with their inner surfaces flush and exactly fitting.

Avoid welding through the pipe wall. The pipe must remain smooth inside. Roughness or welding beads on the inner surfaces must be carefully removed and burnished, as they cause false echoes and encourage product buildup.



On the left, you see the constructional features of a measuring pipe as exemplified by a radar sensor with a DN 100 flange.

Radar sensors with flanges of DN 80, DN 100 and DN 150 are equipped with a horn antenna. Instead of the welding neck flange also a smooth welding flange can be used on the sensor side of these sensors.

In agitated products, fasten the measuring pipe to the vessel bottom. Provide additional fastenings for longer measuring pipes.

With the deflector on the measuring pipe end, the radar signals are reflected away from the vessel bottom. This assures that, in nearly empty vessel and products with low dielectric constants, the medium is detected, not the vessel bottom. Products with low dielectric constant are penetrated by the signals and, when the product level is low, allow the vessel bottom to deliver stronger echoes than the product surface.

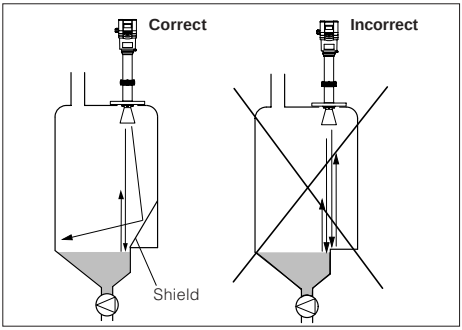
Due to the deflector, the useful signal, and thus the measurement value, can be clearly detected in a nearly empty vessel and the 0 % level can be reliably detected.

3.4 False echoes

The radar sensor must be installed at a location where no installations or inflowing material cross the radar pulses. The following examples and instructions show the most frequent measuring problems and how to avoid them.

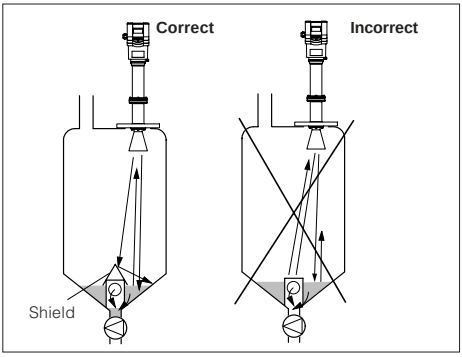
Vessel protrusions

Vessel forms with flat protrusions can make measurement very difficult due to their strong false echoes. Baffles mounted above these flat protrusions scatter the false echoes and guarantee a reliable measurement.



Vessel protrusions (ledge)

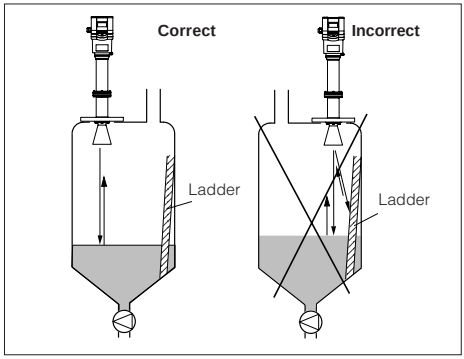
Intake pipes, i.e. for the mixing of materials - with a flat surface directed towards the sensor - should be covered with an angled baffle that scatters false echoes.



Vessel protrusions (intake pipe)

Vessel installations

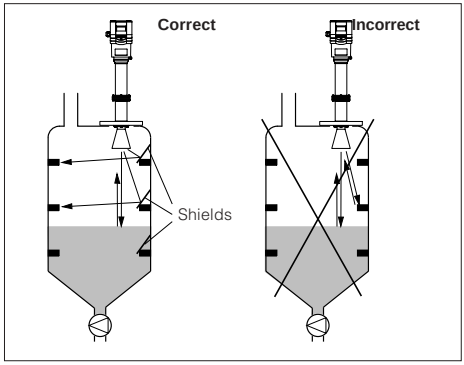
Vessel installations, such as e.g. ladders, often cause false echoes. Make sure when planning your measuring location that the radar signals have free access to the measured product.



Vessel installations

Struts

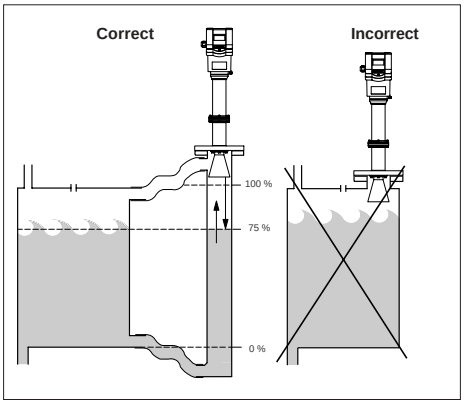
Struts, like other vessel installations, can cause strong false echoes that are superimposed on the useful echoes. Small baffles effectively prevent a direct reception of false echoes. These false echoes are scattered and diffused in the surrounding space and are then filtered out as "echo noise" by the measuring electronics.



Struts

Strong product movements

Strong turbulence in the vessel, e.g. caused by powerful agitators or strong chemical reactions, can seriously interfere with the measurement. A surge or bypass tube (see illustration) of sufficient size always enables reliable and problem-free measurement even if strong turbulence occurs in the vessel, provided there is no product buildup in the tube.

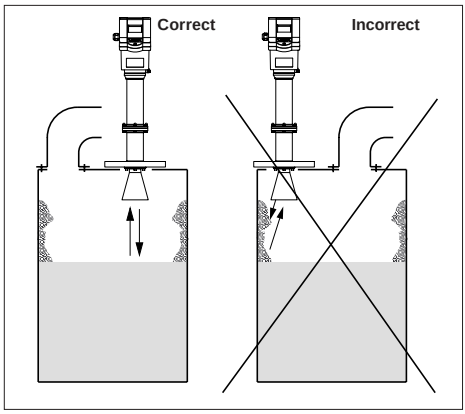


Strong product movements

Products with a tendency to light buildup can be detected by using a measuring tube with 100 mm nominal width or larger. In such a measuring tube, light buildup does not cause any problems.

Buildup

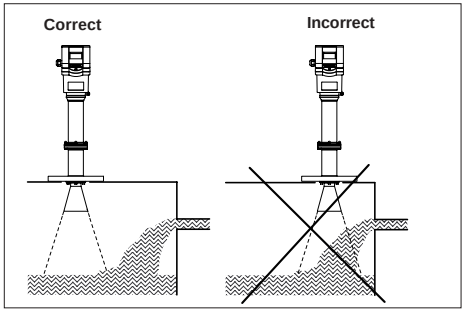
If the sensor is mounted too close to the vessel wall, product buildup and other deposits on the vessel wall cause false echoes. Position the sensor at a sufficient distance from the vessel wall. Please also note chapter "4.1 General installation instructions".



Buildup

Inflowing material

Do not mount the instrument in or above the filling stream. Ensure that you detect the product surface and not the inflowing material.

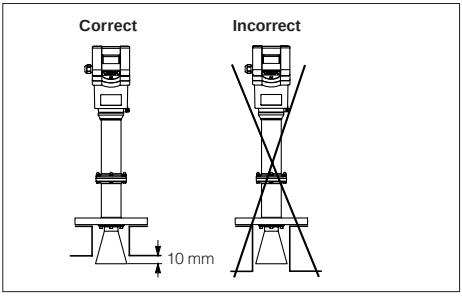


Inflowing liquid

3.5 Common installation mistakes

Socket piece too long

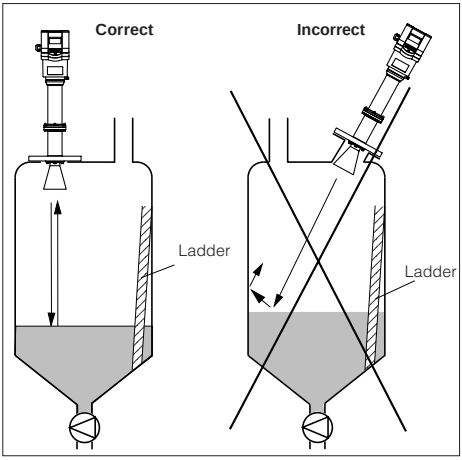
If the antenna is mounted in a socket extension that is too long, strong false echoes are generated which interfere with the measurement. Make sure that the horn antenna protrudes at least 10 mm out of the socket piece.



Horn antenna: Correct and incorrect socket length

Wrong orientation to the product

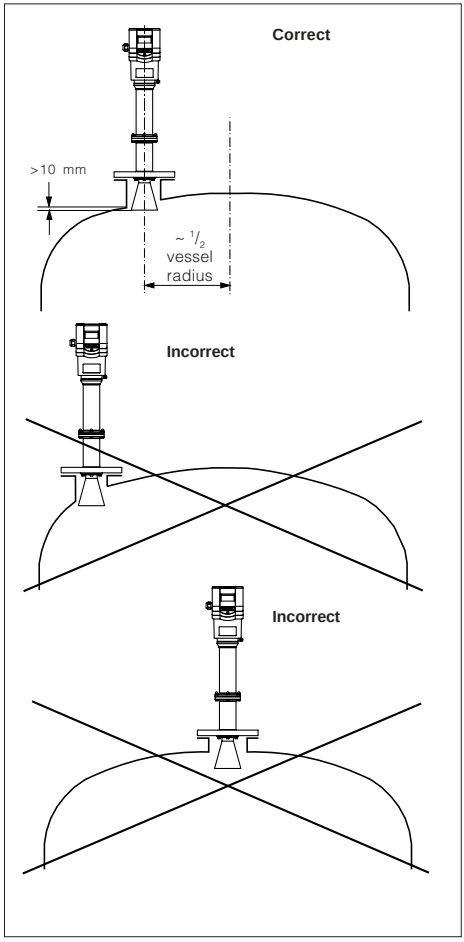
Weak measuring signals are generated if the sensor is not directly pointed at the product surface. Orient the sensor axis perpendicularly to the product surface to achieve optimum measuring results.



Direct sensor vertically to the product surface

Parabolic effects on dished or rounded vessel tops

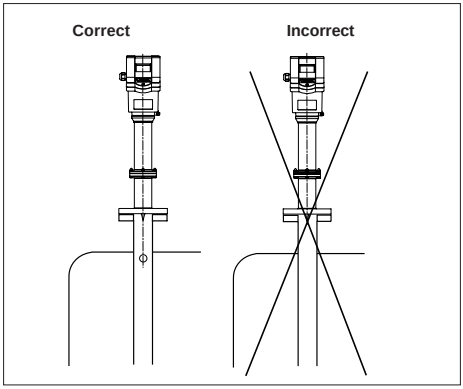
Round or parabolic tank tops act on the radar signals like a parabolic mirror. If the radar sensor is placed at the focal point of such a parabolic tank top, the sensor receives amplified false echoes. The optimum mounting location is generally in the range of half the vessel radius from the centre.



Mounting on a vessel with parabolic tank top

Standpipe (pipe antenna) without ventilation hole

Pipe antenna systems must be provided with a ventilation hole on the upper end of the surge pipe. If this hole is absent, incorrect measurements will result.

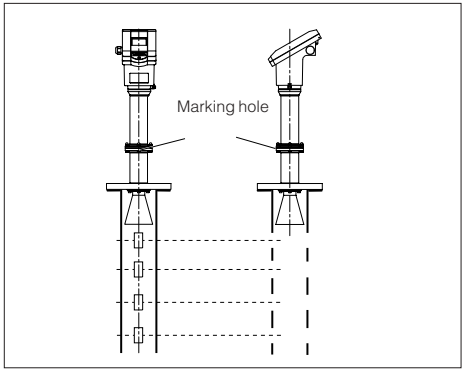


Pipe antenna: The surge pipe open to the bottom must have a ventilation hole

Wrong polarisation direction on the standpipe

When measuring in a surge pipe, especially if there are holes or slots for mixing in the tube, it is important that the radar sensor is aligned with the rows of holes.

The two rows of holes (displaced by 180°) of the measuring tube must be in one plane with the polarisation direction of the radar signals. The polarisation direction is in the same plane as the marking hole. You direct the sensor precisely by means of the marking hole in the intermediate flange.



The polarisation direction is in one plane with the marking hole. The sensor must be directed with the marking hole to the row of holes.

Sensor too close to the vessel wall

Strong false echoes can also result if the radar sensor is mounted too close to the vessel wall. Buildup, rivets, screws or weld joints superimpose their echoes onto the product i.e. useful echo. Please ensure a sufficient distance from the sensor to the vessel wall.

We recommend locating the sensor where there is no vessel wall within the inner emission cone.

For products with less favourable reflection conditions, it is a good idea to also keep the outer emission cone free of interfering installations. Note chapter "3.1 General installation instructions - Emission cone and false echoes".

Foam generation

Thick, dense and creamy foam on the product can cause incorrect measurements. Take measures to avoid foam, measure in a bypass tube or use another measurement technology, e.g. capacitive electrodes or hydrostatic pressure transmitters.

4 Electrical connection

4.1 Connection and connection cable

Safety information

As a rule, do all connecting work in the complete absence of line voltage. Always switch off the power supply before you carry out connecting work on the radar sensors. Protect yourself and the instruments, especially when using sensors which do not operate with low voltage.

Qualified personnel

Instruments which are not operated with protective low voltage or DC voltage must only be connected by qualified personnel.

Connection cable

A standard two or four-wire cable (sensors with separate supply) with max. 2.5 mm^2 wire cross-section can be used for connection. Quite often, the "electromagnetic pollution" caused by electronic actuators, energy cables and transmitting stations is so considerable that the two or four-wire cable must be screened.

We recommend the use of screening. The screening is also a precautionary measure against future sources of interference. Connect the cable screen to earth on two ends (on the sensor and on the processing system) only if you have determined by measurement that no or only low earth compensation currents flow over the screens. Use a very low impedance earth connection (foundation, plate or mains earth).

Ex protection

If an instrument is used in hazardous areas, the appropriate regulations, conformity and type approval certificates for systems in Ex areas must be noted (e.g. DIN 0165).

Connection cable

Make sure that the connection cables are specified for the expected application conditions in your systems. The cable must have an outer diameter between 5 and 9 mm (M20x1.5) or 3.5 … 8.7 mm ($^1/_2$" NPT). Otherwise, the seal effect of the cable entry would not be ensured.

Cables for intrinsically safe circuits must be marked blue and must not be used for other circuits.

Earth conductor terminal

On all VEGAPULS 56 sensors, the earth conductor terminal is galvanically connected to the metal process connections.

4.2 Connecting the sensor

After mounting the sensor at the measurement location according to the instructions in chapter „3 Mounting and installation", loosen the closing screw on top of the sensor. The sensor lid with the optional indicating display can then be opened. Unscrew the sleeve nut and slip it over the connection cable (after removing about 10 cm of cable mantle). The sleeve nut of the cable entry has a self-locking ratchet that prevents it from opening on its own.

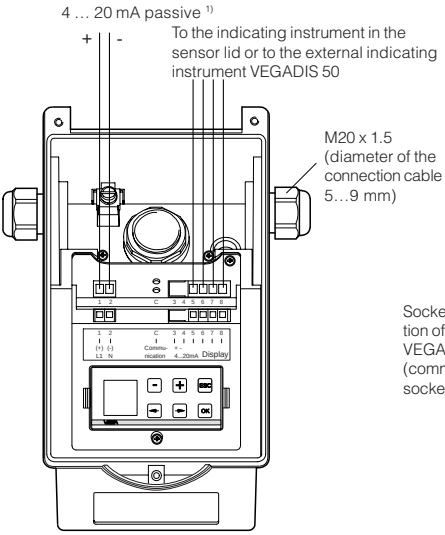
Now insert the cable through the cable entry into the sensor. Screw the sleeve nut back onto the cable entry and clamp the stripped wires of the cable into the proper terminal positions.

The terminals hold the wire without a screw. Press the white opening levers with a small screwdriver and insert the copper core of the connection cable into the terminal opening. Check the hold of the individual wires in the terminals by lightly pulling on them.

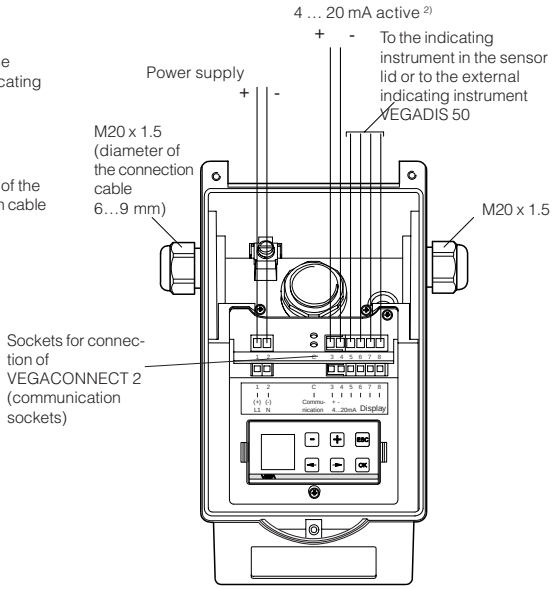
Standard versions

Two-wire technology

(loop powered)



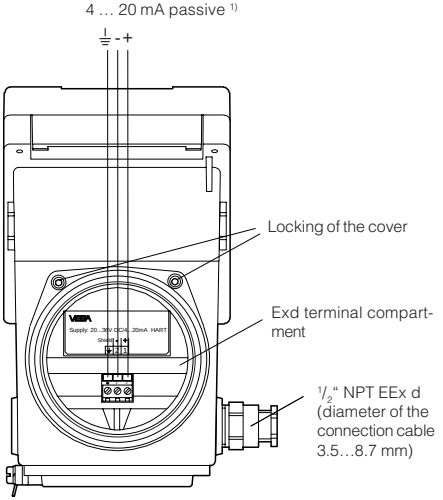
Four-wire technology



Exd version (loop-powered with pressure-tight encapsulated terminal compartment)

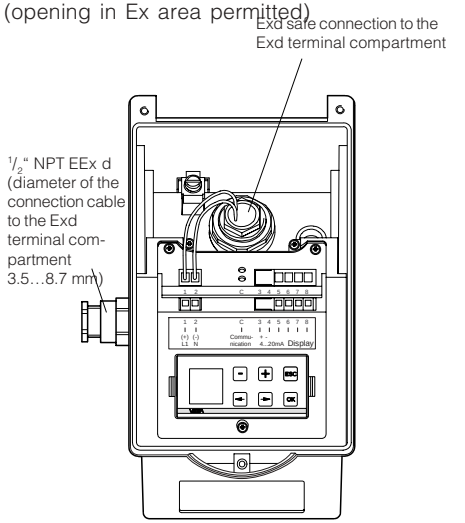
EExd terminal compartment

(opening in Ex atmosphere not allowed)



Adjustment module and indicating terminal compartment

(opening in Ex area permitted)



1) 4 … 20 mA passive means that the sensor consumes a level-dependent current of 4 … 20 mA (consumer).

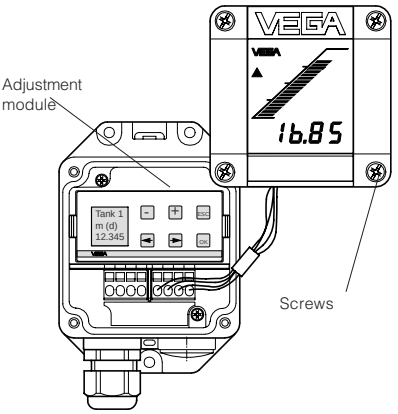
2) 4 … 20 mA active means that the sensor provides a level-dependent current of 4 … 20 mA (current source).

4.3 Connecting the external indicating instrument VEGADIS 50

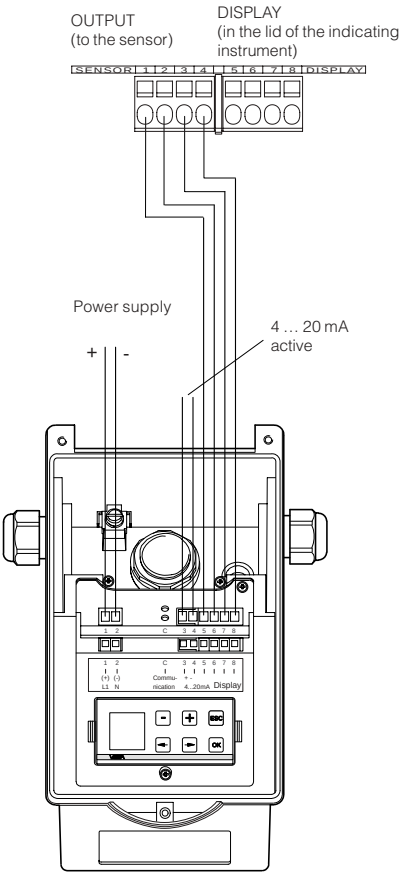
Loosen the four screws of the housing lid on VEGADIS 50.

The connection procedure can be facilitated by affixing the housing cover during connection work with one or two screws on the right of the housing (illustration).

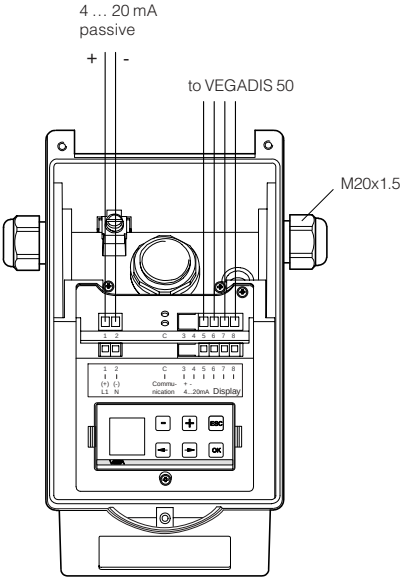
VEGADIS 50



Four-wire sensor
(separate supply)



Two-wire sensor
(loop powered)



4.4 Configuration of measuring systems

A measuring system consists of a sensor with 4 … 20 mA signal output and a unit that evaluates and further processes the level-proportional current signal.

On the following pages, you will see a number of instrument configurations, designated as "measuring systems", some of which are shown with signal processing units.

Measuring systems in two-wire technology:

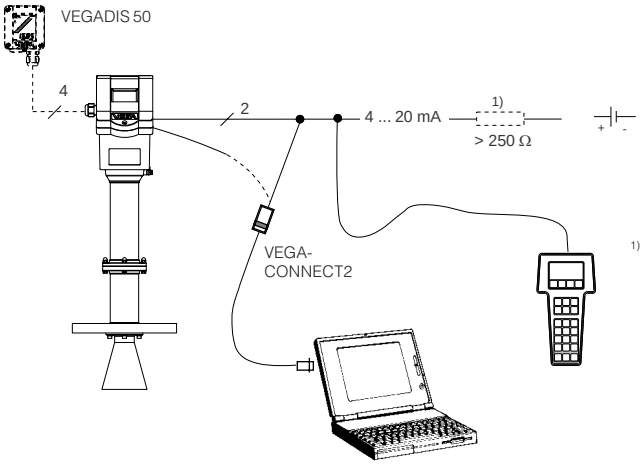
- 4 … 20 mA shown without processing unit;
- 4 … 20 mA on active PLC;
- 4 … 20 mA on active PLC in Ex area (ia);
- 4 … 20 mA on passive PLC in Ex area (ia);
- 4 … 20 mA on passive PLC in Ex area (d);
- 4 … 20 mA on VEGADIS 371 Ex indicating instrument;

Measuring systems in four-wire technology:

- 4 … 20 mA shown without signal conditioning instrument

Measuring systems with VEGAPULS 56K

- Two-wire technology (loop powered), supply and output signal via one two-wire cable
- Optional external indicating instrument with analogue and digital display (can be mounted up to 25 m away from the sensor).
- Adjustment with PC, HART® handheld or the adjustment module MINICOM (can be plugged into the sensor or into the external indicating instrument VEGADIS 50).

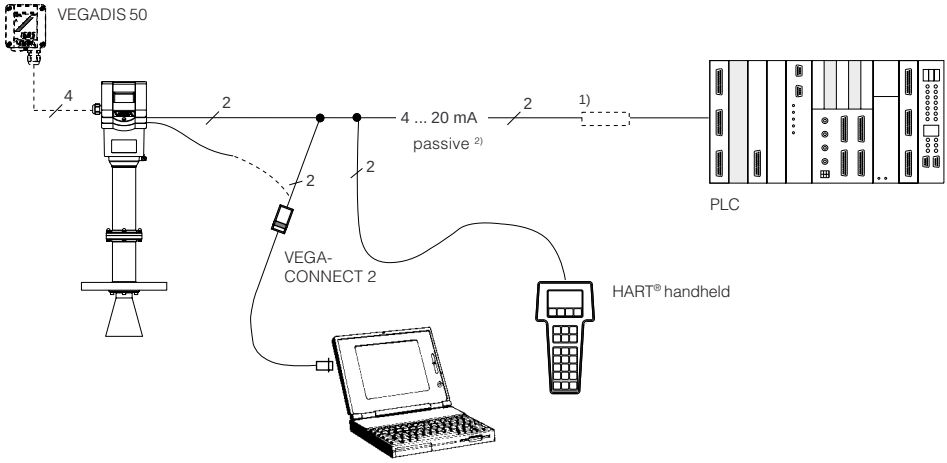


[1] If the resistance of the processing systems connected to the 4 … 20 mA signal output is less than 200 Ω, a resistor must be connected to the connection cable during adjustment to get a loop resistance of 250 Ω up to 350 Ω .

The digital adjustment signal would otherwise be severely damped or short-circuited due to insufficient resistance of the connected processing system. Digital communication with the PC would not be ensured.

Measuring system with VEGAPULS 56K on active PLC

- Two-wire technology, power supply from active PLC.
- Output signal 4 … 20 mA (passive).
- Measured value display integrated in the sensor.
- Optional external indicating instrument (can be mounted up to 25 m away from the sensor in Ex area).
- Adjustment with PC, HART® handheld or the adjustment module MINICOM (can be plugged into the sensor or into the external indication instrument).



1) If the resistance of the processing systems connected to the 4 … 20 mA signal output is less than 200 Ω, a resistor must be connected to the connection cable during adjustment to get a loop resistance of 250 Ω up to 350 Ω .

The digital adjustment signal would otherwise be severely damped or short-circuited due to insufficient resistance of the connected processing system. Digital communication with the PC would not be ensured.

2) 4 … 20 mA passive means that the sensor consumes a level-dependent current of 4 … 20 mA. The sensor reacts electrically like a varying resistor (consumer) to the PLC.

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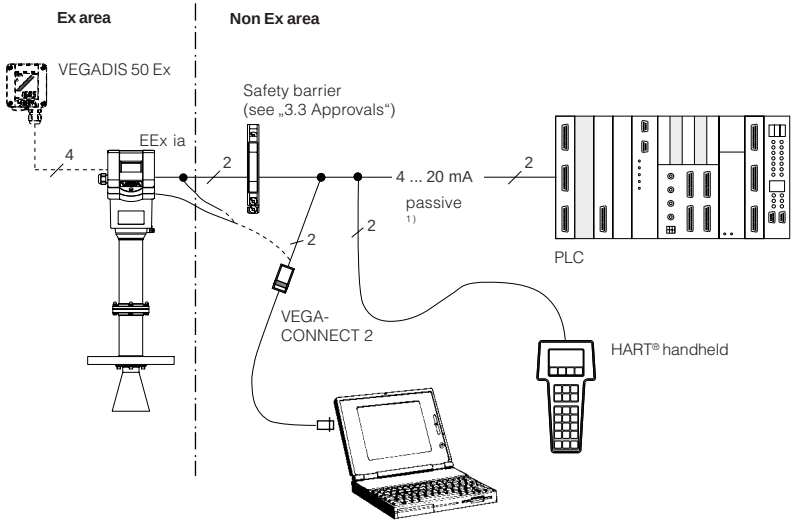
Measuring system with VEGAPULS 56K Ex, 56K Ex0 via a safety barrier in Ex area on active PLC

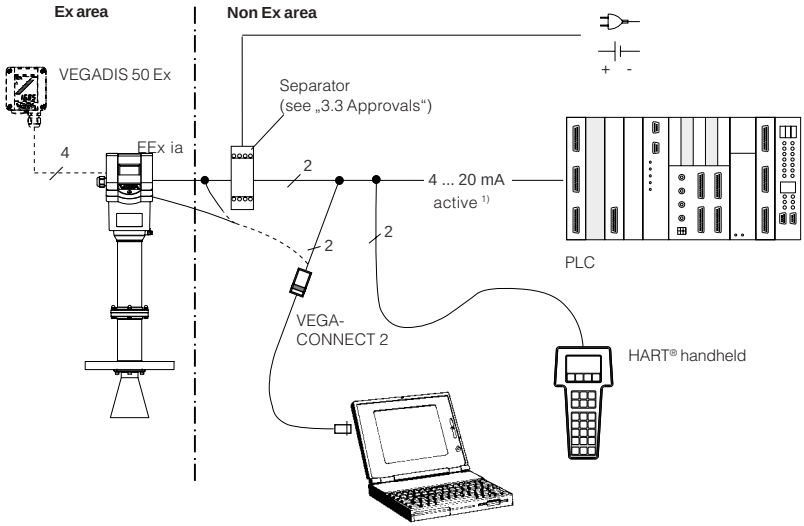
- Two-wire technology (loop powered), power supply via the signal line of the PLC; output signal 4 … 20 mA (passive).
- Separator transfers the non intrinsically safe PLC circuit to the intrinsically safe circuit, so that the sensor can be used in Ex zone 1 (VEGAPULS 56K Ex) or in zone 0 (VEGAPULS 56K Ex0)
- max. resistance of the signal cable 15 Ω per wire
- Optional external indicating instrument with analogue and digital display (can be mounted up to 25 m away from the sensor).
- Adjustment with PC, HART® handheld or adjustment module MINICOM (can be plugged into the sensor or into the external indicating instrument VEGADIS 50).



1) 4 … 20 mA passive means that the sensor or the PLC consumes a level-dependent current of 4 … 20 mA. The PLC reacts electrically like a varying resistor (consumer) to the PLC.

Measuring system with VEGAPULS 56K Ex, 56K Ex0 via separator (Smart-Transmitter) on passive PLC

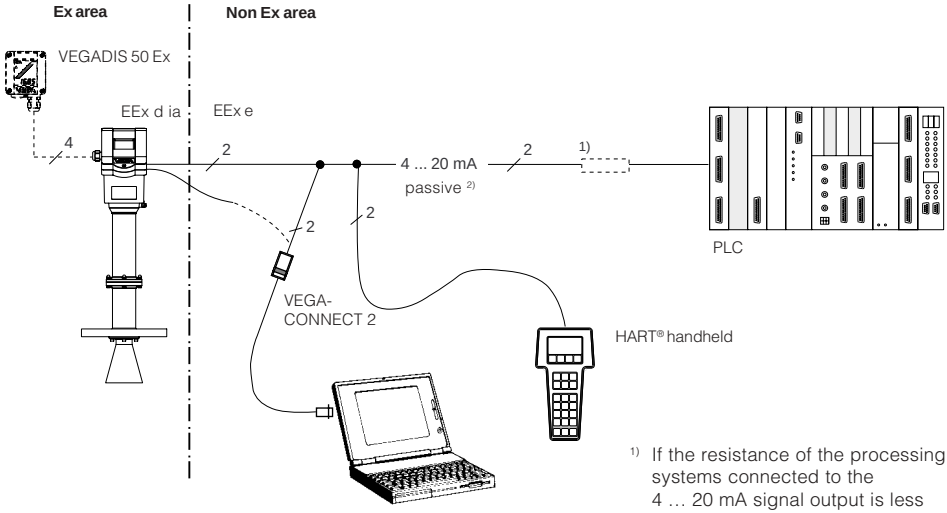
- Two-wire technology (loop powered), intrinsically safe ia supply via the signal cable of the separator for operation of the sensor in Ex zone 1 (VEGAPULS 56K Ex) or in zone 0 (VEGAPULS 56K Ex0)
- Output signal sensor, 4 … 20 mA passive.
- Output signal separator, 4 … 20 mA active
- Optional external indicating instrument with analogue and digital display (can be mounted up to 25 m away from the sensor).
- Adjustment with PC, HART® handheld or adjustment module MINICOM (can be plugged into the sensor or into the external indicating instrument VEGADIS 50)
- Max. resistance of the signal cable 15 Ω per wire



1) 4 … 20 mA active means that the separator delivers a level-dependent current of 4 … 20 mA The separator reacts electrically to the PLC like a current source.

Measuring system with VEGAPULS 56K Ex, 56K Ex 0 with pressure-tight encapsulated connection compartment on active PLC

- Two-wire technology, supply via the cable from active PLC to Exd connection compartment for operation in Ex-Zone 1 (VEGAPULS 56K Ex) or Ex-Zone 0 (VEGAPULS 56K Ex 0)
- Output signal 4 … 20 mA (passive).
- Measured value display integrated in the sensor.
- Optional external indicating instrument with analogue and digital display (can be mounted up to 25 m away from the sensor in Ex area).
- Adjustment with PC, HART® handheld or adjustment module MINICOM (can be plugged into the sensor or into the external indicating instrument VEGADIS 50).



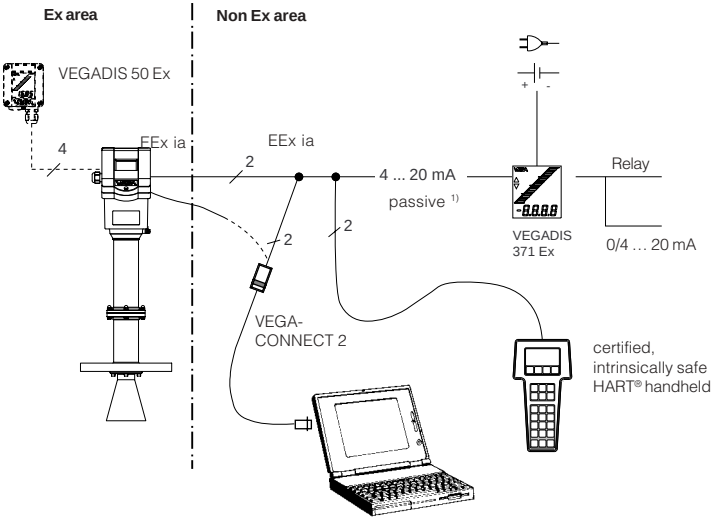
1) If the resistance of the processing systems connected to the 4 … 20 mA signal output is less than 200 Ω, a resistor must be connected to the connection cable during adjustment to get a loop resistance of 250 Ω up to 350 Ω .

The digital adjustment signal would otherwise be severely damped or short-circuited due to insufficient resistance of the connected processing system. Digital communication with the PC would not be ensured.

2) 4 … 20 mA passive means that the sensor consumes a level-dependent current of 4 … 20 mA. The sensor reacts electrically like a varying resistor (consumer) to the PLC.

Measuring system with VEGAPULS 56K Ex, 56K Ex0 on VEGADIS 371 Ex indicating instrument with current and relay output

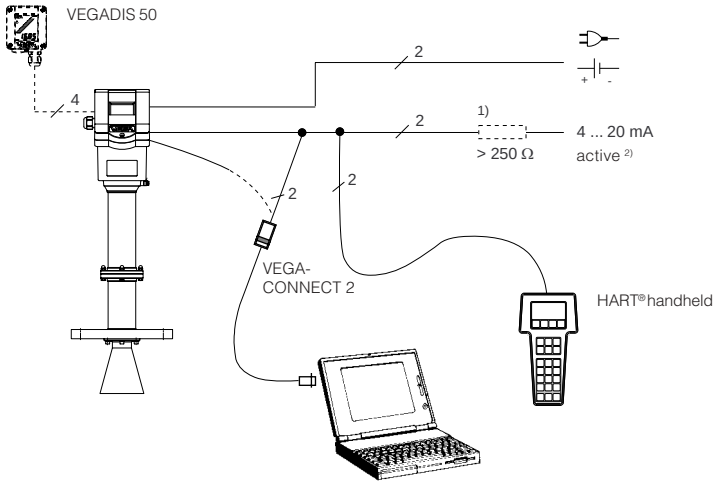
- Two-wire technology (loop powered), intrinsically safe ia supply via the signal cable of the VEGADIS 371 Ex indicating instrument for operation of the sensor in Ex zone 1 (VEGAPULS 56K Ex) or in Zone 0 (VEGAPULS 56K Ex0)
- Optional external indicating instrument with analogue and digital display (can be mounted up to 25 m away from the sensor).
- Adjustment with PC, HART® handheld or adjustment module MINICOM (can be plugged into the sensor or into the external indicating instrument VEGADIS 50)
- Max. resistance of the signal cable 15 Ω per wire



1) 4 … 20 mA passive means that the sensor consumes a level-dependent current of 4 … 20 mA. The sensor reacts electrically like a varying resistor (consumer) to the PLC.

Measuring system with VEGAPULS 56K in four-wire technology

- Four-wire technology, power supply and output signal via two separate two-wire cables.
- Output signal 4 … 20 mA active.
- Optional external indicating instrument with analogue and digital indication (can be mounted up to 25 m away from the sensor).
- Adjustment with PC, HART® handheld or adjustment module MINICOM (can be plugged into the sensor or into the indicating instrument VEGADIS 50)
- Max. load 500 Ω



1) If the resistance of the processing systems connected to the 4 … 20 mA signal output is less than 200 Ω, a resistor must be connected to the connection cable during adjustment to get a loop resistance of 250 Ω up to 350 Ω .

The digital adjustment signal would otherwise be severely damped or short-circuited due to insufficient resistance of the connected processing system. Digital communication with the PC would not be ensured.

2) 4 … 20 mA active means that the sensor delivers a level-dependent current of 4 … 20 mA (source). The sensor reacts electrically in the processing system (e.g. indication) like a current source.

5 Set-up

5.1 Adjustment media

Radar sensors can be adjusted with the
- PC (adjustment software PACT*ware*™)
- detachable adjustment module MINICOM
- HART® handheld.

The adjustment must be carried out with only one adjustment device. If, for example, you attempt to adjust the parameters with the MINICOM and the HART® handheld at the same time, the adjustment will not work.

PC
With the adjustment program PACT*ware*™ on the PC, you can adjust the radar sensors quickly and conveniently. The PC communicates via the interface adapter VEGACONNECT 3 with the sensor. During the process, a digital adjustment signal is superimposed on the signal and supply cable. The adjustment can be carried out directly on the sensor or at any desired location along the signal cable.

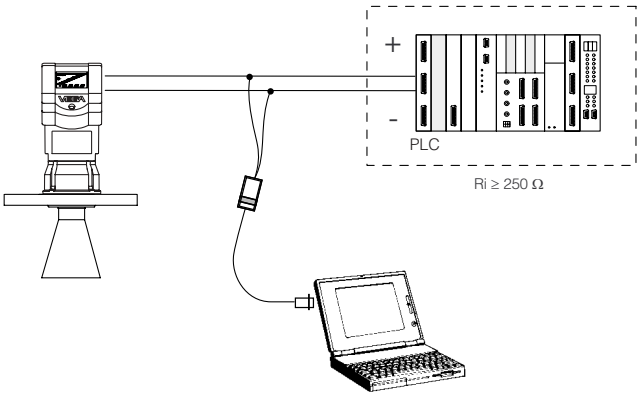
Adjustment module MINICOM
With the adjustment module MINICOM, you adjust directly in the sensor or in the external indicating instrument VEGADIS 50. With a dialogue text display and 6 keys, the module offers the same adjustment functionality as the adjustment software VVO.

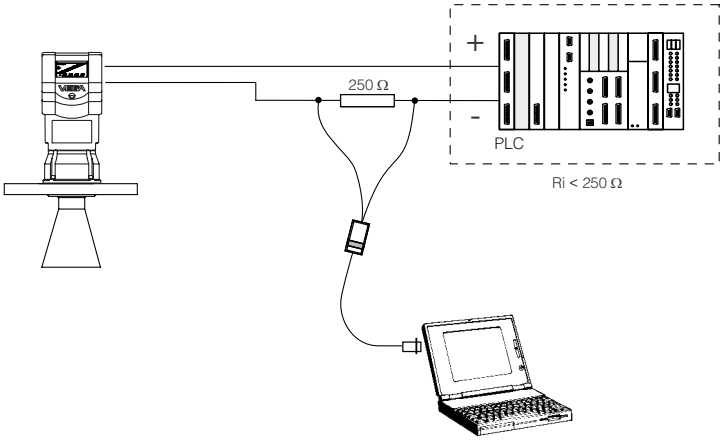
HART® handheld
VEGAPULS series 50K radar sensors, like other HART® protocol compatible instruments, can be adjusted with the HART® handheld. A manufacturer-specific DDD (Data-Device-Description) is not required. The radar sensors are adjusted with the HART® standard menus. All main functions are therefore accessible.
Functions that are rarely used, such as, for example, scaling of the A/D converter for signal output or adjustment with medium, are not possible, i.e. disabled, with the HART® handheld. These functions must be carried out with the PC or the MINICOM.

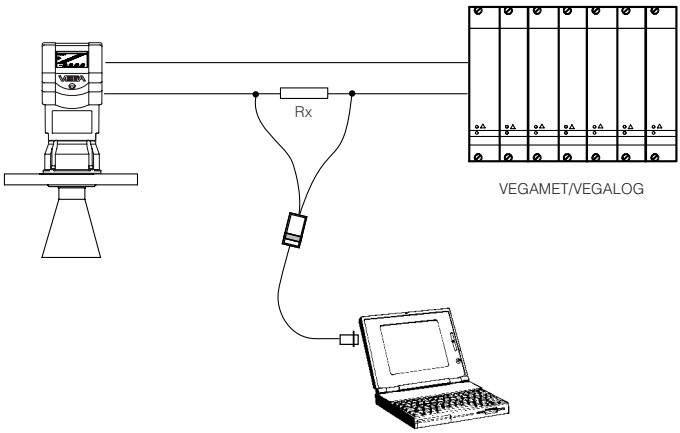
5.2 Adjustment with PC

When using a sensor in conjunction with a VEGA signal conditioning instrument, use a communication resistor according to the following schedule:

VEGA signal conditioning instr.	Rx
VEGAMET 513, 514, 515, 602	50 … 100 Ohm
VEGAMET 614 VEGADIS 371	no additional resistor necessary
VEGAMET 601	200 … 250 Ohm
VEGASEL 643	150 … 200 Ohm
VEGAMET 513 S4, 514 S4 515 S4, VEGALOG EA card	100 … 150 Ohm

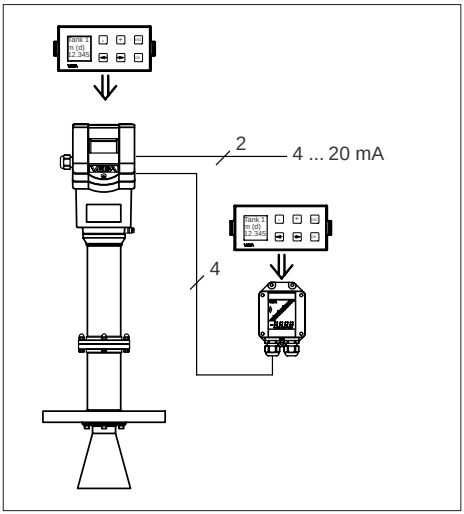

+
-
PLC
Ri ≥ 250 Ω


250 Ω
+
-
PLC
Ri < 250 Ω


Rx
VEGAMET/VEGALOG

5.3 Adjustment with adjustment module MINICOM

You can set up and operate the sensor with the small, detachable adjustment module MINICOM just as well as with the PC. The adjustment module is simply plugged into the sensor or into the external indicating instrument (optional).



The adjustment module, like the adjustment program VVO on the PC, provides adjustment options for all sensor versions. There are some differences with MINICOM, however. For one thing, it is not possible to enter your own linearisation curve.

You carry out all adjustment steps with the 6 keys of the adjustment module. A small display shows you, apart from the measured value, a short message on the menu item or the value entered in a menu item.

The volume of information of the small display cannot be compared with that of the adjustment program VVO, but you will quickly find your way and carry out your adjustments quickly and efficiently with the small MINICOM.

Error codes:

E013 No valid measured value
- Sensor in the warm-up phase
- Loss of the useful echo

E017 Adjustment span too small

E036 Sensor program not operating
- Sensor must be reprogrammed (service)
- Fault signal also appears during programming

E040 Hardware failure, electronics defective

Adjustment steps

On the following pages you will find the complete menu schematic of the adjustment module MINICOM.
Set up the sensor in the numbered sequence:

1. Measuring tube adjustments (only for measurement in a standpipe)
2. Operating range
3. Adjustment
4. Conditioning
5. Meas. conditions
6. False echo storage (only required when errors occur during operation).
7. Indication of the useful and noise level
8. Outputs

Short explanations to the setup steps 1 … 8 follow.

1. Measurement in a standpipe

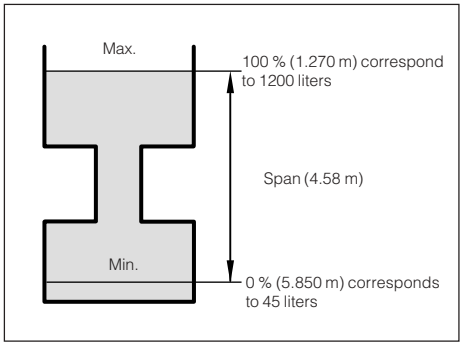
Adjustment is only necessary if the sensor is mounted in a standpipe (surge or bypass tube). When measuring in a standpipe, do a sounding of the distance and correct the measured value display (which can differ several percent from the sounded value) according to the sounding. From then on, the sensor corrects running time shift of the radar signal and displays the correct value of the level in the standpipe (measuring tube).

2. Operating range

Without special adjustment, the operating range corresponds to the measuring range. It is generally advantageous to set the operating range slightly larger (approx. 5 %) than the measuring range.

Example:
Min./max. adjustment: 1.270 … 5.850 m;
adjust operating range to approx.
1.000 … 6.000 m.

3. Adjustment



Under the menu item "*Adjustment*" you inform the sensor of the measuring range it should operate in.

You can carry out the adjustment with or without medium. Generally, you will carry out the adjustment without medium, as you can then adjust without a filling/emptying cycle.

Adjustment without medium
(adjustment independent of the level)

Key entry	Display indication
	Sensor m(d) 4.700
OK	Para- meter
OK	Adjust- ment
OK	w.o medium
OK	Ad- just- ment in *m(d)* (min. adjustment)
+	The distance indication flashes and you can choose "feet" and "m".
OK	Confirm the adjustment with "*OK*".
→	Ad- just- ment in *m(d)* — 0.0% at *m (d)* XX.XXX
+ or –	With "*+*" and "*–*" you adjust the percentage value for the min. value (example 0.0 %).
OK	The entered percentage value is written in the sensor and the min. distance value corresponding to that percentage value flashes.

[+] or [–] With the "*+*" or "*–*" key you can assign a level distance (example 5.85 m) to the previously adjusted percentage value. If you do not know the distance, you have to do a sounding.

[OK] The adjusted product distance is written in the sensor and the display stops flashing.

You thereby adjusted the lower product distance as well as the percentage filling value corresponding to the lower product distance.

Note:
For level detection outside the operating range, the operating range must be corrected accordingly in the menu "*Sensor optimisation/Operating range*".

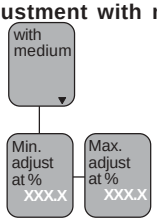
[→]

(max. adjustment)

Now you make the max. adjustment (upper product distance) (example: 100 % and 1.270 m product distance). First, enter the percentage value and then the product distance corresponding to that percentage value.

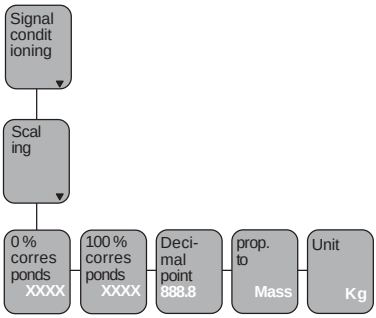
Note:
The difference between the entered values of the lower product distance and the upper product distance should be as big as possible, preferably at 0 % and 100 %. If the values are very close together, e.g. lower product distance at 40 % (3.102 m) and upper product distance at 45 % (3.331 m), the measurement will be less accurate. A characteristic curve is generated from the two points. Even the smallest deviations between actual product distance and entered product distance will considerably influence the slope of the characteristic curve. If the adjustment points are too close together, small errors inflate to considerably larger ones when the 0 % or the 100 % value is outputted.

Adjustment with medium



Fill the vessel e.g. to 10 % and enter 10 % in the menu "*Min. adjust*" with the "*+*" and "*–*" keys. Then fill the vessel, e.g. to 80 % or 100 % and enter 80 % or 100 % in the menu "*Max. adjust*" with the "*+*" and "*–*" keys.

4. Conditioning



Under the menu item "*Conditioning*", you select product distance at 0 % and at 100 % filling. Then, you enter the parameter and the physical unit as well as the decimal point.

Enter in the menu window "*0 % corresponds*" the numerical value of the 0 % filling. In the example of the adjustment with the PC and the adjustment software VVO, this would be 45 for 45 liters.

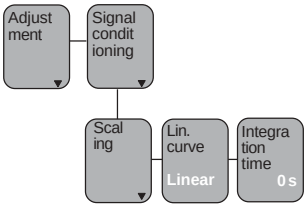
- Confirm with "*OK*".

With the "—>" key you switch to the 100 % menu. Enter here the numerical value of your parameter corresponding to a 100 % filling. In the example 1200 for 1200 liters.

- Confirm with "*OK*".

If necessary, set the decimal point. However, note that only max. 4 digits can be displayed. In the menu "*prop. to*" you choose the physical quantity (mass, volume, distance…) and in the menu "*Unit*" the physical unit (kg, l, ft^3, gal, m^3 …).

Linearisation:



A linear correlation between the percentage value of the product distance and percentage value of the filling volume has been preset. With the menu "Lin. curve" you can choose between linear, spherical tank and cylindrical tank. The generation of a customized linearisation curve is only possible with the PC and the adjustment program VVO.

5. Meas. conditions

(see menu plan no. 5)
Choose "Liquid" or "Solid" and the options corresponding to your application.

6. False echo memory

A false echo storage is always useful when unavoidable false echo sources (e.g. struts) must be minimised. By creating a false echo memory, you authorise the sensor electronics to record the false echoes and save them in an internal database. The sensor electronics treats these (false) echoes differently from the useful echoes and filters them out.

7. Useful level, noise level

In the menu

you get important information on the signal quality of the product echo. The greater the "S-N" value, the more reliable the measurement (menu plan MINICOM).

Ampl.: means amplitude of the level echo in dB (useful level)
S-N: means Signal-Noise, i.e. the useful level minus the level of the background noise

The greater the "S-N" value (difference between the amplitudes of the useful signal level and the noise level), the better the measurement:

> 50 dB	Measurement excellent
40 … 50 dB	Measurement very good
20 … 40 dB	Measurement good
10 … 20 dB	Measurement satisfactory
5 … 10 dB	Measurement sufficient
< 5 dB	Measurement poor

Example:
Ampl. = 68 dB
S-N = 53 dB

68 dB – 53 dB = 15 dB

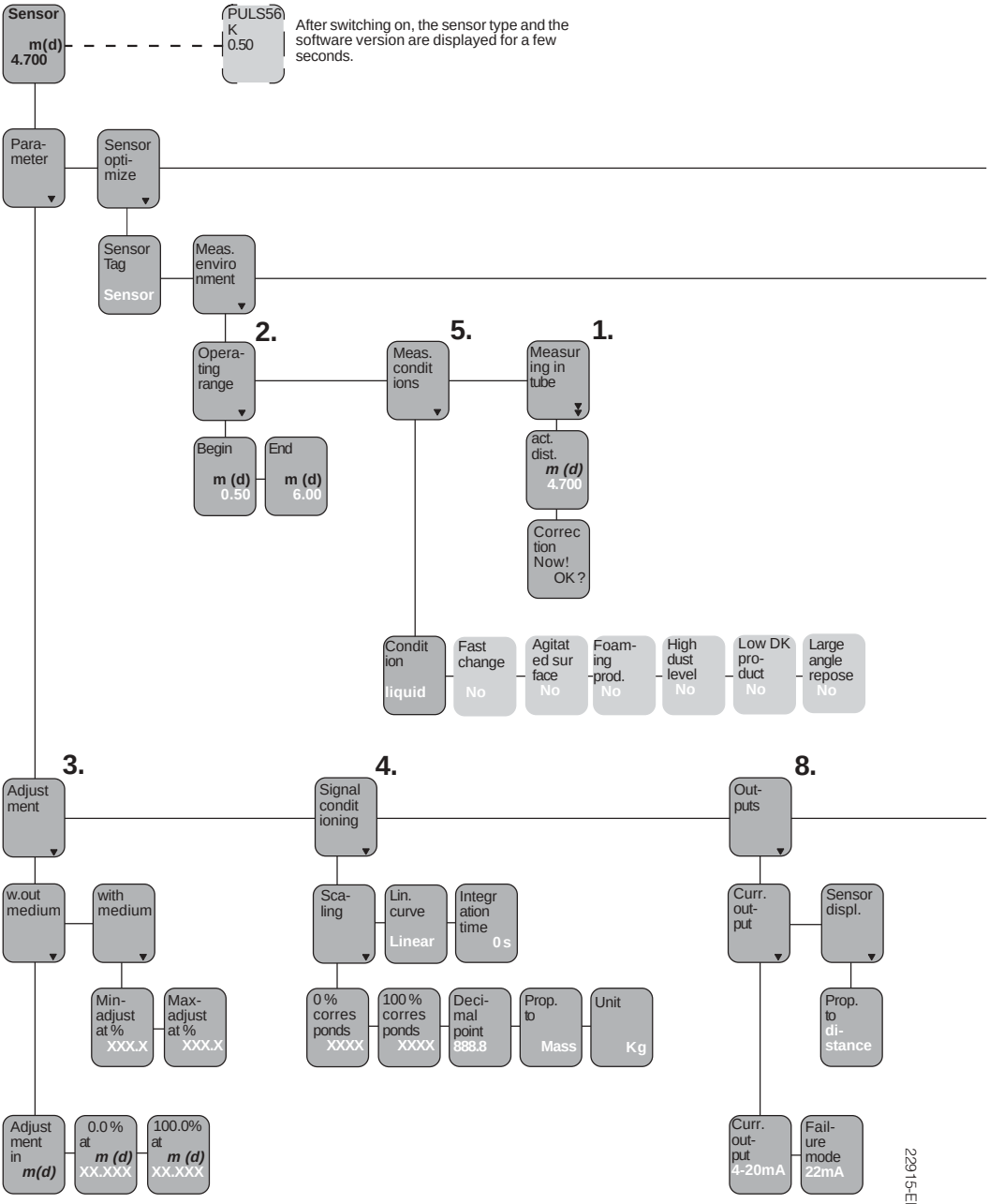
This means that the noise level is only 68 dB – 53 dB = 15 dB.

A 15 dB noise level and a 53 dB signal difference yield a high degree of measurement reliability.

8. Outputs

Under the menu "Outputs" you determine, for example, whether the current output should be inverted, or which unit of measurement should be shown on the sensor display.

Menu schematic for the adjustment module MINICOM



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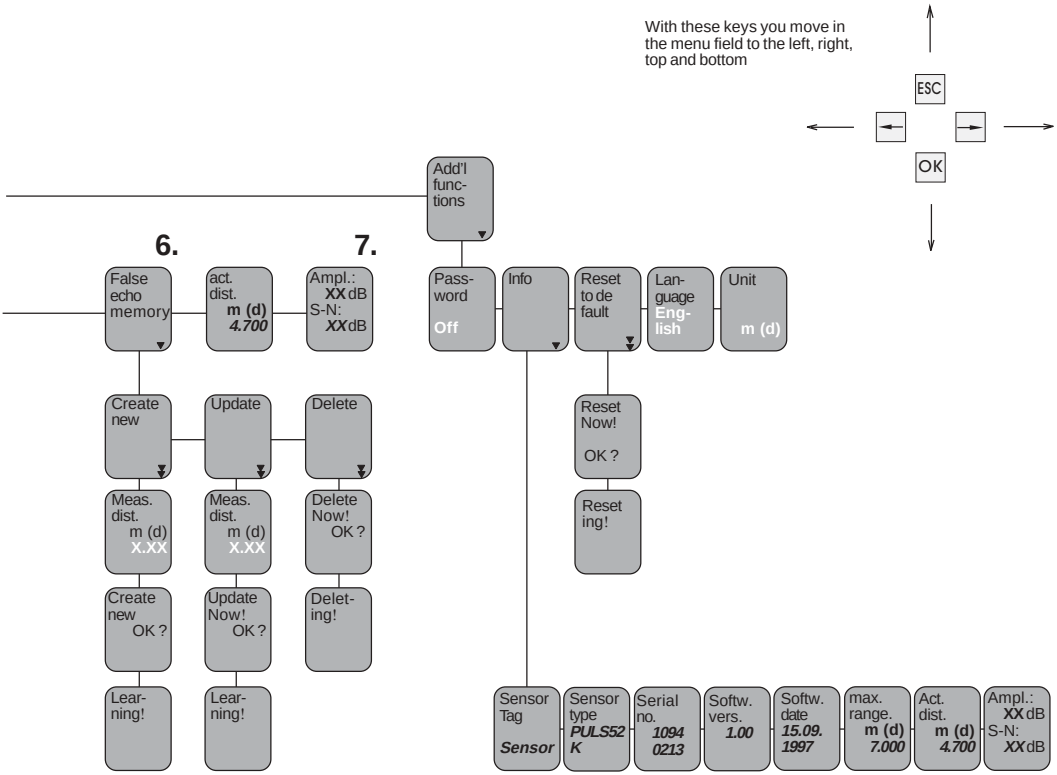
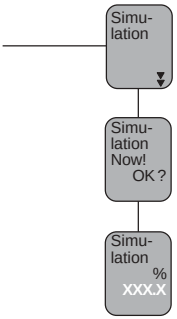
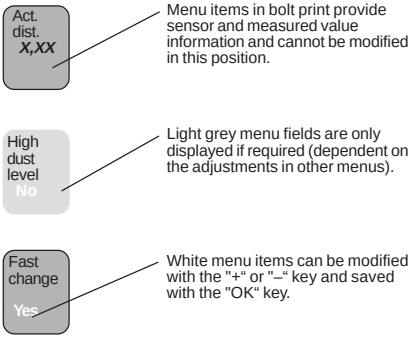




Simulation:
One hour after the last simulation adjustment, the sensor returns automatically to normal operating mode.

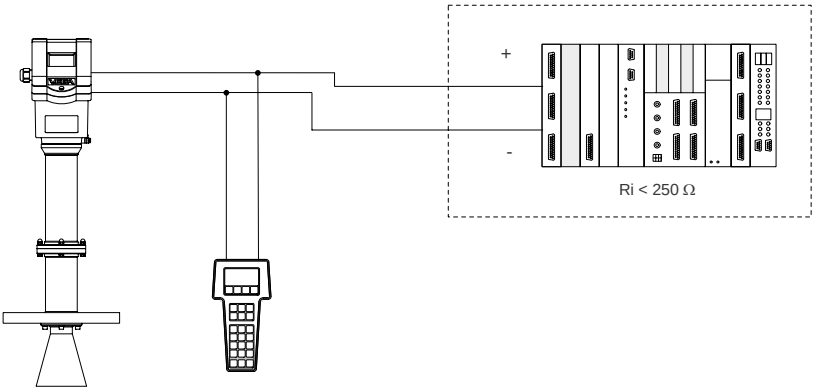
Note:
Set up the sensor in the sequence of the numbers. The menu items under the numbers 1 to 5 are required for set-up. The menus below the numbers 7 and 8 are only necessary for difficult measurement conditions. The menu below number 6 is only necessary for measurement in a standpipe.



5.4 Adjustment with HART® handheld

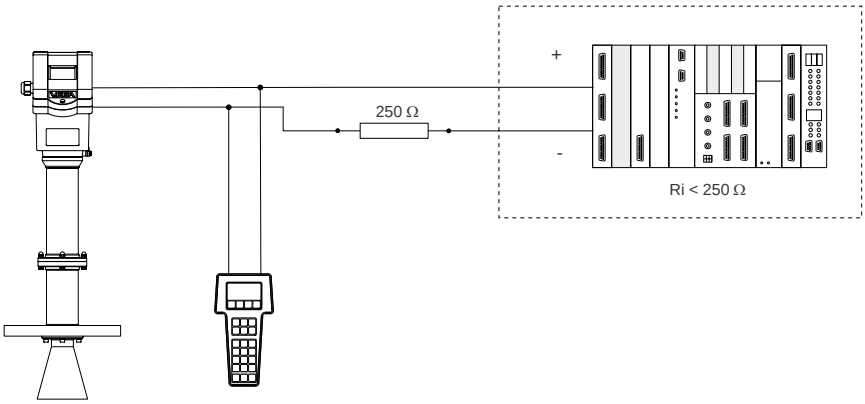
With any HART® handheld you can set up the VEGAPULS series 56K radar sensors like all other HART® compatible sensors. A special DDD (Data Device Description) is not necessary.

Just connect the HART® handheld to the signal cable, after having connected the sensor to power supply.



Note:
If the resistance of the power supply is less than 250 Ohm, a resistor must be connected into the signal/connection loop during adjustment.

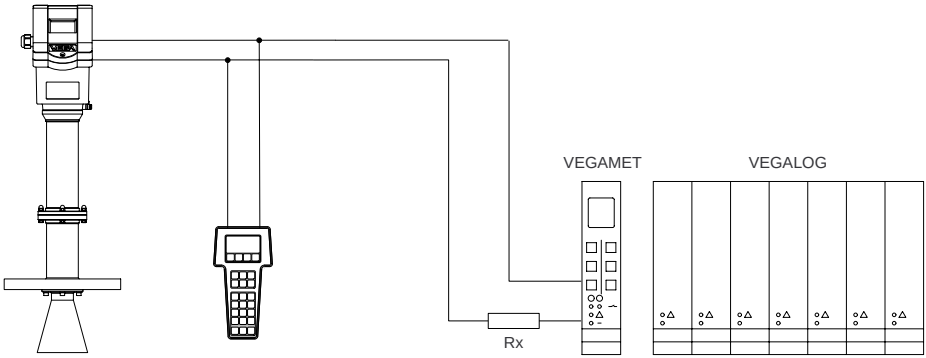
The digital adjustment and communication signals would otherwise be short-circuited due to insufficient resistance of the supply current source or the processing system, and as a result, communication with the sensor would not be ensured.



Connection to a VEGA signal conditioning instrument

If you operate a HART® compatible sensor on a VEGA signal conditioning instrument, you have to connect the sensor via a resistor (see following table) during HART® adjustment. This resistor, together with the internal resistance of the instruments, provides the value of 250 Ohm required for the HART® instrument.

VEGA signal conditioning instr.	Rx
VEGAMET 513, 514, 515, 602 VEGATRENN 544 VEGATOR 521…527	50 … 100 Ohm
VEGAMET 614 VEGADIS 371	no additional resistor required
VEGAMET 601	200 … 250 Ohm
VEGASEL 643	150 … 200 Ohm
VEGAMET 513 S4, 514 S4 515 S4, VEGALOG EA card	100 … 150 Ohm



6 Diagnosis

6.1 Simulation

To simulate a certain filling level, you can call up the function “Simulation” in the adjustment module MINICOM, in the adjustment software PACT*ware*™ or in the HART® handheld.
You simulate a vessel filling and thereby a certain sensor current. Please note that connected instruments, such as e.g. a PLC, react according to their adjustments and will probably activate alarms or system functions. One hour after the last simulation adjustment, the sensor returns automatically to standard operating mode.

6.2 Error codes

Display	Meaning	Rectifying measure
E013	No valid measured value - Sensor in the warm-up phase - Loss of the useful echo	Message is displayed during warm-up phase If the message remains, a false echo storage must be carried out with the adjustment module MINICOM in the menu “sensor optimisation” or better, with the PC and VVO. If the message still remains, carry out a new adjustment.
E017	Adjustment span too small	Carry out a readjustment. Make sure that the difference between min. and max. adjustment is at least 10 mm.
E036	Sensor software does not run	- Sensor must be programmed with new software (service) - Message appears during a software update.
E040	Hardware failure/Electronics defective	Check all connection cables. Contact our service department.

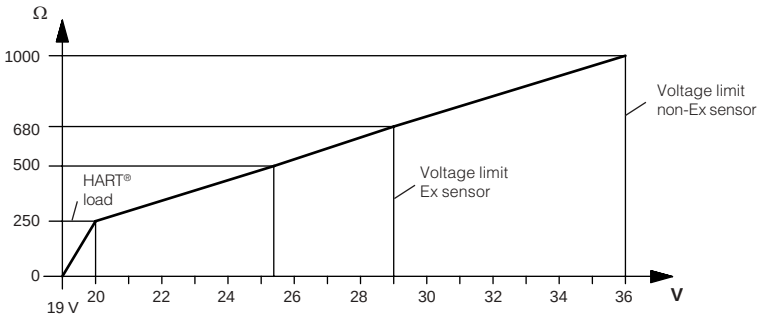
7 Technical data

7.1 Data

Power supply

Supply voltage	
- two-wire sensor	24 V DC (20 … 36 V DC)
- four-wire sensor	24 V DC (20 … 72 V) 230 V AC (20 … 250 V), 50/60 Hz fuse 0.5 A TR

Load diagram (loop resistance of e.g. PLC and supply cable)



Current consumption	
- two-wire sensor	max. 22.5 mA
- four-wire sensor	max. 60 mA
Power consumption	
- two-wire sensor	max. 80 mW, 0.45 VA
- four-wire sensor	max. 200 mW, 1.2 VA

Measuring range [1)]

Standard	0 … 20 m
Measurement in a standpipe	
- VEGAPULS 56 on DN 50	0 … 16 m
- VEGAPULS 56 on DN 100	0 … 19 m

Output signal (see also „Outputs and processing“)

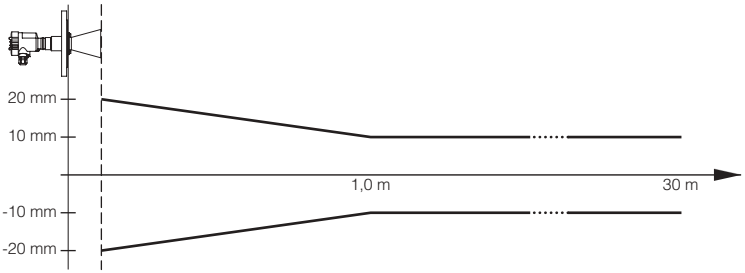
4 … 20 mA current signal	
Load	
- four-wire sensor	max. 500 Ω
- two-wire sensor	see above diagram

[1)] Min. distance from the antenna top to the medium 5 cm

Accuracy [1)]

(typical values under reference conditions, all statements relate to the nominal measuring range)

Influence	
- of the ambient temperature [1)]	0.06 %/10 K
- of the process temperature [1)]	negligible (0.004 %/10 K at 5 bar) (0.003 %/10 K at 40 bar)
- of the process pressure [21]	negligible (0.025 %/bar)
Resolution	1 mm
Resolution of the output signal	1.6 µA, 0,01 % or 1 mm
Accuracy	see diagram



Adjustment time	> 2 s (dependent on the parameter adjustment)

Characteristics

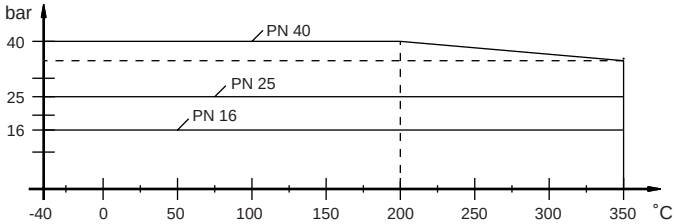
Frequency	5.8 GHz (USA 6.3 GHz)
Intervals	
- two-wire sensor	0.6 s
- four-wire sensor	0.3 s
Min. span between full and empty adjustment	
- analogue output signal	10 mm (recommended 50 mm)
- digital output signal	5 mm (recommended 50 mm)
Beam angle (at –3 dB)	
- with DN 80	38° (only for standpipe measurement)
- with DN 100	30° (only for standpipe measurement)
- with DN 150	20°
- with DN 200	16°
- with DN 250	14°

[1)] Reference conditions acc. to IEC 770

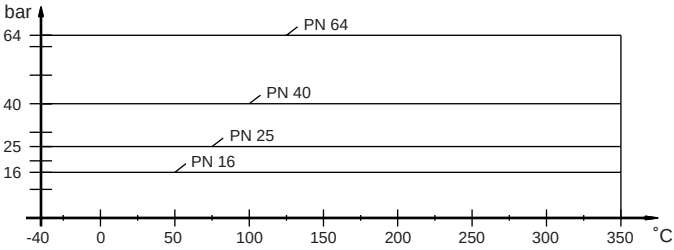
Ambient conditions

Ambient temperature on the housing	-20°C ... +60°C
Flange temperature (process temp.)	-40°C ... +350°C (pressure-dependent), see following diagrams
Vessel installation	with process temperatures > 200°C the rear of the flange must be covered with a heat insulation see chapter „4 Mounting and installation“
Storage and transport temperature	-40°C ... +80°C
Protection	IP 66/IP 67
Protection class	
- two-wire sensor	II
- four-wire sensor	I
Overvoltage category	III
Vessel pressure	max. 64 bar (temperature-dependent), see following diagrams

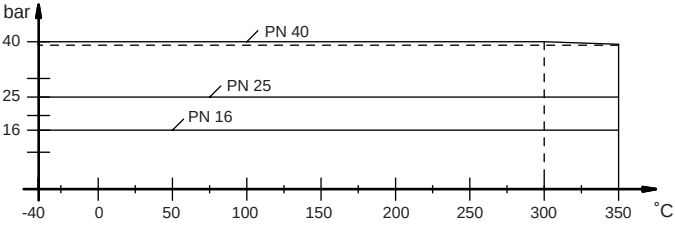
Flange DIN DN 50
Material: 1.4571
Seal surface acc. to DIN 2526 Form B, C, D, E



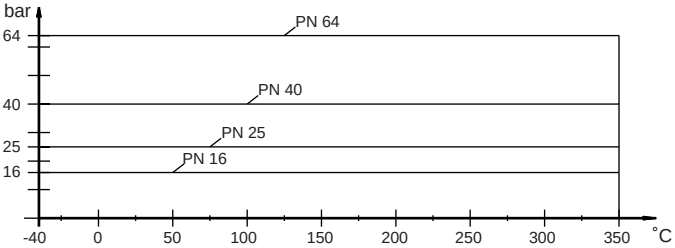
Flange DIN DN 50
Material: 1.4571
Groove and tongue acc. to DIN 2512 Form F, N



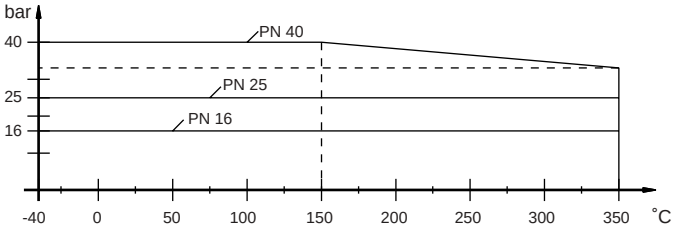
Flange DIN DN 80
Material: 1.4571
Seal surface acc. to DIN 2526 Form B, C, D, E



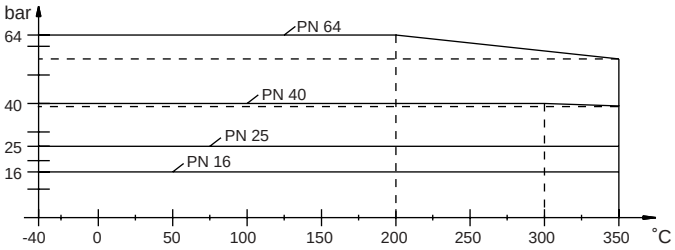
Flange DIN DN 80
Materials: 1.4571
Groove and tongue acc. to DIN 2512 Form F, N



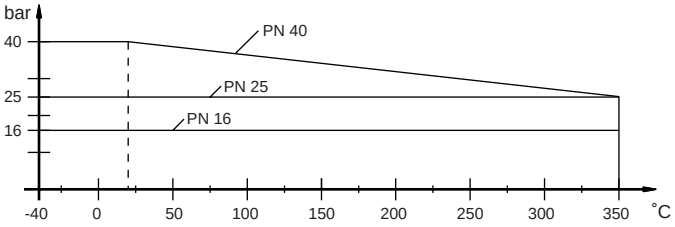
Flange DIN DN 100
Material: 1.4571
Seal surface acc. to DIN 2526 Form B, C, D, E



Flange DIN DN 100
Materials: 1.4571
Groove and tongue acc. to DIN 2512 Form F, N



Flange DIN DN 150
Materials: 1.4571
Seal surface acc. to DIN 2526 Form B, C, D, E



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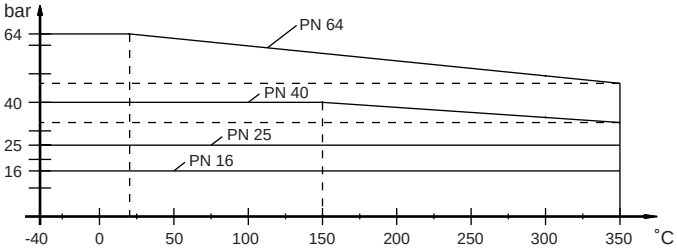
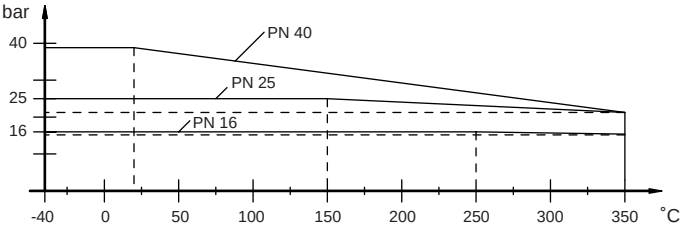
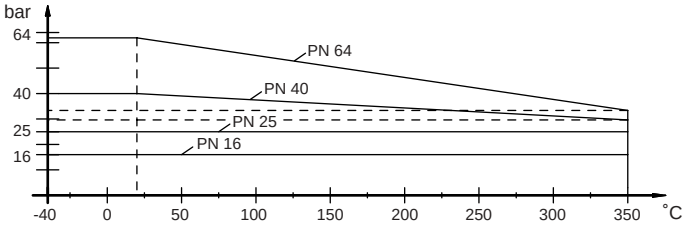
Flange DIN DN 150
Material: 1.4571
Groove and tongue acc. to DIN 2512 Form F, N



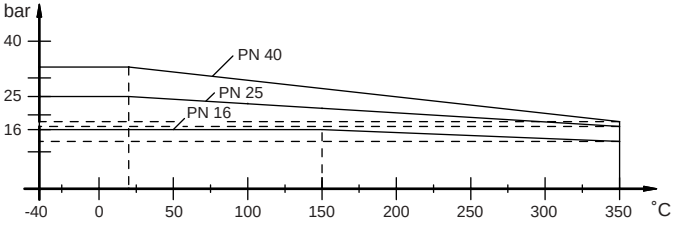
Flange DIN DN 200
Material: 1.4571
Seal surface acc. to DIN 2526 Form B, C, D, E



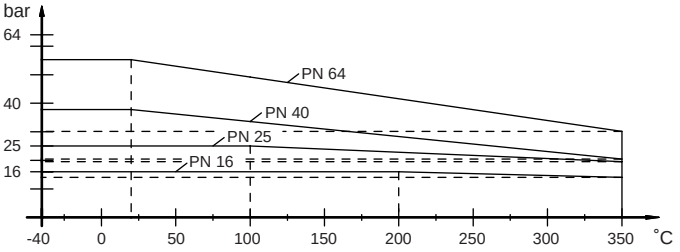
Flange DIN DN 200
Materials: 1.4571
Groove and tongue acc. to DIN 2512 Form F, N



Flange DIN DN 250
Material: 1.4571
Seal surface acc. to DIN 2526 Form B, C, D, E



Flange DIN DN 250
Materials: 1.4571
Groove and tongue acc.
to DIN 2512 Form F, N



Flanges acc. to ANSI (ASA) B16.5 seal surface RF, materials 1.4571 in sizes 2“ up to 10“ can be used over the complete temperature range of -40°C ... 350°C with the respective nominal pressures of 150 lbs, 300 lbs, 600 lbs and 900 lbs.

Further flanges and process data on request.

Ex-technical data

Comprehensive data in the safety instructions manual (yellow binder)

Materials

Housing	Aluminium die casting (GD-AlSi10Mg)
Flange	1.4571 or Hastelloy C22
Antenna	ceramic (Al_2O_3), 1.4571 or Hastelloy C22
Seal	Tantalum
Exd terminal compartment (only EExd version)	Aluminium chill casting (GK-Alsi7Mg)

Weights in kg (1 psi = 0.0689 bar)

DIN	16 bar	25 bar	40 bar	64 bar
- DN 50	6.9	--	7.7	8.5
- DN 80	8.8	--	10.0	10.9
- DN 100	9.8	--	11.7	14.1
- DN 150	14.6	--	18.7	27.5
- DN 200	21.0	--	26	48
- DN 250	29.6	38.2	38.5	61.4

ANSI	150 psi	300 psi	600 psi	900 psi
- 2“	6.3	7.6	8.5	15.3
- 3“	8.1	11.3	13.1	17.2
- 4“	11.7	16.2	22.6	28.5
- 6“	15.8	26.7	44.0	56.2
- 8“	27.0	50.0	85.0	100.0
- 10“	35.8	60.7	108.0	136.0

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Connection cables

Two-wire sensors	power supply and signal via one two-wire cable
Four-wire sensor	power supply and signal separately, line resistance of the 4 … 20 mA signal cable max. 500 Ω
Wire cross section	generally 2.5 mm²
Ground connection	max. 4 mm²
Cable entry	
- Ex ia terminal compartment (adjustment module)	2 x M20 x 1.5 (cable diameter 5 … 9 mm)
- Exd terminal compartment	2 x $^1/_2$" NPT EEx d (cable diameter of 3.5 … 8.7 mm)

CE conformity CE

VEGAPULS series 50 radar sensors meet the protective regulations of EMC (89/336/EWG) and NSR (73/23/EWG) and R & TTE directive (1999/5/EC).

Conformity was judged acc. to the following standards:
EN 300 683-1: 1997
EN 300 440-1: 1995

I-ETS 300-440
Expert opinion No. 0043052-01/SEE, Notified Body No. 0499

EN 61 326: 1997/A1: 1998 (EMC Emission/Susceptibility)
EN 61 010 - 1: 1993 (NSR)

EN 50 020: 1994 (ATEX)
EN 50 018: 1994
EN 50 014: 1997

Outputs and processing

Display

Indication	- optionally mounted, scalable analogue and digital measured value display. - optional external measured value display which can be mounted up to 25 m away from the sensor, measured value display powered by the sensor

Signal output

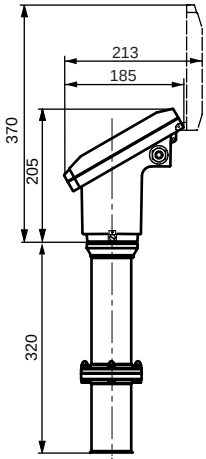
Signal output	
- two-wire technology	4 … 20 mA
- four-wire technology	4 … 20 mA
Resolution of the 20 mA signal	1.6 µA (0.01 % of operating range)
Load	
- four-wire	0 … 500 Ω
- two-wire	see load diagram under „Power supply“
Integration time	0 … 999 seconds

Two-wire technology 4 … 20 mA:
The analogue 4 … 20 mA output signal (measuring signal) is transmitted together with the power supply via one two-wire cable.

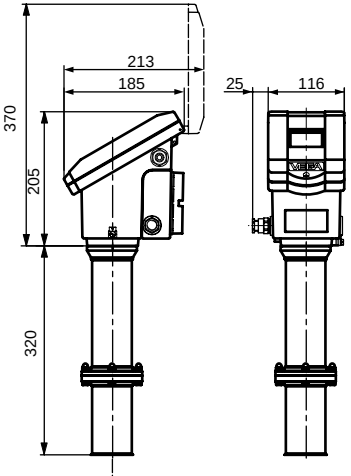
Four-wire technology 4 … 20 mA:
Separate power supply. The analogue 4 … 20 mA output signal (measuring signal) is transmitted in a cable separate from power supply.

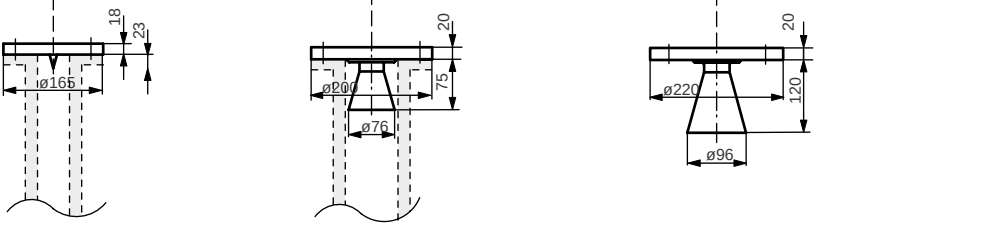
7.2 Dimensions

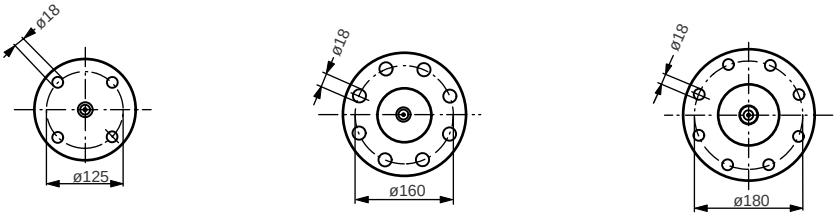
Aluminium housing



Aluminium housing with Exd terminal compartment







DN 50

Pipe antenna

DN 80

Pipe antenna

DN 100

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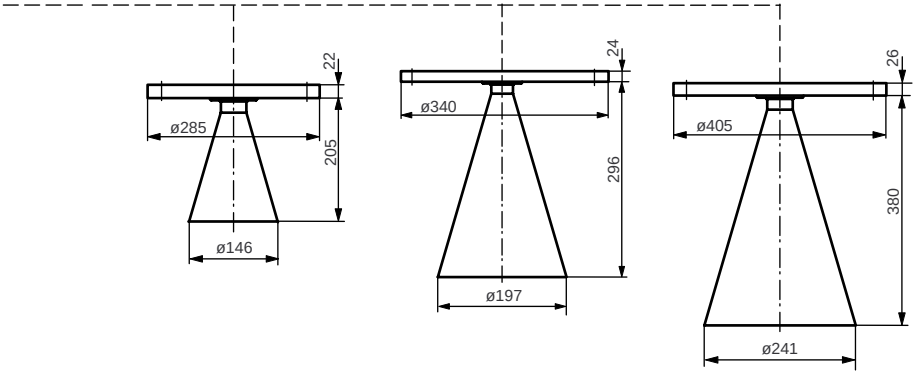

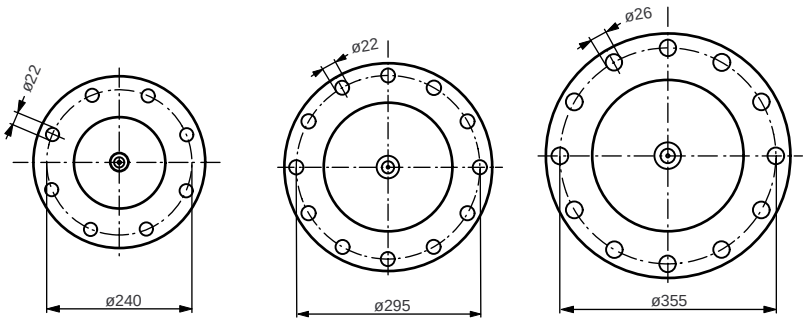

DN 150 DN 200 DN 250

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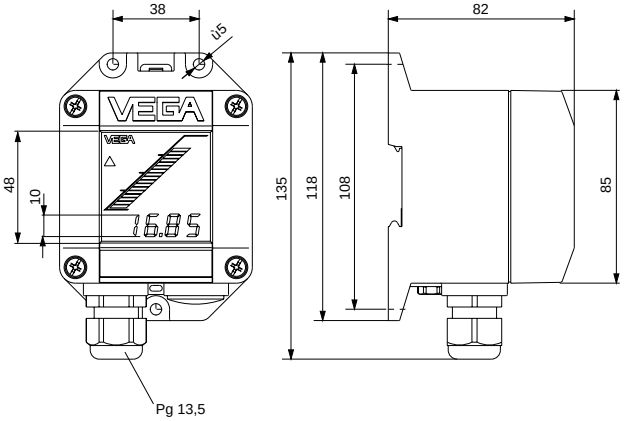
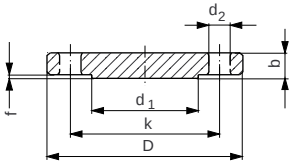
External indicating instrument VEGADIS 50



Mounting on carrier rail 35 x 7.5 acc. to EN 50 022 or flat screwed

Note:
The diameter of the connection cable should be min. 5 mm and max. 9 mm.
Otherwise the seal effect of the cable entry would not be ensured.

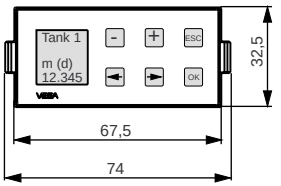
Flange dimensions acc. to ANSI



D = outer flange diameter
b = flange thickness
k = diameter of hole circle
d_1 = seal ledge diameter
f = seal ledge thickness
$^1/_{16}$" = approx. 1.6 mm
d_2 = diameter of holes

Size	Flange			Seal ledge	Holes	
	D	b	k	d_1	No.	d_2
2" 150 psi	152.4	19.0	120.7	91.9	4	19.1
3" 150 psi	190.5	23.8	152.4	127.0	4	19.1
4" 150 psi	228.6	23.8	190.5	157.2	8	19.1
6" 150 psi	279.4	25.4	241.3	215.9	8	22.4

Adjustment module MINICOM



Adjustment module for insertion into sensors or into the external indicating instrument VEGADIS 50

7.3 Approvals

When radar sensors are used in Ex and dust-Ex areas or on ships, the instruments must be suitable and approved for the explosion zones and applications.
The suitability is checked by the approval authorities and is certified in approval documents.

VEGAPULS 56 radar sensors are approved for Ex-Zone 1 and Zone 0.

Please note the attached approval documents (yellow binder) when using a sensor in Ex area.

Test and approval authorities

VEGAPULS radar sensors are tested and approved by the following monitoring, test and approval authorities:

- **PTB**
  (Physikalisch Technische Bundesanstalt - Physical Technical Approval Authority)
- **FM**
  (Factory Mutual Research)
- **ABS**
  (American Bureau of Shipping)
- **LRS**
  (Lloyds Register of Shipping)
- **GL**
  (German Lloyd)
- **CSA**
  (Canadian Standards Association)

Ex area Zone 0/Zone 1

Series 50 sensors require for operation in Ex area special safety barriers or separators providing intrinsically safe (ia) circuits.

The following shows a selection of instruments with which VEGAPULS 56 sensors work reliably. In conjunction with separators, the resistance of the signal cable and the separator resistance (voltage loss of the separator) must not exceed the max. load (see load diagram in chapter „3.1 Data“).

Ex area Zone 0/Zone 1 without Exd connection housing:
Separator and signal conditioning instrument:
- VEGADIS 371 Ex

Separator:
- VEGATRENN 149 Ex
- Stahl 9303/15/22/11
- Knick WG 21 A 7 (opt. 470, 336)
- CEAG GHG 124 3111 C1206

Safety barrier:
- Stahl 9001/01/280/085/10
- Stahl 9001/01/280/110/10
- Stahl 9001/01/280/165/10
- CEAG GHG 11 1 9140 V0728

Pressure-tight encapsulated in Ex area

Series 50 sensors in EEx d ia (pressure-tight encapsulated) version can be used in Ex areas without special safety barriers due to their pressure-tight encapsulated terminal compartment (provided the appropriate installation regulations are observed).

SIL conformity and IEC 61508 / IEC 61511

VEGAPULS radar sensors meet the requirements on functional safety acc. to IEC 61508 / IEC 61511. For further information see Supplement under „Safety Manual“.

Supplement

Safety Manual

Functional safety acc. to IEC 61508 / IEC 61511

VEGAPULS series 50 radar sensors; 4 ... 20 mA/HART® compact sensor

1 General

1.1 Validity

This safety manual applies to VEGAPULS series 50 radar sensors in two-wire version 4 ... 20 mA/HART®, called “measuring system” in the following.

1.2 Area of application

The measuring system can be used for the following functions which meet the specific requirements of the safety technology:
- overfill protection
- dry run protection
- detection of an individual level

The functions can be also used simultaneously.

The functions can be used in the mode of operation with low demand mode as well as in the mode of operation with high demand or continuous mode.

The measuring system is qualified in all modes to meet the requirement degree SIL2 acc. to IEC 61508-2 / IEC 61511-1.

The measuring system is designed for 15 years of use in safety-related applications.

In safety-related systems with an architecture 1oo2D and the requirement SIL3, the measuring system must be combined with a second, different measuring system (diversely redundant). The safety-related characteristics must be calculated separately.

1.3 Relevant standards

- IEC 61508 part 1, 2, 4
  Functional safety of electrical/electronic/programmable electronic systems

- IEC 61511-1
  Functional safety – safety instrumented systems for the process industry sector – Part 1: Framework, definitions, system, hardware and software requirements

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1.4 Determination of safety-related characteristics

The failure limit values for a safety function, depending on the SIL class.

Safety integrity level	Low demand mode	High demand or continuous mode
SIL	**PFD_{avg}**	**PFH**
4	$\geq 10^{-5}$ up to $<10^{-4}$	$\geq 10^{-9}$ up to $<10^{-8}$
3	$\geq 10^{-4}$ up to $<10^{-3}$	$\geq 10^{-8}$ up to $<10^{-7}$
2	**$\geq 10^{-3}$ up to $<10^{-2}$**	**$\geq 10^{-7}$ up to $<10^{-6}$**
1	$\geq 10^{-2}$ up to $<10^{-1}$	$\geq 10^{-6}$ up to $<10^{-5}$

(from IEC 61508, part 1/7.6.2)

Safety integrity of the hardware:
Limitations due to the architecture for safety-related subsystems of type B

Safe failure fraction SFF	Hardware fault tolerance HFT		
	0	**1 (0) [1)]**	**2**
< 60 %	not allowed	SIL 1	SIL 2
60 % up to < 90 %	SIL 1	**SIL 2**	SIL 3
90 % up to < 99 %	SIL 2	SIL 3	(SIL 4)
≥ 99 %	SIL 3	(SIL 4)	(SIL 4)

(from IEC 61508, part 2/7.4.3)

[1)] Acc. to IEC 61511-1, paragraph 11.4.4 the fault tolerance specified acc. to the above chart can be reduced by one for all subsystems if the following conditions are met:
- instrument has proven during operation
- only process-relevant parameters can be modified on the instrument (e.g. measuring range, ...)
- the adjustment of this process-relevant parameters is protected (e.g. password, ...)
- the safety function needs less than SIL 4

2 Planning

2.1 Low demand mode

If the demand rate is only once a year, then the measuring system can be used as safety-relevant subsystem in „low demand mode“ (see IEC 61508-4, 3.5.12).

Corresponding characteristics : PFD_{avg} (average probability of dangerous failure on demand). It is dependent on the test interval T_{Proof} between the function tests of the protective function.

2.2 High demand or continuous mode

If the demand rate is more than once a year, the measuring system must be used as safety-relevant subsystem in „high demand or continuous mode“ (see IEC 61508-4, 3.5.12).

The fault reaction time of the measuring system must be set to less than or at the most, equal to the fault tolerance time of the total system. The smallest fault reaction time of the measuring system is 60 sec.

Corresponding characteristics: PFH (probability of a dangerous failure per hour)

2.3 General

The safe condition of the measuring system in case of failure is defined for both modes of operation at an output current > 21 mA. An output current < 3.6 mA and > 21 mA must be configured as alarm in the processing unit.

Definition of a dangerous undetected failure:
- the instrument does not react to the demand of the process
- the output current deviates by more than 2 % from the actual value.

Otherwise the tolerance data in the operating instructions manual are applicable. Make sure that the measuring system is used as it was intended for the application (see operating instructions manual). The application-specific limits must be complied with and the specifications must not be exceeded (see operating instructions manual). Use only in products against which the materials of the antenna system are sufficiently chemically resistant.

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3 Set-up

3.1 Mounting and installation

The prevailing plant conditions influence the safety of the measuring system. Therefore note the mounting and installation instructions of the appropriate operating instructions manual.

3.2 Adjustment instructions and parameter adjustment

Adjustment instructions
The activation of the measuring system as safety-relevant subsystem is only possible via PC adjustment programs. Not all safety-relevant parameters can be adjusted with the adjustment module MINICOM. The set parameters must be checked and protected against unauthorised access (password, screwed housing cover, ...).

General instructions, see operating instructions manual

Parameter adjustment
The following software versions are required:
- Sensor software: from 4.50.00
- DTM-Collection: from 10/2003

With the adjustment program PACT*ware*™, the SIL parameter adjustment must be activated in the Device Type Manager (DTM).

Note
If a reset is triggered on the sensor after the SIL parameter adjustment or if the failure mode = 22 mA is changed, the sensor will loose its SIL qualification.

3.3 Configuration of the processing unit

If the measuring system delivers output currents > 21 mA or < 3.6 mA, it must be assumed that a failure has occurred.

The processing unit must therefore interpret such current values as a failure and trigger a suitable fault signal.

4 Reaction during operation and in case of failure

In case of modifications during operation, you have to take note of the safety functions. It must be ensured that the safety-relevant parameter adjustments remain activated.

Occurring fault signals are described in the appropriate operating instructions manual.

In case of detected failures or fault signals, the entire measuring system must be switched out of service and the process held in a safe condition by means of other measures.

5 Recurring function test

The recurring function test serves to reveal potential dangerous errors that are otherwise not discernible.

The function of the measuring system must be checked at adequate intervals. The operator is responsible for choosing the type of test and the intervals in the stated time frame.

The time intervals depend upon the applied PFD_{avg} value acc. to the chart and diagram in the paragraph „Safety-related characteristics“.

The test must be carried out in a way that verifies the flawless operation of the safety functions in conjunction with all system components. This is ensured by a controlled reaching of the response height during a filling.

If filling up to the response height is not possible, then a response of the measuring system must be triggered by a suitable simulation of the level or the physical measuring effect. If the proper functioning of the measuring system is otherwise discernible (exclusion of function-restraining errors), it is also possible to carry out the test by simulating the appropriate output signal.

If the function test proves negative, the entire measuring system must be switched out of service and the process held in a safe condition by means of other measures.

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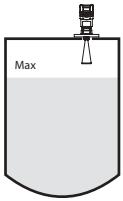
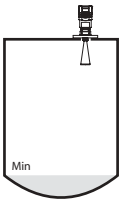
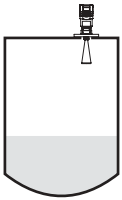
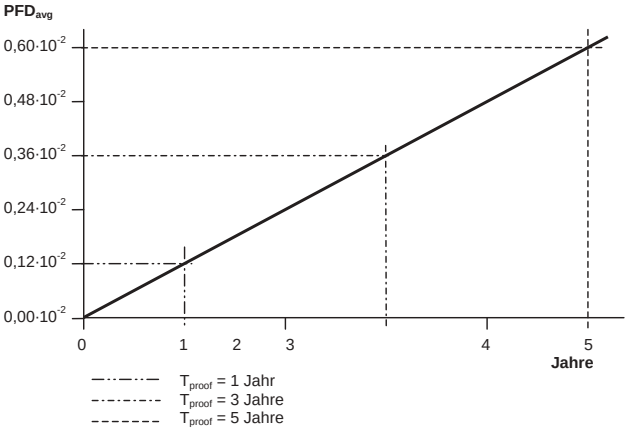
6 Safety-related characteristics

The failure rate of the electronics and the antenna system was determined by an FMEDA (Failure Mode, Effects and Diagnostics Analysis) acc. to IEC 61508. The number values are based on an output current tolerance of max. 2 %.

Architecture 1oo1D		**SIL 2**	
VEGAPULS 51 VEGAPULS 52 VEGAPULS 53 VEGAPULS 54 VEGAPULS 56	Overfill protection 	Dry run protection 	Individual level 
HFT	0		
SFF	> 86%		
PFD_{avg} [1]	$< 0.12 \bullet 10^{-2}$ $< 0.60 \bullet 10^{-2}$	with T_{Proof} = 1 year [2] with T_{Proof} = 5 years	
PFH [1/h] [3]	$< 0.28 \bullet 10^{-6}$		
Failure reaction time	$T_{Reaction}$ = 60 sec		



[1] PFD_{avg} this value correlates almost linearly to the operating time. It is only valid for the corresponding selection circuit.

[2] T_{Proof} is the interval after which a periodically recurring complete function test (to check the safety function) must be carried out.

[3] PFH is valid for the stated Failure reaction time $T_{Reaction}$ of the measuring system. This means that the failure tolerance time of the complete system must be higher than $T_{Reaction}$.

SIL declaration of conformity

Füllstand - Grenzstand - Druck

S I L - K o n f o r m i t ä t s e r k l ä r u n g

Funktionale Sicherheit nach IEC 61508 / IEC 61511

VEGA Grieshaber KG, Am Hohenstein 113, D-77761 Schiltach

erklärt als Hersteller, dass für die Füllstandaufnehmer der Produktfamilien

VEGAPULS Serie 40 und 50 (4 ... 20 mA HART®)

die Betriebsbewährtheit entsprechend der IEC 61508 / IEC 61511 nachgewiesen wurde.
Die Geräte sind deshalb für den Einsatz in sicherheitsrelevanten Einrichtungen
z.B. für Überlaufschutz, Trockenlaufschutz oder Erfassung eines beliebigen Füllstandes geeignet.
Die entsprechenden Sicherheitshinweise im Safety Manual sind zu beachten. [1]

Sicherheitstechnische Kenndaten:

			VEGAPULS 40	VEGAPULS 50	
SIL	Safety Integrity Level		SIL 2	SIL 2	
HFT	Hardware Fault Tolerance	[2]	0	0	
SFF	Safe Failure Fraction		> 88 %	> 86 %	
PFD_{avg}	average Probability of dangerous Failure on Demand (für niedrige Anforderungsrate)	[3]	< 0,10 x 10^{-2}	< 0,12 x 10^{-2}	T_{Proof} 1 Jahr
			< 0,50 x 10^{-2}	< 0,60 x 10^{-2}	T_{Proof} 5 Jahre
PFH [1/h]	Probability of a dangerous Failure per Hour (für hohe Anforderungsrate oder kontinuierliche Anforderung)	[4]	< 0,22 x 10^{-6}	< 0,28 x 10^{-6}	Fehlerreaktionszeit 60sec

Die Ausfallraten wurden über eine FMEDA (Failure Modes, Effects and Diagnostics Analysis) ermittelt:

		VEGAPULS 40	VEGAPULS 50	
λ_{sd}	safe detected failure	107 FIT	111 FIT	[5]
λ_{su}	safe undetected failure	494 FIT	518 FIT	
λ_{dd}	dangerous detected failure	1090 FIT	1140 FIT	
λ_{du}	dangerous undetected failure	221 FIT	277 FIT	
MTTF	Mean Time To Failure	60 Jahre	56 Jahre	MTTR = 8h

[1] Safety Manual siehe Anhang der Betriebsanleitung
[2] HFT ist gemäß IEC 61511-1, Abschnitt 11.4.4 um eins reduziert
[3] PFD_{avg} gilt nur für das T_{Proof} – Intervall, nach dem ein wiederkehrender Funktionstest durchgeführt werden muss
[4] PFH ist über die Zeit konstant. Nach der Norm ist kein wiederkehrender Funktionstest notwendig.
Die Fehlertoleranzzeit des Gesamtsystems muss größer sein als die Fehlerreaktionszeit des Standaufnehmers
[5] Fehlerrate: 1 FIT = 1 Ausfall /10^9 h

Die Beurteilung des Änderungswesens war Bestandteil des Nachweises der Betriebsbewährtheit.

Schiltach, 28.10.03
VEGA Grieshaber KG

i.V. Frühauf
Leiter Zertifizierung

i.A. Blessing
Beauftragter für Funktionale Sicherheit

SIL-KE_PULS40+50_DE_031028

CE declaration of conformity

CE

Konformitätserklärung

Declaration of conformity
Déclaration de conformité

VEGA

VEGA Grieshaber KG
Am Hohenstein 113
77761 Schiltach

erklärt in alleiniger Verantwortung, daß das Produkt / declare under our sole responsibility that our product / déclare sous sa seule responsabilité que le produit

VEGAPULS 51...56

auf das sich diese Erklärung bezieht, mit den folgenden Normen übereinstimmt / to which this declaration relates is in conformity with the following standards / auquel se réfère cette déclaration est conforme aux normes

EN 50081-1 : 1992
EN 50082-2 : 1995
EN 61010-1 : 1993

gemäß den Bestimmungen der Richtlinien / following the provision of Directives / conformément aux dispositions des Directives

73/23 EWG
89/336 EWG
93/68 EWG

Schiltach, 15.04.1999

Hubert Nöll
Geschäftsführer

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All statements concerning scope of delivery, application, practical use and operating conditions of the sensors and processing systems correspond to the information available at the time of printing.

Technical data subject to alterations