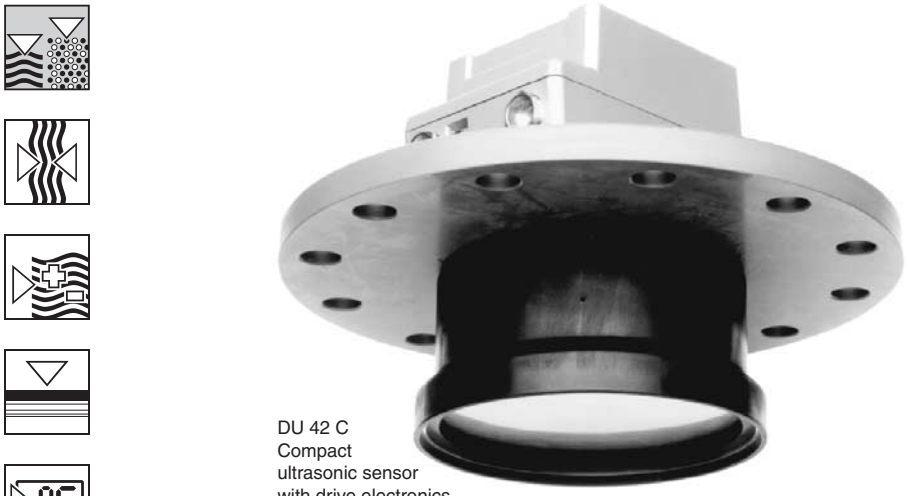
Technical
Information
TI 175F/00/en

Operating Instructions
015081-1006

Ultrasonic Level Measurement
Sensors DU 42 C, DU 42 S

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



DU 42 C
Compact
ultrasonic sensor
with drive electronics

DU 42 S
Ultrasonic sensor without
drive electronics

Features and Benefits

- Measuring range in liquid tanks: up to 28 m (90 ft)
- Measuring range in bulk solid silos: up to 18 m (60 ft)
- Compact or separate sensor versions with Protection IP 68
- Version with corrosion-resistant metal coating for Dust-Ex area, ATEX Zone 20
- Mounting with flange or thread connection
- Insensitive to condensate or build-up
- Resistant to corrosive vapours

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Application

The ultrasonic sensor DU 42 is designed for continuous non-contact level measurement as well as for use in Dust-Ex hazardous area, ATEX Zone 20.

Application examples:
- all types of liquids, pastes, sludges, etc.
- granular and lumpy bulk solids, such as crushed stone, gravel, ore, coal, granulated plastic, glass cullet, grain, etc.

The surface coarseness of these bulk solids allows the level to be measured by using diffuse reflection which is independent of the slope of material or the outlet cone.

Measuring ranges:
- in liquid tanks: up to 28 m (90 ft)
- in bulk solid silos: up to 18 m (60 ft)

Measuring System

The complete measuring system consists of
- the Nivosonic FMU 671, FMU 676 or FMU 677 transmitter mounted in the control room,
- the ultrasonic sensor DU 42 on the tank or silo and
- the drive electronics for the ultrasonic sensor.

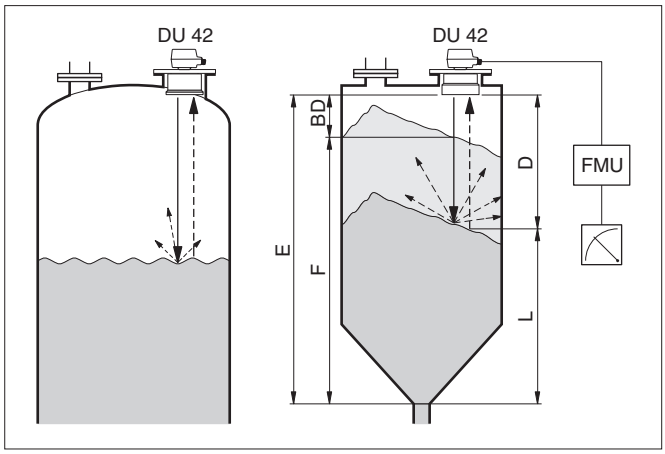
- Version DU 42 C:
  The drive electronics and the sensor are a single unit.
- Version DU 42 S:
  The drive electronics FHU 42 are mounted separately.

A temperature probe is integrated into the sensor in order to compensate for variations in the run time caused by temperature fluctuations.

Operating Principle

The ultrasonic emitter in the sensor is excited electrically and sends an ultrasonic pulse downwards in the direction of the material which is partially reflected at the surface.
The sensor, now operating as a directional microphone, reconverts the echo into an electrical signal.
The time taken between emitting and receiving the pulse – the run time – is directly proportional to the distance between the sensor and material.
The distance D is calculated from the velocity of sound c and the run time t as given in the equation:

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



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

Measuring Range
The maximum measuring range possible is limited by the attenuation of the ultrasonic pulse in air and the strength of reflection from the product surface.

Measurement Conditions
Ultrasonic measurement ultimately depends upon an echo signal being received from the surface of the material.

- Liquids:
  The sensor must be aligned exactly perpendicular above the surface of the liquid.
  The surface must not be covered by a thick layer of foam.

- Bulk solids:
  A sufficiently large number of scattered echoes coming from the surface of the product will be received by the sensor if the surface coarseness of the filling mound is greater than 3 mm (0.12 in)
  (diffuse reflection). With fine-grained or powdery solids, e.g. quartz sand, cement, powdered plastic, raw meal, etc., correct functioning of the sensor depends on the profile of the surface (mirror reflection).

Blocking Distance
Due to the attenuation characteristic of the sensor, there is an area immediately below it in which no pulses can be received. This so-called blocking distance BD is the minimum distance between the sensor diaphragm and the maximum height in the tank or silo.
For the DU 42, this blocking distance is approx. 1 m (3.3 ft).

Planning Recommendations

Maximum Possible Range

The measurement range depends upon the following factors:

- the strength of the signal from the surface of the material (diffuse echo)
- attenuation of the signal in the area between the sensor and material
- background noise due to, e.g., the filling process
- interference echoes coming from fittings within the silo

The first three factors are dependent upon the conditions of the application. Interference echoes can be reduced if the recommendations given in this brochure are followed.

Conditions are favourable when:

- the lower edge of the sensor projects into the tank or silo
- the detection zone does not include any internal fittings
- the tank or silo is not filled during measurement
- the surface of the liquid is calm and not covered with a layer of foam
- little vapour is present in the tank
- the bulk solid is hard and coarse-grained
- no dust is present in the silo
- temperature difference in silo is small.

Calculating the range of the ultrasonic sensor for your particular application:

- Refer to the table to identify which factors affect the measurement.
- Add together the corresponding attenuation values (dB).

The diagram shows the ideal echo attenuation curve for the sensor DU 42.

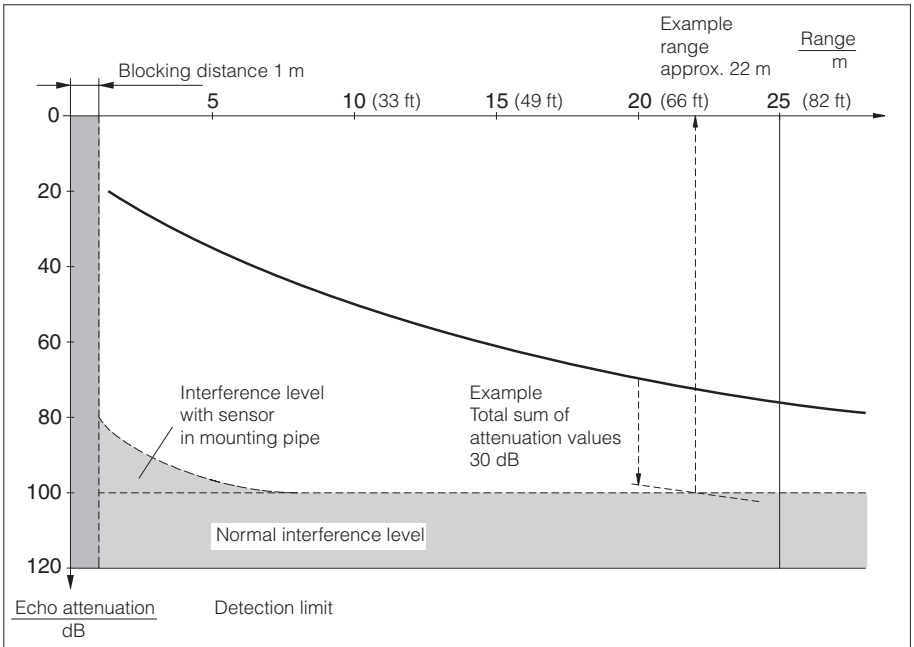
- Move the curve downwards until it corresponds to the sum of the attenuation values.
- Subtract the value of noise expected from the detection limit 120 dB. A common level of noise, caused by filling or discharging and by interference reflections coming from the tank or silo walls is approx. 20 dB.
- The maximum range is that point where the curve crosses the interference level. See example.

Is the calculated range sufficient for your specific application?

Factors		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 in the detection zone		5 … 10
large amounts in the detection zone		10 … 20
Liquid surface		
calm		0
Heavy waves		5 … 10
very agitated (e.g. agitator blades)		10… 20
Foam		
Please contact Endress+Hauser		
Solids surface		
hard, rough		20
soft		20 … 40
e.g. peat, dust-coated clinker		
Dust		
none		0
light		5
heavy		5 … 10

Above:
Attenuation in dB with interference in a tank or silo.

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



Right:
Echo attenuation as function of range with specimen calculation.

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

Example for calculating the range (liquid tank):

Factors:	Attenuation
Temperature difference in tank max. 30°C	5 dB
Filling curtain: outside the detection zone	0 dB
Sensor mounted on a wide pipe	15 dB
Heavy waves	10 dB
Total sum of attenuation values	30 dB

Under these conditions the range is therefore approx. 22 m

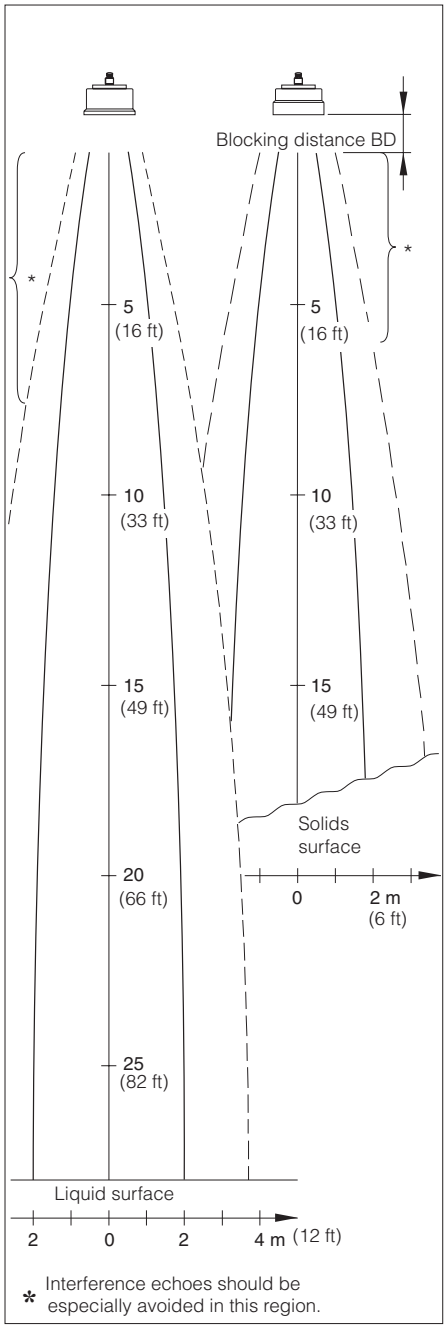
Detection Limits and Interference Signals

If internal fixtures are present in the tank or silo, then careful alignment of the sensor is critical in order to keep the interference echoes as low as possible. The ultrasonic pulse should arrive unimpeded to the surface of the material. The signal leaves the sensor as a narrow beam which widens as the distance increases. Every object within this beam gives rise to an echo which is then received by the sensor.

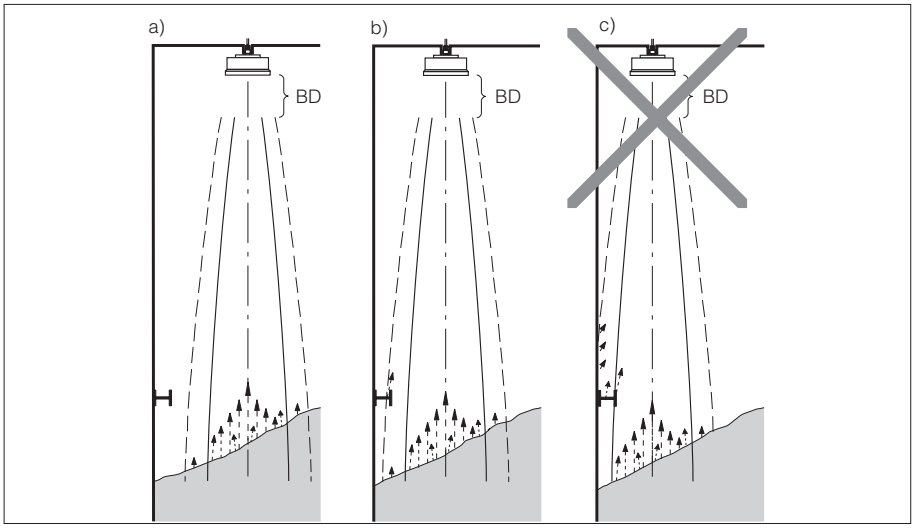
- Edges, fixtures, etc. within the sound cone are of great importance in the first third of the range as the energy of the beam is highly concentrated and, due to the short distance, the interference echoes are only weakly attenuated. Small surfaces can therefore produce strong interference echoes.
- The energy in the last third of the range is distributed over a larger area so that internal structures and edges are not as critical.
- Objects in the middle of the beam (continuous line in the diagram) produce strong echoes.
- Echoes from the edge of the beam (dashed lines) are important only when a weak working signal is coming from the surface of the material.

Accuracy

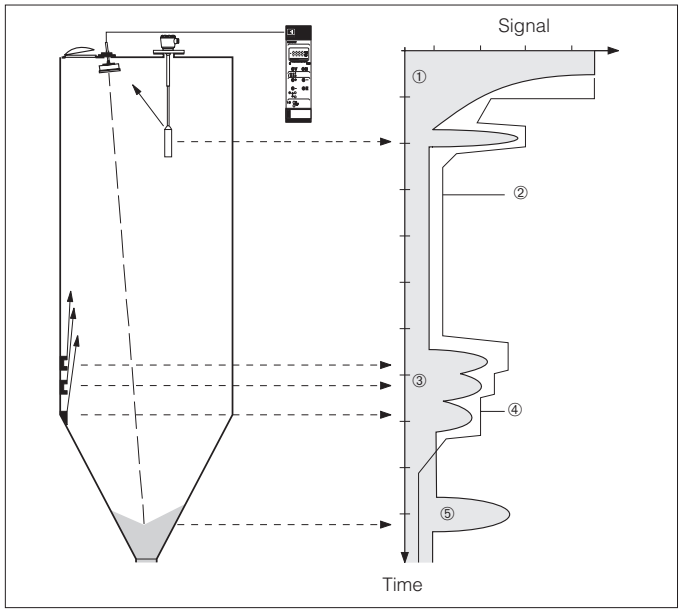
- The effect of pressure variations is < 0.1% (in air or nitrogen).
- A constant temperature and sound velocity within the measuring path enable a high degree of accuracy to be achieved; error limits ± 1%.
  The effects of large temperature variations within the measuring path and changing gas mixtures must be calculated and the Nivosonic programmed accordingly.
  A nitrogen atmosphere increases the sound velocity by +1% only.
- With liquids having a high partial pressure, the gas composition must be determined to see if it remains constant.
- The resolution is 1.7 cm at a sound velocity of 340 m/s.



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



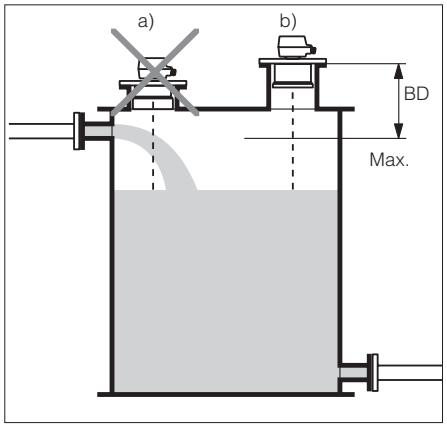
Avoid interference echoes from internal structures and round silo walls!
a) ideal installation, no interference echo
b) non-critical mounting, weak interference echo only
c) incorrect mounting, strong interference echo from internal structures and uneven wall (e.g. welding seams)



Suppression of interference echoes from internal fixtures:
① Decay curve of the sensor
② Time dependent threshold which an echo signal must overstep in order to be detected by the evaluating unit.
③ Interference echoes
④ Interference echo suppression (with characteristic detection threshold)
⑤ Working signal from the material surface

Interference Signal Suppression
Interference echoes coming from internal fixtures can be suppressed by the Nivosonic FMU… using fixed target suppression.
This enables the detection level to be automatically adjusted to the interference profile so that these signals are no longer included and used for further signal processing.
Note that adjusting the detection level to the interference profile shortens the measuring range.
With weak working signals (e.g. in cement silos), the interference level should be kept as low as possible by mounting and aligning the sensor correctly.

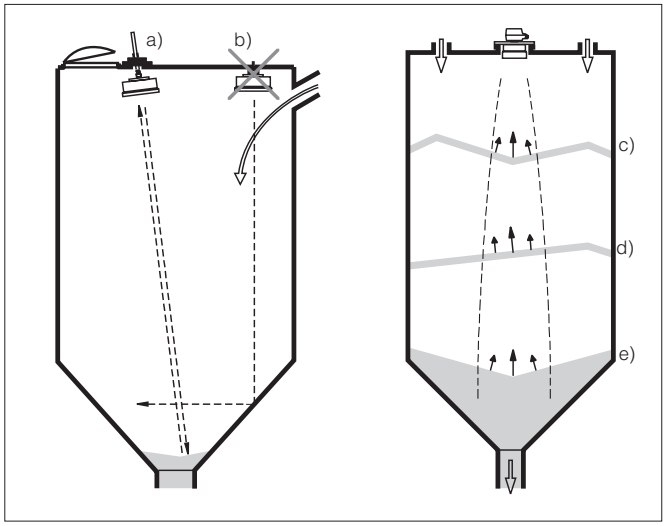
Installation



a) Do not measure through the filling stream
b) Distance BD (blocking distance) to maximum level must be observed. See diagram on the next page for the height and shape of the pipe

Mounting on a Tank
- Align the sensor exactly perpendicular above the surface of the liquid.
- Avoid measurements through the filling curtain.
- The sensor should be high enough so that the blocking distance is not overstepped even when the tank overfills.
- Note the sizes recommended for mounting pipes on page 6.

Mounting on a Silo
- Align the sensor with the centre of the outlet cone so that an echo is reflected even when the silo is empty.
- Positioning is easier if the sensor DU 42 S is mounted using the alignment unit FAU 40 (accessory).
- Avoid measurement through the filling curtain.
- No diffuse reflections are produced from the smooth surfaces of very fine-grained or dusty bulk solids.
The wave is reflected back in a similar way to light (angle of incidence = angle of reflection) so that selecting the installation point is critical for carrying out measurement. Please refer to the diagram, below right.



Left:
a) Correct mounting
As far as possible from the silo wall and material inlet. The centre of the outlet cone also produces an echo which is received, by the sensor even when the silo is empty.

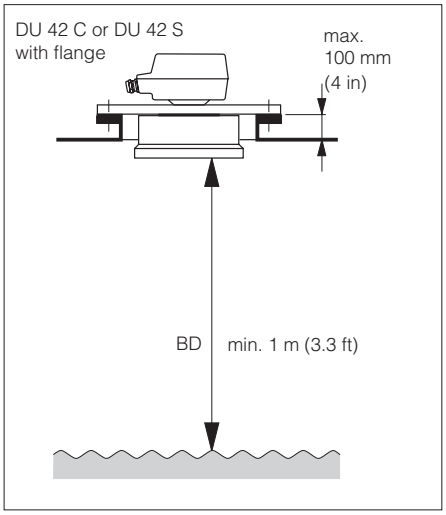
b) Incorrect mounting
1. Detection through the filling curtain
2. The echo is reflected to the side when the silo is empty and the sensor. cannot receive

Right:
Installation point with powdery solids.
c) A trough between mounds produces a strong echo in the direction of the sensor

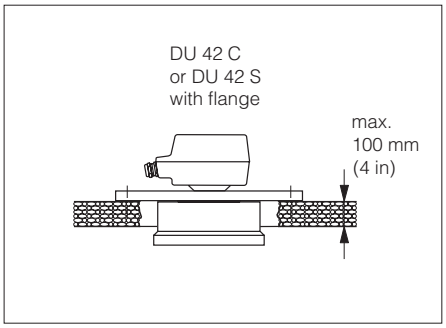
d) Slightly skew surfaces with slopes up to 5° reflect enough of the signal in the direction of the sensor

e) The centre of the outlet cone produces a sufficiently strong echo in the direction

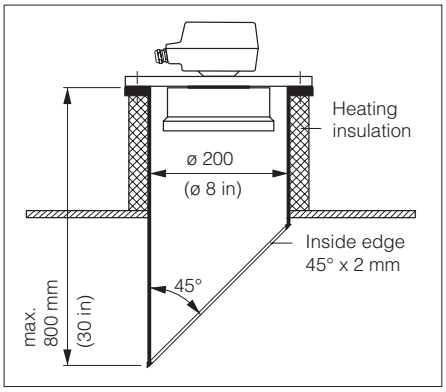
Mounting examples for **closed** tanks or silos



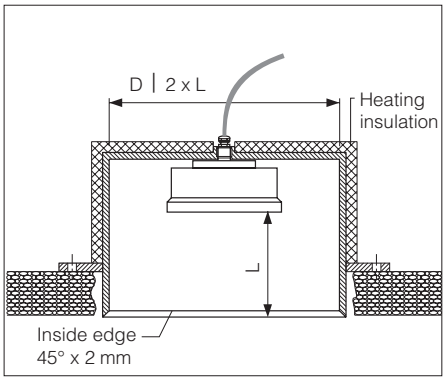
Sensor with flange on a short pipe with counter flange



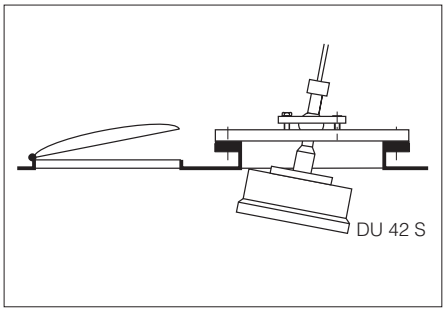
Sensor with flange mounted directly on the roof of a concrete silo



Installation on a chamfered pipe



Installation in a straight pipe.
The ratio of diameter D to length L must be at least 2:1, e.g. for material build-up caused by spatter



Sensor DU 42 S with FAU 40 alignment unit near a manhole

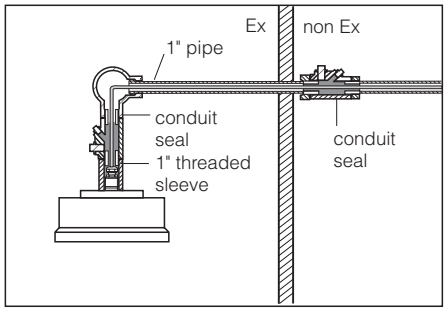
Mounting Recommendations

- Select the installation point so that the lower edge of the sensor is below the roof of the tank or silo.
  This can be done if the blocking distance is not overstepped at the maximum level, i.e. when the tank or silo is full and there is still a gap of at least 1 m (3.3 ft) between the maximum height and the sensor.
- If the level in the tank or silo has to be increased, then the sensor can be mounted on a pipe.

- Note when mounting on a pipe:
  – There should be no material build-up or condensation in the pipe.
  – The pipe should have the largest possible diameter.
  – The inner surface should be as smooth as possible (no edges or welded seams).
  – Insulate the pipe when mounting in the open or the temperature in it will be significantly different from that in the tank or silo.

- When mounting in the open, protect the sensor by using an all-weather cover (accessory). This prevents build-up of condensation in the housing which is caused by wide temperature variations. It also increases the measuring accuracy of the temperature probe inside the sensor by protecting it from direct sunlight.
- Cylindrical tanks and silos:
  Avoid mounting the sensor in the centre of the roof as interference echoes and multiple echoes will be focussed here. This is especially important with curved domes.
- Mounting is simplified if the installation point of the sensor DU 42 S is near a manhole.

Sensor on a 1" pipe in combustible dust area (for FM, Class II)



Mounting

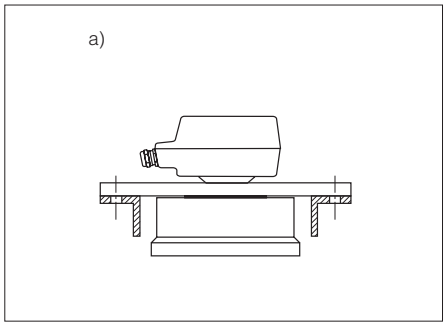
Mounting examples for **open** tanks or silos

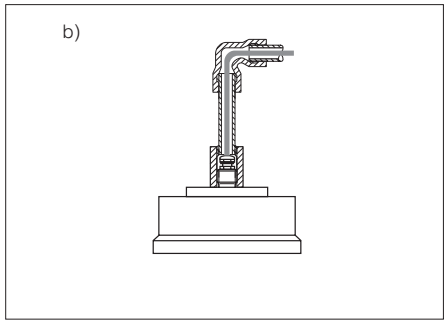
a) DU 42 S or DU 42 C with flange on two angle brackets

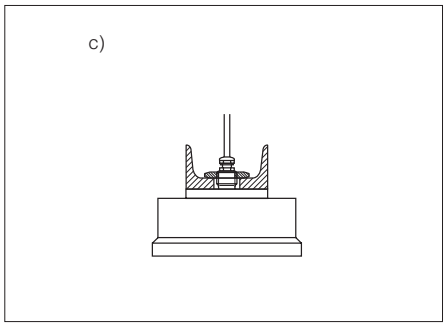
b) DU 42 S on a 1" pipe

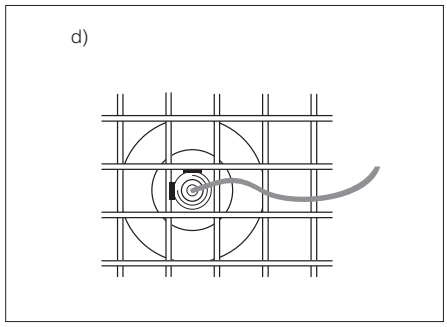
c) DU 42 S on U-supports or bracket

d) DU 42 S on a 1" sleeve which is welded to a grating









DU 42 C or DU 42 S with Flange

- In a tank or silo which is under pressure or vacuum, use a suitable flange seal.
- Tighten the screws on opposite sides first. The maximum torque is 75 Nm (55 ft lbs).

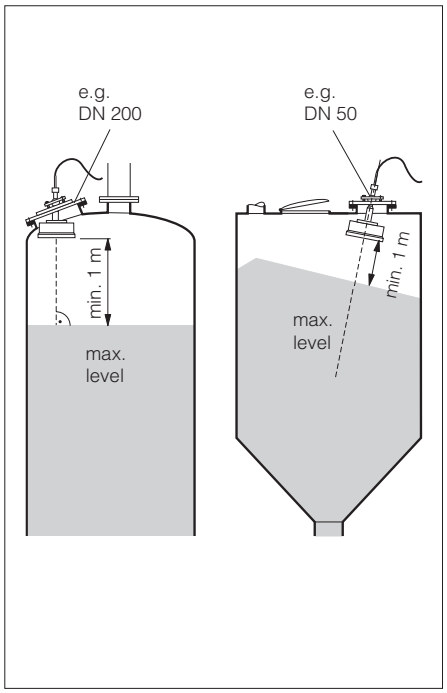
DU 42 S without Flange

- The cable of the DU 42 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 (Germany): the cable may not be laid unprotected in ATEX Zone 20.

Mounting the Drive Electronics FHU 42

- Fasten the mounting plate onto a smooth surface.
- Position the housing so that the upper edge of the lower housing section snaps together with the upper edge of the latch.
- Push the housing approx. 1 cm downwards.

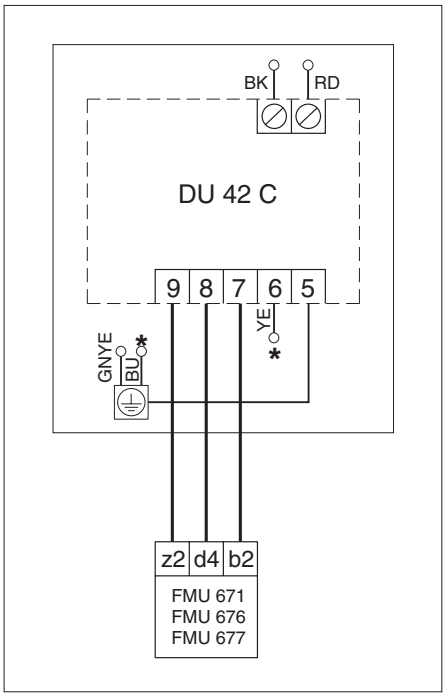
- Removal: Press the latch against the wall (e.g. with a screwdriver) and pull the housing approx. 1 cm upwards.



DU 42 S with Alignment Unit FAU 40

- Align the sensor, e.g. exactly perpendicular above the surface of the liquid in the tank or the outlet cone of a silo, depending on the particular application and conditions.
- Push the sensor downwards as far as possible until its lower edge is below roof of the silo or tank.
- Note that there must still be a minimum gap of 1 m (3.3 ft) (blocking distance) between the maximum level and lower edge of the sensor.

Electrical Connection



Connecting the compact ultrasonic sensor DU 42 C to the Nivosonic FMU 67.

Colour coding of wires:
BK = black
RD = red
BU = blue
YE = yellow
GNYE = yellow/green

* = temperature sensor connection

Connection DU 42 C

- The connection between the ultrasonic sensor DU 42 C and the Nivosonic FMU can be standard 3-core cable or 3 cores of a multi-core general purpose cable.
- Cable resistance max. 25 Ω per 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 42 C only!
- External temperature sensor:
  If the integrated sensor is to be replaced with an external one, disconnect the blue core* coming up from below from the ground terminal and the yellow core* from Terminal 6 and then connect the external sensor (KTY 81, E+H accessory) to these.

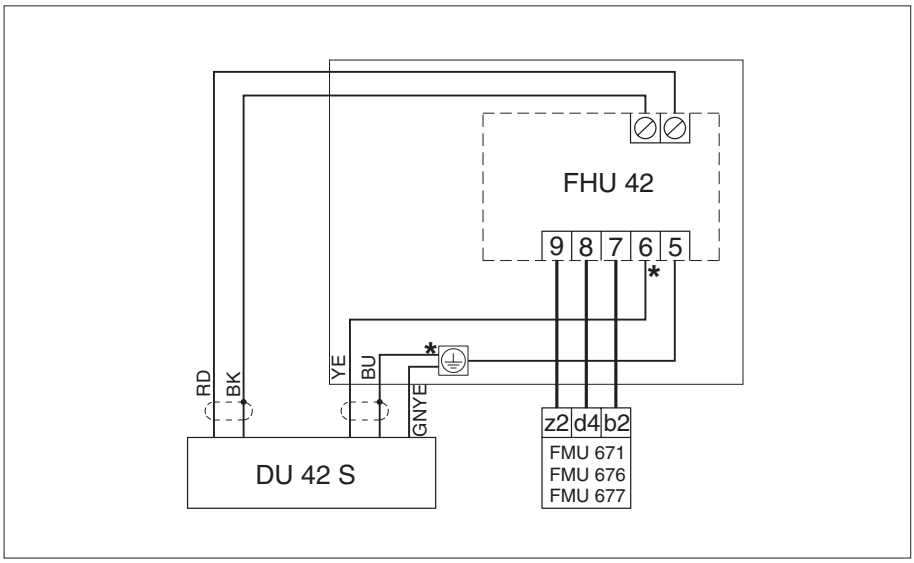
Connecting the DU 42 S and FHU 42

Connecting the DU 42 S to the FHU 42:

- A 5 m cable is permanently attached to the ultrasonic sensor.
- If the cable is to be shortened, then the exposed screening must be insulated in order to prevent short-circuiting and ground loops.
- External temperature sensor:
  If the integrated sensor is to be replaced with an external one, then do not connect (but insulate!) the blue and yellow wires of the DU 42 S cable. Connect the external sensor (KTY 81, E+H accessory) to the ground terminal and to Terminal 6.

Connecting the FHU 42 to the Nivosonic FMU :

- The connection between the ultrasonic sensor FHU 42 and the Nivosonic FMU can be standard 3-core cable or 3 cores of a multi-core general purpose cable.
- Cable resistance max. 25 Ω per core
- If the connecting cable is to be laid in areas of strong magnetic or electrical alternating fields, then screened, twisted cabling is recommended.
  Connect the screening to the FHU 42 drive electronics only!
- 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.



Connecting the separate ultrasonic sensor DU 42 S to the drive electronics FHU 42 and the Nivosonic FMU 67.

Colour coding of wires:
BK = black
RD = red
BU = blue
YE = yellow
GNYE = yellow/green

* = temperature sensor connection

Technical Data

①

②

③

④

⑤

Versions

① DU 42 C:
Compact, with flange

② DU 42 C for ATEX Zone 20/22:
with steel shell and steel-plated flange

③ DU 42 S:
Sensor without drive electronics, with flange or thread

④ DU 42 S for ATEX Zone 20/21:
with steel shell

⑤ FHU 42:
Drive electronics in protective housing for DU 42 S (for ATEX Zone 22)

- For Product Structure with process connections see page 11

Dimensions

- For dimensions see page 10
- Flange standards:
  EN: agreeable to EN 1092-1
  ANSI: ANSI B 16.5
  JIS: JIS B 2210, Table 3-1 (“thick”)
- Flange standards:
  G 1 A (parallel) to DIN ISO 228/I
  1 – 11 $^1/_2$ NPT (tapered) to ANSI B 1.20.1

Operating Data

- Pressure p_e: max. 0.5 bar (7 psi)
- Air temperature in tank or silo
  DU 42 C: –20°C…+80°C (–4…176°F)
  DU 42 S: –20°C…+80°C (–4…176°F)
- Ambient temperature:
  DU 42 C: –20°C…+60°C (–4…140°F)
  FHU 42: –20°C…+60°C (–4…140°F)
- Extended temperature range:
  from –40°C (–40°F) (measuring range reduced by approx. 20%)
- Storage temperature: –40°C…+80°C
- Max. permissible relative humidity in tank or silo: 100%
- Ultrasonic run time compensation: with silicon temperature sensor, integrated behind diaphragm of sensor. External sensor can be connected
- Operating frequency: approx. 30 kHz
- Pulse frequency: approx. 2 Hz
- Measuring range with liquids:
  up to 28 m (90 ft)
- Measuring range with bulk solids:
  up to 18 m (60 ft) under favourable conditions
- Blocking distance BD: approx. 1 m (3.3 ft) below the diaphragm
- Angle of beam at –6 dB: 4°
- Protection for sensor DU 42 S: IP 68 (immersed 1 m for 24 hours)

Materials

- Sensor housing in silo: PA, fibre-glass reinforced
- Flange: PP-FR
- Seal between sensor and flange: EPDM
- Thread mountings of the sensor DU 42 S: aluminium or 1.4301
- Diaphragm: 0.5 mm stainless steel 1.4571
- Diaphragm seal: EPDM
- Spring washer (holding the diaphragm): stainless steel 1.4571
- Coating of sensor for ATEX Zone 20: stainless steel 1.4301
- Flange plating of sensor for ATEX Zone 20:
  stainless steel 1.4301
- Housing for drive electronics:
  cast aluminium (Al Si 12), plastic coated
- Mounting plate for separate drive electronics FHU 42: stainless steel

Measuring Instruments

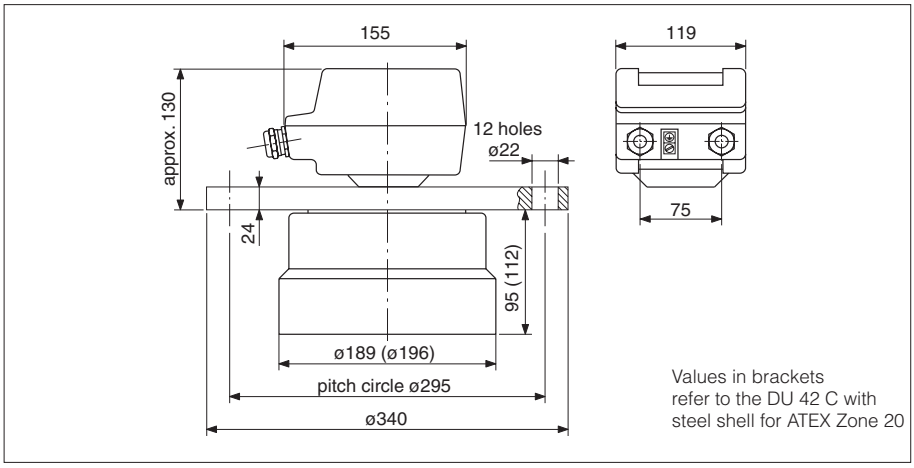
- Nivosonic FMU 671: 7 HP wide Racksyst plug-in board with adjustment elements for on-site dialogue, digital LCD to indicate measured value and parameters entered, switching status of the limit value relays.
- Nivosonic FMU 676: Like the FMU 671, but for on-site dialogue with the Commulog VU 260 Z or for remote dialogue via a computer and the ZA 672 computer interface. There are no adjustment elements or digital display on the front panel.
- Multipoint FMU 677: 7 HP wide Racksyst plug-in board without front panel elements. For on-site dialogue using the Commulog VU 260 Z handheld terminal or for remote dialogue using a computer and the ZA 672 computer interface. LEDs to indicate switching status of the limit value relays.
  Additional instruments can be connected to a Multipoint echo level system in an assembly rack behind a common front panel.

Electromagnetic compatibility (EMC):

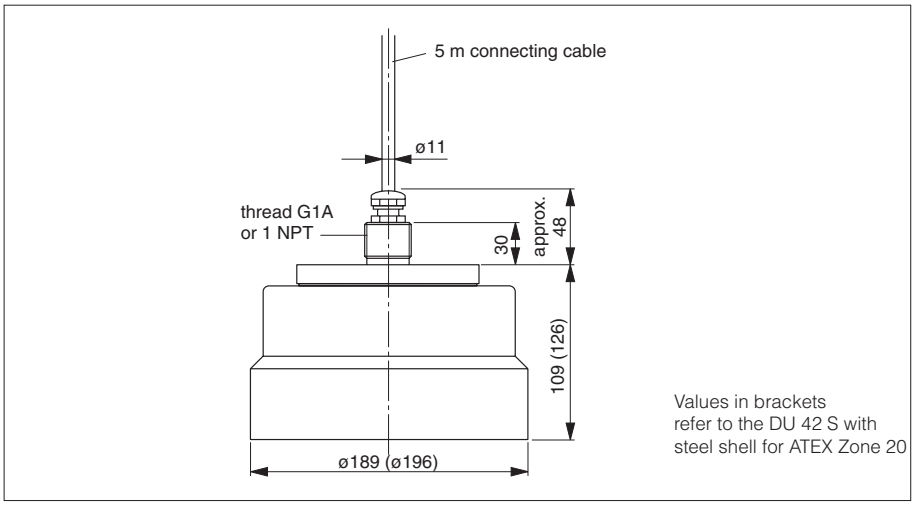
- Interference Emission to EN 61326, Electrical Equipment Class B
  Interference Immunity to EN 61326, Annex A (Industrial) and NAMUR Recommendation NE 21 (EMC).

Dimensions

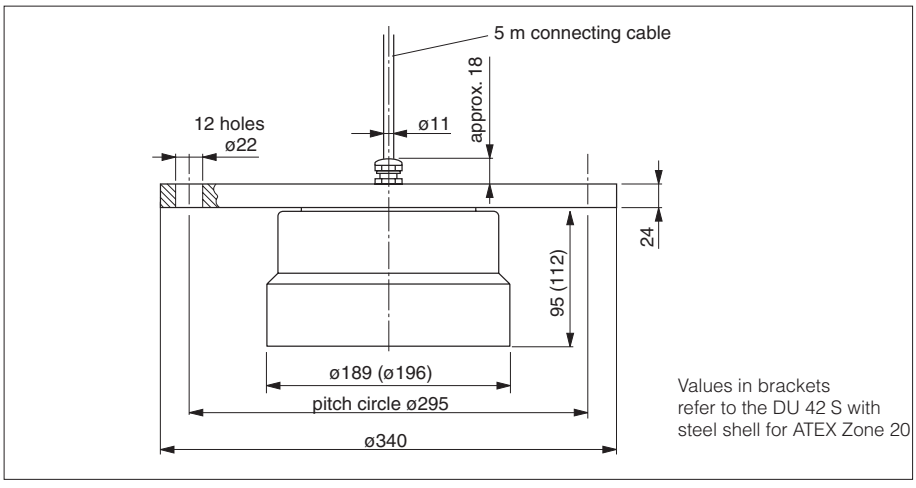
All dimensions
are in mm
100 mm = 3.94 in
1 in = 25.4 mm



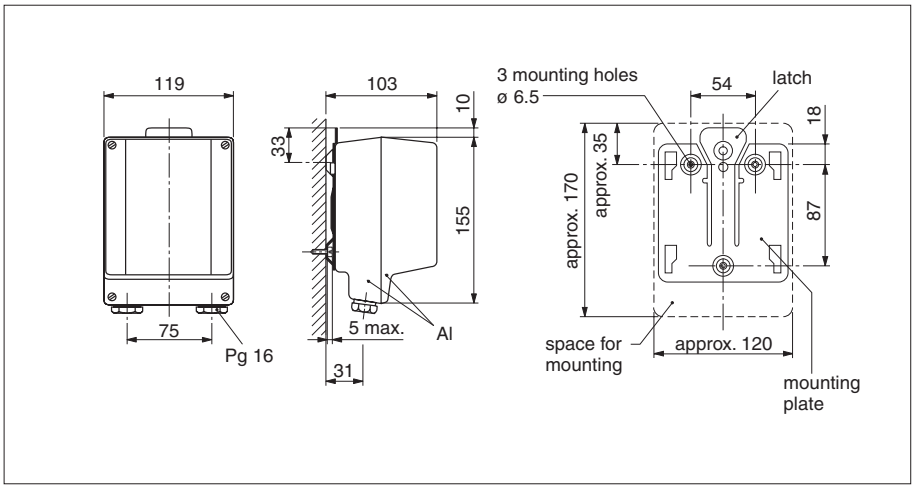
Dimensions of
ultrasonic sensor
DU 42 C (shown with
DIN flange DN 200,
PN 16)



Dimensions of
ultrasonic sensor
DU 42 S with thread
connection



Dimensions of
ultrasonic sensor
DU 42 S with flange
connection (shown with
DIN flange DN 200,
PN 16)



Dimensions of
drive electronics
in protective housing
FHU 42

Product Structure

DU 42 C, compact ultrasonic sensor with drive electronics

Certificate		Weight Standard	Weight ATEX
R	Standard (non-certified)		
E	ATEX II 1/3 D, s. XA 234F-A		
T	CSA Class II, Div. 1, Groups E, F, G		
	Process connection / Material		
A	Flange 10" 150 lbs FF, PP max. 22 psia	5,5 kg	7,0 kg
B	Flange DN 200, PN 16 B, PP max. 1.5 bar abs.	6,5 kg	8,0 kg
D	Flange DN 250, PN 16 B, PP max. 1,5 bar abs.	5,5 kg	7,0 kg
E	Flange 10K 200A FF, PP max. 1,5 bar abs.	6,5 kg	8,0 kg
K	Flange 10K 200A FF, PP max. 1,5 bar abs.	5,5 kg	7,0 kg
U	Flange 8" 150 lbs FF, PP max. 22 psia	6,5 kg	8,0 kg
	Housing / Cable gland		
1	Aluminium IP 65 / Pg 16 (IP 65)		
2	Aluminium IP 65 / $^1/_2$ NPT		
3	Aluminium IP 65 / M 20 x 1.5		
4	Aluminium IP 65 / G $^1/_2$ A		

Ordering key for DU 42 C: DU 42 C [ ] [ ] [ ] — Product designation

DU 42 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 234F-A		
T	CSA Class II, Div. 1, Groups E, F, G		
	Process connection / Material		
G	Thread G 1 A / Aluminium	3.5 kg	4.5 kg
S	Thread G 1 A / 1.4301	3.5 kg	4.5 kg
N	Thread 1 NPT / Aluminium	3.5 kg	4.5 kg
V	Thread 1 NPT / 1.4301	3.5 kg	4.5 kg
A	Flange 10" 150 lbs FF, PP max. 22 psia	4,0 kg	5,5 kg
B	Flange DN 200, PN 16 B, PP max. 1.5 bar abs.	5,0 kg	6,5 kg
D	Flange DN 250, PN 16 B, PP max. 1,5 bar abs.	4,0 kg	5,5 kg
E	Flange 10K 200A FF, PP max. 1,5 bar abs.	5,0 kg	6,5 kg
K	Flange 10K 200A FF, PP max. 1,5 bar abs.	4,0 kg	5,5 kg
U	Flange 8" 150 lbs FF, PP max. 22 psia	5,0 kg	6,5 kg
	Cable length		
1	5 m		

Ordering key for DU 42 S: DU 42 S [ ] [ ] [ ] — Product designation

FHU 42, drive electronics for DU 42 S

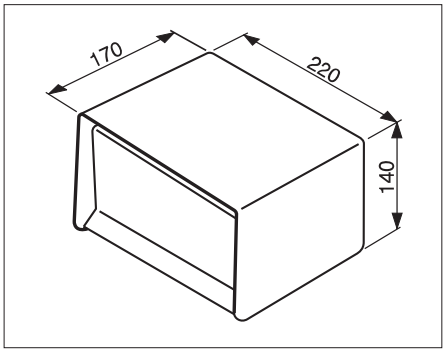
Certificate		Weight
R	Standard / ATEX II 3 D, s. XA 234F-A	
T	CSA Class II, Div. 1, Groups E, F, G	
	Housing / Cable gland	
1	Aluminium IP 65 / Pg 16 (IP 65)	1.5 kg
2	Aluminium IP 65 / $^1/_2$ NPT	1.5 kg
3	Aluminium IP 65 / M 20 x 1.5	1.5 kg
4	Aluminium IP 65 / G $^1/_2$ A	1.5 kg

Ordering key for FHU 42: FHU 42 [ ] [ ] — Product designation

Accessories

Alignment unit
FAU 40

Alignment Unit FAU 40
for simple installation and alignment of the sensor DU 42 S.
For a detailed description see Technical Information TI 179F/00/en



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

All-Weather Protective Cover
for sensor DU 42 C
Material: PVC, light grey
Weight: 0.9 kg
Ambient temperature:
–20°C…+80°C
Order No. 918624-0000

All-weather cover for
DU 42 S and FHU 42

Supplementary Documentation

- ❑ Summary of non-contact level measurement using ultrasonics in liquids and solids
  System Information SI 005F/00/en
- ❑ Summary of non-contact level measurement using the Nivosonic ultrasonic echo system
  Product Information PI 004F/00/en
- ❑ Nivosonic FMU 671, FMU 676
  Transmitter for connecting to the ultrasonic sensor DU 42
  Technical Information TI 062F/00/en
- ❑ Multipoint echo measurement system for level measurement at multiple measuring points
  Technical Information TI 086F/00/en

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