Technical
Information
TI 145F/00/en

Ultrasonic Level Measurement
Sensors DU 43 C, DU 43 S

Non-contact continuous level measurement in bulk solid silos, and for ATEX Zone 20

DU 43 C
Compact
ultrasonic sensor
with drive electronics

DU 43 S
Ultrasonic sensor without
drive electronics

Features at a Glance

- Large measuring range in bulk solid silos (up to 25 m = 80 ft)
- Short distance between maximum level and sensor (0.8 m = 2.6 ft)
- Compact or separate sensor version with Protection IP 68
- Version with corrosion-resistant metal coating for ATEX Zone 20
- Mounting with flange or thread connection
- Insensitive to build-up

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Application

The ultrasonic sensor DU 43 is primarily designed for continuous non-contact level measurement in silos containing bulk solids and also for dust Ex hazardous area ATEX Zone 20. It has a measuring range of 25 m (80 ft) (under optimum conditions).

Application examples:
Granular and lumpy bulk solids such as crushed stone, gravel, ore, coal, granulated plastic, glass cullet, grain, etc.

The surface coarseness of such bulk solids allows the level to be measured by using diffuse reflection which is independent of the slope of material cone or depression.
With fine-grained or powdery bulk solids, e.g. quartz sand, cement, powdered plastics, raw meal etc., function is dependent on the surface of the material (mirrored reflection).

Measuring System

The complete measuring system consists of

- the measuring unit Nivosonic FMU 671, FMU 676 or FMU 677 in the control room,
- the ultrasonic sensor DU 43 in the silo and
- the drive electronics for the ultrasonic sensor.

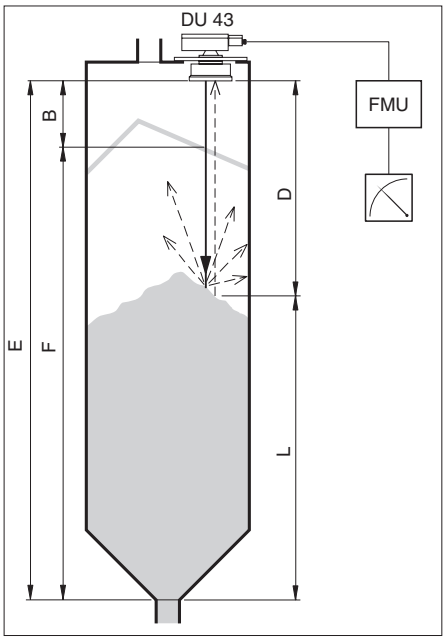
Version DU 43 C:
the drive electronics and the sensor are a single unit.

Version DU 43 S:
the drive electronics FHU 43 are mounted separately.

Operating Principle

The ideal mounting point for the sensor is directly underneath the silo roof.
The ultrasonic emitter in the sensor is excited electrically and sends an ultrasonic pulse in the direction of the surface of the product. 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 between the sensor and the product surface. The distance D is determined from the velocity of sound c and the run time t by the formula:

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



Measuring system and function
B = Blocking distance
D = Distance from sensor to material surface
L = Height in silo (Level)
F = Maximum level (100%, Full)
E = Zero point of measurement (0%, Empty)

Example:
With the velocity of sound c = 340 m/s, a run time of 50 ms corresponds to a transmission path of 17 m and thus to a distance of 8.5 m.

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 reflection from the product surface.

Blocking distance
Due to the attenuation characteristic of the sensor, there is a zone immediately below it from which returning echoes cannot be detected. This so-called blocking distance B determines the minimum distance between the sensor diaphragm and the maximum level in the silo.
The blocking distance for the DU 43 sensor is approx. 0.8 m (2.6 ft).

Measuring conditions
The primary requirement for ultrasonic measurement is the reflection of an echo from the product surface.
The sensor receives a sufficiently high proportion of diffuse echoes when the surface roughness of the material is greater than 4 mm (0.15 in).
With powdery or fine-grained solids, function is dependent on surface contours.

Planning Recommendations

Maximum range

The measuring range depends upon the following factors:

- The strength of the signal from the product surface (diffuse echo)
- The attenuation of the signal 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 on the requirements of the application.

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

Optimum conditions are achieved if:

- the lower edge of the sensor projects into the silo
- internal fittings are not located within the detection zone
- the silo is not filled during measurement
- the bulk solid is hard and coarse-grained
- no dust is present in the silo
- temperature difference in silo is small.

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

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

The diagram shows the ideal echo attenuation curve for DU 43 sensors.

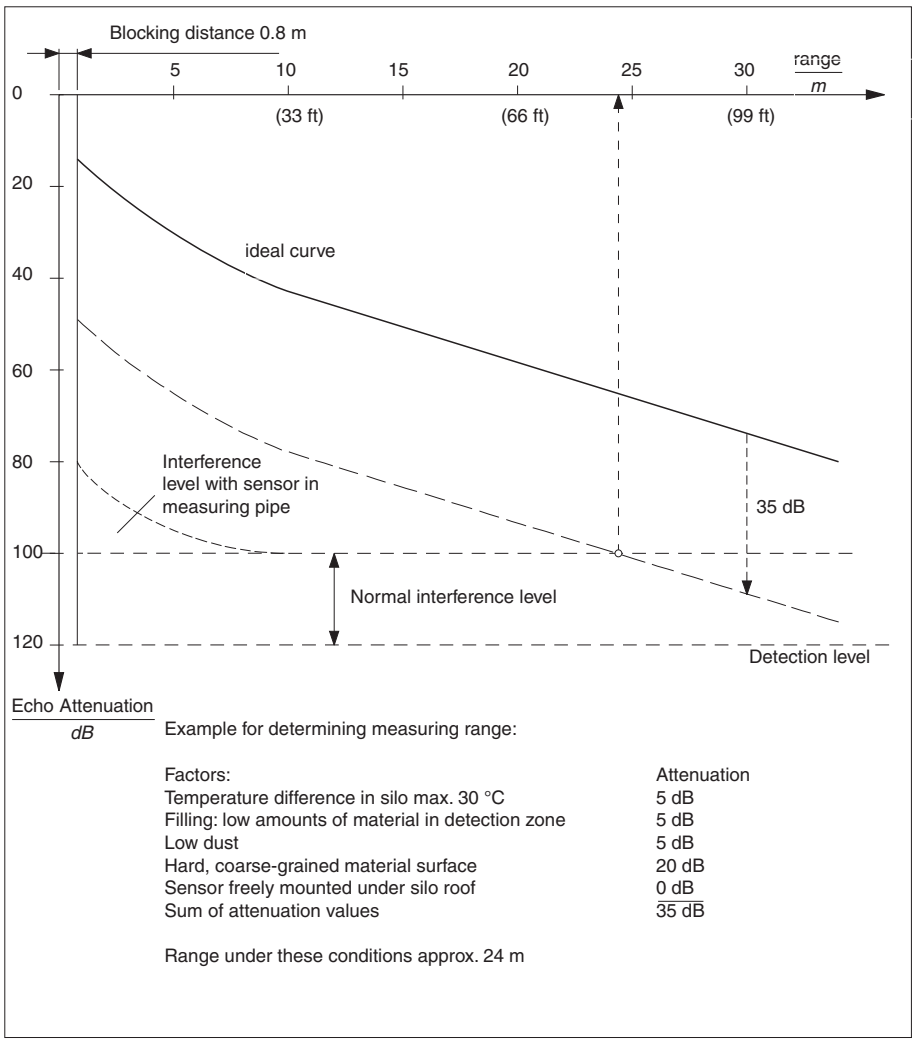
- Move the ideal curve downwards corresponding to the sum of the attenuation values.
- Read off the noise expected from the 120 dB level. A typical noise level of approx. 20 dB is caused by the silo filling and discharging and by interference echoes at the silo walls.
- The maximum range is indicated at the intersection where the ideal curve and the interference level line meet. Please refer to the example.

Does this range meet your specific requirements?

Factors in bulk solids silos		Attenuation dB
Temperature Layering	*	
Difference in air	up to 20 °C	0
temperature between	up to 40 °C	5...10
sensor and product	up to 60 °C	10...20
surface		
Filling curtain		
outside detection zone		0
low amounts in detection zone		5...10
large amounts in detection zone		10...20
Dust		
no dust		0
low dust		5
high dust		5...10
Surface		
coarse-grained, rough		20
soft		20...40
e.g. peat, dust-covered clinker		

Attenuation in dB with interference in silo

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



Example for determining measuring range:

Factors:	Attenuation
Temperature difference in silo max. 30 °C	5 dB
Filling: low amounts of material in detection zone	5 dB
Low dust	5 dB
Hard, coarse-grained material surface	20 dB
Sensor freely mounted under silo roof	0 dB
Sum of attenuation values	35 dB

Range under these conditions approx. 24 m

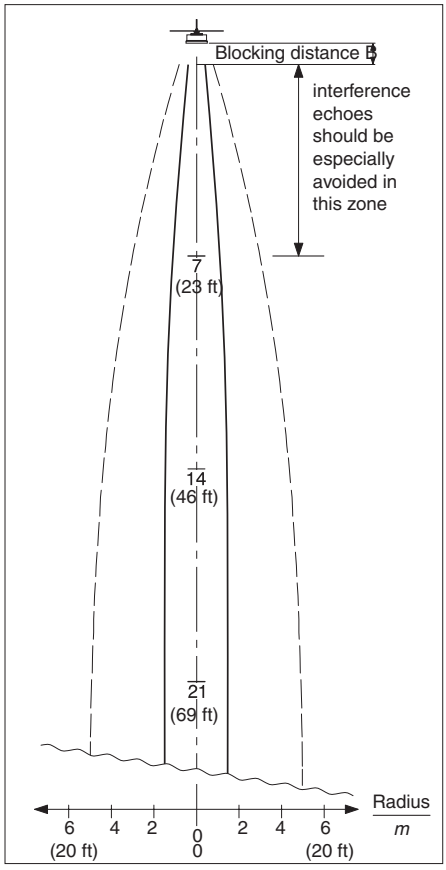
Echo attenuation as a function of range with example for determining measuring range

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

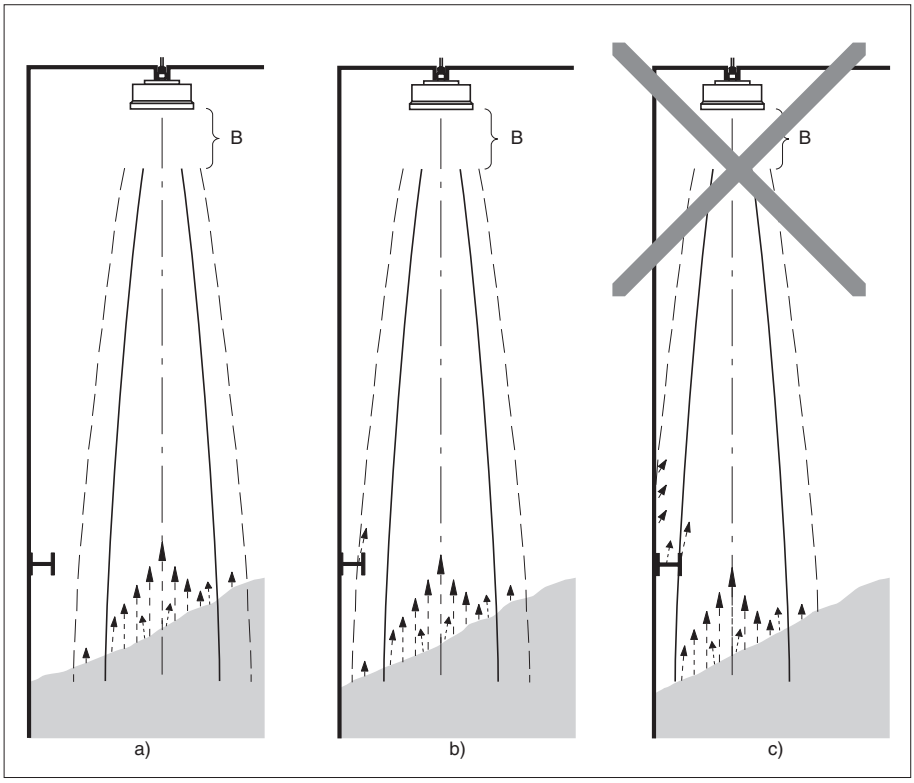
Detection limits and interference signals

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

- Edges, internal fittings etc. within the sound cone in the first third of the measuring range are critical as the sonic energy is still highly concentrated and, due to the short distance, the interference echoes are only weakly attenuated. Obstructions with small surface areas can result in large interference 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 (full line in diagram) produce strong echoes.
- Echoes from the outside zone are only significant when the working signal from the product surface is weak.



Detection area as a function of range (Lines of equal attenuation)

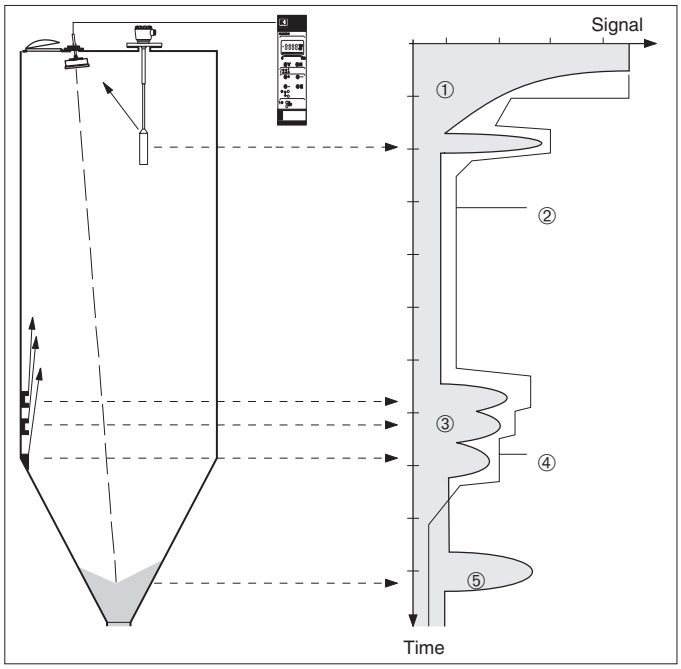


Avoid interference echoes from internal fittings and silo walls!
a) correct installation, no interference echo
b) non-critical installation, weak interference echo only
c) incorrect installation, strong interference echo from internal fittings and from wall irregularities (e.g. welding seams)

Interference signal suppression

Interference echoes from stationary internal fittings can be suppressed using the »fixed target suppression« mode of the Nivosonic FMU….
The detection limits are therefore automatically adjusted to the interference echo profile so that these signals are no longer identified and processed further.

Note that adjusting the detection limits to the interference profile reduces the measuring range.
With especially weak working signals (e.g cement silos), the interference level should be minimised by first correctly installing and positioning the sensor.



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

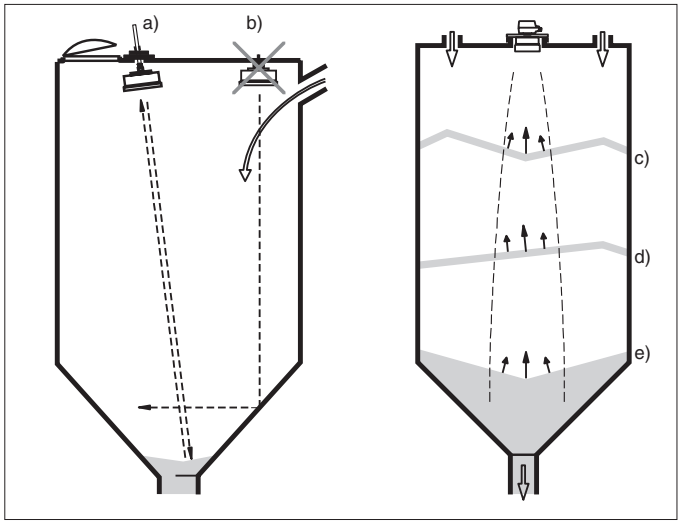
Installation

Guidelines when mounting

- Direct the sensor to the centre of the outflow funnel so that an echo is received when the silo is empty.
- Positioning the DU 43 S sensor is simplified using the alignment unit FAU 40 (accessory).
- 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 mounting point is therefore of critical importance for correct measurement. See Fig. below right.

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 filling curtain
2. With an empty silo the echo is reflected to one side and the sensor cannot receive a working signal.

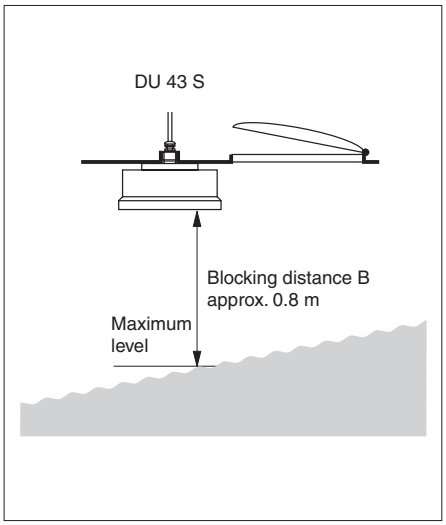


Right:
Mounting point for powdery bulk solids.
c) A dip between slopes reflects a strong echo towards the sensor
d) Slightly rising surfaces with angles up to 5° still reflect enough sonic energy towards the sensor
e) The centre of the material depression reflects a sufficiently strong echo towards the sensor

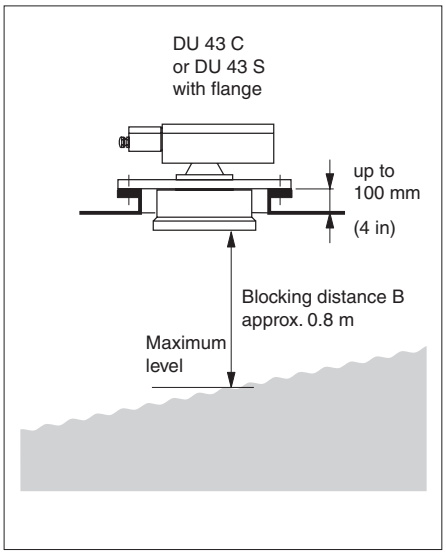
Recommendations for mounting

- Select a place for mounting where the lower edge of the sensor is below the silo roof.
  When the silo is filled there must be at least an 80 cm (2.6 ft) air gap between the maximum level and the sensor (blocking distance).
- Mounting can be simplified by installing the DU 43 S sensor in the vicinity of a service access.

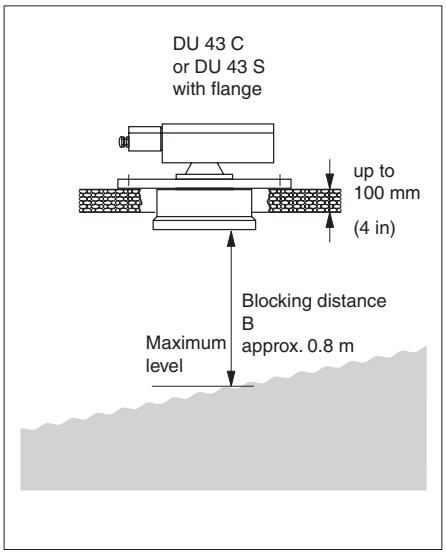
Mounting recommendations for *closed* silos



Sensor (DU 43 S) mounted directly on the silo roof near a service access. Mounted in a 1" threaded sleeve or with a bolt.



Sensor with flange on a short mounting pipe with counter flange.



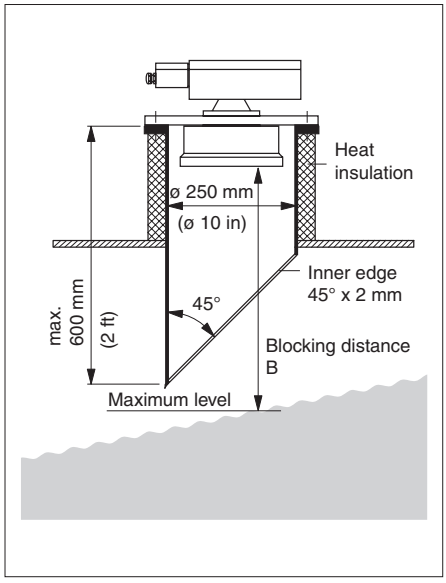
Sensor with flange mounted directly on the roof of a concrete silo.

For special applications: installing a sensor with mounting pipe

Use only when with mounting in a silo the blocking distance cannot be maintained.

Note:

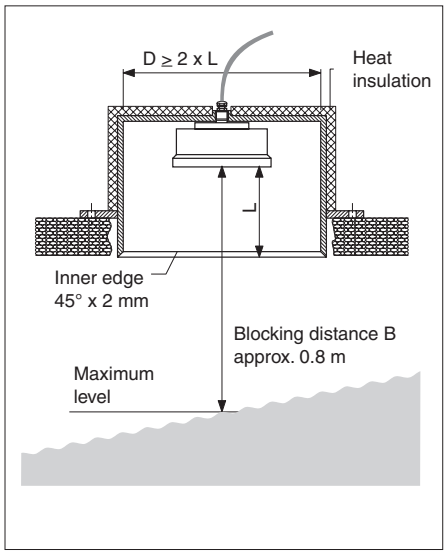
- No build-up of material and no condensate should form in the pipe.
- Select a mounting pipe with a diameter as large as possible.
- The inner surface of the pipe should be smooth (no edges, no welding seams).
- When mounting outdoors, insulate the mounting pipe

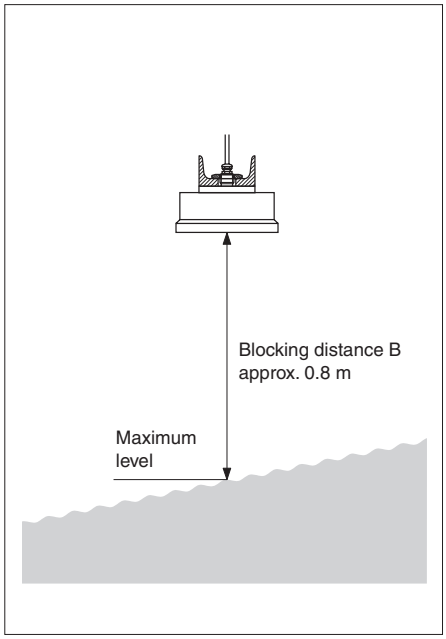


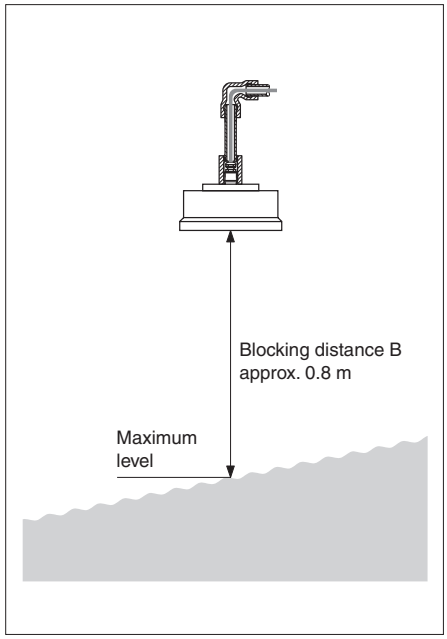
Above:
Slanted collar

Below:
Horizontal pipe;
The ratio of diameter D to height L must be at least 2:1, e.g. for material build-up caused by spatter.

With silos in the open, the pipe and sensor should be protected against direct sunlight or else the pipe should be insulated as otherwise the temperature in the pipe will differ significantly from that in the silo. This will result in a false correction for the ultrasonic run time.



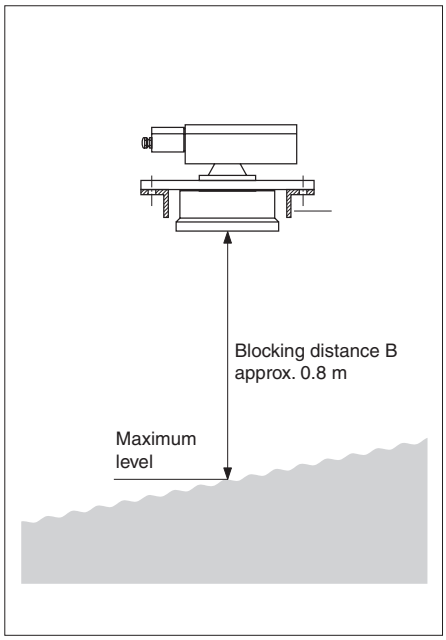


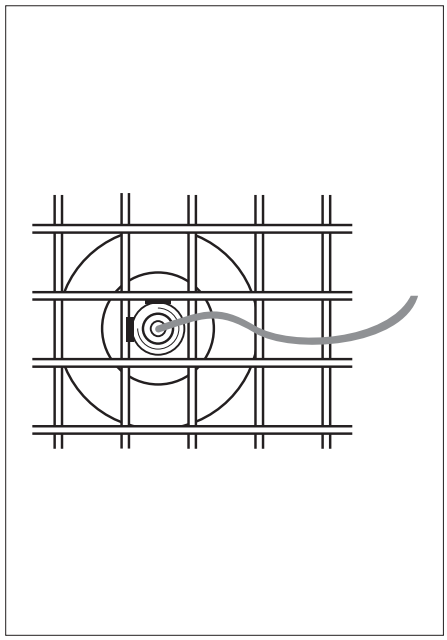


Mounting recommendations for *open* silos

Left:
DU 43 S on U-supports or brackets

Right:
DU 43 S with 1" tube





Mounting recommendations for *open* silos

Left:
DU 43 S or DU 43 C with flange on two angle brackets

Right:
DU 43 S on a 1" sleeve which is welded to a grating (seen from above).

Mounting

- The PE coating on the diaphragm is an integral part of the measuring system and must not be damaged during installation.
- The connecting cable of the ultrasonic sensor DU 43 S is not designed as a supporting cable. Do not use it as a suspension wire.
- For ATEX Zone 20: The connecting cable of the ultrasonic sensor is not to be laid unprotected in ATEX Zone 20. If laying cable in dust explosion area is unavoidable, then local regulations must be observed.
- The DU 43 C sensor should be protected against the environment using an all-weather cover (accessory) when mounting it in the open.

Protect the diaphragm against damage when mounting

Electrical Connection

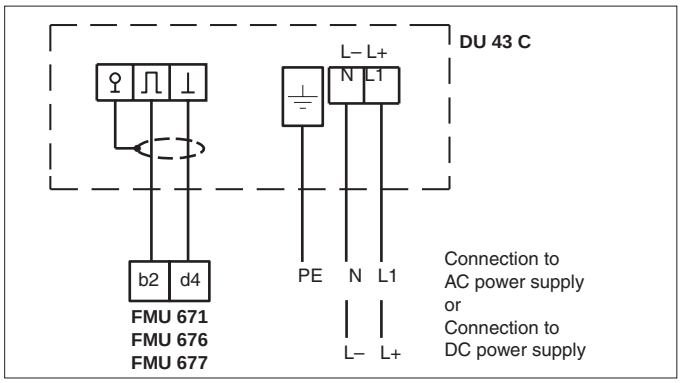
Connecting the DU 43 C

Power connection:

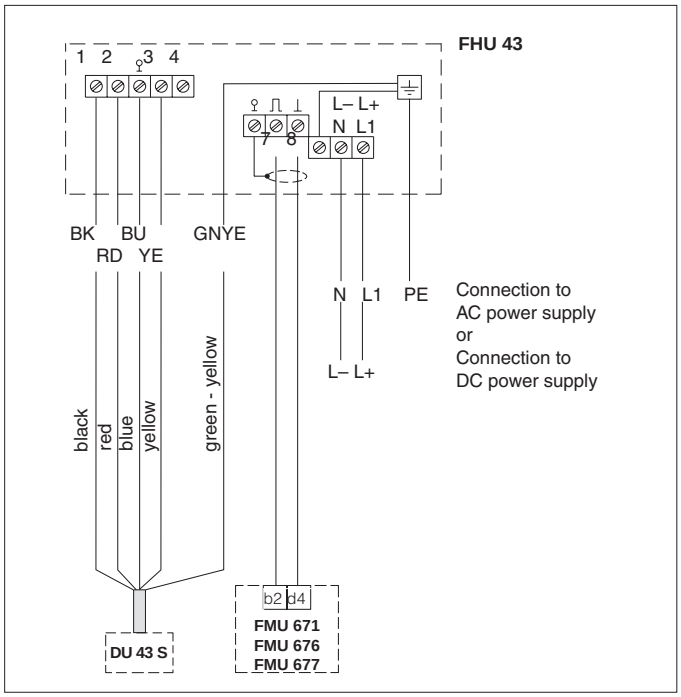
- The connection terminals are designed for cable diameters up to 2.5 mm^2.
- No special fusing is required as the ultrasonic sensor DU 43 C has an integrated fine-wire fuse.

Connecting the DU 43 C to the Nivosonic FMU :

- The connecting cable between the ultrasonic sensor DU 43 C and the Nivosonic FMU can be commercial two-core installation cabling or two cores of a multicore all-purpose cable.
- Cable resistance max. 25 Ω/core
- Use a screened cable between the sensor and transmitter. Refer to TI 241F for installation instructions pertaining to screened cables and general instructions on EMC test conditions for E+H equipment. Connect the screening to the DU 43 C only!



Connecting the compact ultrasonic sensor DU 43 C to the Nivosonic FMU 67. and to the power supply



Connecting the separate ultrasonic sensor DU 43 S to the drive electronics FHU 43, to the Nivosonic FMU 67. and to the power supply

Connecting the DU 43 S and the FHU 43

Connecting the DU 43 S to the FHU 43:

- For this connection, a 5 m long cable is attached to the ultrasonic sensor
- If the drive electronics FHU 43 need to be further from the ultrasonic sensor DU 43 S, then a connection cable up to 30 m can be supplied.
  An extention of the cable is possible up to a total length of 100 m.

Power connection to the FHU 43:

- The connection terminals are designed for cable diameters up to 2.5 mm^2.
- No special fusing is required as the drive electronics FHU 43 have an integrated fine-wire fuse.

Connecting the FHU 43 to the Nivosonic FMU :

- The connecting cable between the drive electronics FHU 43 and the Nivosonic FMU can be commercial two-core installation cabling or two cores of a multicore all-purpose cable.
- Cable resistance max. 25 Ω/core
- Use a screened cable between the sensor and transmitter. Refer to TI 241F for installation instructions pertaining to screened cables and general instructions on EMC test conditions for E+H equipment.

Technical Data

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Versions

① DU 43 C:
Compact version,
with flange connection

② DU 43 C for ATEX Zone 20/22
with steel shell and steel-plated flange

③ DU 43 S:
Sensor without drive electronics,
with flange or thread connection

④ DU 43 S: for ATEX Zone 20/21
with steel shell

⑤ FHU 43:
Drive electronics in protective housing for DU 43 S, for ATEX Zone 22

- For order specification keys see Page 11

Dimensions

- For dimensions see Page 10
- Flange sizes and standards:
  EN/DIN: DN 250, PN 16 B agreeable to EN 1092-1
  ANSI: 10", 150 psi conf. to ANSI B 16.5
  JIS: 10 K 250 conf. to JIS B 2210, Table 3-1 (“thick”)
- Thread sizes and standards:
  G 1 A (parallel) conf. to DIN ISO 228/I
  NPT 1" (tapered) conf. to ANSI B 1.20.1

Operating data

- Pressure p_e: max. 0.5 bar (7 psi)
- Temperature in silo
  DU 43 C: –20 °C…+80 °C (-4°F...176°F)
  DU 43 S: –20 °C…+80 °C (-4°F...176°F)
- Ambient temperature:
  DU 43 C: –20 °C…+60 °C (-4°F...140°F)
  FHU 43: –20 °C…+60 °C (-4°F...140°F)
- Max. permissible relative humidity in silo:
  100 % up to +60 °C (+ 140°F)
  95 % up to +80 °C (+ 176°F)
- Ultrasonic run time compensation:
  with silicon temperature sensor, integrated behind diaphragm of sensor
- Operating frequency: approx. 21 kHz
- Pulse frequency: approx. 3 Hz
- Measuring range with bulk solids: up to 25 m (80 ft) (under ideal conditions)
- Blocking distance B: approx. 0.8 m (2.6 ft) below the diaphragm
- Power consumption: approx. 7 VA
- Version for DC power connection
  - power consumption: approx. 5.5 W
  - mean current consumption: 220 mA
  - max. pulse current ≤ 800 mA

Materials

- Housing for drive electronics: cast aluminium (Al Si 12), powder coated
- Sensor housing in silo: PA, fibreglass-reinforced
- Flange: PPs
- Gasket between sensor and flange: EPDM
- Thread connection to sensor DU 43 S: aluminium or 1.4301
- Diaphragm: 0.5 mm 1.4571 stainless steel with 4 mm closed-cell PE coating on side nearest product
- Diaphragm gasket: EPDM
- Spring washer (mounting diaphragm): 1.4571 stainless steel
- Coating of sensor for ATEX Zone 20: 1.4301 stainless steel
- Flange plating of sensor for ATEX Zone 20:
  1.4301 stainless steel

Measuring instruments

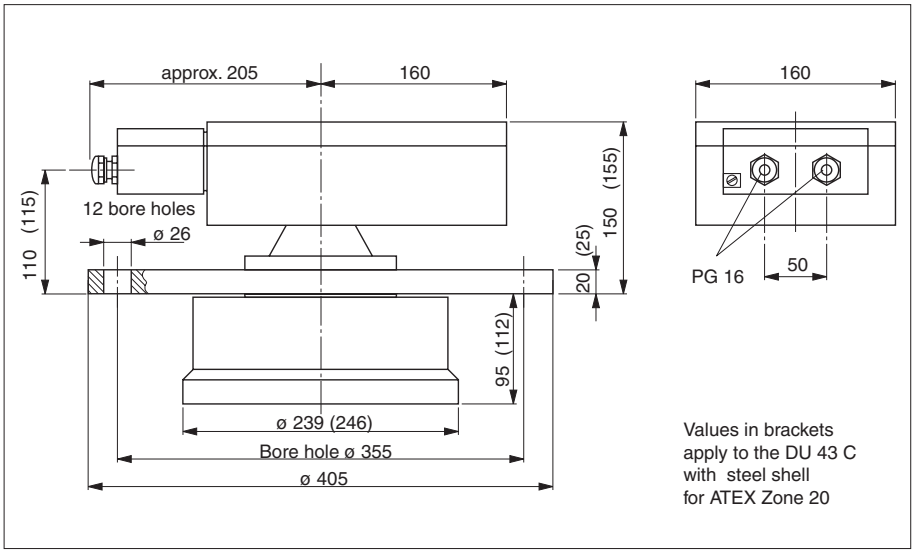
- Nivosonic FMU 671
  7 HP wide Racksyst plug-in board with adjusting elements for local dialogue, digital LCD for measurement values and entered parameters, status of limit switches.
- Nivosonic FMU 676
  The same as the FMU 671, but for local dialogue with the Commulog VU 260 or for remote dialogue with a computer using the computer interface ZA 67...
  There are no calibration elements or digital display on the front panel.
- Multipoint FMU 677
  7 HP wide Racksyst plug-in board without front panel.
  For local dialogue using the handheld terminal Commulog VU 260 or for remote dialogue with a computer using the computer interface ZA 67... With LEDs for showing the status of limit switches.
  Additional measuring units are installed in a rack behind a common front panel as a Multipoint level measuring system.

Electromagnetic Compatibility (EMC)

- Interference Emission to EN 61326, Electrical Equipment Class B
  Interference Immunity to EN 61326, Annex A (Industrial).

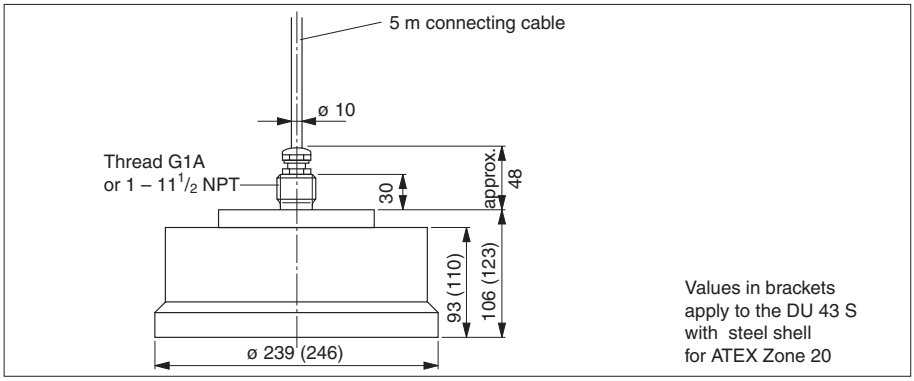
Dimensions

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



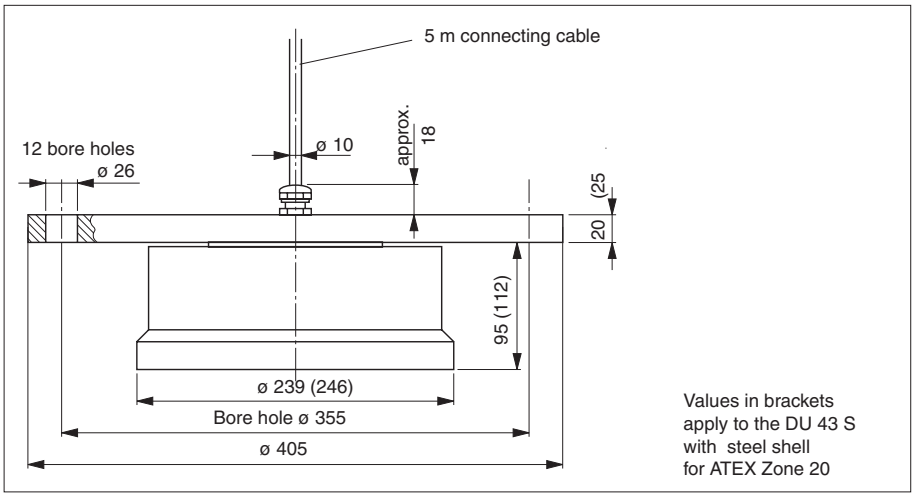
Dimensions of the ultrasonic sensor DU 43 C (shown with DIN flange DN 250, PN 16).

Values in brackets apply to the DU 43 C with steel shell for ATEX Zone 20



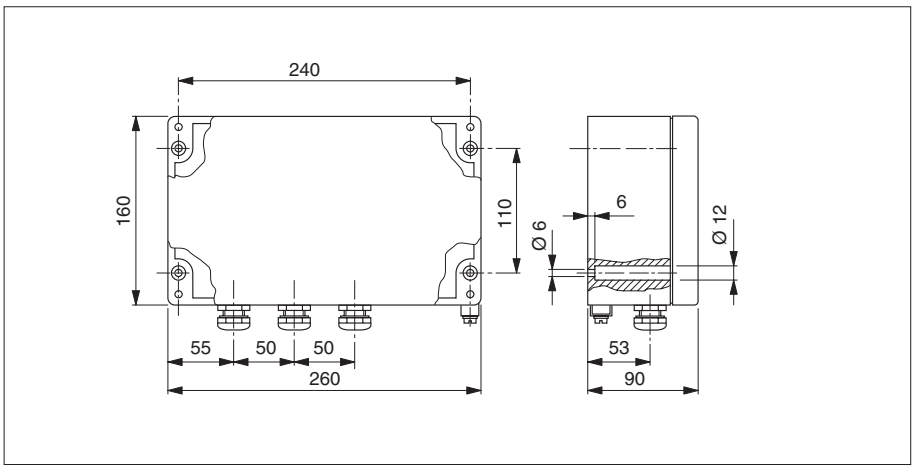
Dimensions of the ultrasonic sensor DU 43 S with thread connections

Values in brackets apply to the DU 43 S with steel shell for ATEX Zone 20



Dimensions of the ultrasonic sensor DU 43 S with flange connection (shown with DIN flange DN 250, PN 16).

Values in brackets apply to the DU 43 S with steel shell for ATEX Zone 20



Dimensions of the drive electronics in protective housing FHU 43.

Order Specifications

DU 43 C, compact ultrasonic sensor with drive electronics

Certificate		Weight Standard	Weight ATEX
R	Standard (non-certified)		
E	ATEX II 1/3 D, s. XA 232F-A		
Process Connection / Material			
A	Flange 10" 150 lbs FF, PP max. 22 psia	appr.11.4 kg	13.5 kg
D	Flange DN 250, PN 16 B, PP max. 1,5 bar abs.	appr.11.4 kg	13.5 kg
K	Flange 10K 200A FF, PP max. 1,5 bar abs	appr.11.4 kg	13.5 kg
Housing, Protection / Cable Gland			
1	Aluminium housing, IP 65 / PG 16		
2	Aluminium housing, IP 65 / NPT $^1/_2$"		
3	Aluminium housing, IP 65 / M 20 x 1.5		
4	Aluminium housing, IP 65 / G $^1/_2$		
Power Supply			
A	180 V...276 V, 50/60 Hz		
B	90 V...146 V, 50/60 Hz		
C	36 V... 60 V, 50/60 Hz		
D	20 V... 30 V, 50/60 Hz		
E	20 V... 30 V, DC		

Order code key for DU 43 C

(1 kg = 2.2 lbs)

DU 43 C [ ][ ][ ][ ] Order code

DU 43 S, sensor without drive electronics, Protection IP 68

Certificate		Weight Standard	Weight ATEX
R	Standard (non-certified)		
E	ATEX II 1/2 D, s. XA 232F-A		
Process Connection / Material			
G	Thread G 1 / Aluminium	appr. 5.4 kg	6.2 kg
N	Thread NPT 1" / Aluminium	appr. 5.4 kg	6.2 kg
S	Thread G1 / 1.4301	appr. 6.2 kg	7.0 kg
V	Thread NPT 1" / 1.4301	appr. 6.2 kg	7.0 kg
A	Flange 10" 150 lbs FF, PP max. 22 psia	appr. 7.3 kg	9.5 kg
D	Flange DN 250, PN 16 B, PP max. 1,5 bar abs.	appr. 7.3 kg	9.5 kg
K	Flange 10K 200A FF, PP max. 1,5 bar abs.	appr. 7.3 kg	9.5 kg
Cable Length			
1	5 m		
9	…m (any length up to 30 m)		

Order code key for DU 43 S

DU 43 S [ ][ ][ ] Order code

FHU 43, drive electronics in protective housing for DU 43 S

Certificate		Weight
R	Standard/ATEX II 3 D, s. XA 232F-A	
Housing, Protection / Cable Gland		
1	Aluminium housing, IP 65 / PG 16	appr. 4.0 kg
2	Aluminium housing, IP 65 / NPT $^1/_2$"	appr. 4.0 kg
3	Aluminium housing, IP 65 / M 20 x 1.5	appr. 4.0 kg
4	Aluminium housing, IP 65 / G $^1/_2$	appr. 4.0 kg
Power Supply		
A	180 V...276 V, 50/60 Hz	
B	90 V...146 V, 50/60 Hz	
C	36 V... 60 V, 50/60 Hz	
D	20 V... 30 V, 50/60 Hz	
E	20 V... 30 V, DC	

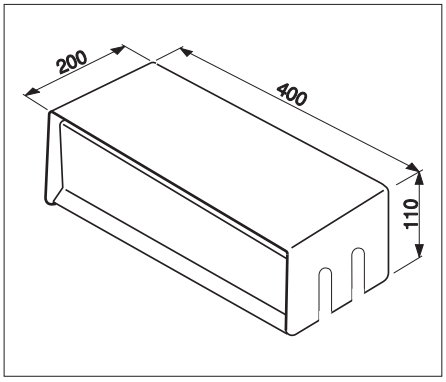
Order code key for FHU 43

FHU 43 [ ][ ][ ] Order code

Accessories

Alignment unit FAU 40
for DU 43 S

Alignment unit FAU 40
to align the sensor DU 43 S.
For a detailed description see
Technical Information TI 179F/00/en.



All-weather cover for
DU 43 S
(Dimensions in mm)

All-weather protective cover
for sensor DU 43 C
Material: PVC, light grey
Weight: 1.4 kg
Order No. 919207-0000

Supplementary Documentation

- ❑ Summary of non-contact level measurement using the ultrasonic echo detector Nivosonic
  Product Information PI 004F/00/en
- ❑ Nivosonic FMU 671, FMU 676
  Transmitters for connecting to the ultrasonic sensor DU 43
  Technical Information TI 062F/00/en
- ❑ The Multipoint ultrasonic echo system for level measurement at various measuring points
  Technical Information TI 086F/00/en
- ❑ The ultrasonic sensors DU 44 Z, DU 46 Z for especially large measuring ranges
  Technical Information TI 066F/00/en

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