Technical
Information
TI 178F/00/en

Operating Instructions
016090-1000

Ultrasonic Level Measurement
Sensors DU 73 C, DU 73 S

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

DU 73 C
Compact
ultrasonic sensor
with drive electronics

DU 73 S
Ultrasonic sensor without
drive electronics

Features at a Glance

- Large measuring range, for bulk solid silos up to 45 m (150 ft) high
- Short distance between maximum level and sensor 0.8 m (2.6 ft)
- Compact or separate sensor version with Protection IP 68
- Mounting with flange or thread connections
- Small sensor diameter for small apertures
- Insensitive to build-up

Endress+Hauser

The Power of Know How

Application

The ultrasonic sensor DU 73 is primarily designed for continuous non-contact measurement in silos containing bulk solids and also for use in dust Ex hazardous areas, Zone 20. It has a measuring range of 45 m (150 ft) (under optimal 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 contours of the material (mirrored reflection).

Measuring System

The complete measuring system consists of
- the transmitter Nivosonic FMU 671, FMU 676 or FMU 677 in the control room,
- the ultrasonic sensor DU 73 in the silo and
- the drive electronics for the ultrasonic sensor.

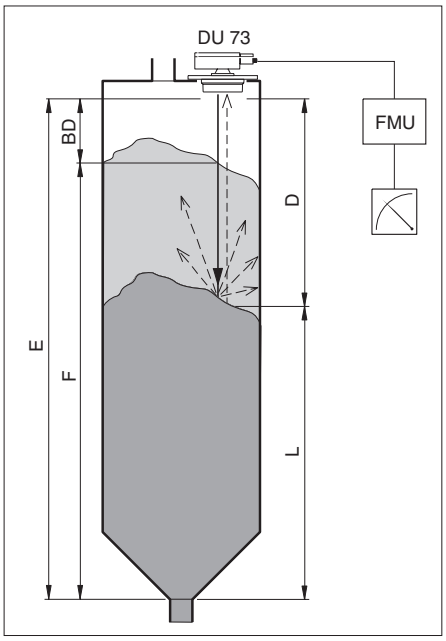
Version DU 73 C:
the drive electronics and the sensor are a single unit.

Version DU 73 S:
the drive electronics FHU 73 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
BD=Blocking distance
D = Distance from sensor to surface of material
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 (55.8 ft) and thus to a distance of 8.5 m (27.9 ft).

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 characteristics of the sensor, there is a zone immediately below it from which returning echoes cannot be detected. This so-called blocking distance BD determines the minimum distance between the sensor diaphragm and the maximum level in the silo.
The blocking distance for the DU 73 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 urface roughness of the material is greater than 5 mm (0.2 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
- the temperature difference in the 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 73 sensors.

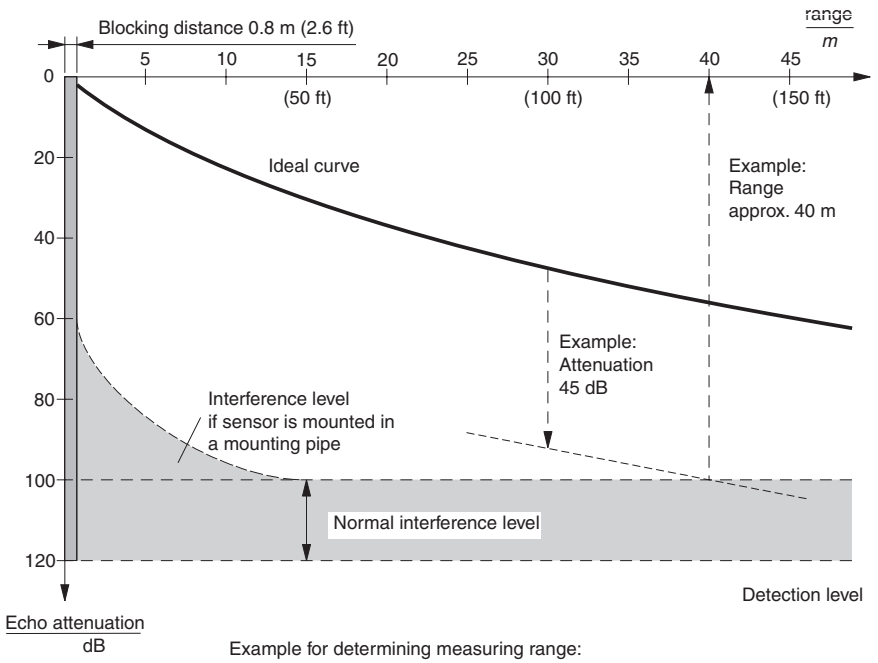
- Move the ideal curve downwards corresponding to the sum of the attenuation values.
- Subtract the interference level expected from the 120 dB level. A typical interference level of approx. 20 dB is caused by the silo filling or discharging and by interference echoes at the silo walls.
- The maximum 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 solid silos		Attenuation dB
Temperature variations		
Difference in air temperature between sensor and surface of material	* up to 20°C	0
	up to 40°C	5...10
	up to 60°C	10...20
Filling curtain		
outside detection zone		0
small 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 e.g. peat, dust covered clinker		20...40

Attenuation in dB with interference in the silo

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



Example for determining measuring range:

Factors:	Attenuation
Temperature difference in silo max. 40°C	10 dB
Filling: low amounts of material in detection zone	5 dB
Low dust	10 dB
Hard, coarse-grained material surface	20 dB
Sum of attenuation values	45 dB

Range under these conditions approx. 40 m

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

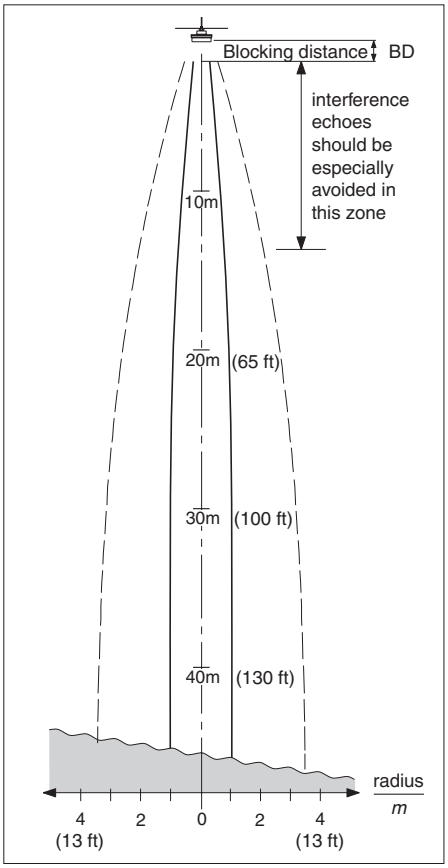
In mounting pipes the sensor generates an interference signal which decreases with increasing path

Detection Limits and Interference Signals

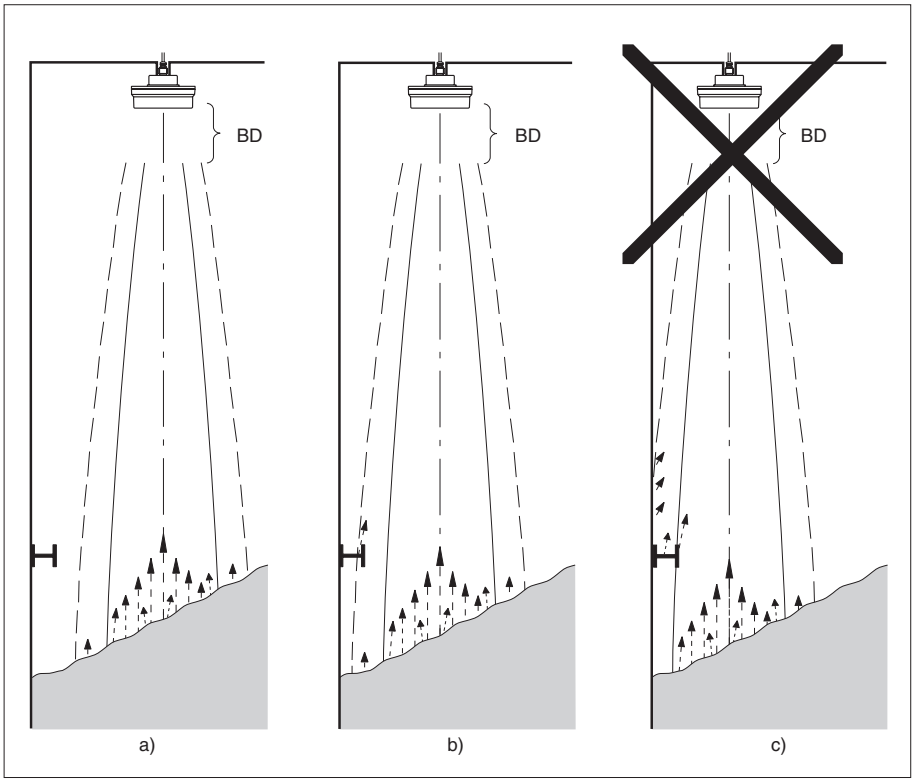
If fixtures are present in the tank or silo, then careful positioning of the sensor is critical in order to keep the interference level as low as possible. The ultrasonic pulse should arrive unobstructed at the product surface.

The 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. in the first third of the measuring range and within the echo envelope are more critical since the sonic energy is still highly concentrated and the short path only slightly attenuates the interference echoes. Small reflecting surfaces can therefore result in large interference signals.
- 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 diagram) produce strong echoes.
- Echoes from the outside zone (broken lines) are only significant when the working signal from the product surface is weak.



Detection zone as a function of range (lines of equal attenuation)

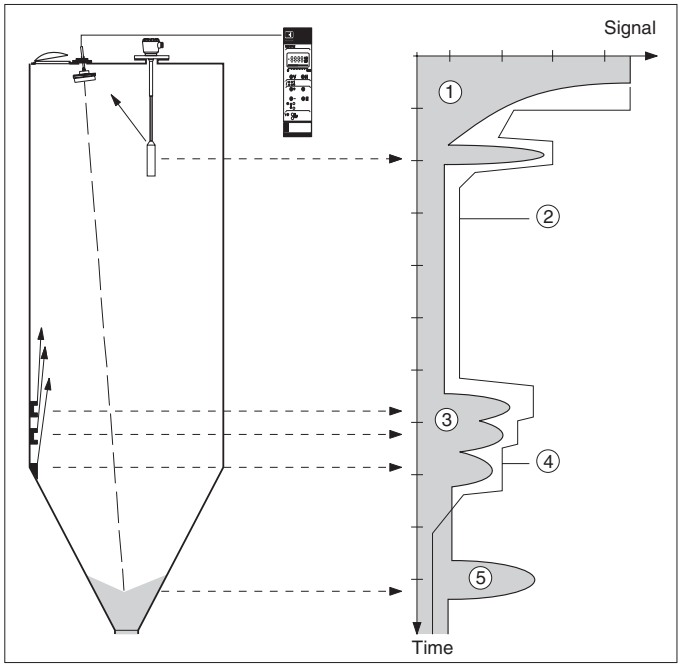


Avoid interference echoes from internal fittings and silo walls!

a) correct installation, no interference echoes
b) non-critical installaion, weak interference echoes only
c) incorrect installation, strong interference echoes 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.

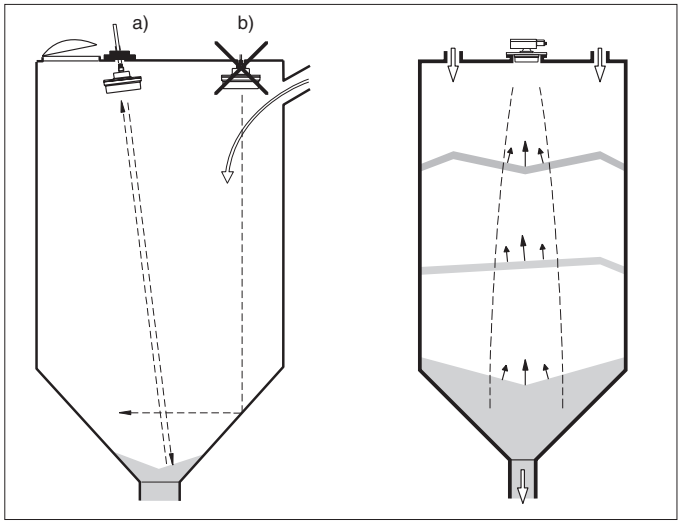


Suppression of interference echoes from internal fittings

① Signal decay of the sensor
② Time dependent 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 73 S sensor is simplified using the FAU 40 alignment unit (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.



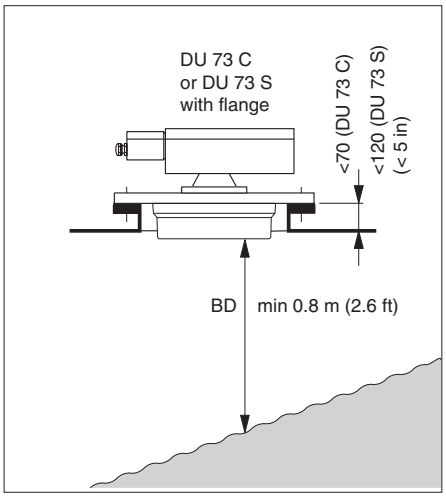
Left:

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

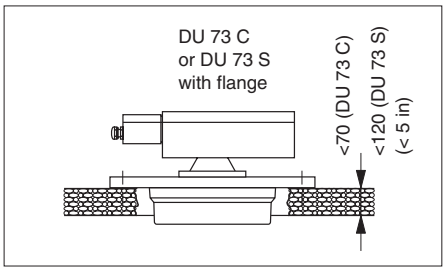
Right:

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 outflow cone reflects a sufficiently strong echo towards the sensor

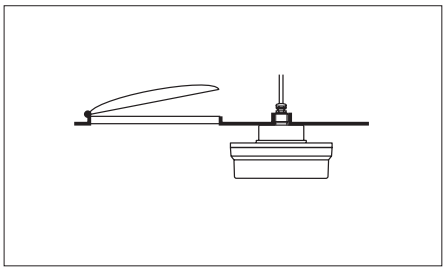
Mounting recommendations for **closed** silos



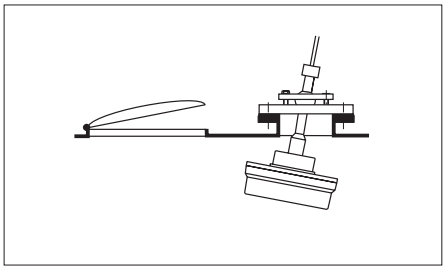
Sensor with flange on a short mounting pipe with counter flange



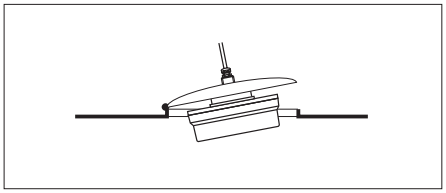
Sensor with flange mounted directly on the roof of a cement silo



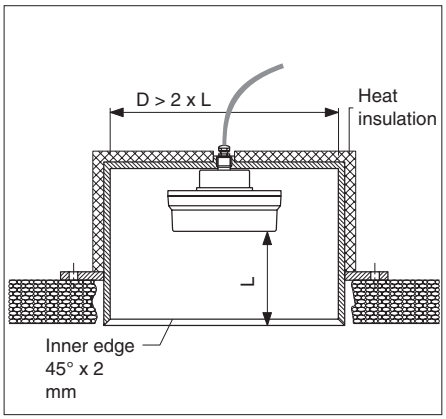
Sensor DU 73 S near to a service access



Sensor DU 73 S with alignment unit FAU 40 near to a service access



Sensor DU 73 S mounted on a service access cover



Mounting in a horizontal mounting pipe

The ratio of diameter D to height L must be at least 2:1, e.g. with build-up due to spatter

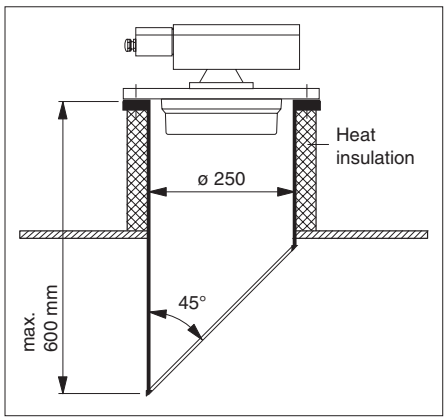
Recommendations for Mounting

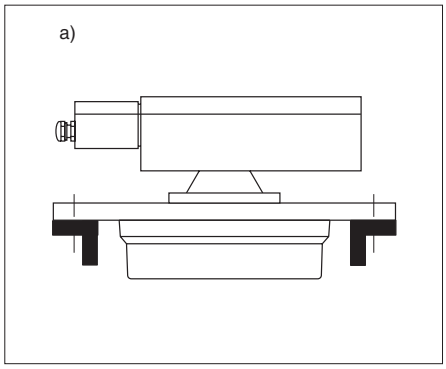
- Select a place for mounting where the lower edge of the sensor is below the silo roof.
  When the silo is filled there must be at least an 80 cm (2.6 ft) air gap between the maximum level and the sensor (blocking distance).
- Mounting can be simplified by installing the DU 73 S sensor in the vicinity of a service access. When using the FAU 40 alignment unit, a small diameter low-cost mounting pipe can be used and the sensor inserted through the service access.
- If the service access is suitable, then the sensor can be mounted directly on its cover – with or without the FAU 40 alignment unit.
- To protect it from weather conditions, the DU 73 C sensor should be protected with an all-weather protective cover (accessory) when mounting in the open.

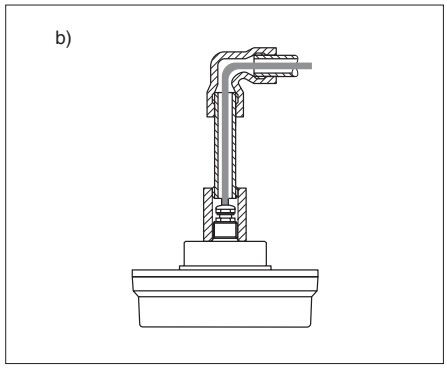
Mounting on a Mounting Pipe:

- This type of mounting should only be done if no blocking distance can be allowed for when mounting in the silo.
- No build-up of material or condensation should form in the mounting pipe.
- Use a mounting pipe with the largest possible diameter.
- The inner surface of the mounting pipe should be as smooth as possible (no edges or welding seams).
- When mounting in the open, the mounting pipe should be insulated otherwise the temperature within it may be significantly different from that in the silo. This results in inaccurate run time correction.
  In addition, interference reflections could occur due to condensation.

Mounting on a slanted mounting pipe



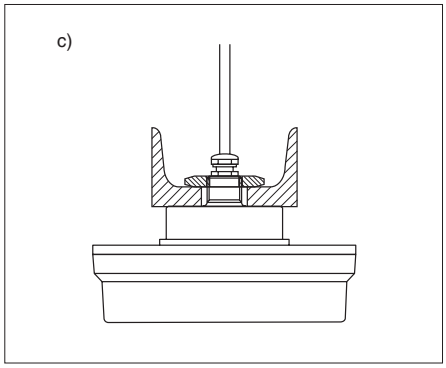


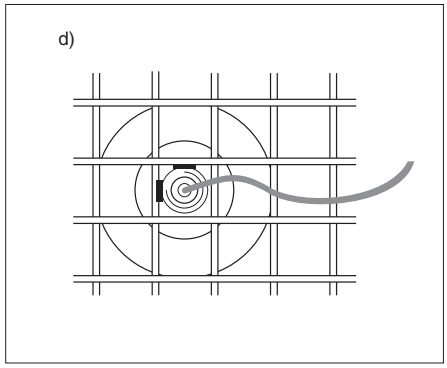


Mounting recommendations for

open silos

a) DU 73 S or DU 73 C with flange on two angle brackets
b) DU 73 S with a 1" pipe
c) DU 73 S on U-supports or brackets
d) DU 73 S with a 1" sleeve which is welded to a grating





Mounting

Protect the diaphragm against damage when mounting

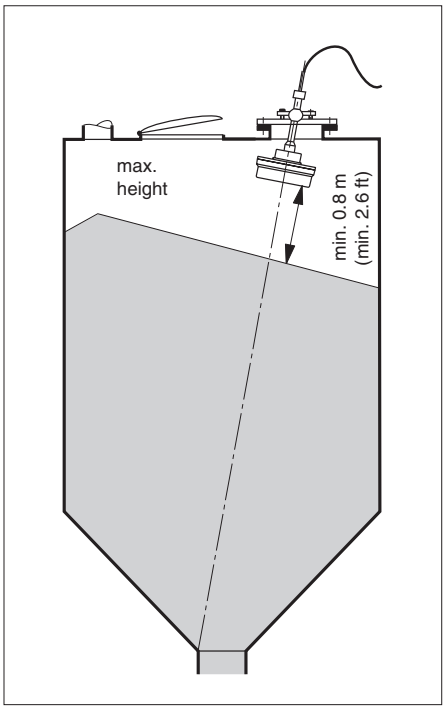
The PE coating on the diaphragm is an integral part of the measuring system and must not be damaged during installation.

DU 73 S without Flange

- The cable of the DU 73 S ultrasonic sensor is not designed as a supporting cable. Do not use it as a suspension wire.
- For silos containing combustible dusts: observe local regulations when laying the cable.
- For ATEX Zone 20 the cable may not be laid unprotected in ATEX Zone 20.

DU 73 S with the FAU 40 Alignment Unit

Mounting and positioning are described in Technical Information TI 179.
The sensor DU 73 S - EG□ for use with combustible dusts is supplied with a gasket which must be inserted between sensor and alignment unit.



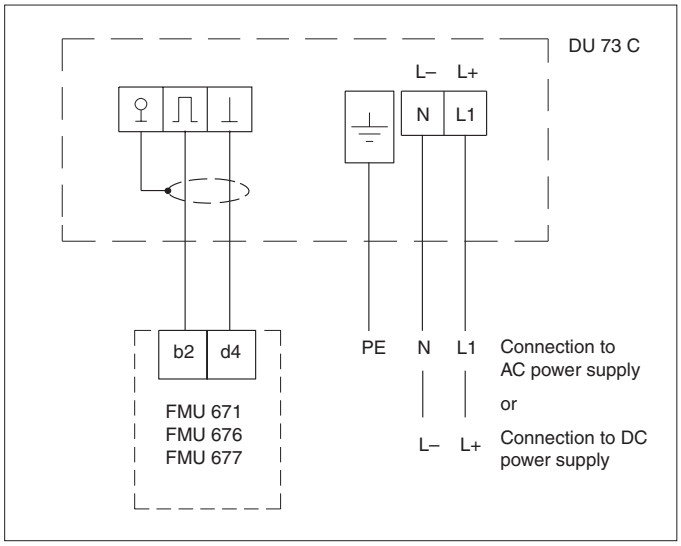
Mounting the DU 73 S sensor with the FAU 40 alignment unit

Electrical Connection

Connecting the DU 73 C

Power connection:

- The connection terminals are designed for cable diameters up to 2.5 mm^2.
- No special fusing is required as the DU 73 C ultrasonic sensor has an integrated fine-wire fuse.



Connecting the compact ultrasonic sensor DU 73 C to the Nivosonic FMU 67 and to the power supply

Connecting the DU 73 C to the Nivosonic FMU :

- The connecting cable between the DU 73 C ultrasonic sensor 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
- Shielded and twisted cabling is recommended if it is to be laid in strong, alternating magnetic or electrical fields.
  Connect the shielded to the DU 73 C only!

These measures ensure that the sensor correspond to industrial (NAMUR) and European EMC Standards EN 50081-1 for interference emission and EN 50082-2 for interference immunity.
For general information on EMC (test methods, installation hints) see TI 241F/00/en.

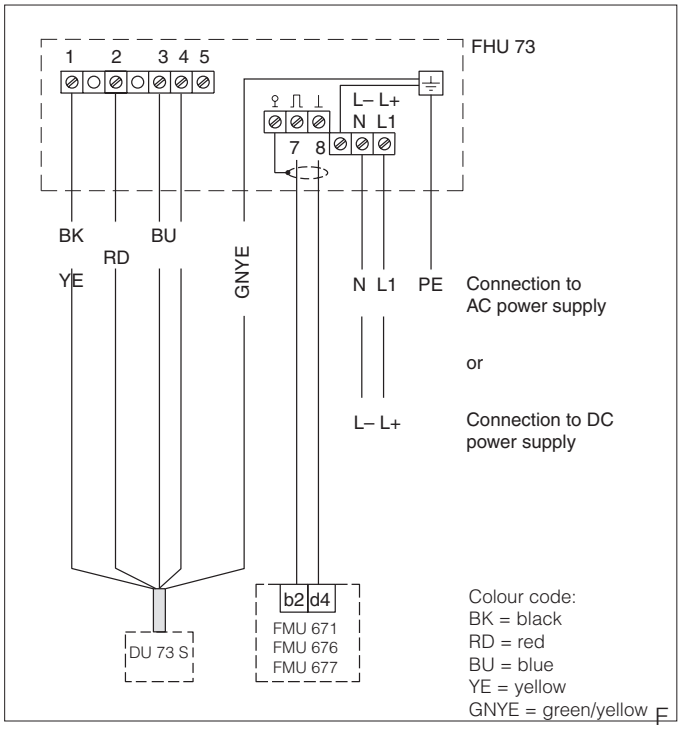
Connecting the DU 73 S and the FHU 73

Connecting the DU 73 S to the FHU 73:

- For this connection, a 5 m long cable is attached to the ultrasonic sensor.
- If the drive FHU 73 electronics are located further from the DU 73 S ultrasonic sensor, then a connection cable up to a distance of 30 m can be supplied. An extension of the cable is possible up to a total length of 100 m (300 ft).

Power connection to the FHU 73:

- The connection terminals are designed for cable diameters up to 2.5 mm^2.
- No special fusing is required as the FHU 73 drive electronics unit has an integrated fine-wire fuse.



Connecting the separate ultrasonic sensor DU 73 S to the drive electronics FHU 73, to the Nivosonic FMU 67X and to the power supply

Connecting the DU 73 S to the FMU 67X :

- The connecting cable between the FHU 73 drive electronics 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
- Shielded and twisted cabling is recommended if it is to be laid in strong, alternating magnetic or electrical fields.

Connect the shielding to the FHU 73 drive electronics only!

These measures ensure that the sensor correspond to industrial (NAMUR) and European EMC Standards EN 50081-1 for interference emission and EN 50082-2 for interference immunity.
For general information on EMC (test methods, installation hints) see TI 241F/00/en.

Technical Data

Versions

① DU 73 C:
Compact version;
with flange connection

Version for ATEX Zone 20/22
with clad flange

② DU 73 S:
Sensor without drive electronics,
with flange or thread connection
Version for ATEX Zone 20/21

③ FHU 73:
Drive electronics in protective housing for DU 73 S
for ATEX Zone 22

- For order specification keys see Page 11

Operating Data

- Pressure p_e: max. 0.5 bar (7 psi)
- Air temperature in silo
  DU 73 C:–20…+80°C (–4...+176°F)
  DU 73 S:–20 …+80°C (–4...+176°F)
  Please enquire about higher *product* temperatures
- Ambient temperature:
  DU 73 C: –20…+60°C (–4...+140°F)
  FHU 73: –20…+60°C (–4...+140°F)
- Extended temperature range:
  up to –40°C (–40°F), with modified technical specifications
- Storage temperature: –40°C…+60°C
- Ultrasonic run time compensation:
  with silicon temperature sensor, integrated behind diaphragm of sensor
- Operating frequency: approx. 17 kHz
- Pulse frequency: approx. 1.3 Hz
- Measuring range with bulk solids:
  up to 45 m (150 ft)
  (under ideal conditions)
- Blocking distance B: approx. 0.8 m (2.6 ft) below the diaphragm
- Power consumption: approx. 7 VA
- DC versions
  – power consumption: approx. 5.5 W
  – mean current consumption: 220 mA
  – max. pulse current ≤ 800 mA
- Electromagnetic compatibility (EMC):
  Interference emission to EN 50 081-1
  Interference immunity to EN 50 082-2 and Industrial Standard NAMUR, with 10 V/m.
- By attaching the CE Mark, Endress+Hauser confirms that the Sensors DU 73 C and 73 S fulfils all legal requirements of the relevant EC directives.

Materials

- Housing for drive electronics:
  cast aluminium (AlSi12), plastic coated
- Sensor housing in silo:
  SMC, fibreglass-reinforced (unsaturated polyester)
- Flange: PPs
- Gasket between sensor and flange:
  EPDM
- Thread connection to sensor DU 73 S:
  SMC, fibreglass-reinforced
- Diaphragm: 1 mm aluminium with 5 mm closed-cell PE on side nearest product
- Diaphragm gasket: EPDM

Dimensions

- For dimensions see Page 10
- Flange sizes and standards:
  DIN: DN 250, PN 16 to DIN 2501, Page 1
  ANSI: 10", 150 psi to ANSI B 16.5
  JIS: 10 K 250 to JIS B 2210, Table 3-1 (“thick”)
- Thread sizes and standards:
  G 1 A (parallel) to DIN ISO 228/I
  1 – 11 $^1/_2$ NPT (tapered)
  to ANSI B 1.20.1

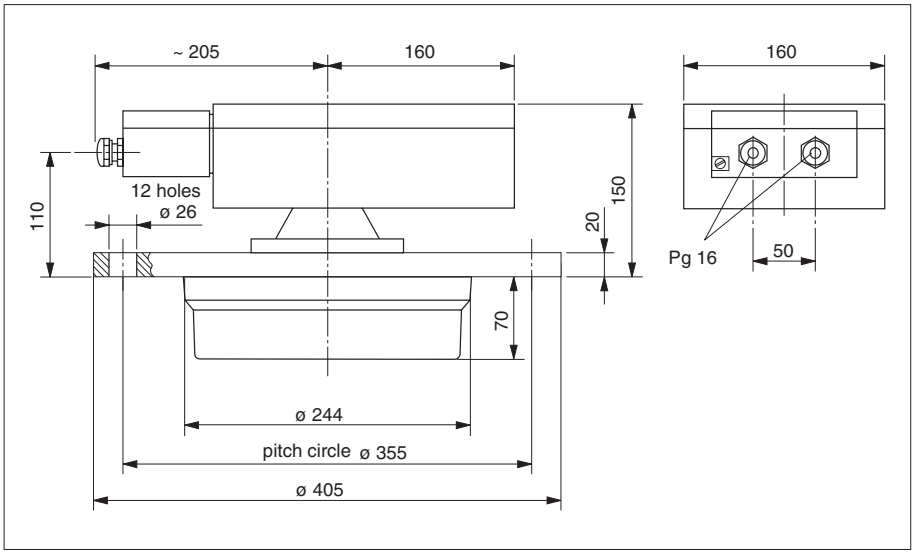
Transmitters

- 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 Z or for remote dialogue with a computer using the computer interface ZA 672.
  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 672. 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 ultrasonic level measuring system.

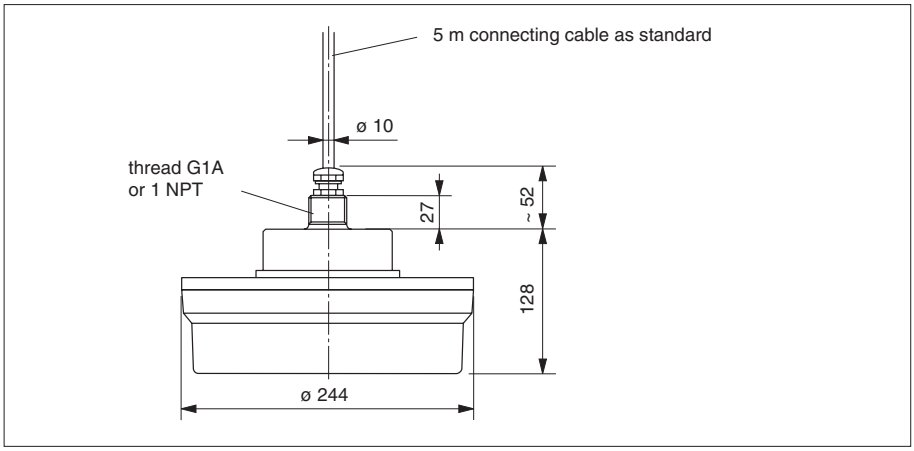
Dimensions

All dimensions in mm

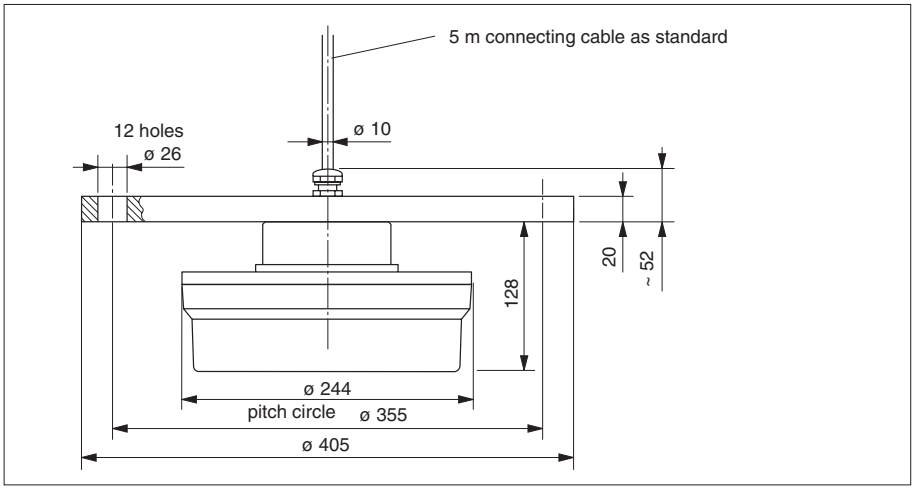
100 mm = 3.94 in
1 in = 25.4 mm



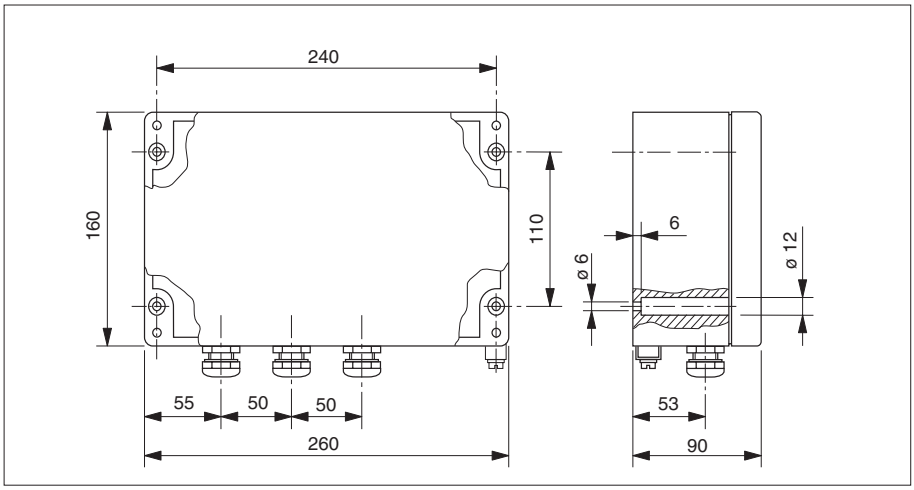
Dimensions of the ultrasonic sensor DU 73 C (shown with DIN flange DN 250, PN 16)



Dimensions of the ultrasonic sensor DU 73 S with thread connection



Dimensions of the ultrasonic sensor DU 73 S with flange connection (shown with DIN flange DN 250, PN 16)



Dimensions of the drive electronics in protective housing FHU 73

Product Structure

DU 73 C, compact ultrasonic sensor with drive electronics, Protection IP 65

Order code key, DU 73 C

		Weight
Certificate		
R	Standard (non-certified)	
T	CSA Class II, Div.1; Groups E,F,G	
E	ATEX II 1/3 D, s. XA 034F-A	
Process Connection / Material		
D	Flange DN 250, PN 16 / PPs	approx.11 kg
A	Flange ANSI 10", 150 psi / PPs	approx.11 kg
K	Flange JIS 10 K 250 / PP_S	approx.11 kg
Housing, Protection / Cable Gland		
1	Aluminium, IP 65 / Pg 16	
2	Aluminium, IP 65 / $^1/_2$ NPT	
3	Aluminium, IP 65 / M 20 x 1.5	
4	Aluminium, 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	24 V, 50/60 Hz	
E	24 V, DC	

DU 73 C — Product designation

1 kg = 2.2 lbs

DU 73 S, sensor without drive electronics, Protection IP 68

Order code key, DU 73 S

		Weight
Certificate		
R	Standard (non-certified)	
T	CSA Class II, Div.1; Groups E,F,G	
E	ATEX II 1/2 D, s. XA 034F-A	
Process Connection / Material		
G	Thread G1A / plastic	approx.5 kg
N	Thread 1 NPT / plastic	approx.5 kg
D	Flange DN 250, PN 16 / PPs	approx.7 kg
A	Flange ANSI 10", 150 psi / PPs	approx.7 kg
K	Flange JIS 10 K 250 / PPs	approx.7 kg
Cable length		
1	5 m (standard length)	
8	… m (any length, 6 m to 30 m)	

DU 73 S — Product designation

1 kg = 2.2 lbs

FHU 73, drive electronics in protective housing for DU 73 S

Order code key, FHU 73

		Weight
Certificate		
R	Standard/ATEX II 3 D, s. XA 034F-A	
Housing, Protection / Cable Gland		
1	Aluminium, IP 65 / Pg 16	approx. 4 kg
2	Aluminium, IP 65 / $^1/_2$ NPT	approx. 4 kg
3	Aluminium, IP 65 / M 20 x 1.5	approx. 4 kg
4	Aluminium, IP 65 / G $^1/_2$	approx. 4 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	24 V, 50/60 Hz	
E	24 V, DC	

FHU 73 — Product designation

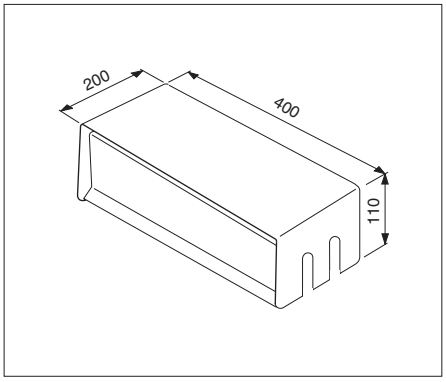
1 kg = 2.2 lbs

Accessories

Alignment unit FAU 40
for DU 73 S

Alignment unit
to align the sensor DU 73 S

For further information see
Technical Information TI 179F/00/en.



All-weather protective
cover for DU 73 S

All-weather protective cover
for the DU 73 C sensor
Material: PVC, light grey
Weight: 1.4 kg
Order No. 919207-0000

Supplementary Documentation

- ❑ Summary of non-contact level measurement using the Nivosonic ultrasonic transmitter
  Product Information PI 004F/00/en
- ❑ Design approval BVS 93.Y.8007 for use of sensor DU 73 and alignment unit FAU 40 with combustible dusts (Germany)
  Certificate ZE 091F/00/de
- ❑ Nivosonic FMU 671, FMU 676 Transmitters for connecting to the ultrasonic sensor DU 73
  Technical Information TI 062F/00/en
- ❑ The Multipoint ultrasonic system for level measurement at various measuring points
  Technical Information TI 086F/00/en
- ❑ Ultrasonic sensor DU 46 Z for especially large measuring ranges
  Technical Information TI 066F/00/en

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Part No. 016090-1000
CCS/CV8.0