Technical
Information
TI 078F/00/en

Ultrasonic Level Measurement
Sensor DU 51 Z

Continuous, non-contact level measurement for liquids and solids, with approval for explosion hazardous area Zone 0

Application

The DU 51 Z ultrasonic sensor can be used in liquid tanks of all kinds up to 15 m (50 ft) high and in coarse or fine-grained bulk solids silos up to 7 m (23 ft) high.

The «measuring blind flange» is designed especially for use with aggressive and flammable vapours and gases.

It is approved for use in explosion hazardous area, Zone 0.

Intrinsically safe sensor power is supplied by the Nivosonic FMU 673 Z or FMU 678 Z transmitter.

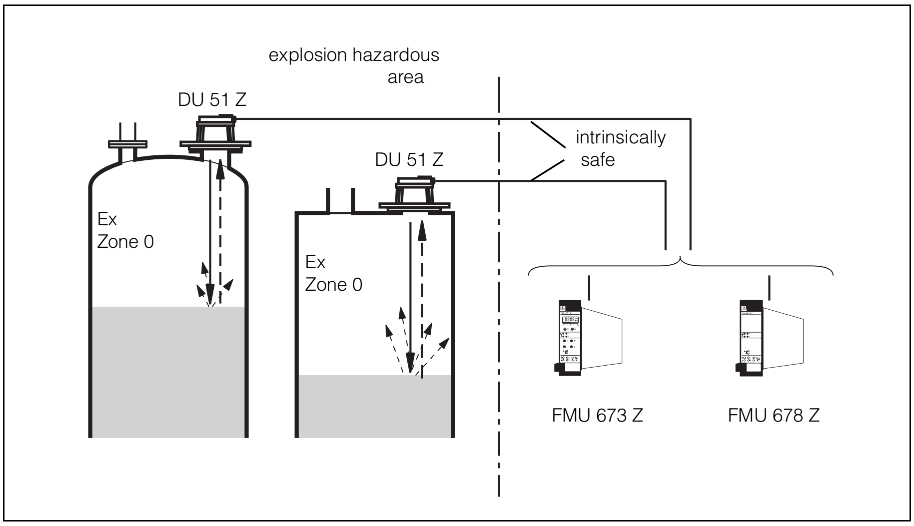
Features and Benefits

- The flange and oscillating diaphragm are made from a single unit of 1.4571 stainless steel. This ensures no sealing problems can occur.
- High chemical resistance to aggressive vapours coming from the material.
- The resonant frequency of the sensor automatically compensates for condensation or material build-up to ensure maximum operating efficiency at all times.
- The connection between the transmitter and sensor is intrinsically safe, i.e. simple laying of three-core (unscreened) cable.
- The ultrasonic sensor is fed by the transmitter so that no auxiliary power is required.

Endress+Hauser

Nothing beats know-how

Measuring System



The ultrasonic measuring system for continuous, non-contact level measurement in tanks and silos

The complete measuring system consists of

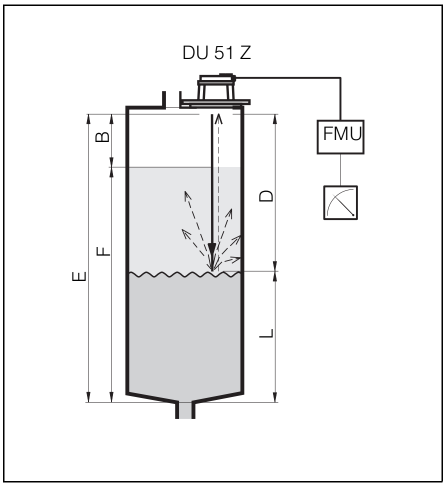
- the Nivosonic FMU 673 Z or FMU 678 Z transmitter in the control room and
- the ultrasonic sensor DU 51 Z on the tank or silo

A temperature probe integrated in the sensor is used to compensate for run time errors caused by temperature variations.

Operating Principle

The ultrasonic emitter in the sensor is excited electrically and sends an ultrasonic pulse in the direction of the surface of the material. The surface partially reflects the pulse. This echo is detected by the same sensor, now acting as a directional microphone, and converted back into an electrical signal. The time between transmission and reception of the pulse – the sonic run time – is directly proportional to the distance from the surface of the material to the sensor. The distance D is determined from the velocity of sound c and the run time t using the formula:

$$D = \frac{c \cdot t}{2}$$



Measuring system and function
B = blocking distance (maximum level)
D = distance from sensor to surface of material
L = level in tank or silo
F = maximum level (100 %, Full)
E = zero point of measurement (0 %, Empty)

Measuring Range

The maximum measuring range is limited by the attenuation of the ultrasonic pulse by the air as well as by the strength of the reflections from the product surface.

Measurement Conditions

The principal requirement for ultrasonic measurement is the reflection of an echo from the surface of the material. Gas layering can affect the accuracy of the measuring system.

- Liquids
  The sensor must be positioned exactly perpendicular to the surface of the liquid.
  The surface must not be fully covered by a thick layer of foam.

- Bulk Solids
  The sensor receives a sufficiently high proportion of diffuse echoes when the surface roughness of the mounds is greater than 4 mm (diffuse reflection). With fine-grained or powdery bulk solids, e.g. quartz sand, cement, powdered plastics, raw meal, etc., function is dependent on the surface contours of the material (mirrored reflection).

Blocking Distance

Due to the decay characteristic of the sensor, there is a zone immediately below it in which returning echoes cannot be detected. This is known as the blocking distance B and determines the minimum distance between the sensor diaphragm and the maximum level of the material in the tank or silo. This blocking distance is approx. 0.8 m (2.6 ft).

Planning Recommendations

Maximum Range
The maximum measuring range depends upon the following factors:
- The strength of the signal coming from the surface of the material (diffuse echo)
- The attenuation of the signal in the space between the sensor and the product
- The level of background interference caused by, e.g. noise when filling.
- Interference echoes from fittings in the silo

The first three factors depend upon the requirements of the application.

Interference echoes can be prevented if the recommendations given in this technical information brochure are observed.

Optimum conditions are achieved if:
- no internal fittings are located within the detection zone
- the tank or silo is not filled or emptied during measurement
- the surface of the liquid is calm and without foam
- there is no high concentration of vapour in the tank
- the solid is hard and coarse-grained
- there is no dust in the silo
- the air temperature is not high.

Calculate the measuring range of the ultrasonic sensor for your particular application:

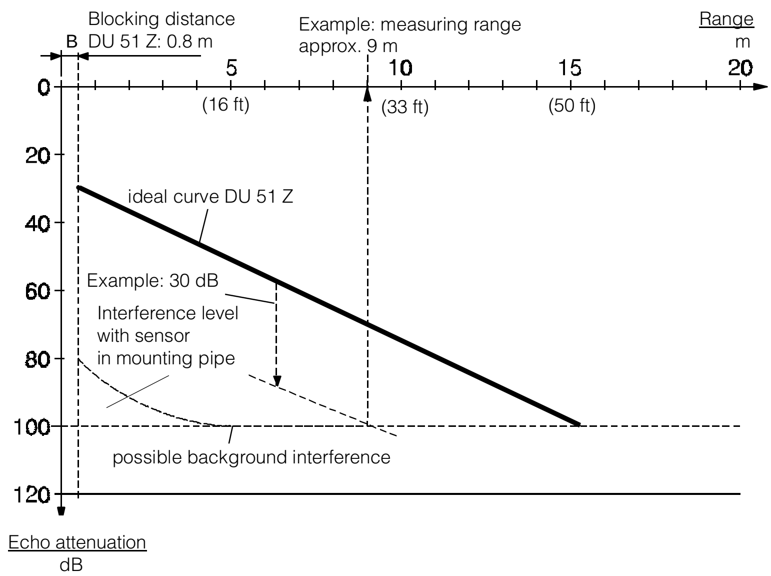
- By using the table, check which factors affect the measurement.
- Add together the attenuation values (dB).

The diagram shows the ideal echo attenuation curve for the DU 51 Z sensor.
- Move the ideal curve downwards by the amount which corresponds to the sum of the attenuation values.
- Subtract the noise expected from the 120 dB noise level. A typical noise level of approx. 20 dB is caused by the silo filling or emptying and by interference echoes coming from the silo walls. The interference level is increased for short measuring paths due to stronger interference echoes.
- The maximum range is indicated by the point where the ideal curve and the interference level line meet. Please refer to the example.

Effects		Attenuation (dB)
Temperature layering*		
Difference in air temperature between sensor and product surface	up to 20 °C	0
	up to 40 °C	5...10
	up to 60 °C	10...20
Filling curtain		
outside the detection zone		0
small amounts within the detection zone		5...10
large amounts within the detection zone		10...20
Liquid of liquid		
calm		0
waves		5...10
strong turbulence (e.g. agitator)		10...20
Foam		
Please contact Endress+Hauser		
Surface of bulk solid		
hard, rough		20
soft		20...40
e.g. peat, dust-covered clinker		
Dust		
none		0
low		5
high		5...10

Above:
Attenuation in dB with interference factors in the tank or silo.

* $x\,°C = (x \cdot \frac{9}{5} + 32)\,°F$



Example for calculating the range: (liquid tank):

Factor:	Attenuation
Temperature difference in the tank max. 60 °C	20 dB
Filling curtain outside the detection zone	0 dB
Agitated liquid surface	10 dB
Total sum of attenuation values	30 dB

Measuring range under these conditions approx. 9 m

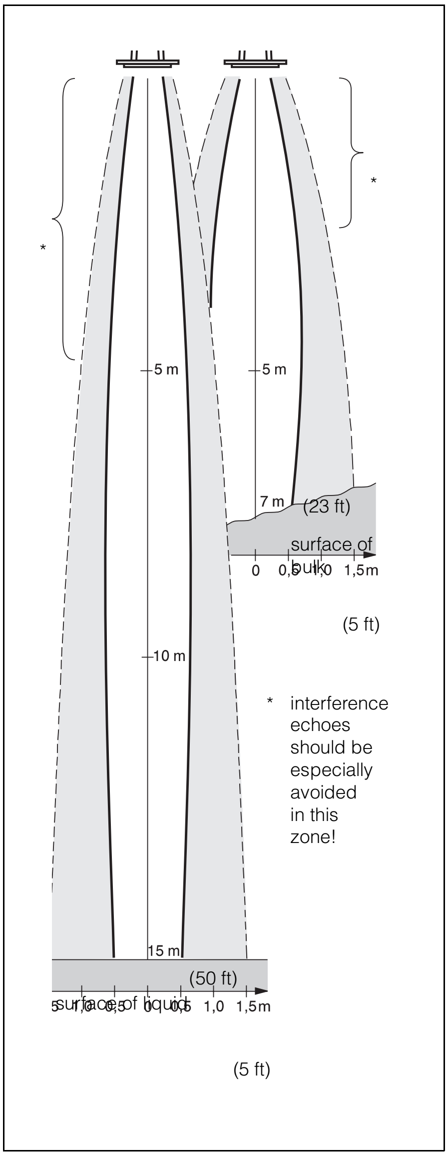
Right:
Echo attenuation as a function of measuring range with an example for calculating the measuring range.

In mounting pipe, the sensor generates an interference signal which decreases with increasing path

Detection Limits and Interference Signals

If fixtures are present in the tank or silo, then careful positioning of the sensor is critical in order to keep the interference level as low as possible. The ultrasonic pulse should arrive unobstructed at the product surface. The pulse leaves the sensor as a narrow beam which widens as the distance increases. Every object within this beam causes an echo which is received by the sensor.

- Edges, internal fittings, etc. in the first third of the measuring range are more critical since the sonic energy is still highly concentrated: small objects can cause large echoes.
- In the last third of the measuring range, the sonic energy is spread across a much larger area. Internal fittings and edges are much less critical.
- Objects in the middle of the beam (continuous lines in the diagram) produce strong echoes.
- Echoes from the outside zone (broken lines) are only significant when the working signal from the surface of the solid is weak.

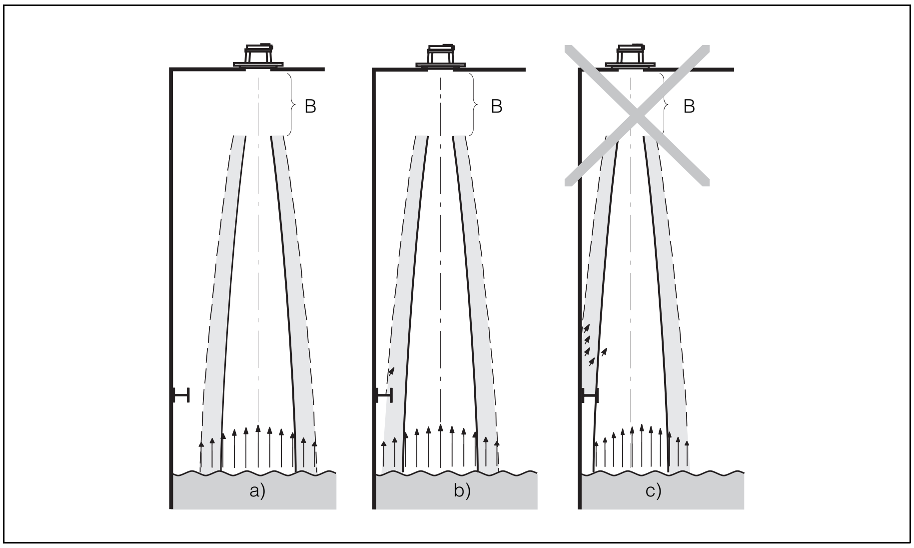


Detection zone as a function of application conditions.
Continuous lines: good reflection characteristics, low attenuation giving low amplification in the Nivosonic FMU transmitter.

Broken lines: poor reflection characteristics, strong attenuation giving high amplification in the Nivosonic FMU transmitter.

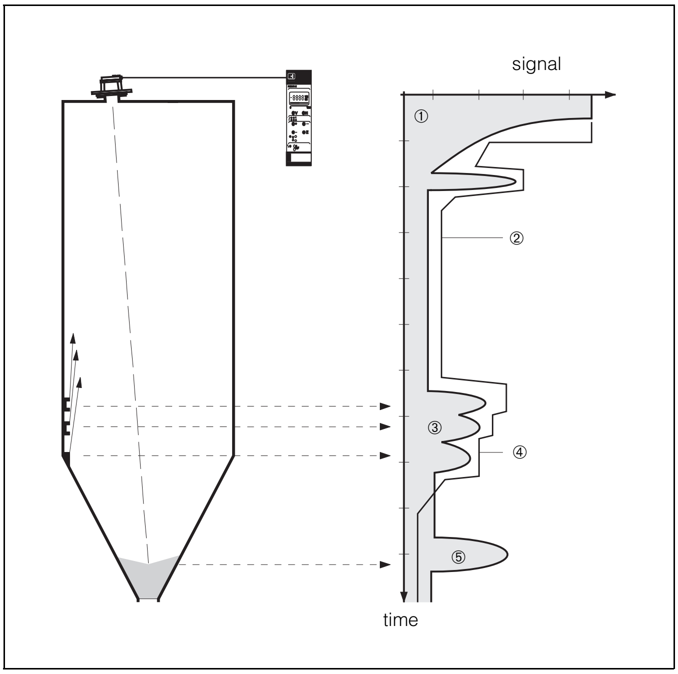
Accuracy

- The effect of pressure variations is < 0.1% (in air or nitrogen).
- A constant temperature and sonic velocity along the entire measuring path ensure a high degree of accuracy with error limits ≤1%. The effect of steep temperature gradients along the measuring path and changing product components must be calculated and the Nivosonic programmed accordingly. A layer of nitrogen above the product alters the sonic velocity by only +1%. Liquids with high partial pressures must have gas compositions which remain constant.
- The resolution is 1.7 cm at a sonic velocity of 340 m/s.



Avoid interference echoes from internal fittings and rough silo walls!
a) correct installation, no interference echoes
b) non-critical installation,weak interference echoes only
c) incorrect installation, strong interference echoes from internal fittings and from wall irregularities (e.g. welding seams)

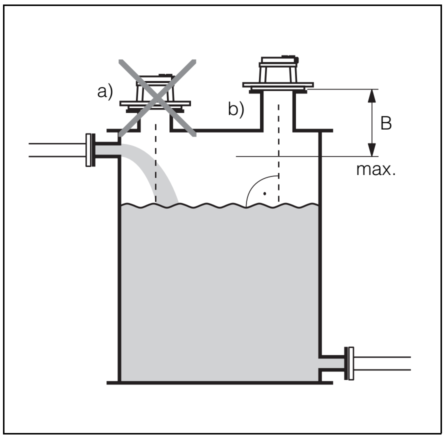
Suppression of interference echoes from fixed installations:
① Signal decay of the sensor
② Time dependent threshold which an echo signal must exceed to be processed by the transmitter.
③ Interference echoes
④ Interference echo suppression (adjusted detection threshold)
⑤ Working signal from the surface of the bulk solid



Interference Signal Suppression
Interference echoes from stationary internal fittings can be suppressed using then fixed target suppression“ mode of the Nivosonic FMU 673 ... 678 Z.
This adjusts the detection limits such that interference echoes are no longer identified and are therefore excluded from further signal processing. Note that adjusting the detection limits to the interference profile reduces the measuring range. With weak working signals especially, (e.g. cement silos) the interference level should be minimised at the start by correctly installing and positioning the sensor.

Installation

a) Do not carry out measurement through the filling curtain
b) Distance B (blocking distance) to maximum level must be observed. See diagram on the next page for height of the mounting pipe

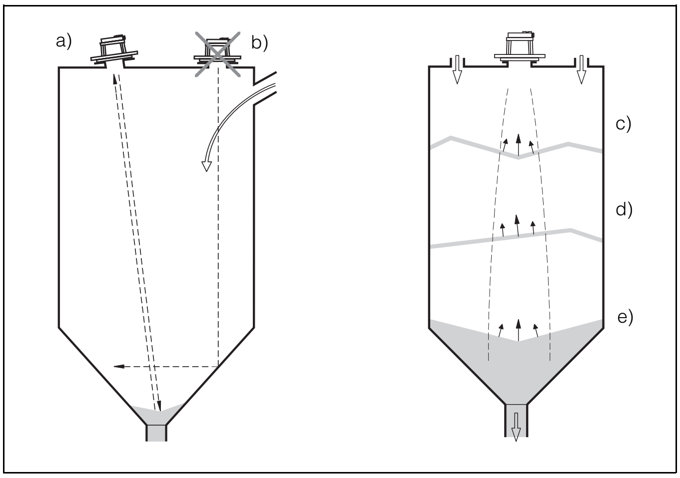


Recommendations for Mounting on a Tank
- Position the sensor exactly perpendicular to the surface of the liquid.
- Avoid measuring through the filling curtain.
- Mount the sensor high enough so that no material enters the blocking distance even with overfilling.
- Use the recommended sizes for mounting pipes.

Recommendations when Mounting on a Silo
- Direct the sensor to the centre of the outflow funnel so that an echo is received even when the silo is empty.
- Avoid measuring through the filling curtain.
- The smooth surface of a very fine-grained bulk solid or one producing dust gives no significantly diffuse reflection. The beam is reflected like light (angle of incidence = angle of reflection). The installation point is, therefore, of critical importance for correct measurement.

Left:
a) Correct installation
As far from the silo wall and material inflow as possible. The centre of the outflow funnel reflects an echo which is received by the sensor even when the silo is empty.

b) Incorrect installation
1. Detection through the filling curtain
2. With an empty silo, the echo is reflected to one side so that the sensor cannot receive a working signal.

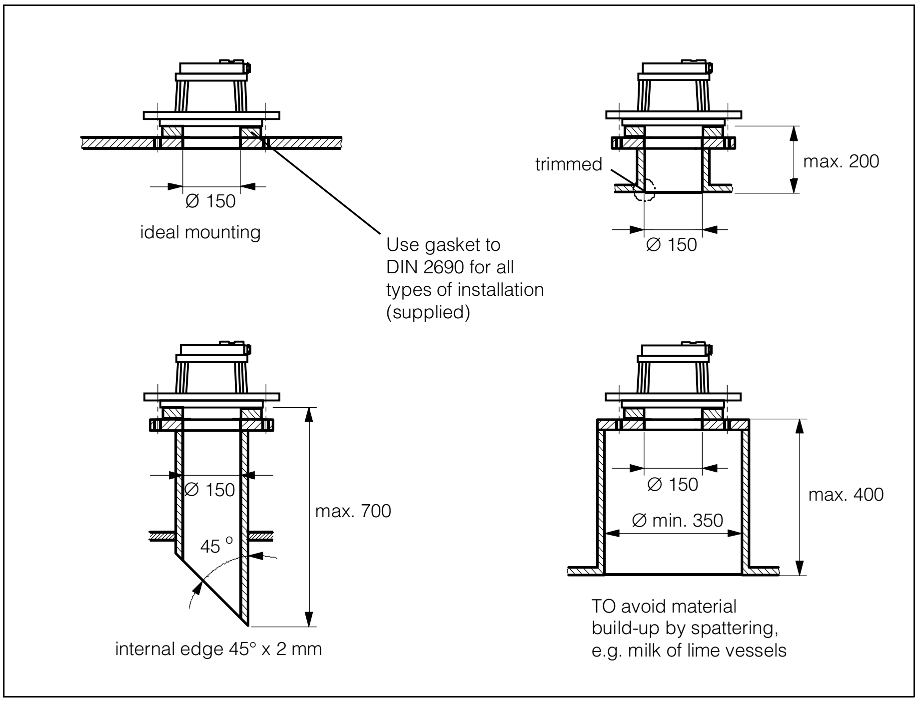


Right:
Installation point for powdery bulk solids.
c) A trough between slopesreflects a strong echo in the direction of the sensor.
d) Slightly rising surfaces with angles up to 5°still reflect enough sonic energy towards the sensor
e) The centre of the outflow cone reflects a sufficiently strong echo towards the the sensor.

Mounting

Mounting examples for closed tanks or silos

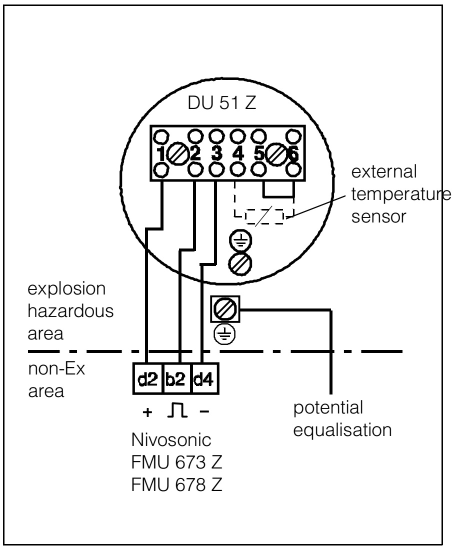
All dimensions in mm
100 mm = 3.94 in
1 in = 25.4 mm



- No material build-up and no condensation should occur in a narrow mounting pipe.
- Select a mounting pipe with the largest possible diameter.
- The internal wall of the mounting pipe should be as smooth as possible (no edges or welding seams).
- Insulate the mounting pipe when mounting in the open to avoid condensation.
- With cylindrical tanks or silos: Avoid mounting the sensor in the centre of the roof. This applies especially to curved roofs as interference or multiple echoes will tend to occur.
- When mounting the DU 51 Z, the counter flange must be as smooth as possible.
  Lay the gasket supplied on the counterflange to ensure sonic decoupling. When using other types of gasket: The same thickness of gasket must have a hardness of 60 ... 70 Shore A.
- Install securely using all 8 screws supplied.
- Tighten the screws crosswise with an even pressure applied, recommended torque: approx. 100 Nm ... 110 Nm, (75 ... 80 ft lbs). maximum torque 120 Nm (90 ft lbs).

Electrical Connection

Connecting the ultrasonic sensor DU 51 Z to the Nivosonic FMU ...

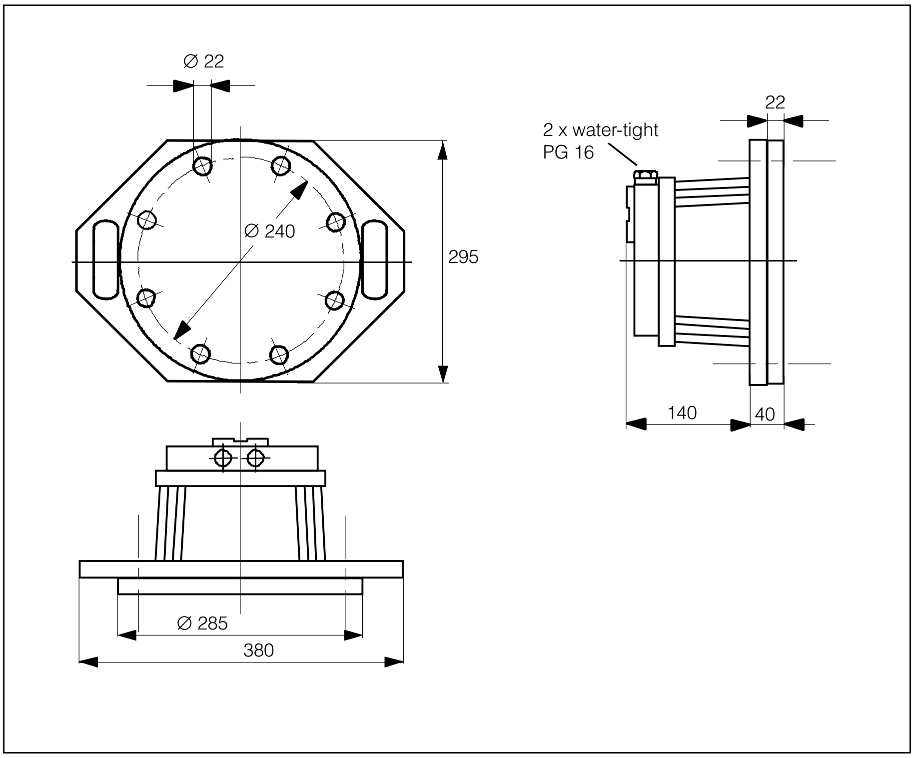


Intrinsically safe connection of the DU 51 Z ultrasonic sensor to the Nivosonic FMU 673 Z or FMU 678 Z using normal, unscreened, three-core multipurpose cable, max. 25 Ω per core. (Observe all explosion protection regulations when laying cables!) Screened and twisted cabling is recommended if it is to be laid in strong magnetic or electrical fields. Connect the screening to the DU 51 Z only! If a Pt100 sensor is required, then this must be stated when ordering the DU 51 Z sensor. Connect it to Terminals 4 and 6 without jumper 5 – 6.

Technical Data

Measuring Range
Up to 15 m (liquids),
under ideal conditions:
- ambient temperature 0 . . . 30 °C
- atmospheric pressure
- ideal mounting, see Page 6
- calm liquid surface, no foam or turbulence
- measuring path free of obstacles

Up to 7 m (solids) under
ideal conditions
- ambient temperature 0 . . . 30 °C
- atmospheric pressure
- ideal mounting, see Page 6
- dust-free, hard surface with a grain size of greater than 10 mm (e.g. ballast)
- measuring path free of obstacles



Dimensions of the DU 51 Z ultrasonic sensor in mm

100 mm = 3.94 in
1 in = 25.4 mm

Sizes for the standard flange DN 150, PN 16, DIN 2501

Operating Data
- Bursting pressure: 5 bar (70 psi)
- Operating temperature in the tank or silo: –20 °C . . . +80 °C (4 ... 170 °F)
- Ambient temperature for the housing: –20 °C . . . +60 °C (4 ... 140 °F)
- Ultrasonic run time compensation: silicon temperature sensor mounted behind the diaphragm of the sensor
- Operating pressure p_e: max. 3 bar
- Ultrasonic frequency: approx. 21 kHz
- Pulse frequency: approx. 2 Hz
- Blocking distance: approx. 0.8 m
- Emission angle at – 3 dB: 3°

Construction and Materials
- Flange and oscillator: machined from a single piece of stainless steel 1.4571
- Flange size: DN 150, PN 16
- Gasket supplied: NBR
- Housing: aluminium (AlSi 9)
- Protection according to DIN 40050: IP 65
- Degree of protection: EEx de ib IIC T 6
- Weight: 16.2 kg

Subject to modification.

How to Order

Ultrasonic sensor DU 51 Z
Order Code DU 51 Z - A11 A1

Supplementary Documentation

- ☐ Certificate of conformity
  PTB No. Ex-89.C.2069
  and
  Certificate of design
  01/PTB No. Ex-89.C.2069
  Certificate ZE 023/00/e

- ☐ Level measurement transmitter
  Nivosonic FMU 673 Z, FMU 678 Z
  Technical Information TI 128/00/e

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