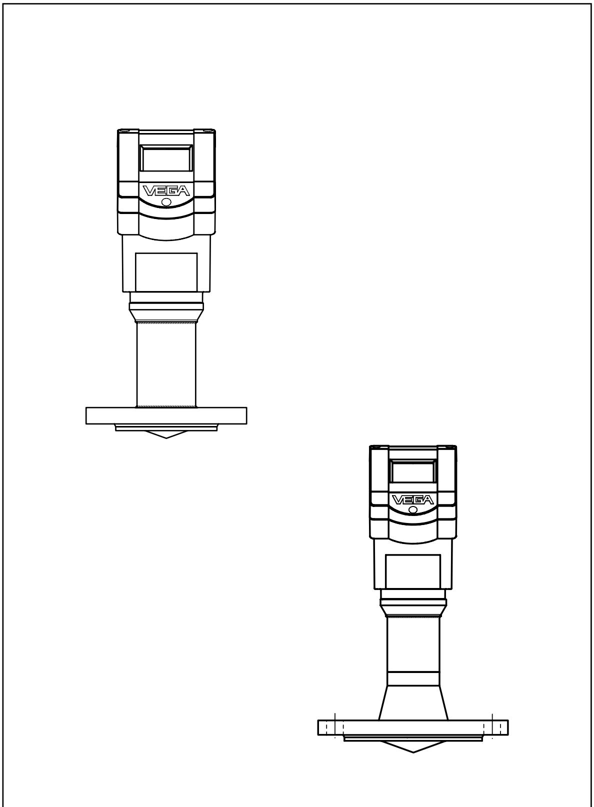
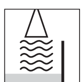
Operating Instructions

VEGAPULS 43

4 … 20 mA; HART® compact sensor





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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 qualified 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.

1 Product description

Sensors used in the food and pharmaceutical industries must meet very high demands: they must have long-term stability, they must be accurate, robust, easy to set up, chemically resistant and flawlessly hygienic. Many level sensors meet those demands only halfway. Radar sensors, which are otherwise widely used, are not usually found in hygienic and sterile applications because their antennas are difficult to clean. The newly developed VEGAPULS 43 radar sensor was designed especially for areas of application in hygienic and sterile production. Radar sensors are ideal because they operate without touching the medium, are free of wear and ageing, and perform well regardless of pressure (-1 … +40 bar) or temperature (-40°C … +150°C). The new antenna design of VEGAPULS 43, having no recesses or gaps, presents a smooth surface (like a smooth vessel wall) to CIP and SIP processes. It allows all the methods of modern, environment-friendly system hygiene and has, of course EHEDG, FDA and 3A approvals. The sensor faces the medium only with a small, extremely dense TFM-PTFE surface through which it transmits very small (0.15 mW) radar pulses. A very fast, intelligent electronics creates from the resulting echoes a precise image of the surroundings and calculates from the pulse running time the level in the vessel every 0.1 s. This value is then outputted as a 4 … 20 mA signal. Compared with the PTFE commonly used in hygienic applications, the improved TFM-PTFE has a far denser polymer structure and a noticeably higher surface quality (Ra < 0.8). As a result, proven radar technology is now available for sterile production processes. The spectrum of applications for the new radar sensor is broad and varied: serum production, face cream, fruit juice, etc.

Due to their small housing dimensions and process fittings, the compact sensors are unobstrusive and, above all, cost-effective monitors of your product levels. With their integrated display, they enable high-precision level measurements and can be used for applications in which the advantages of non-contact measurement could never before be realized.

VEGAPULS radar sensors are perfectly adapted to two-wire technology. The supply voltage and the output signal are transmitted via one two-wire cable. The instruments produce an analogue 4 … 20 mA signal as output, i.e. measurement signal.

1.1 Function

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

Measuring principle:

emission – reflection – reception
Extremely small 26 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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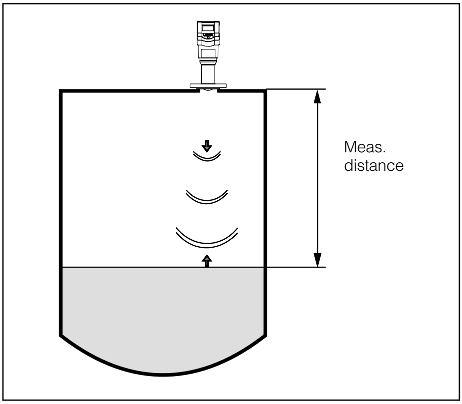
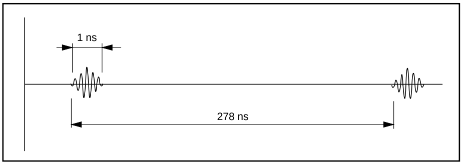


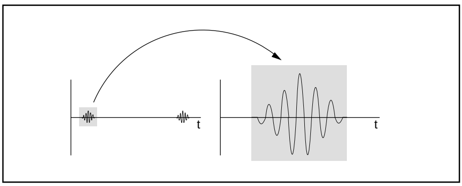
emission - reflection - reception

The radar pulses are emitted by the antenna system as pulse packages 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 radar sensors can achieve this through a special time transformation procedure which spreads out the more than 3.6 million echo images per second into a quasi slow-motion picture, then freezes and processes them.



Time transformation

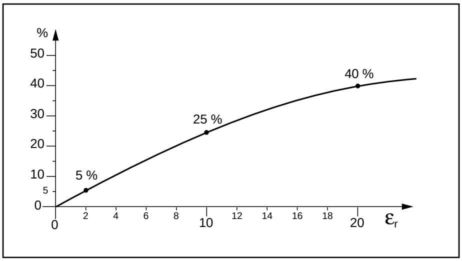
Hence, it is possible for the radar sensors to process the slow-motion pictures of the sensor environment precisely and in detail in cycles of 0.5 to 1 second without using time-consuming frequency analysis (e.g. FMCW, required by other radar techniques).

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



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

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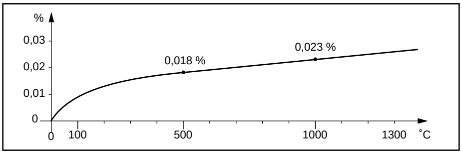
With standard flanges of DN 50 to DN 150, ANSI 2“ to ANSI 6“ or G 1½ A and 1½“ NPT, the sensor antenna systems can be adapted to various products and measuring environments.

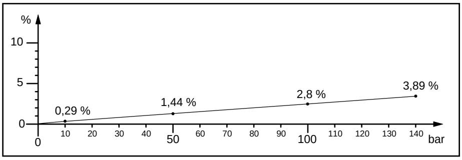
The high-quality materials can also withstand extreme chemical and physical conditions. The sensors deliver stable, reproducible analogue or digital level signals with reliability and precision.

Continuous and reliable

Unaffected by temperature, pressure and atmosphere content, VEGAPULS radar sensors are used for quick and reliable continuous level measurement 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 1.44 %)

1.2 Application features

Applications
- level measurement of any liquid
- measurement also in vacuum
- all slightly conductive materials and all substances with a dielectric constant > 2.0
- measuring range 0 … 10 m (DN 50). measuring range 0 … 20 m (DN 80, DN 100, DN 150).

Two-wire technology
- power supply and output signal on one two-wire cable (Loop powered)
- 4 … 20 mA output signal or HART® output signal.

Rugged and abrasionproof
- non-contact
- high-resistance materials

Exact and reliable
- accuracy 0.05 %.
- resolution 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 16 bar and product temperatures up to 150°C.

Communicative
- integrated measured value display
- optional display module separate from sensor
- adjustment with detachable adjustment module, pluggable in the sensor or in the external display
- adjustment with HART® handheld
- adjustment with the PC.

Approvals
- CENELEC, ATEX, PTB, FM, CSA, ABS, LRS, GL, LR, FCC.

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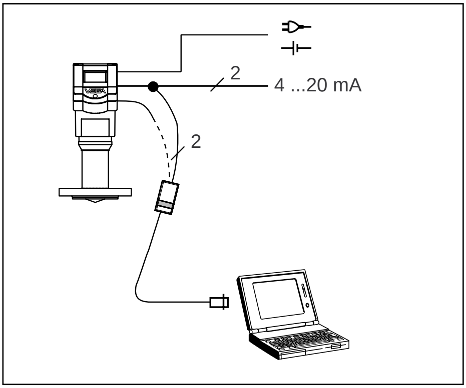
1.3 Adjustment

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

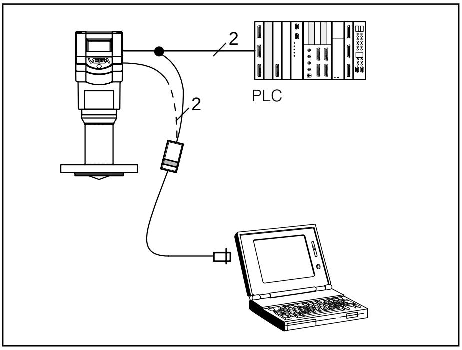
Adjustment with the PC

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.



Adjustment with the PC on the analogue 4 … 20 mA signal and supply cable or directly on the sensor (four-wire sensor)

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. 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 or directly on the sensor (figure: a two-wire sensor)

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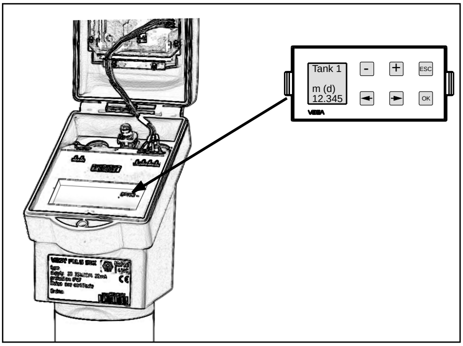
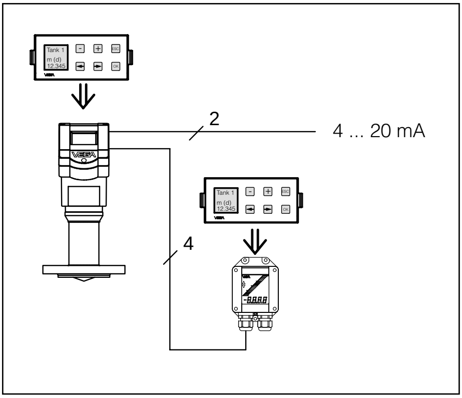
Adjustment with the adjustment module MINICOM

The small (3.2 cm x 6.7 cm) 6-key adjustment module with display allows the adjustment to 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

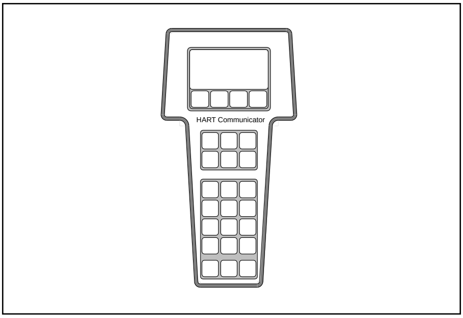
Unauthorised sensor adjustments can be prevented by removing the adjustment module.



Adjustment with detachable adjustment module. The adjustment module can be plugged into the radar sensor or into the external indicating instrument VEGADIS 50.

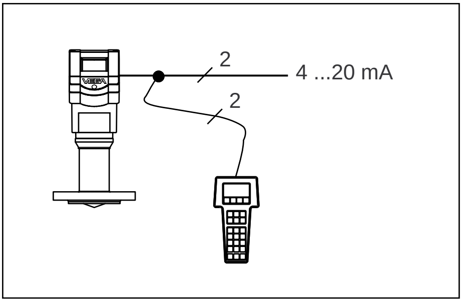
Adjustment with the HART® handheld

Series 40 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.



HART® handheld

To make adjustments, simply connect the 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

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2 Types and versions

2.1 Type survey

VEGAPULS 43 sensors are manufactured with three process connections:
- flange connections (block flanges) in DN 50, 80, 100, 150, ANSI 2“, 3“, 4“, 6“
- TRI-Clamp 2“
- hygienic fitting DN 50.

Survey of features

General features
- Application preferably for liquids in storage tanks and process vessels with increased accuracy requirements.
- Measuring range 0 … 10 m or 0 … 20 m.
- Ex approved in Zone 1 (IEC) or Zone 1 (ATEX) classification mark EEx ia [ia] IIC T6.
- Integrated measured value display.

Survey

Signal outputs - active (4 … 20 mA) - passive (4 … 20 mA, loop powered)	
Process fitting, optionally available with - DN 50; ANSI 2“ - DN 80; ANSI 3“ - DN 100; ANSI 4“ - DN 150; ANSI 6“ - TRI-Clamp (50, 80) - hygienic fitting (50, 80)	
Adjustment - PC - adjustment module in the sensor - adjustment module with external indicating instrument - HART® handheld	
Measuring range - DN 50, ANSI 2“ - DN 80, ANSI 3“ - DN 100, ANSI 4“ - DN 150, ANSI 6“ - TRI-Clamp 50, 80 - hygienic fitting 50, 80	 0 … 10 m 0 … 20 m 0 … 20 m 0 … 20 m 0 … 10 m 0 … 10 m

2.2 Antenna

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 hygienic VEGAPULS 43 radar sensors are equipped with an antenna that can be cleaned as easily as a smooth vessel wall. The previously used horn and rod antennas are gone. Only a small cone-shaped bulge protrudes into the process vessel. The small cone acts like a lens that focuses the radar signals into a high-frequency beam. The relative dielectric constant of the small 140° PTFE cone represents the calculation index of the lens. The visible part of the antenna (small cone), however, does not give a clue as to how precisely the geometrical form of the antenna has to be adapted to the physical properties of electromagnetic waves. The shape governs the focusing of the waves and hence the sensitivity, just as shape governs the sensitivity of a unidirectional microphone. The production of such an electromagnetic lens requires much empirical knowledge in the areas of high-frequency physics and materials science.

Hygienic design

Beside the aforementioned geometry necessary for antennas used in the food and pharmaceutical industry, the choice of materials for the newly developed VEGAPULS 43 sensors is critical for cleaning and sterilisation. Fully automatic cleaning (CIP) and sterilisation (SIP) of entire production facilities (without disrupting production or having to dismantle and disassemble parts of the equipment) is, in practice, not an easy task. Dirt and contaminants get trapped mechanically in pores, fissures, scratches and recesses, and even remain on smooth walls due to electrostatic attraction.

PTFE is commonly found in hygienic applications. The small plastic cone of the sterile, pharmaceutical VEGAPULS 43 radar sensor, which is at the same time antenna and process seal, consists of a TFM-PTFE material. This is a fluorothermoplastic which has additional distinct advantages compared to PTFE, such as e.g., reduced load deformation, denser polymer structure as well as smoother surface (Ra < 0.8 µm). The other known advantages of PTFE, such as, e.g., higher temperature resistance (< 200°C), high chemical resistance as well as resistance to brittleness and ageing are still present or have even been enhanced. Perfluorelastomers and fluorthermoplasts are resistant to virtually all chemical media, such as e.g., amines, ketones, esters, acids (sulphuric acid, phosphoric acid, hydrochloric acid, nitric acid), alkalis (caustic soda), oxidants, fuels and oils. Beside their use in the chemical industry, these materials are being applied more and more in sterilisation and pharmaceutical technologies. The only limits to these materials are in applications with fluorine under high pressure or with liquid alkali metals (sodium or potassium), where explosive reactions may occur.

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3 Mounting and installation

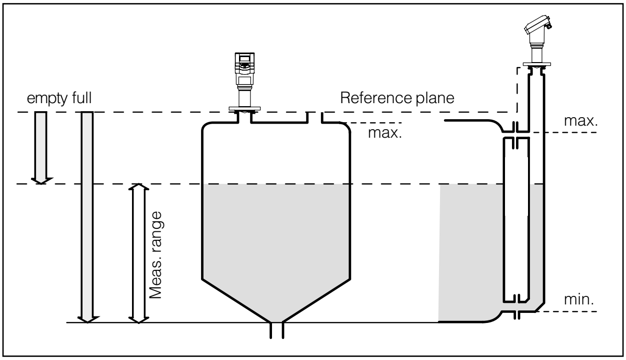
3.1 General installation instructions

Measuring range

The reference plane for the measuring range of the sensor is the lower edge of the flange.

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.

Note: The series 40 sensors are suitable for measurement of solids only under certain conditions.

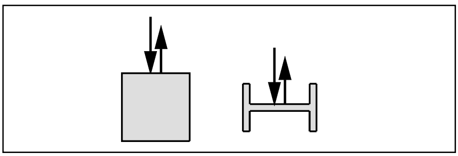


Measuring range (operating range) and max. measuring distance
Note: Use of the sensors for applications with solids is limited.

False echoes

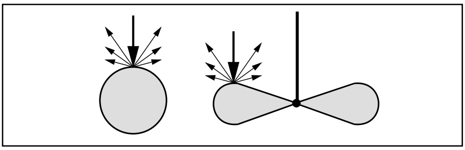
Flat obstructions and struts cause strong false echoes. They reflect the radar signal with high energy density.

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.

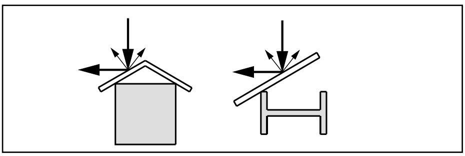


Profiles with smooth interfering surfaces cause large false signals

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, flat 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 keep vessel installations (e.g. pipes and struts) out of the emission cone.

The illustrations of the emission cones are simplified and represent only the main beam - a number of weaker beams also exist. Under difficult measuring conditions, the antenna location and alignment must be chosen with the objective of reducing false echoes. Only giving attention to the size of the useful echo is not adequate when measuring conditions are unfavourable.

In a difficult measuring environment, searching for a mounting location with the lowest possible false echo intensity will bring the best results. In most cases, the useful echo will then be present with sufficient strength. With the adjustment software PACT*ware*™ on the PC, you can have a look at the echo image and optimise the mounting location.

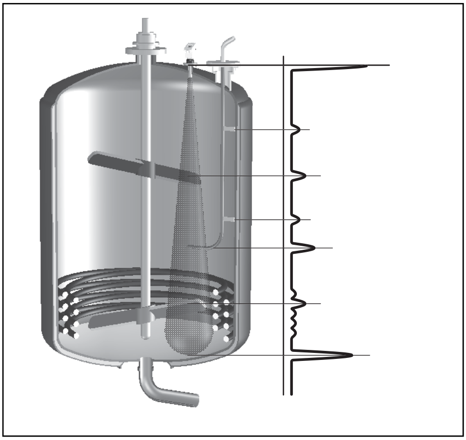
If possible, provide a "clear view“ to the product inside the emission cone and avoid vessel installations in the first third of the emission cone.

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

Examples of vessel echoes

The following vessel images show a typical echo pattern in a vessel. The example shows a process vessel with a slow double-bladed stirrer. In the lower area, the vessel is equipped with heating spirals. A thin, angled inlet tube ends in the vessel centre between the stirrer blades.

Empty vessel



When the vessel is empty, you see the echoes of the vessel installations around the emission cone. Beside the large bottom echo, you see a number of additional false echoes. The false echoes of the vessel installations are saved during a false echo recording. For this reason, the false echo recording must be carried out when the vessel is empty.

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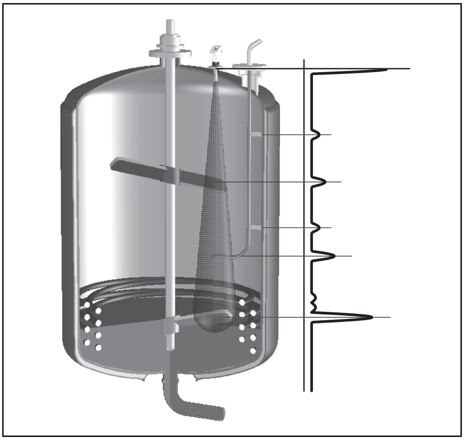
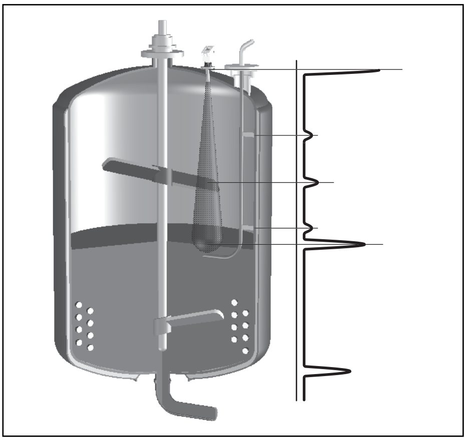
False echoes from the top down:
- first inlet tube fastening
- upper stirrer blade
- second inlet tube fastening
- angled inlet tube
- upper heating tubes
- lower stirrer blade
- remaining heating tubes
- vessel bottom

¼ filling



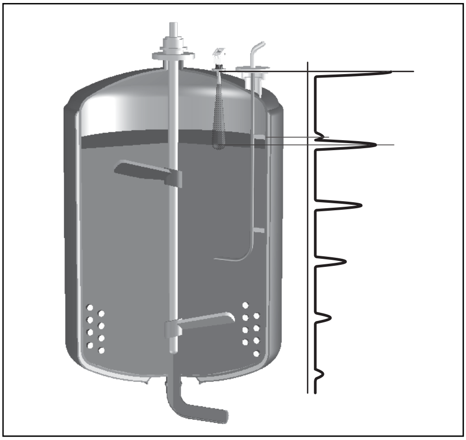
After filling, the bottom echo is replaced by the product echo.

½ filling



The product echo moves to the centre of the meas. range. At the end of the meas. range, you now see an echo at a position where the bottom echo previously was in the empty vessel. This echo is a multiple echo of the product echo and is located at twice the distance of the product echo.

Filled vessel

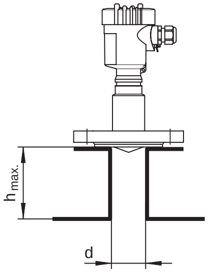


When the vessel is completely filled, you see additional multiple echoes at two, three or four times the distance of the product surface echo.

3.2 Measurement of liquids

Flange antenna

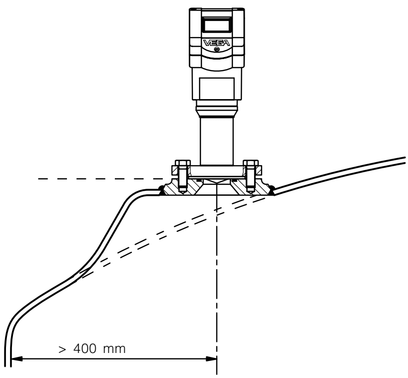
Horn antenna on DIN socket piece
Radar sensors are usually mounted on short DIN socket pieces. The lower side of the instrument flange is the reference plane for the measuring range. The socket piece should be as short as possible.



d	h max.
50 mm/2"	100 mm
80 mm/3"	150 mm
100 mm/4"	250 mm
150 mm/6"	400 mm

Deviating socket dimensions

Mounting on a block flange is especially advantageous. Due to its very shallow recess, it is an ideal solution also for hygienic and aseptic applications.



Mounting on dished tank end

In vessels with dished or rounded tops, please do not mount the instrument in the centre or close to the vessel wall.

The flange screws of VEGAPULS 43 must always be tightened with a torque of approx. 60 Nm so that the PTFE seal is tight.

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.

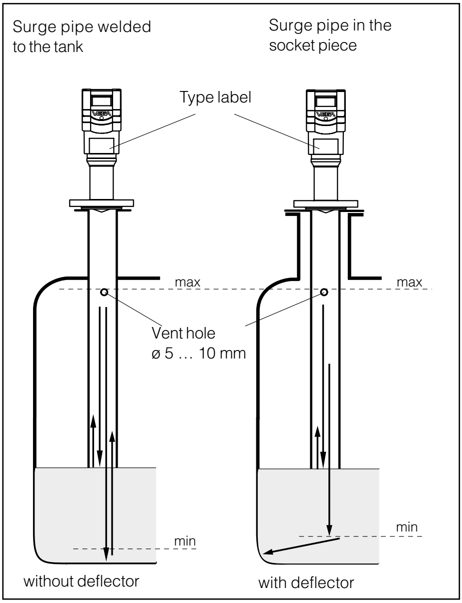
Horn antenna directly on the vessel top
If the stability of the vessel will allow it (sensor weight), flat mounting directly on the vessel top is a good and cost-effective solution. The top side of the vessel is the reference plane.

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 stirrers. 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.



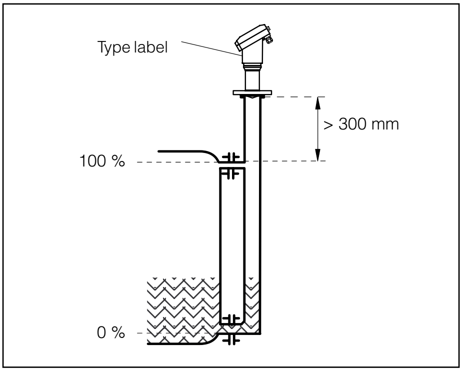
Pipe antenna system in the tank

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. The tube inner diameter should be max. 100 mm or correspond to the size of the antenna horn.

Make sure the required upper vent hole in the surge pipe is aligned with the sensor type label.

As an alternative to a surge pipe in the vessel, a pipe antenna system outside the vessel in a bypass tube is also possible.
The surge and bypass tubes must generally be made of metal. For plastic tubes, a closed, conductive jacket is always required. When using a metal tube with plastic inner coating, make sure that the thickness of the coating is minimal (approx. 2 … 4 mm).

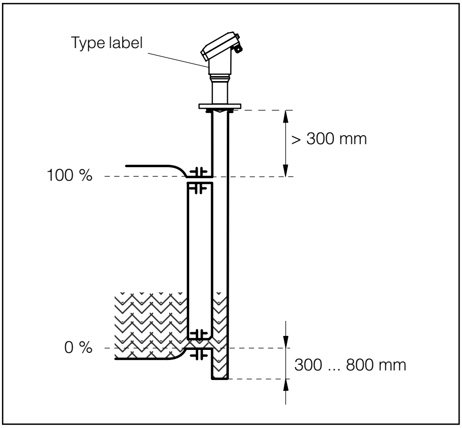
Align the sensor so that the type label lies on the same axis as the tube holes or the tube connection openings. The polarisation of the radar signals enables a considerably stabler measurement with this alignment.



Tube flange system as bypass tube

When mounting a VEGAPULS 43 on a bypass tube (e.g. on a previous floating or displacer unit), the radar sensor should be placed approx. 300 mm or more from the max. level.

For products with small dielectric constants (< 4), the bypass tube should have a length greater than would normally be required for the lower tube connection. Products with small dielectric constants are partly penetrated by the radar signals, allowing the tube bottom to produce a stronger echo than the product (when the bypass tube is nearly empty). By extending the tube downward, some liquid remains at the bottom even when the vessel is completely empty.



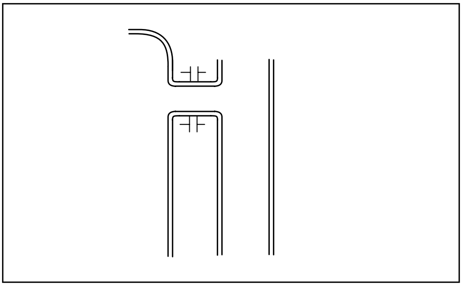
Tube flange system as bypass tube

If enough liquid (300 … 800 mm) remains in the blind lower end of the tube, the portion of the signal that penetrates the liquid and reflects from the tube bottom is sufficiently damped - the sensor can then easily distinguish it from the echo of the liquid surface. In cases where there is not enough liquid at the bottom of the tube, a deflector situated there will carry out the same function. It deflects signals that reach the tube bottom into the standard connection opening.

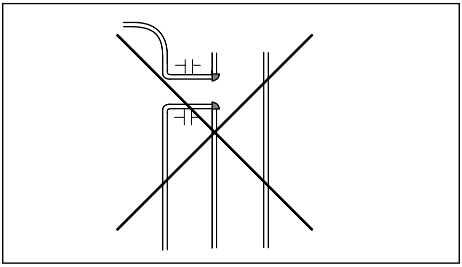
Connections to the bypass tube

The connections to the bypass tubes must be fashioned in such a way that only minimal reflections are caused by the walls of the connecting tubes. This is especially important for the breather connection in the upper part of the tube. Observe the following points:

- Use small openings for the connection.
- The diameter of the connecting tubes should not exceed 1/3 of the bypass diameter.
- The tube connections must not protrude into the bypass tube.
- Large welding beads in the tubes should be avoided.
- Additional connections to the bypass tube must lie in the same plane as the upper and lower vessel connection (above each other or displaced by 180°).



Optimum connection to the bypass tube



Welding beads too large

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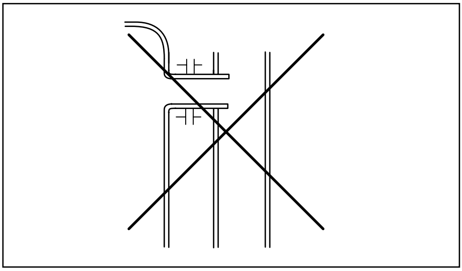
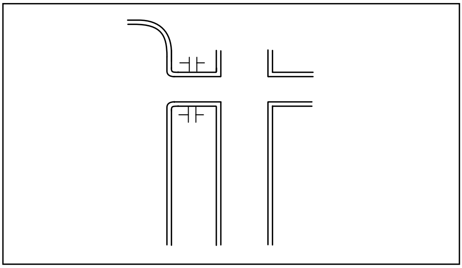


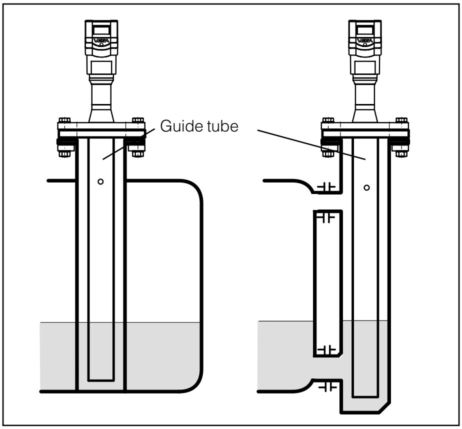
Tube connection protrudes



Additional connection in the bypass tube in one plane

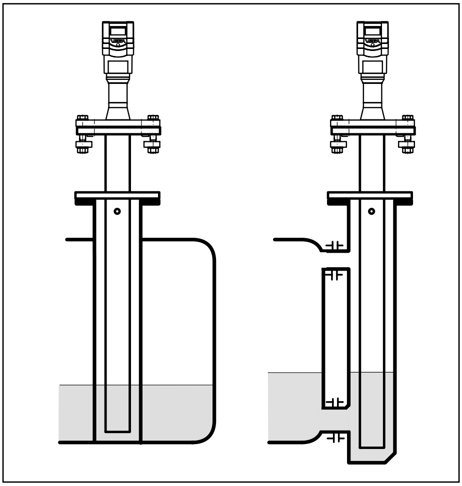
Use of guide tubes

In case of very rough inner surfaces in existing bypass tubes (e.g. due to corrosion), large connecting tube openings, as well as bypass tubes with more than 100 mm inner diameter, the use of a guide tube inside the existing bypass tube is recommended. This reduces the noise level and increases measurement reliability considerably. The flange of the guide tube can be easily mounted as a sandwich flange between vessel and sensor flange.



Guide tube in existing surge or bypass tubes

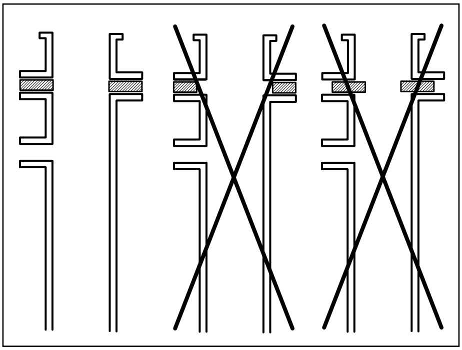
To increase the min. distance, the guide tube can project out of the surge or bypass tube. This can be done by welding a flat welding flange on the outside of the extended guide tube. In both cases, an appropriate breather hole is necessary.



Extended guide tube

Seals on tube connections and tube extensions

Microwaves are very sensitive to gaps in flange connections. If connections are made without proper care, distinct false echoes as well as increased signal noise can result. Observe the following points:
- The applied seal should correspond to the tube inner diameter.
- If possible, conductive seals such as conductive PTFE or graphite should be used.
- There should be as few seal positions as possible in the guide tube.



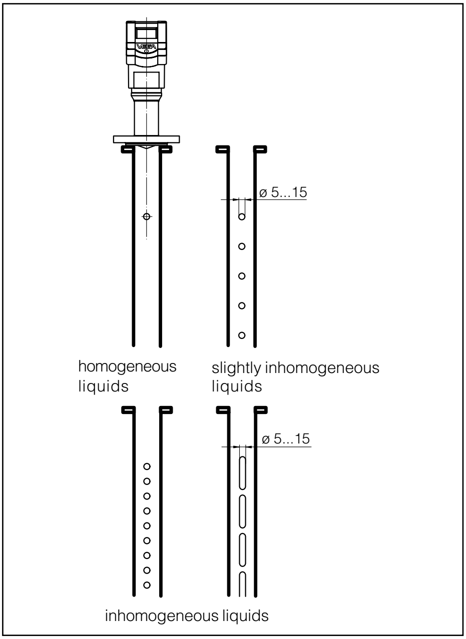
Flange connections on bypass tubes

Adhesive products

With non-adhesive or slightly adhesive products, use a surge pipe with a nominal width of e.g. 50 mm. VEGAPULS 43 radar sensors with 26 GHz technology are for the most part insensitive to buildup in the measuring tube. Nevertheless, buildup should not block the measuring tube.

For products with somewhat heavier buildup, the use of a DN 80 to max. DN 100 standpipe or surge pipe can make measurement possible despite buildup. But with extremely adhesive products, measurement in a standpipe is not possible at all.

Standpipe measurement of inhomogeneous products



Openings in a surge pipe for mixing 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.

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

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.

Every wider slot causes a false echo. The slots should therefore not exceed a width of 10 mm in order to keep the signal noise level to a minimum. Round slot ends are better than rectangular ones.

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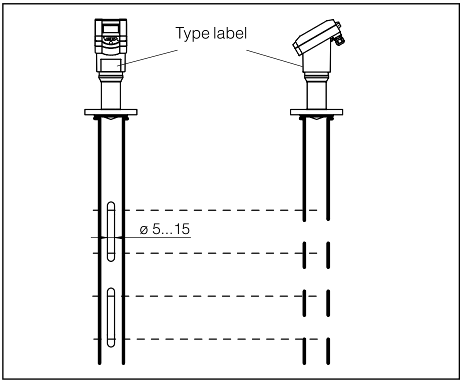
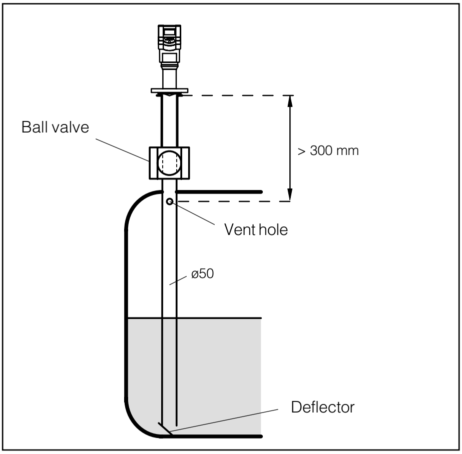


Row of holes in one axis with the type label

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).



Tube antenna system with ball valve cutoff in measuring tube

A prerequisite for trouble-free operation is a ball valve throat that corresponds to the pipe diameter and provides a flush surface with the pipe inner wall. The valve must not have any rough edges or constrictions in its channel. The distance to the sensor flange should be at least 300 mm.

Guidelines for standpipe construction

The radar sensors with a DN 50 flange only form a functioning measuring system in conjunction with a measuring tube.

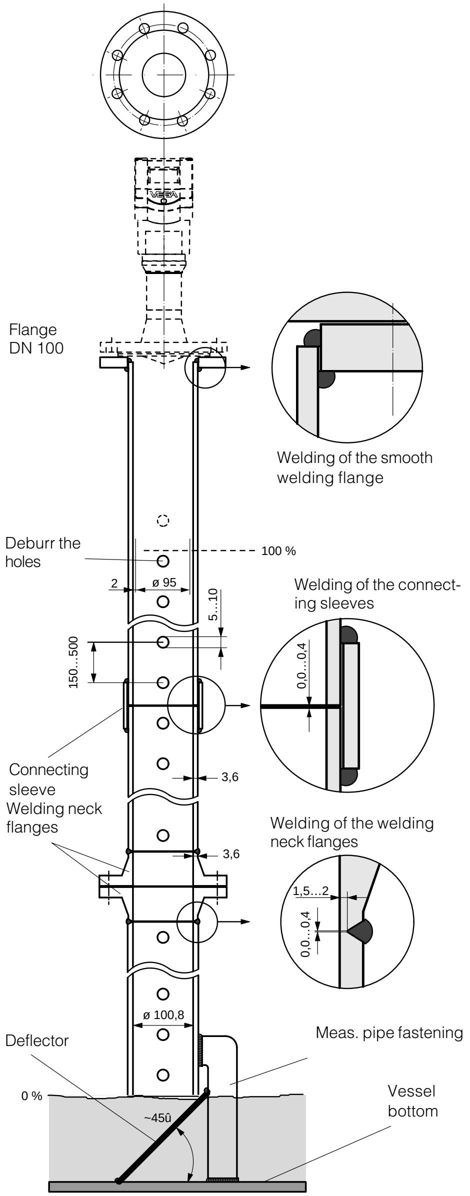
The measuring pipe must be smooth inside (average roughness Rz ≤ 30). Use stainless steel tubing (drawn or welded lengthwise) for construction of the measuring pipe. Extend the measuring pipe to the required length with weld-on flanges or with connecting sleeves. Make sure that no shoulders or projections 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 adhesion.

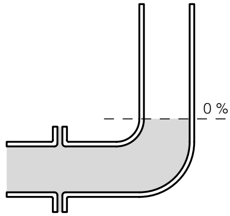
If the vessel contains agitated products, fasten the measuring pipe to the vessel bottom. Provide additional fastenings for longer measuring pipes.

In products with lower dielectric values (< 4), a part of the radar signal penetrates the medium. If the vessel is nearly empty, echoes are generated by both the product and the vessel bottom. The echo from the vessel bottom can in some cases be stronger than the echo from the product surface. If a deflector is installed below the open end of the measuring tube, the radar signals are scattered and prevented from reaching the vessel bottom. This ensures that, in nearly empty vessels or with products of low dielectric value, the product delivers a more distinct echo than the vessel bottom.

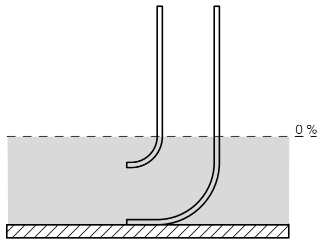
Due to the deflector, the useful echo (and thus the measured value) remains clearly detectable in a nearly empty vessel, and the 0 % level can be reliably measured.



The standpipe or surge pipe can be equipped with a quadrant pipe at its end instead of a deflector. The quadrant pipe reflects the radar signals that penetrate the medium diffusely to the side and diminishes strong echoes from the tube end or the vessel bottom.



Quadrant pipe on the bypass tube end



Quadrant pipe on the standpipe end

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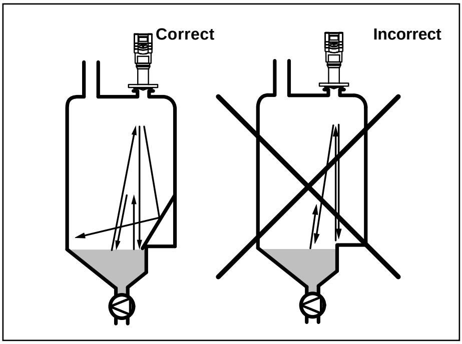
3.4 False echoes

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

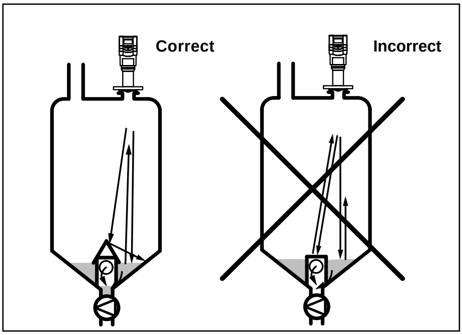
Vessel protrusions

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)

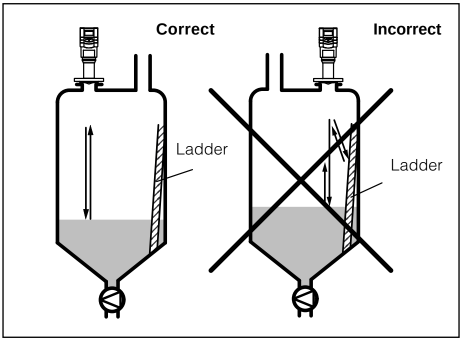
Intake pipes, i.e. for the mixing of materials - with a flat surface directed towards the sensor - should be covered with an angled baffle that scatters false echoes.



Vessel protrusions (intake pipe)

Vessel installations

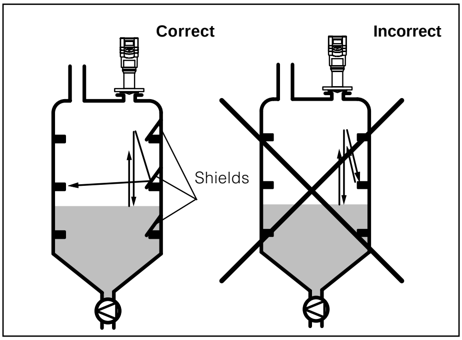
Vessel installations, such as e.g. ladders, often cause false echoes. Make sure when planning your measuring location that the radar signals have free access to the measured product.



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 false echo reception. These false echoes are scattered and diffused in the surrounding space and are then filtered out as "echo noise“ by the measuring electronics.



Struts

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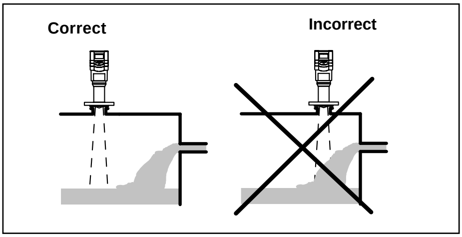
Inflowing material

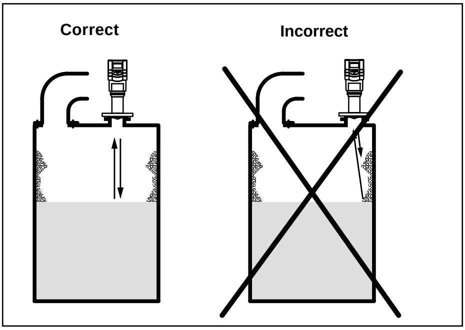
Do not mount the instrument in or above the filling stream. Ensure that you detect the product surface and not the inflowing material.



Inflowing material

Buildup

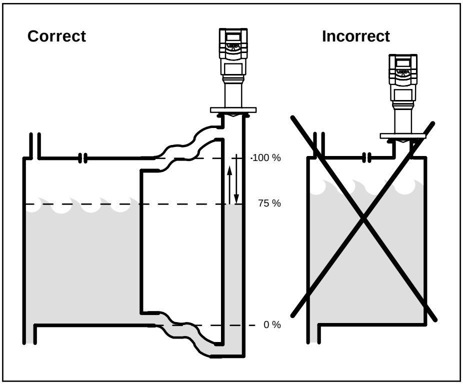
If the sensor is mounted too close to the vessel wall, product buildup and other deposits on the vessel wall cause false echoes. Position the sensor at a sufficient distance from the vessel wall. Please also note chapter "3.1 General installation instructions".



Buildup

Strong product movements

Strong turbulence in the vessel, e.g. caused by powerful stirrers 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.

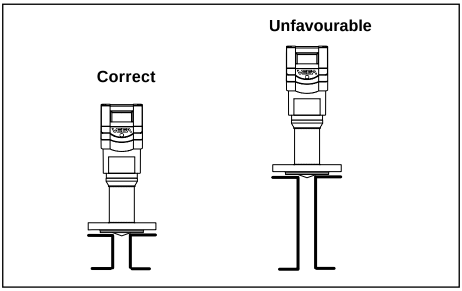


Strong product movements

3.5 Common installation mistakes

Socket piece too long

If the sensor is mounted in a socket extension that is too long, strong false echoes arise which interfere with the measurement.



Flange antenna: Correct and unfavourable socket length

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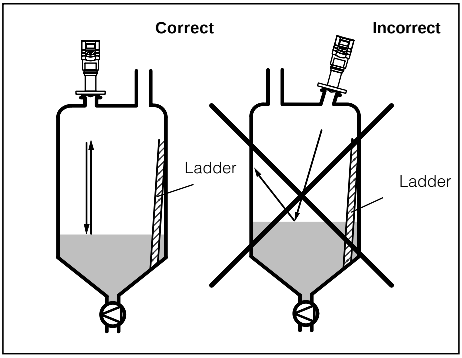
Wrong orientation to the product

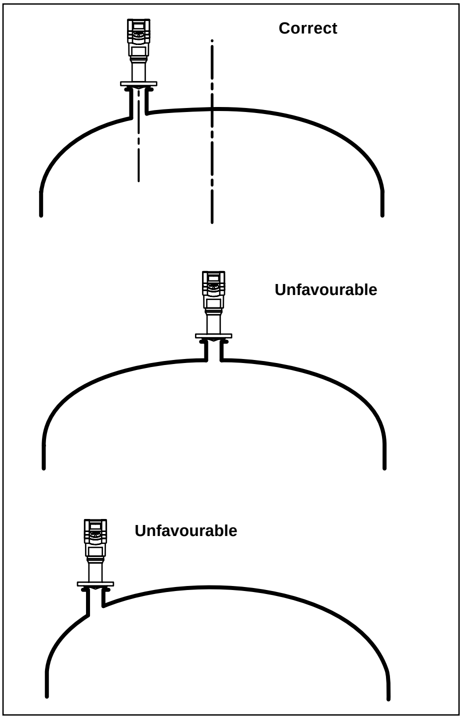
Weak measuring signals are generated if the sensor is not directly pointed at the product surface. Orient the sensor axis perpendicularly to the product surface to achieve optimum measuring results.



Direct sensor vertically to the product surface

Parabolic effects on dished or arched 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

Sensor too close to the vessel wall

If the radar sensor is mounted too close to the vessel wall, strong false echoes can be caused. 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.

If there are good reflection conditions (liquid medium, no vessel installations), we recommend locating the sensor where there is no vessel wall within the inner emission cone. For products in less favourable reflection environments, it is a good idea to also keep the outer emission cone free of interfering installations. Note chapter "3.1 General installation instructions“.

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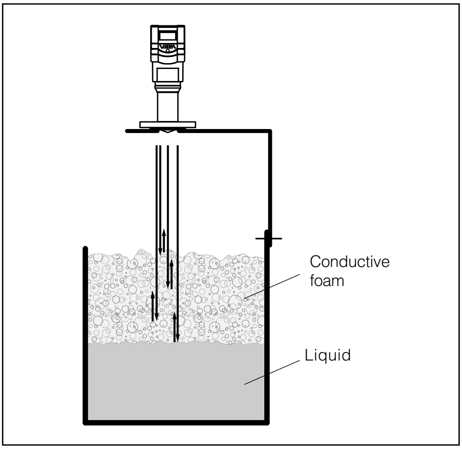
Foam generation

Conductive foam is penetrated to different depths by the radar signals and generates a number of individual (bubble) echoes. At the same time, the signals are damped in foam, similar to the way heat radiation is damped by Styrofoam. Thick, dense, creamy and conductive foam can cause incorrect measurements.



Foam generation

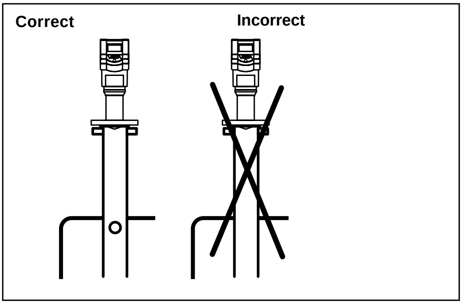
Provide preventative measures against foam or measure in a bypass tube. Check, if necessary, the possibility of using a different measurement technology, e.g. capacitive electrodes or hydrostatic pressure transmitters.

In many cases, VEGAPULS 54 radar sensors with 5.8 GHz operating frequency achieve considerably better and more reliable measuring results in foam applications than series 40 sensors with 26 GHz technology.

Standpipe installation mistakes

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.

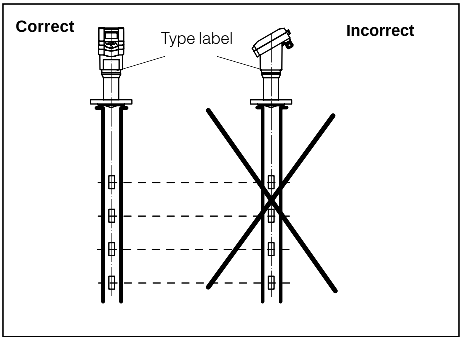


Pipe antenna: The surge pipe open to the bottom must have a ventilation or equalisation hole at the upper end

Wrong polarisation direction

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 the same plane as the polarisation direction of the radar signals. The polarisation direction is always in the same plane as the type label.



VEGAPULS on the surge pipe: The sensor type plate must be aligned with the rows of holes

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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 and screening

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.

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 (1/2 to 1/3 inch), with NPT threads, 3.6 … 8.7 mm (0.12 to 0.34 inch) and with threaded PG cable entries, 5 … 10.5 mm. Otherwise, the seal effect of the cable entry would not be ensured.

Quite often, the "electromagnetic pollution" caused by electronic actuators, energy cables and transmitting stations is so considerable that measures against the effects of electrical and magnetic fields can be necessary. This so-called "electromagnetic pollution" has increased considerably in the last few years, caused e.g. by fast-cycle power supply units and mobile phones, especially in the high-frequency range. VEGAPULS radar sensors take this into account. They are generally insensitive to electromagnetic pollution.

In critical systems, the signal cables are the source of the problem. The signal cables often act as antennas that pick up interfering signals. The 4 … 20 mA signal lines are affected by earth equalisation currents and especially by current peaks in the ms or µs range (more so than digital signal lines). This can be avoided with sophisticated wiring, of which screening at both ends is a major feature.

Circumspect system planning, however, will take into account possible sources of interference from electromagnetic pollution. Due to the complex interrelationships, it may be difficult to decide whether measures against such interference should be taken, and if so, which ones. And in fact, it is extremely difficult to describe in theoretical terms the actual forces at work, since the effects depend greatly on the frequency of the interfering magnetic fields: what is very effective for one frequency can produce completely opposite results with other frequencies.

Experience has shown that even some relatively simple measures can protect the signal current circuits against electromagnetic influence. As one of the more costly measures, screening usually comes at the end of any catalogue of preventive measures (interference suppression).

Wiring instructions

The signal cables should be wired close to the ground potential. Wiring in well-grounded metal cable channels is an effective protection against interference. Obviously, signal cables should not be wired directly together with high-energy cables, but should be separated from them, e.g., with sheet metal strips in the cable channels. Twisted cable (twisted pair) is especially suitable for signal circuits, as it compensates coupled voltage vectors. The distance between the outbound and the return conductor is just as important as the distance to ground when it comes to interference signal reception. For that reason, the distance between the two conductors should be as small as possible. Twisted pair cable meets this requirement. These measures are described by specialists with the expression "wiring close to the structure". To wire the signal cable still "closer to the structure", i.e. even closer to the ground potential, the signal cable can be provided with screening.

Earthing the screen only on one end is not always effective, see the following table. The table gives a simple overview of the effectiveness of the different protective measures against electromagnetic pollution. In practice, earthing of both sides is often useful. This allows the option of earthing only one end later by simply disconnecting the other earth contact points of the screen. Why? Actual interference only appears in the operating environment. Earthing only one end of the screen prevents interference, e.g. in the 100 kHz range, better than earthing both ends, especially if there is insufficient potential equalisation. However, you must make sure that no ground equalisation currents flow through the cable screening. Ground equalisation currents can be avoided by ground potential equalisation systems. When earthing on both ends, it is possible to connect the cable screen on one earth side (e.g. in the switching cabinet) via a Y_C capacitor[1)] to the earth potential. Use a very low-resistance earth connection (foundation, plate or mains earth).

Screening	magnetic fields	low-frequency electrical fields $l < \frac{\lambda}{7}$	high-frequency electrical fields $l > \frac{\lambda}{7}$	Ground currents and superimposed potential currents
none	–	–	–	–
one end	–	++	–	–
both ends	+	+	++	++

++ good protection against electromagnetic pollution
+ protection against electromagnetic pollution
– no protection against electromagnetic pollution

Note: $\lambda \text{ (Lambda)} = \frac{c}{f}$

l cable length
c speed of light (300000 km/s)
f interference frequency
λ wave length

Example: Interference frequency approx. 100 kHz

$$l < \frac{1}{7} \bullet \frac{c}{f} = \frac{1}{7} \bullet \frac{3 \bullet 10^9 \frac{m}{s}}{100 \bullet 10^3 \frac{1}{s}} = 4285 \text{ m}$$

This means that with an interference frequency of 100 kHz up to a cable length of approx. 4000 m, earthing the screen on only one end provides better protection than earthing on both ends. However, with a cable length of more than 4000 m, earthing on both ends usually produces better results.

1) max. 10 nF, e.g. voltage resistance 1500 V, ceramic

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Ex protection

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

Intrinsically safe circuits with more than one active instrument (instrument delivering electrical energy) are not allowed. Special installation regulations (DIN 0165) must be noted.

Note!
Due to the possibility of potential transfer, earthing on both ends is prohibited in Ex applications.

Ground terminals

On VEGAPULS 44/45 as well as on VEGAPULS 42 sensors with metal thread, the ground terminal is galvanically connected to the flange or thread.

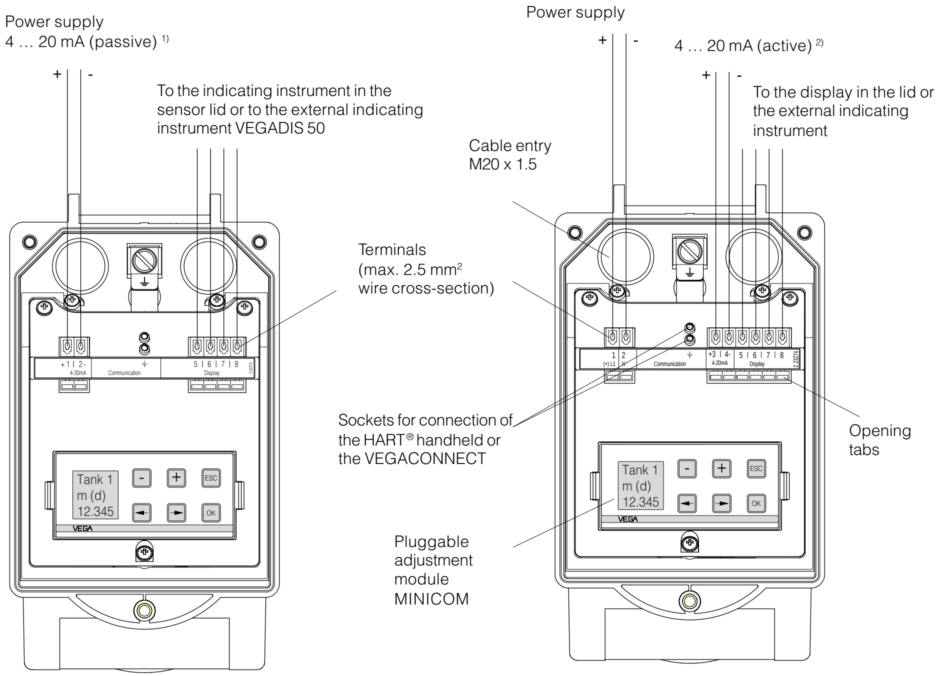
4.2 Connection of the sensor

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 indication 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.

Version with plastic housing



Two-wire technology in plastic housing
(loop powered)

Four-wire technology in plastic housing
(separate supply)

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).

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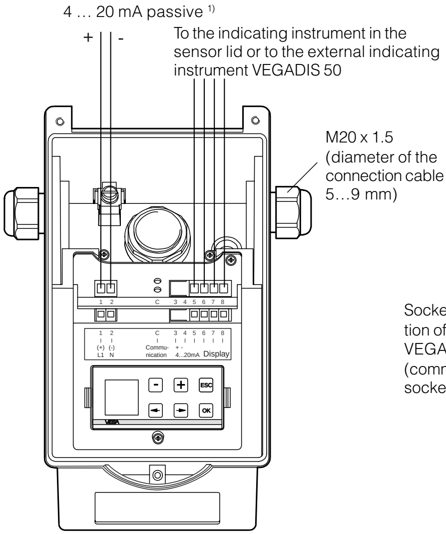
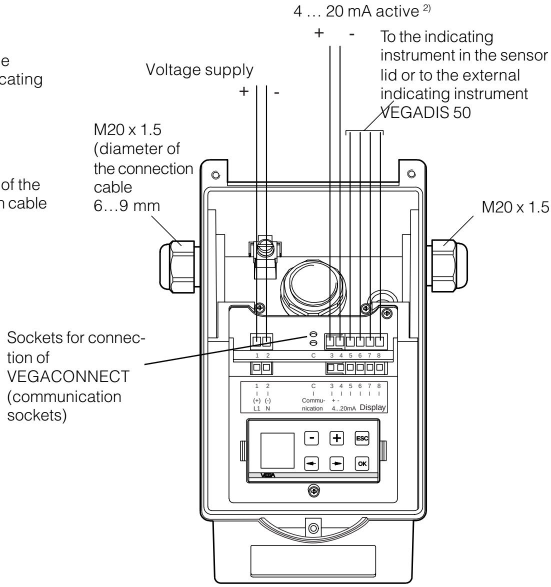
Version with aluminium housing

Two-wire technology
(loop powered)



Four-wire technology

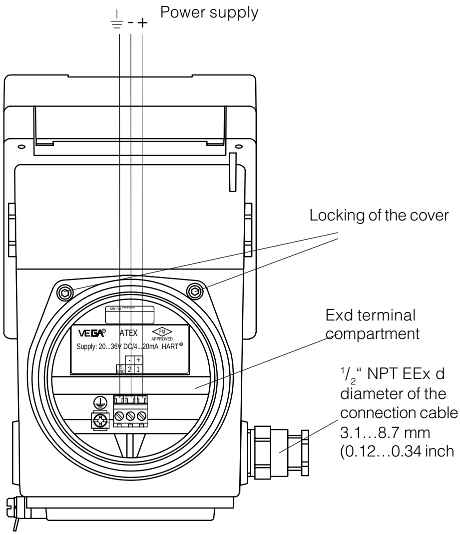


[1] 4 … 20 mA passive means that the sensor consumes a level-dependent current of 4 … 20 mA (consumer).

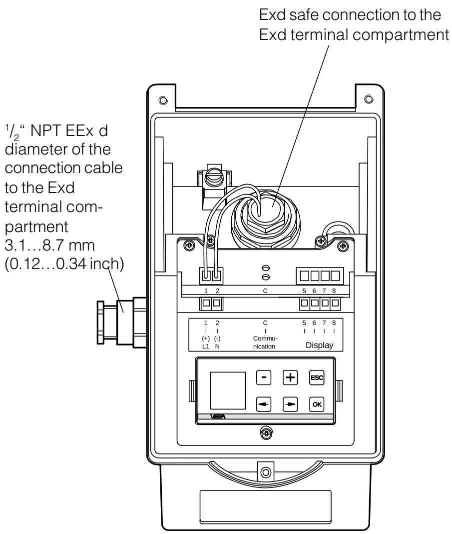
[2] 4 … 20 mA active means that the sensor provides a level-dependent current of 4 … 20 mA (current source).

Version with aluminium housing and pressure-tight encapsulated terminal compartment

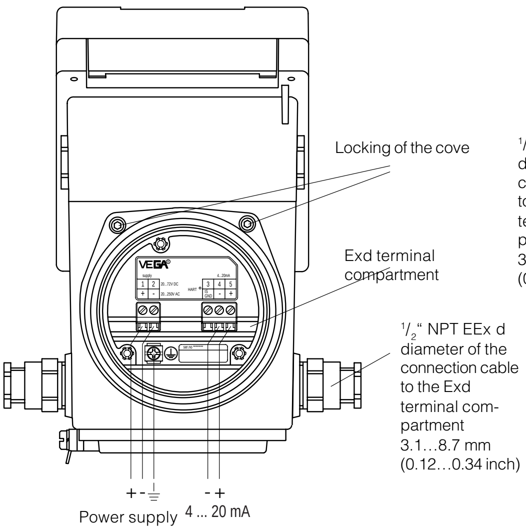
Two-wire EEx d terminal compartment
(opening in Ex atmosphere not allowed)



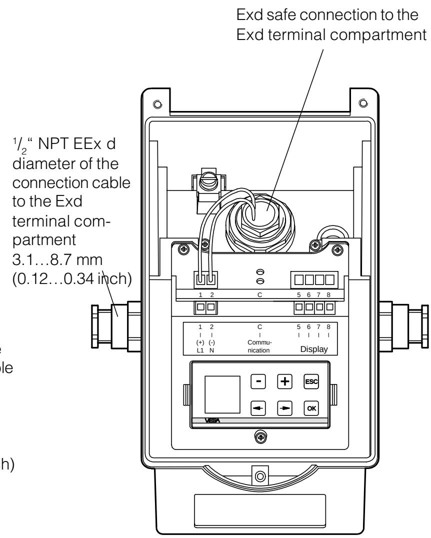
Two-wire adjustment module terminal compartment
(opening in Ex area permitted)



Four-wire EEx d terminal compartment



Four-wire adjustment module terminal compartment
(opening in Ex area permitted)



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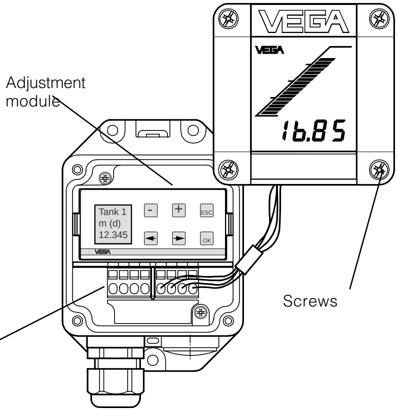
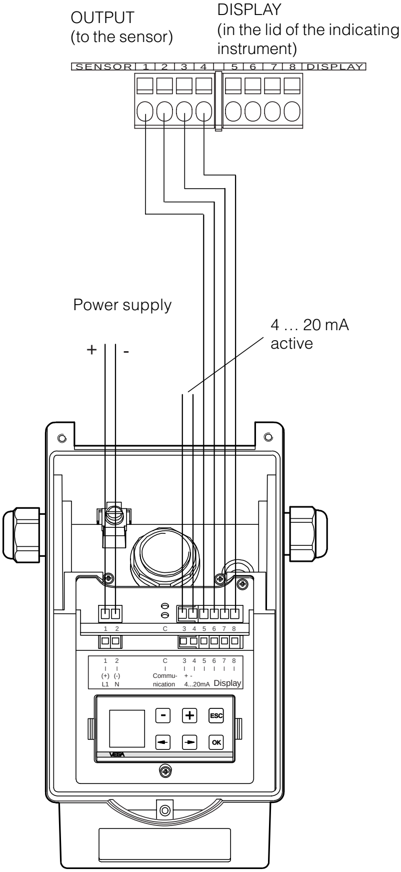
4.3 Connection of the external indicating instrument VEGADIS 50

Loosen the four screws of the housing lid on VEGADIS 50.
The connection procedure can be facilitated by fixing the housing cover during connection work with one or two screws on the right of the housing.

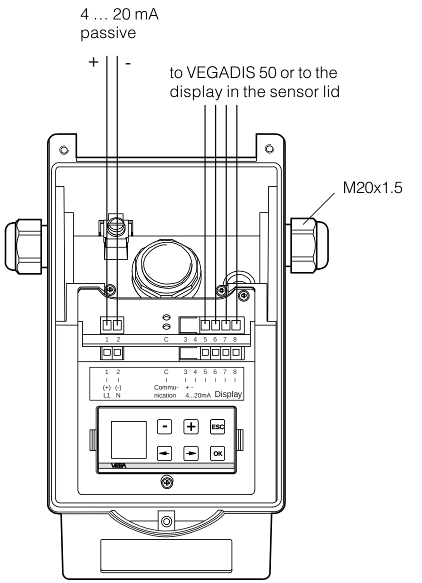
VEGADIS 50



Four-wire sensor in aluminium housing (separate supply)



Two-wire sensor in aluminium housing (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.

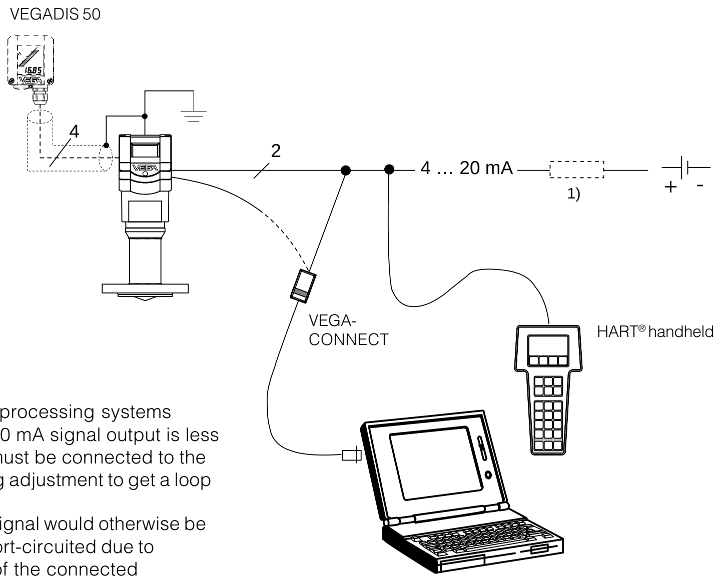
On the following pages, you will see a number of instrument configurations, designated as "measuring systems“, some of which are shown with signal processing units.

Measuring systems in two-wire technology:
- 4 … 20 mA shown without processing unit
- 4 … 20 mA on active PLC
- 4 … 20 mA in Ex area on active PLC
- 4 … 20 mA in Ex area on passive PLC
- 4 … 20 mA in Ex area on indicating instrument VEGADIS 371 Ex

Measuring systems in four-wire technology:
- 4 … 20 mA shown without signal conditioning instrument

Measuring systems with VEGAPULS 43 connected to any 4 … 20 mA signal processing unit

- Two-wire technology (loop powered), supply and output signal via one two-wire cable.
- Output signal 4 … 20 mA (passive).
- 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 250 Ω, a resistor must be connected to the connection cable during adjustment to get a loop resistance of 250 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.

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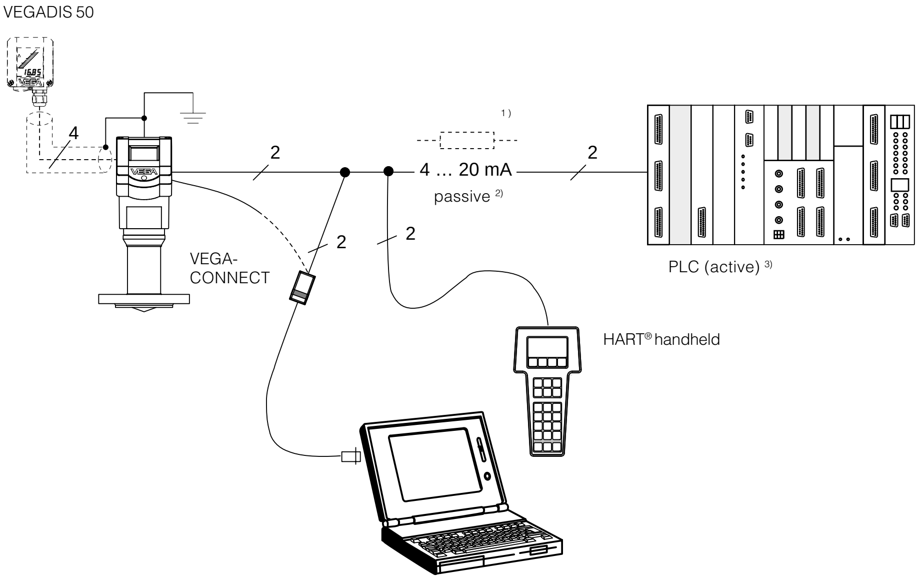
Measuring system with VEGAPULS 43 on active PLC

- 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 250 Ω, a resistor must be connected to the connection cable during adjustment to get a loop resistance of 250 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.

3) Active means that the PLC powers the passive sensor as voltage source.

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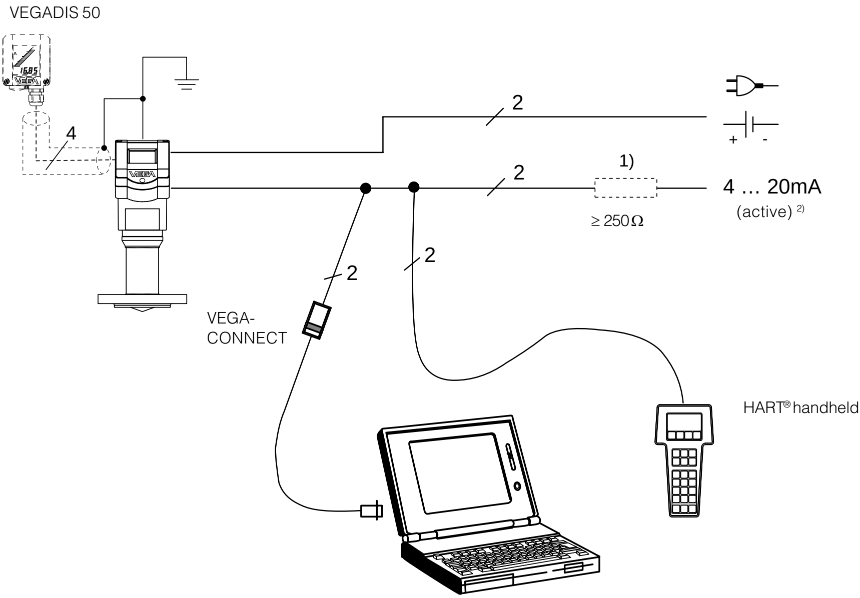
Measuring system with VEGAPULS 43 in four-wire technology

- 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. resistance on the signal output (load) 500 Ω.



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

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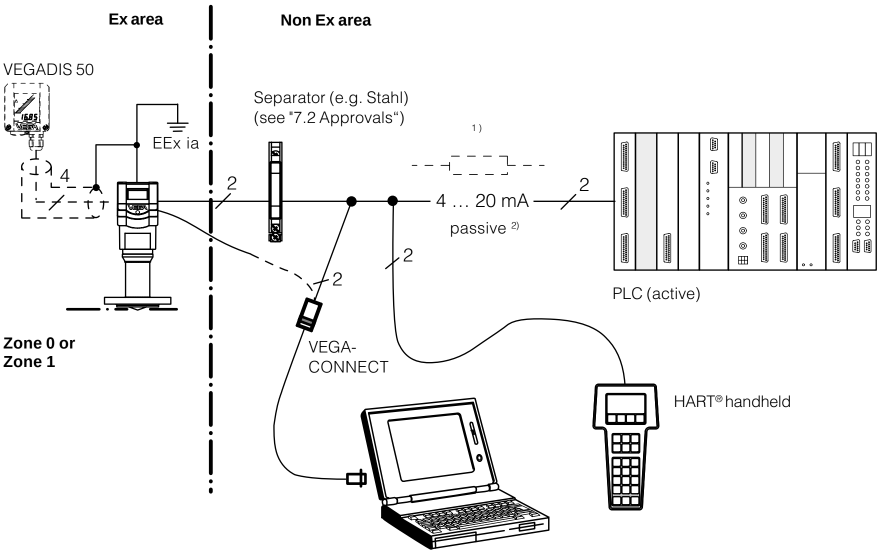
Measuring system with VEGAPULS 43 via separator in Ex areas on active PLC (Ex ia)

- 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 or Ex zone 0.
- 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] If the resistance of the processing systems connected to the 4 … 20 mA signal output is less than 250 Ω, a resistor must be connected to the connection cable during adjustment to get a loop resistance of 250 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 or the PLC consumes a level-dependent current of 4 … 20 mA. The PLC reacts electrically like a varying resistor (consumer) to the PLC. The PLC operates actively, i.e. as current or voltage source.

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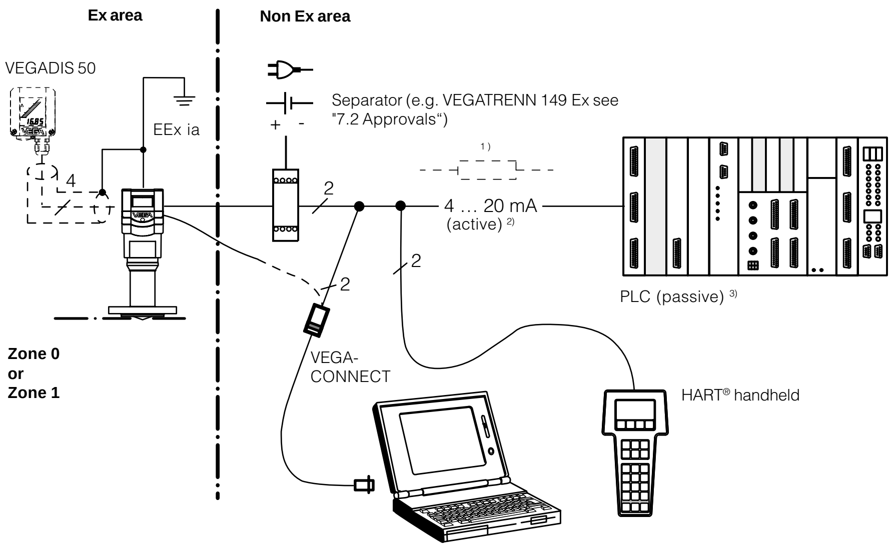
Measuring system with VEGAPULS 43 via separator (Smart-Transmitter) on passive PLC (Ex ia)

- 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 or Ex zone 0.
- 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)..



1) If the resistance of the processing systems connected to the 4 … 20 mA signal output is less than 250 Ω, a resistor must be connected to the connection cable during adjustment to get a loop resistance of 250 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 separator delivers a level-dependent current of 4 … 20 mA The separator reacts electrically to the PLC like a current source.

3) 4 … 20 mA passive means that the PLC consumes a level-dependent current of 4 … 20 mA. The PLC reacts electrically like a varying resistor (consumer).

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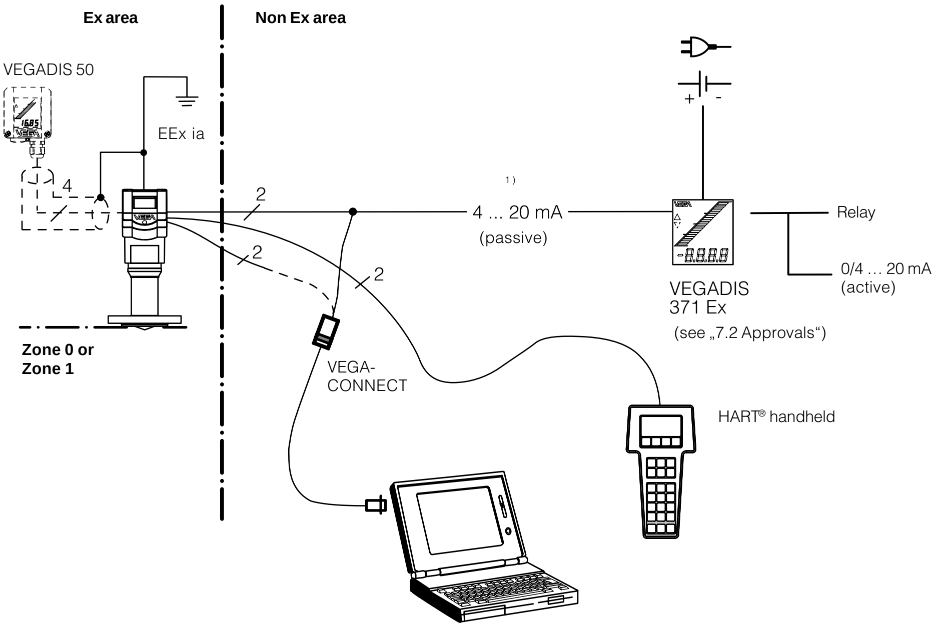
Measuring system with VEGAPULS 43 on VEGADIS 371 Ex indicating instrument with current and relay output (Ex ia)

- 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 or Ex zone 0.
- 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) If the resistance of the processing systems connected to the 4 … 20 mA signal output is less than 250 Ω, a resistor must be connected to the connection cable during adjustment to get a loop resistance of 250 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.

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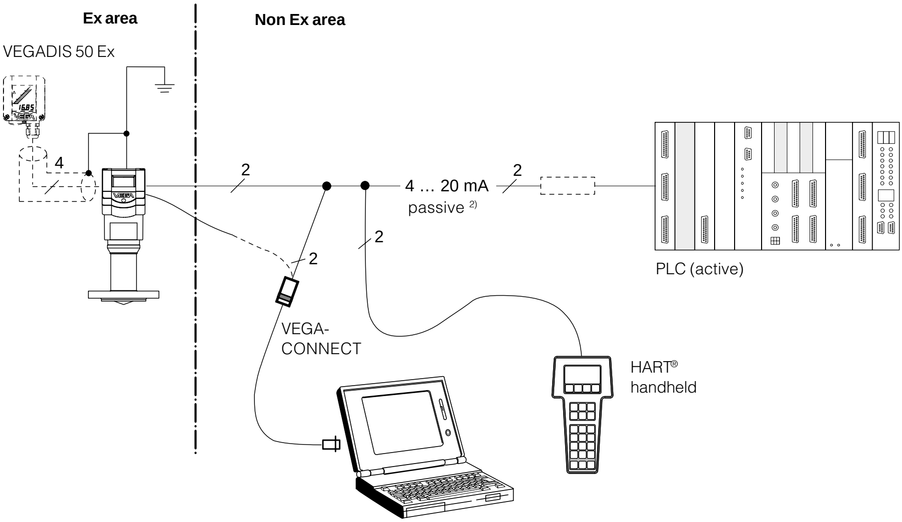
VEGAPULS 43 Ex (loop powered) with pressure-tight encapsulated connection compartment on active PLC (Ex d)

- Two-wire technology, supply via the cable from active PLC to Exd connection housing for operation in Ex-Zone 1 (VEGAPULS …Ex) or Ex-Zone 0 (VEGAPULS …Ex0).
- 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 250 Ω, a resistor must be connected to the connection cable during adjustment to get a loop resistance between 250 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 or the HART® handheld 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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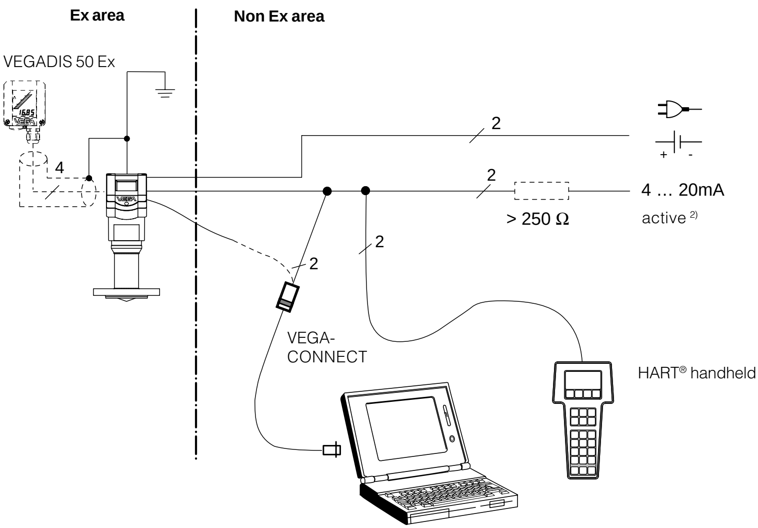
VEGAPULS 41 Ex with pressure-tight encapsulated connection compartment in four-wire technology (Ex d)

- Four-wire technology, supply and output signal via two separate two-wire cables for operation in Ex-Zone 1 (VEGAPULS …Ex) or Ex-Zone 0 (VEGAPULS …Ex0).
- Output signal 4 … 20 mA (active).
- 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).
- Load max. 500 Ω.



1) If the resistance of the processing systems connected to the 4 … 20 mA signal output is less than 250 Ω, a resistor must be connected to the connection cable during adjustment to get a loop resistance between 250 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 or the HART® handheld would not be ensured.

2) 4 … 20 mA active means that the sensor delivers a level-dependent current of 4 … 20 mA (source). The measuring signal of the sensor reacts electrically to the processing system (e.g. display) 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 43 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 or are blocked 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

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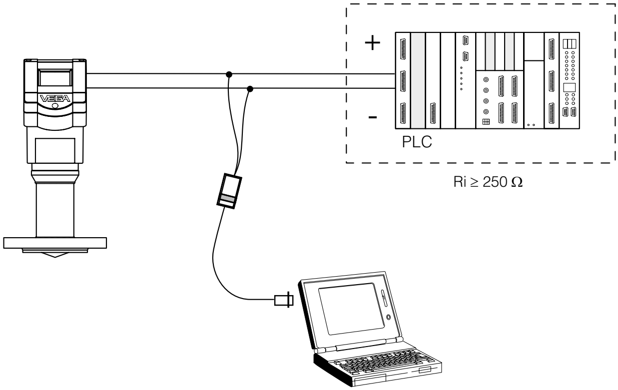

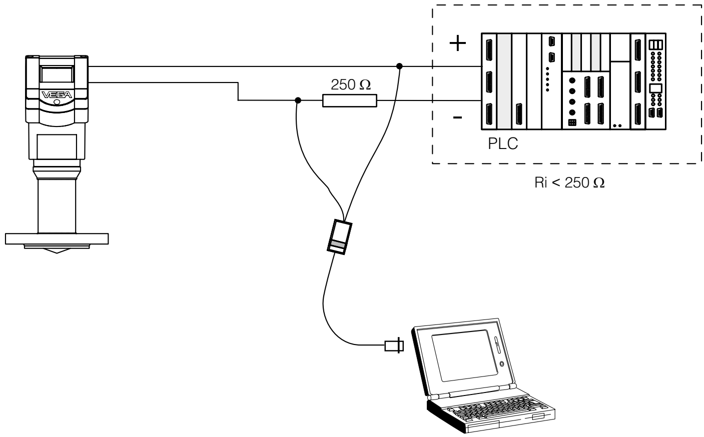

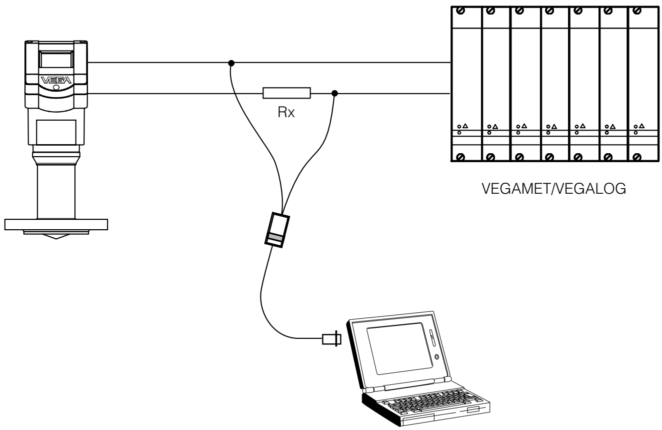

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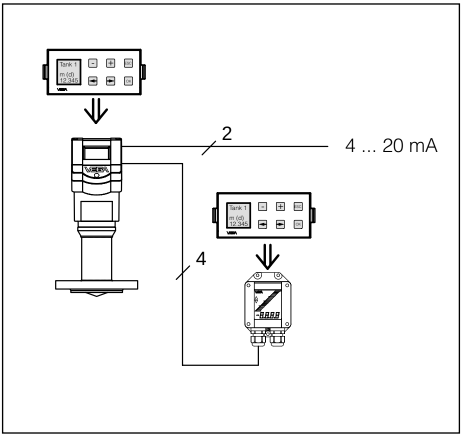
5.3 Adjustment with adjustment module MINICOM

Much like with the PC, you can set up and operate the sensor with the small, detachable adjustment module MINICOM. 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. 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, however, cannot be compared with that of the adjustment program VVO, but you will soon get used to it and be able to 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 the running time shift of the radar signal and displays the correct value of the level in the standpipe (measuring tube).

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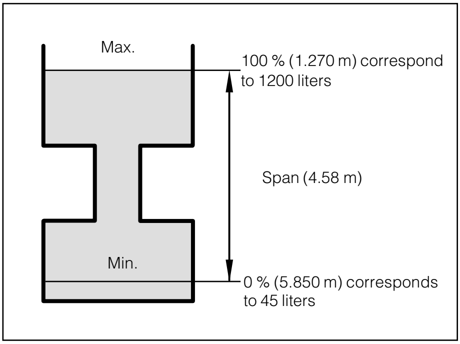
2. Operating range

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 | Display indication

OK

OK

OK

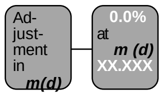
OK

(min. adjustment)

+ The distance indication flashes and you can choose "feet“ and "m“.

OK Confirm the adjustment with "*OK*“.

→



+ 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.

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+ 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.

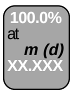
OK

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“*.

→

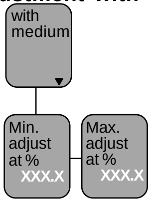


(max. adjustment)

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.

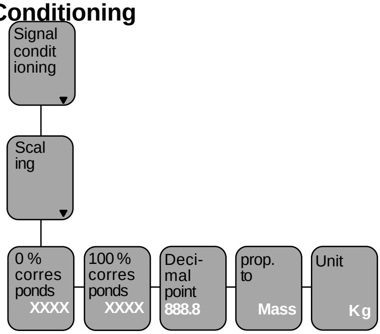
Note:
The difference between the adjustment values of the lower product distance and the upper product distance should be as large as possible, preferably at 0 % and 100 %. If the values are very close together, e.g. lower product distance at 40 % (3.102 m) and upper product distance at 45 % (3.331 m), 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 assign a 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.

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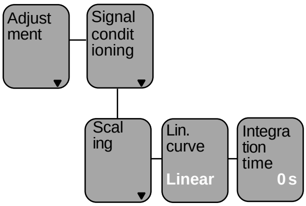
In the example 1200 for 1200 liters.
• Confirm with "*OK*".

If necessary, choose a 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.

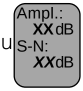
5. Meas. conditions

(see Menu schematic, point no. 5)
Choose "Liquid" or "Solid" and the options corresponding to your application.

6. False echo storage

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

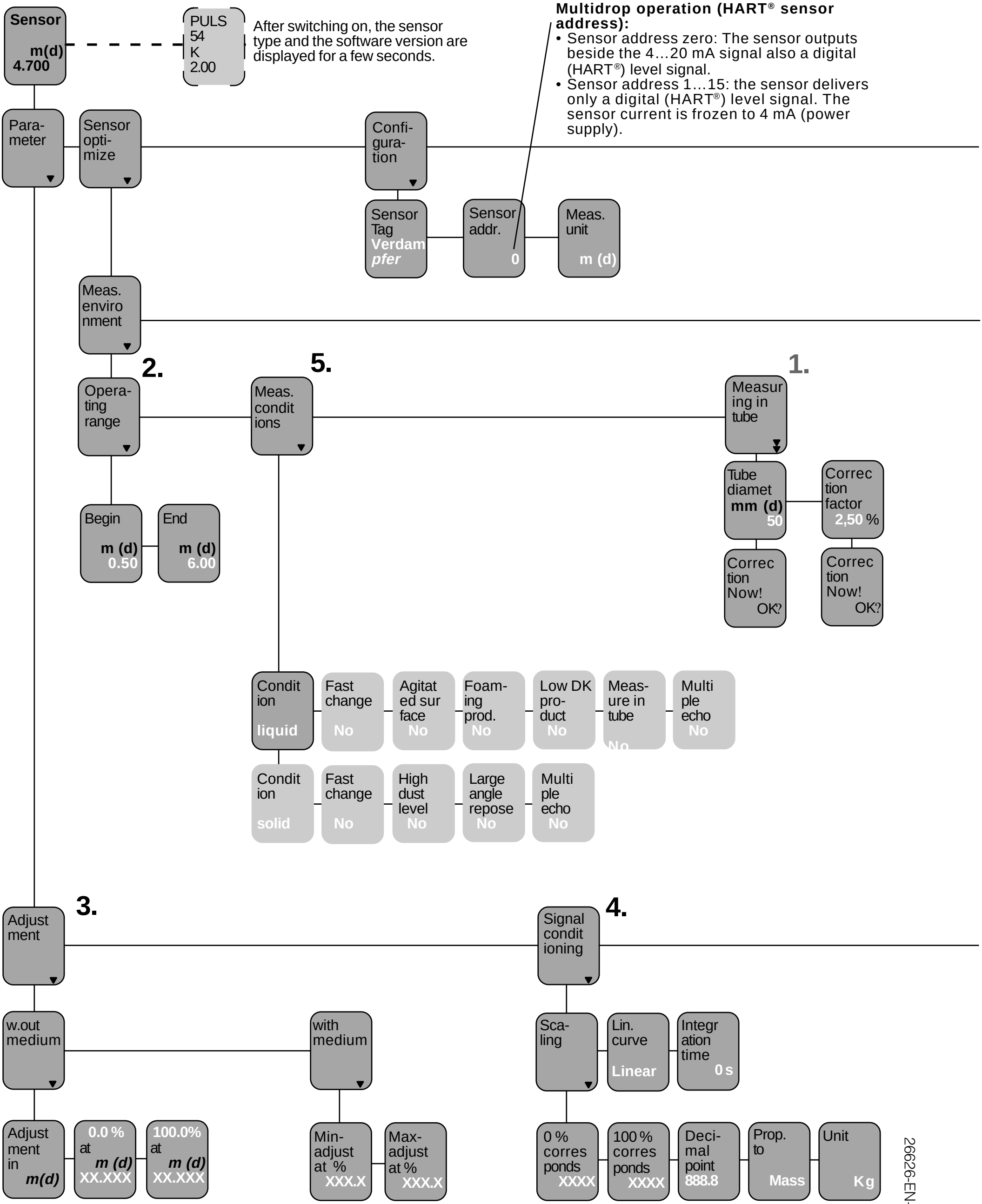
This means that the noise level is only
68 dB – 53 dB = 15 dB.

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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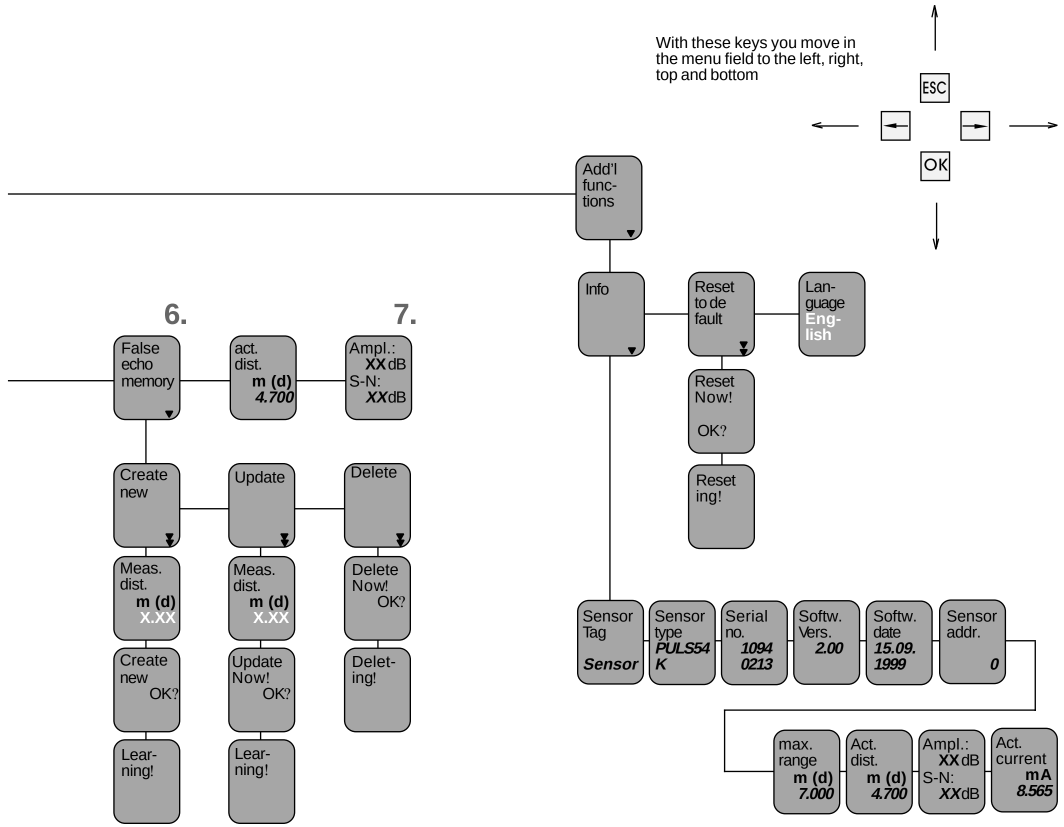
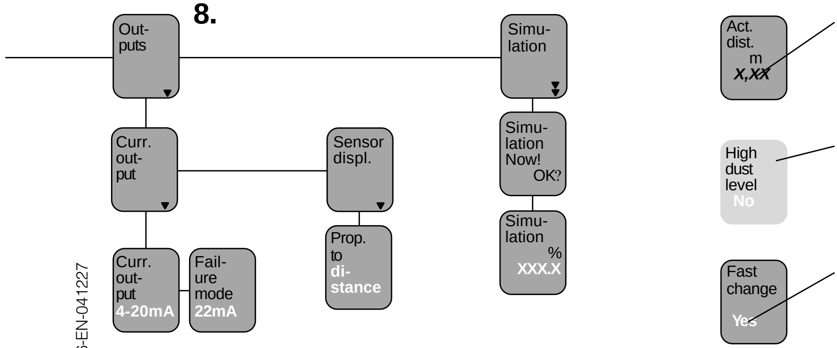


Simulation:

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



Menu items in bolt print provide sensor and measured value information and cannot be modified in this position.

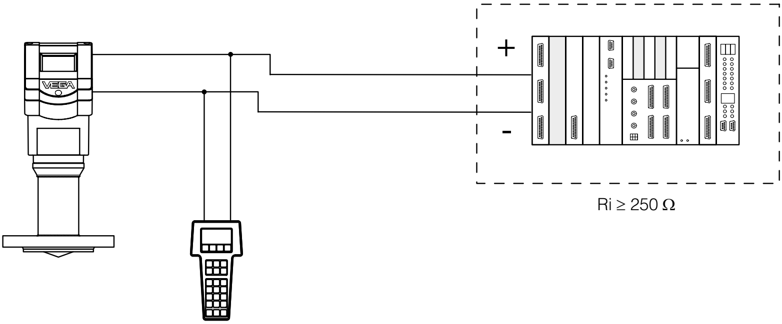
Light grey menu fields are only displayed if required (dependent on the adjustments in other menus).

White menu items can be modified with the "+“ or "–“ key and saved with the "OK“ key.

5.4 Adjustment with HART® handheld

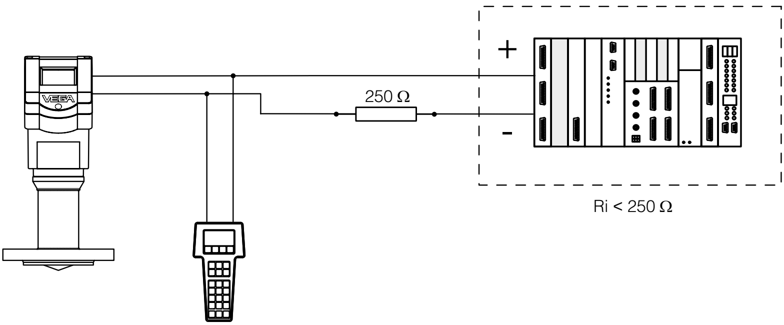
With any HART® handheld you can set up the VEGAPULS series 40K radar sensors like all other HART® compatible sensors. A special DDD (Data Device Description) is not necessary.

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. An inherent system load resistance allows a corresponding reduction of Rx.

VEGA signal conditioning instr.	Rx
VEGAMET 513, 514, 515, 602	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

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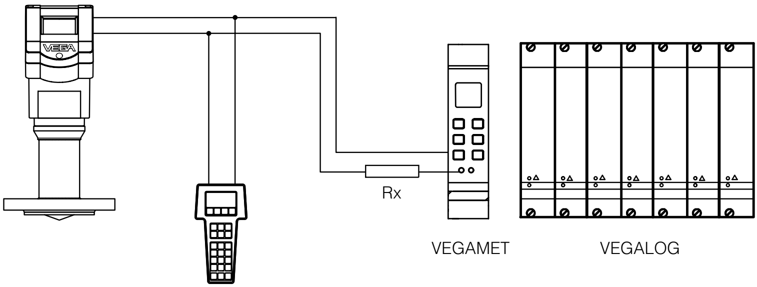
Rx
VEGAMET
VEGALOG

6 Diagnostics

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.

5.2 Error codes

Display	Meaning	Rectifying measure
E013	No valid measured value - Sensor in the warm-up phase - Loss of the useful echo better, with the PC and VVO.	Message is displayed during warm-up phase If the message remains, a false echo storage must be made with the adjustment module MINICOM in the menu “Sensor optimize” or If the message still remains, carry out a fresh 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.

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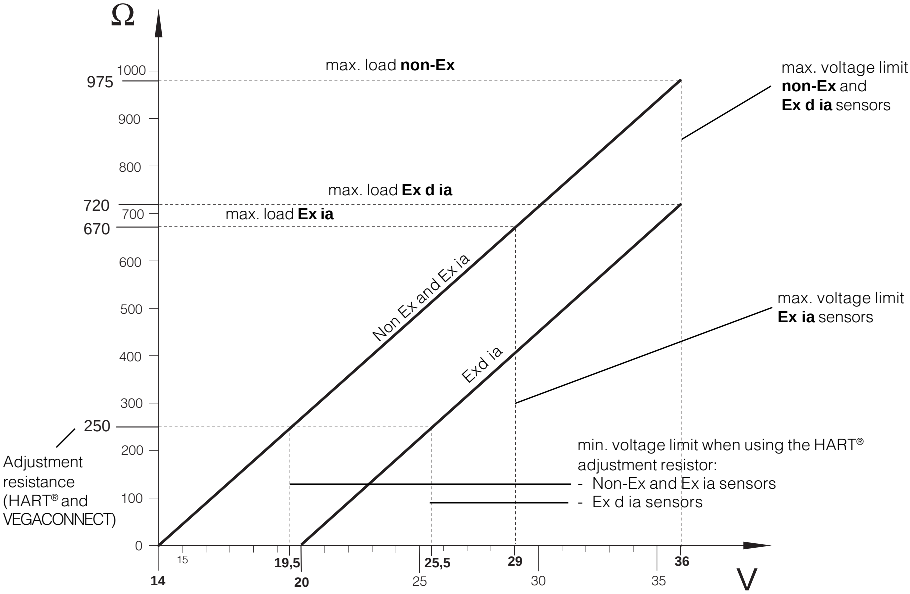
7 Technical data

7.1 Technical data

Power supply

Supply voltage	
- four-wire sensor (non-Ex and Ex d ia)	24 V DC (20 … 72 V DC) 230 V AC (20 … 253 V AC), 50/60 Hz fuse 0.315 A TR
- two-wire sensor	24 V DC (14 … 36 V DC)
- two-wire Ex ia sensor	24 V DC (14 … 29 V DC)
- two-wire Exd ia sensor	24 V DC (20 … 36 V DC)
Permissible residual ripple of the power supply with two-wire sensors	
- 0 … 125 Hz	1 V_{ss}
- 125 Hz … 500 Hz	1.0 … 0.01 V_{ss} declining linearly
- 500 Hz … 10 kHz	0.01 V_{ss}
Current consumption	
- four-wire sensor	max. 130 mA
- two-wire sensor	max. 22.5 mA
Power consumption	
- four-wire sensor	max. 21 W, 7.7 VA
- two-wire sensor	55 … 810 mW
Load	
- four-wire sensor	max. 500 Ohm
- two-wire sensor	see diagram



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Parameter and measuring range [1)]

Parameter	distance between product surface and process fitting (e.g. lower flange side of the sensor)
Measuring range	
- DN 50, ANSI 2“	0 … 10 m
- DN 80, ANSI 3“	0 … 20 m
- DN 100, ANSI 4“	0 … 20 m
- DN 150, ANSI 6“	0 … 20 m
- TRI-Clamp 2“, 3“	0 … 10 m
- socket DN 50, DN 80	0 … 10 m

Output signal

Signal output	4 … 20 mA current signal in two-wire or four-wire technology; the HART® signal is modulated to the 4 … 20 mA signal
Fault signal	current output unchanged, 20.5 mA, 22 mA (adjustable)
Resistance/Load of the signal cable	
- 4 … 20 mA two-wire	
non-Ex:	max 975 Ω
Ex d ia:	max. 720 Ω
Ex ia:	max. 670 Ω
- 4 … 20 mA four-wire	500 Ω
Integration time	
- analogue 4 … 20 mA	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.

Measured value display (optional)

Liquid crystal indication	
- in the sensor	scalable output of measured values as graph and number
- in the external indicating instrument powered by the sensor	scalable output of measured values as graph and number. The display unit can be mounted up to 25 m away from the sensor

Adjustment

- PC and adjustment software VEGA Visual Operating
- adjustment module MINICOM
- HART® handheld

1) Min. distance of the antenna to the medium 5 cm

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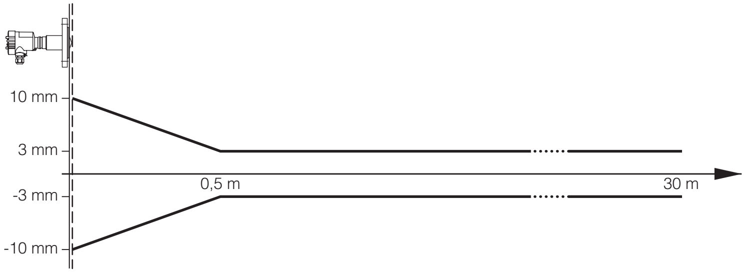
Accuracy [1]
(typical values under reference conditions, all statements relate to the nominal measuring range, with VEGAPULS 45 relating to a nominal measuring range of 4 m)

Characteristics	linear
Accuracy	see diagram



Resolution, general	max. 1 mm
Resolution of the output signal	1.6 µA or 0.01 %

Ambient conditions

Vessel pressure	-100 … 1600 kPa (-1 … 16 bar)
Ambient temperature on the housing	
- 4 … 20 mA two-wire sensor	-40°C … +80°C
- 4 … 20 mA four-wire sensor	-40°C … +80°C
- 4 … 20 mA four-wire sensor Ex d ia	-40°C … +60°C
Process temperature (flange temp.)	-40°C … +150°C
Storage and transport temperature	-60°C … +80°C
Protection	IP 66 and IP 67
Protection class	
- two-wire sensor	II
- four-wire sensor	I
Overvoltage category	III

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[1] Similar to DIN 16 086, reference conditions acc. to IEC 770, e.g. temperature 15 °C … 35 °C; moisture 45 % … 75 %; pressure 860 mbar … 1060 mbar

Characteristics [1)]
(typical values under reference conditions, all statements relate to the nominal measuring range)

Min. span between full and empty	> 10 mm (recommended > 50 mm)
Meas. frequency	26 GHz technology
Intervals	
- two-wire sensor (4 … 20 mA)	1 s
- two-wire sensor (digital)	0.6 s
- four-wire sensor	0.5 s
Beam angle (at -3 dB)	
- DN 50, ANSI 2“	18°
- DN 80, ANSI 3“	10°
- DN 100, ANSI 4“	10°
- DN 150, ANSI 6“	10°
- TRI-Clamp 2“	18°
- TRI-Clamp 3“	18°
- socket DN 50	18°
- socket DN 80	18°
Adjustment time (response time) [2)]	> 1 s (dependent on the parameter adjustment)
Influence of the process temperature	cannot be measured at 0 bar; at 5 bar 0.004 %/10 °K; at 40 bar 0.03 %/10 °K
Influence of the process pressure	0.0265 %/bar
Adjustment time [2)]	> 1 s (dependent on the parameter adjustment)
Emitted radar power (average)	0.717 µW
Received average emitted power [3)]	
- distance 1 m	0.4 … 3.2 nW per cm^2 (0.4 … 3.2 x 10^{-9}W/cm^2)
- distance 5 m	0.02 … 0.13 nW per cm^2

Ex technical data ⟨Ex⟩

Comprehensive data in the safety instructions manual (yellow binder)

WHG approvals

VEGAPULS 43 radar sensors are approved as part of an overfill protection system for stationary vessels storing water-endangering liquids.

Materials

Housing	PBT (Valox) or Aluminium die casting (GD-AlSi 10 Mg)
Connection housing with Exd version	Aluminium mould casting (GK-AlSi 7 Mg)
Process flange	1.4435
Antenna (wetted parts)	TFM-PTFE

1) Similar to DIN 16 086, reference conditions acc. to IEC 770, e.g. temperature 15 °C … 35 °C; moisture 45 % … 75 %; pressure 860 mbar … 1060 mbar
2) The adjustment time (also actuating time, response time or adjustment period) is the time required by the sensor to output the correct level (with max. 10% deviation) after a sudden level change.
3) Average emitted power (electromagnetic energy) received by a body per cm^2 directly in front of the antenna. The received emitted power depends on the antenna version and the distance.

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Connection cables

Two-wire sensors	power supply and signal via one two-wire cable
Four-wire sensors	power supply and signal separated
Electrical connection	
- cable entry	for Aluminium and plastic housing: one cable entry (four-wire: two cable entries) and spring-loaded terminal connection up to max. 2.5 mm² wire cross-section
- plug connection	optional for plastic housing: four-pole, polarity reversal-proof screwed plug connection (four-wire: two plug connections)
Cable entry	
- ia terminal compartment	1 … 2 x M20 x 1.5 (cable-ø 5 … 9 mm) or 1 … 2 x ½“ NPT EEx d (cable-ø 3.1 … 8.7 mm or 0.12 … 0.34 inch)
- Exd terminal compartment (pressure-tight encapsulated)	1 x½“ NPT EEx d (cable-ø 3.1 … 8.7 mm or 0.12 … 0.34 inch)
Ground connection	max. 4 mm²
Intermediate housing between process flange and housing	1.4435

Weights

Weights dependent on the housing materials and Ex concepts.

DN 50	4.2 … 5.0 kg
DN 80	6.8 … 7.6 kg
DN 100	8.0 … 9.1 kg
DN 150	13.2 … 14.3 kg
ANSI 2“	5.2 … 5.7 kg
ANSI 3“	6.9 … 7.5 kg
ANSI 4“	10.5 … 11.1 kg
ANSI 6“	14.6 … 15.4 kg
TRI-Clamp 2“	3.5 … 4.5 kg
TRI-Clamp 3“	5.0 … 6.0 kg
Socket DN 50	3.8 … 4.8 kg
Socket DN 80	5.2 … 6.2 kg

CE conformity CE

VEGAPULS 43 radar sensors meet the protective regulations of EMC (89/336/EWG), NSR (73/23/EWG) and R & TTE regulation (1999/5/EC).

Conformity has been judged acc. to the following standards:

		EN 300 683 - 1: 1997
		EN 300 440 - 1: 1995
		IETS 300-440
		Expert opinion No. 0043052-02/SEE, Notified Body No. 0499
EMC	Emission/Susceptibility	EN 61 326: 1997/A1: 1998
ATEX		EN 50 020: 1994
		EN 50 018: 1994
		EN 50 014: 1997
NSR		EN 61 010 - 1: 1993

7.2 Approvals

When radar sensors are used in 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.

Please note the attached approval documents 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)

Intrinsically safe in Ex environment

Series 40 sensors in EEx ia (intrinsically safe) version require for use in Ex areas special separators or safety barriers. The separators or safety barriers provide intrinsically safe (ia) circuits. Below, a selection of instruments with which series 40 sensors work reliably.

Separator and signal conditioning instrument:
- VEGADIS 371 Ex
- A puissance 3 PROFSI 37-24070A
- VEGAMET 614 Ex
- Apparatebau Hundsbach
  AH MS 271-B41EEC 010

Separator, safety barrier:
- Stahl 9001/01/280/110/10
- Stahl 9001/51/280/110/14
- MTL 787 S+
- CEAG CS 3/420-106

Separator:
- VEGATRENN 149 Ex…
- Stahl 9303/15/22/11
- CEAG GHG 124 3111 C1206

Pressure-tight encapsulated in Ex area

Series 40 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 of functional safety acc. to IEC 61508 / IEC 61511. For further information see Supplement under „Safety Manual“.

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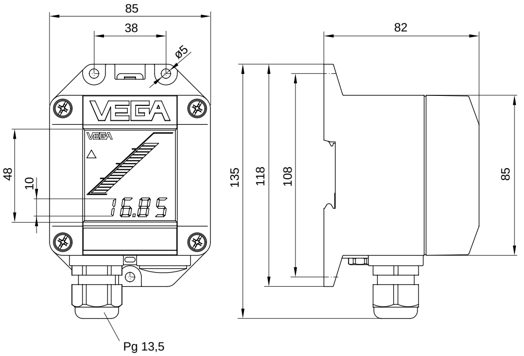
7.3 Dimensions

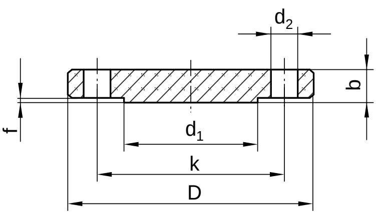
External indicating instrument VEGADIS 50



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.

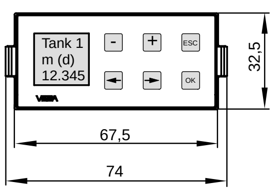
Flange dimensions acc. to ANSI (RF)



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 D	Flange b	Flange k	Seal ledge d_1	Holes No.	Holes d_2
2" 150 psi	152.4	20.7	120.7	91.9	4	19.1
3" 150 psi	190.5	25.5	152.4	127.0	4	19.1
4" 150 psi	228.6	25.5	190.5	157.2	8	19.1
6" 150 psi	279.4	27.0	241.3	215.9	8	22.4

Adjustment module MINICOM



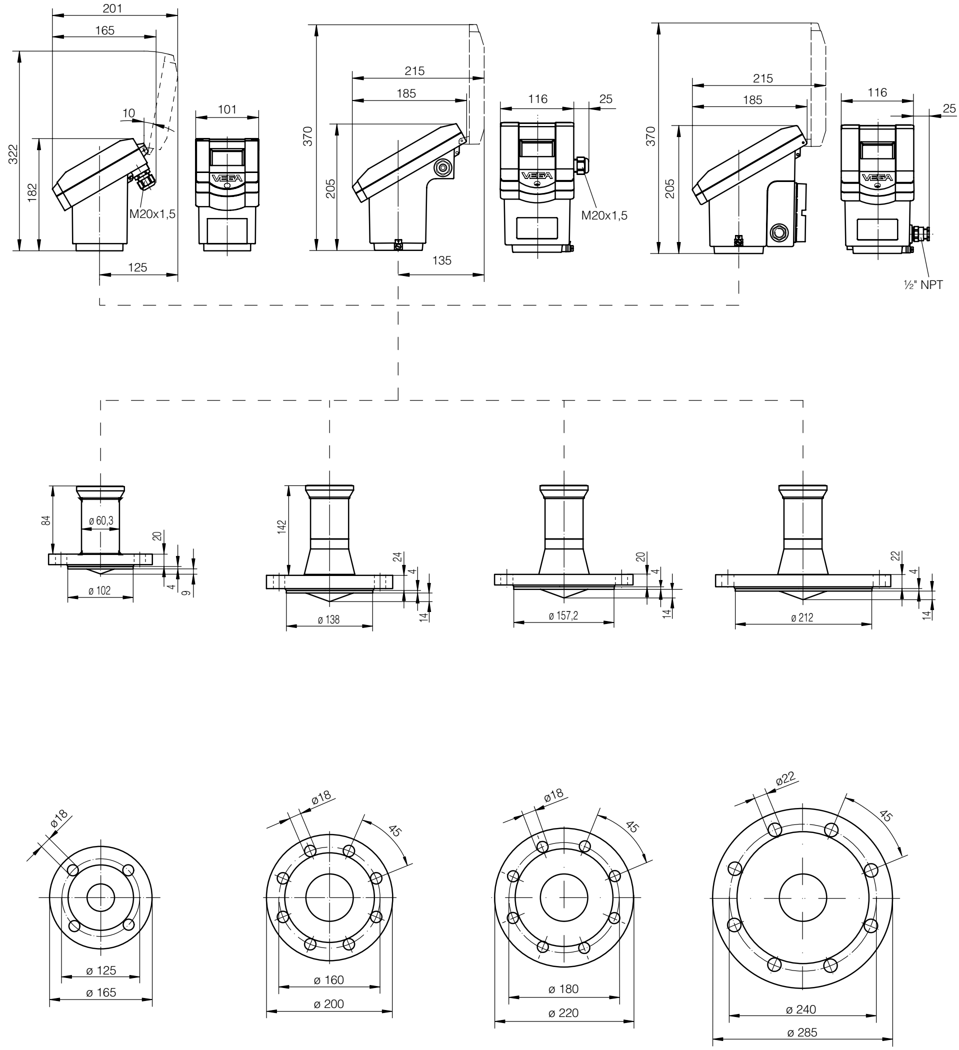
Adjustment module for insertion into sensors or into the external indicating instrument VEGADIS 50

Sensor dimensions

PBT

Aluminium

Aluminium with Exd terminal compartment



DN 50 PN 40 C
(ANSI 2" RF)

DN 80 PN 40 C
(ANSI 3" RF)

DN 100 PN 16 C
(ANSI 4" RF)

DN 150 PN 16 C
(ANSI 6" RF)

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Supplement

Safety Manual

Functional safety acc. to IEC 61508 / IEC 61511

VEGAPULS series 40 radar sensors; 4 … 20 mA/HART® compact sensor

1 General

1.1 Validity

This safety manual applies to VEGAPULS series 40 radar sensors in two-wire version 4 … 20 mA/HART®, called “measuring system”.

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 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)
$\geq$ 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

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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.

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".

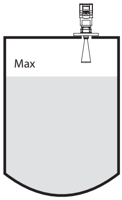
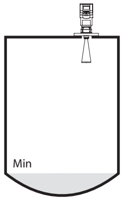
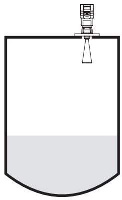
The test must be carried out in a way that verifies the flawless operation of the safety functions in conjunction with all system components. This is ensured by a controlled reaching of the response height during a filling.

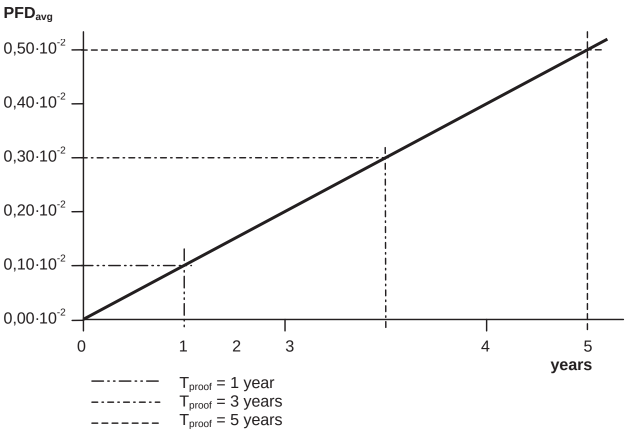
If filling up to the response height is not possible, then a response of the measuring system must be triggered by a suitable simulation of the level or the physical measuring effect. If the proper functioning of the measuring system is otherwise discernible (exclusion of function-restraining errors),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

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 41 VEGAPULS 42 VEGAPULS 43 VEGAPULS 44 VEGAPULS 45	Overfill protection  	Dry run protection  	Individual level 
HFT	0		
SFF	> 88%		
PFD_{avg} [1)]	$< 0.10 \bullet 10^{-2}$ $< 0.50 \bullet 10^{-2}$	with T_{Proof} = 1 year [2)] with T_{Proof} = 5 years	
PFH [1/h] [3)]	$< 0.22 \bullet 10^{-6}$		
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

SIL declaration of conformity

Functional safety according to IEC 61508 / IEC 61511

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

declares as manufacturer, that for the radar sensors of the product families

VEGAPULS series 40 and 50 (4 ... 20 mA HART®)

the reliability ("proven in use") was verified according to IEC 61508 / IEC 61511.
Therefore the devices are suitable for safety-related applications
e.g. overfill protection, dry run protection or recording of an arbitrary fill level.
The corresponding instructions of the safety manual must be considered. [1)]

Safety related characteristics:

		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 (for low demand mode) [3)]	< 0,10 x 10^{-2}	< 0,12 x 10^{-2}	T_{Proof} 1 year
		< 0,50 x 10^{-2}	< 0,60 x 10^{-2}	T_{Proof} 5 years
PFH [1/h]	Probability of a dangerous Failure per Hour (for high demand or continuous mode) [4)]	< 0,22 x 10^{-6}	< 0,28 x 10^{-6}	Error response time 60sec

The failure rates were determined by a FMEDA (Failure Modes, Effects and Diagnostics Analysis)

		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 years	56 years	MTTR = 8h

[1)] Safety Manual see supplement of the operating instructions
[2)] HFT is reduced by one according to IEC 61511-1, section 11.4.4
[3)] PFD_{avg} is valid only for the T_{Proof} interval according to which a recurring function test must be carried out
[4)] PFH is constant over the time. According to the standard, a recurring function test is not necessary.
The failure tolerance time of the overall system must be higher than the error response time of the sensor.
[5)] FIT = failure in time [10^{-9} h]

The assessment of the modification management was part of the proof for reliability ("proven in use").

Schiltach, 28.10.03
VEGA Grieshaber KG

i.V. Frühauf
Head of Certification department

i.A. Blessing
Commissioner for functional safety

SIL-KE_PULS40+50_EN_031028

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CE conformity declaration

CE

Konformitätserklärung

Declaration of conformity
Déclaration de conformité

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 41, VEGAPULS 42, VEGAPULS 43,
VEGAPULS 44, VEGAPULS 45
mit 2Leiter-Netzteilprint

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 61326 : 1997 / A1 : 1998 (Klasse B)
EN 61326 : 1997 / A1 : 1998
EN 61010 – 1 : 1993
EN 300 683 –1 : 1997
EN 300 440 –1 : 1995

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

73/23 EWG
89/336 EWG
99/5 EG

Schiltach, 23.11.2001 ppa. J. Fehrenbach

Josef Fehrenbach
Entwicklungsleitung

26626-EN-041227

CE

Konformitätserklärung

Declaration of conformity
Déclaration de conformité

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 41, VEGAPULS 42, VEGAPULS 43,
VEGAPULS 44, VEGAPULS 45
mit 4Leiter-Netzteilprint

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 61326 : 1997 / A1 : 1998 (Klasse B)
EN 61326 : 1997 / A1 : 1998
EN 61010 – 1 : 1993
EN 300 683 –1 : 1997
EN 300 440 –1 : 1995

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

73/23 EWG
89/336 EWG
99/5 EG

Schiltach, 23.11.2001 ppa. J. Fehrenbach

Josef Fehrenbach
Entwicklungsleitung

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ISO 9001

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

26626-EN-041227