

Ultrasonic flowmeters

SITRANS F US SONOKIT 1-track

Operating instructions · 03/2009



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Flowmeters SONOKIT 1- track

Operating Instructions

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A

Ultrasonic retrofit flow sensor kit for use with
SITRANS F US transmitter types SITRANS FUS060
or SITRANS FUS080.

Legal information

Warning notice system

This manual contains notices you have to observe in order to ensure your personal safety, as well as to prevent damage to property. The notices referring to your personal safety are highlighted in the manual by a safety alert symbol, notices referring only to property damage have no safety alert symbol. These notices shown below are graded according to the degree of danger.

⚠ DANGER
indicates that death or severe personal injury will result if proper precautions are not taken.
⚠ WARNING
indicates that death or severe personal injury may result if proper precautions are not taken.
⚠ CAUTION
with a safety alert symbol, indicates that minor personal injury can result if proper precautions are not taken.
CAUTION
without a safety alert symbol, indicates that property damage can result if proper precautions are not taken.
NOTICE
indicates that an unintended result or situation can occur if the corresponding information is not taken into account.

If more than one degree of danger is present, the warning notice representing the highest degree of danger will be used. A notice warning of injury to persons with a safety alert symbol may also include a warning relating to property damage.

Qualified Personnel

The device/system may only be set up and used in conjunction with this documentation. Commissioning and operation of a device/system may only be performed by **qualified personnel**. Within the context of the safety notes in this documentation qualified persons are defined as persons who are authorized to commission, ground and label devices, systems and circuits in accordance with established safety practices and standards.

Proper use of Siemens products

Note the following:

⚠ WARNING
Siemens products may only be used for the applications described in the catalog and in the relevant technical documentation. If products and components from other manufacturers are used, these must be recommended or approved by Siemens. Proper transport, storage, installation, assembly, commissioning, operation and maintenance are required to ensure that the products operate safely and without any problems. The permissible ambient conditions must be adhered to. The information in the relevant documentation must be observed.

Trademarks

All names identified by ® are registered trademarks of the Siemens AG. The remaining trademarks in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owner.

Disclaimer of Liability

We have reviewed the contents of this publication to ensure consistency with the hardware and software described. Since variance cannot be precluded entirely, we cannot guarantee full consistency. However, the information in this publication is reviewed regularly and any necessary corrections are included in subsequent editions.

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Introduction

1.1 Preface

These instructions contain all the information you need for using the device.

The instructions are aimed at persons mechanically installing the device, connecting it electronically, configuring the parameters and commissioning it as well as service and maintenance engineers.

Note

It is the responsibility of the customer that the instructions and directions provided in the manual are read, understood and followed by the relevant personnel before installing the device.

1.2 Items supplied

- Marking paper (1x) (up to DN1000)
- Technical documentation (e.g. Operating Instructions)
- Alignment tool (no. depends on pipe size by the order code)
- Transducer holder (2x)
- Mounting plate (2x)
- Transducer element (2x)
- Terminal housing (2x)
- Transducer coaxial cable (2x)
- Transducer inserting tool (1x)
- Sub. Kit with injector (1x)
- Accessories (tool box)
- Transmitter with wall mounting kit / bracket (type FUS060 or FUS080)

Note

Depending on the ordered version of the SONOKIT, the scope of delivery may vary. The contents list in the package will show included parts.

1.3 How to read this document

These instructions are only for the sensor part of the flowmeter system consisting of sensor mounting kit type SONOKIT and transmitter type FUS060 or FUS080. The transmitter FUS060 and FUS080 have separate operating instructions.

Note

These instructions only describe the SONOKIT installation in empty unpressurized pipes. If the SONOKIT is to be installed in pressurized pipes (hot tapping), please contact Siemens Flow Instruments for further instructions.

History

The contents of these instructions are regularly reviewed and corrections are included in subsequent editions. We welcome all suggestions for improvement.

The following table shows the most important changes in the documentation compared to each previous edition.

Edition	Remarks
1993	Instruction SONOKIT mounting kit type SONO 3100, SONOKIT 1- and 2-tracks
02/2003	Handbook SONOKIT (A5E00253093)
02/2007	SONOKIT 1 and 2-tracks with transmitter type FUS060 Operating Manual (A5E00814557)
06/2008	SONOKIT 1 track Operating Instructions

1.4 Further Information

The contents of these Operating Instructions shall not become part of or modify any prior or existing agreement, commitment or legal relationship. All obligations on the part of Siemens AG are contained in the respective sales contract which also contains the complete and solely applicable warranty conditions. Any statements contained herein do not create new warranties or modify the existing warranty.

Product information on the Internet

The Operating Instructions are available on the CD-ROM shipped with the device, and on the Internet on the Siemens homepage, where further information on the range of SITRANS F flowmeters may also be found:

Product information on the internet (<http://www.siemens.com/flowdocumentation>)


Worldwide contact person

If you need more information or have particular problems not covered sufficiently by the operating instructions, please get in touch with your contact person. You can find contact information for your local contact person on the Internet:

Local contact person (<http://www.automation.siemens.com/partner>)

Safety notes

2.1 General safety instructions

 CAUTION
Correct, reliable operation of the product requires proper transport, storage, positioning and assembly as well as careful operation and maintenance. Only qualified personnel should install or operate this instrument.

Note

Alterations to the product, including opening or improper repairs of the product, are not permitted.

If this requirement is not observed, the CE mark and the manufacturer's warranty will expire.

2.2 Installation of sensor in hazardous area

For safety reasons it is important that the following points are read and understood before the installation of the equipment:

1. Installation, connection, commissioning and service must be carried out by personnel qualified and authorized to do so.
2. It is the responsibility of the customer that the instructions and directions provided in the Quick Start and in the manual on the enclosed CD-ROM are read, understood and followed by the relevant personnel before installing the equipment.
3. In applications with working pressures/media that can be dangerous to people, surroundings, equipment or others in case of pipe fracture, we recommend that special precautions such as special placement, shielding or installation of a security guard or a security valve are taken when the sensor is installed.
4. Siemens Flow Instruments can provide assistance with the selection of wetted sensor parts. However, the full responsibility for the selection rests with the customer and Siemens Flow Instruments can take no responsibility for any failure due to material incompatibility.
5. Equipment used in hazardous areas must be Ex-approved and marked for Europe, FM for USA and CSA for Canada. It is required that the special conditions for safe use provided in the manual and in the Ex certificate are followed!
6. Installation of the equipment must comply with national regulations. For example EN 60079-14 for the European Community.
7. The customer has to carry out periodic inspections according to use to ensure PED specifications are obtained.
8. Repair and service must be carried out by approved Siemens Flow Instruments personnel only.

Description

3.1 Measuring principle

Physical principle

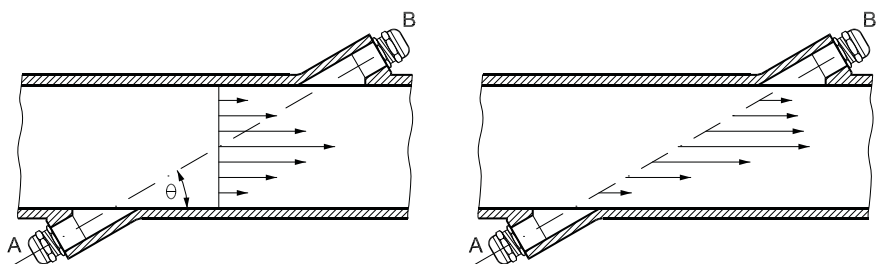


Figure 3-1 Velocity distribution along sound path

A sound wave travelling in the same direction as the liquid flow arrives at point B from point A in a shorter time than the sound wave travelling against the direction of flow (from point B to A).

The difference in sound transit time indicates the flow velocity in the pipe.

Since delay time is measured at short intervals both in and against flow direction, viscosity and temperature have no influence on measurement accuracy.

SiTRANS F US flowmeters

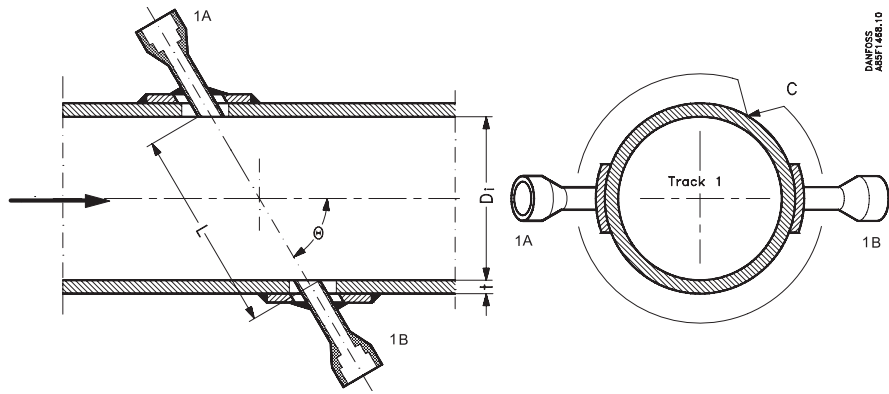
In SiTRANS F US flowmeters two ultrasonic transducers are placed at an angle θ in relation to the pipe axis. The transducers function as transmitters and receivers of the ultrasonic signals. Measurement is performed by determining the time the ultrasonic signal takes to travel with and against the flow. The principle can be expressed as follows:

$$v = K \times (t_{B,A} - t_{A,B}) / (t_{A,B} \times t_{B,A}) = K \times \Delta t / t^2$$

v = Average flow velocity
 t = Transit time
 K = Proportional flow factor

This measuring principle offers the advantage that it is independent of variations in the actual sound velocity of the liquid, i.e. independent of the temperature.

The Proportional factor K is determined by wet calibration or calculated by "Auto" in case of manual programming of mechanical geometrical pipe data (SONOKIT only). The transducer angle (Θ), distance between sensors (L) and pipe dimension (D_i) are shown in the figure below.



The ultrasonic signal is sent directly between the transducers. The advantage gained sending signals from point to point is an extremely good signal strength.

3.2 Design

Description

The SITRANS F US SONOKIT retrofit sensor kit is used for installing one or two sets of ultrasonic transducers type SONO 3200 in existing pipes made of steel or concrete.

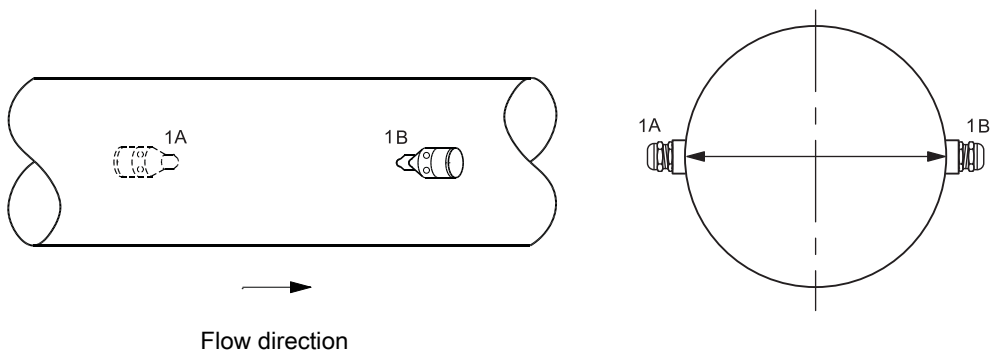


Figure 3-2 Ultrasonic 1-track flowmeter with 2 transducers (1A and 1B)

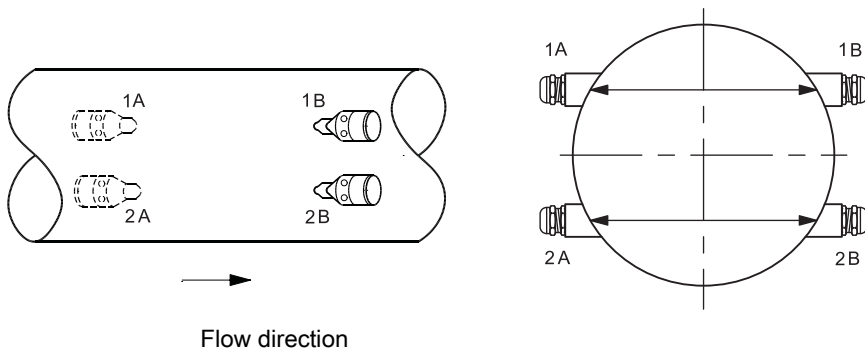
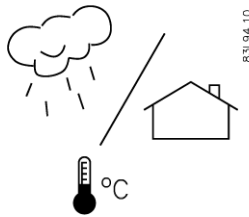


Figure 3-3 Ultrasonic 2-tracks flowmeter with 4 transducers (1A and 1B; 2A and 2B)

Application planning

4.1 Basic installation requirements

Installation location



The SONOKIT sensor can be installed both indoors and outdoors, even in exposed surroundings.

The enclosure rating of the transducer is IP67 or optionally IP68. For underground installation a submersible kit is recommended.

Media, surface and ambient temperatures

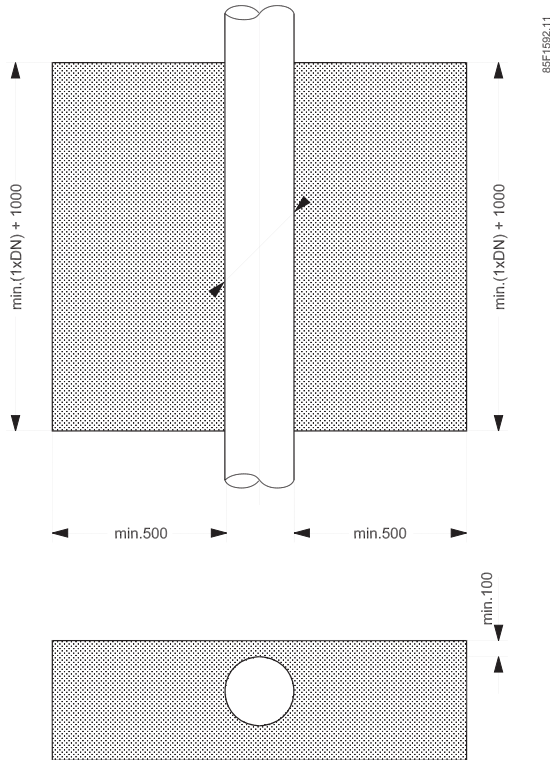
	Std. [°C /°F]	High temp. [°C /°F]	Ex-d [°C /°F]	Ex i [°C /°F]
Media / surface temperature	-20...+100 °C -4...+212 °F	-20...+200 °C -4...+392 °F	-20...+180 °C -4...+356 °F	-10...+190 °C +14...+374 °F
Ambiente temperature sensor	-20...+60 °C -4...+140 °F	-20... +60 °C -4...+140 °F	-20... +60 °C -4... +140 °F	-20... +60 °C -4... +140 °F

The temperature range is stated on the data plate on the transducer.

CAUTION

In case of large temperature differences between the medium and the environment, the transducer must be isolated to avoid 2-phase flow which will result in inaccurate measuring results.

Space requirements (empty pipe installation)



Note

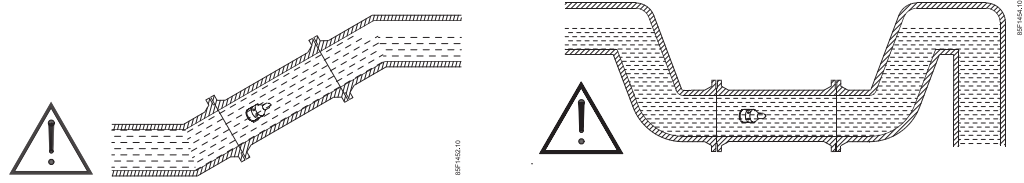
The dimensions are minimum values stated in mm. Different space requirements apply when retrofitting takes place in pressurized pipes or when the transducers are exchanged under pressure.

4.2 Location in the system

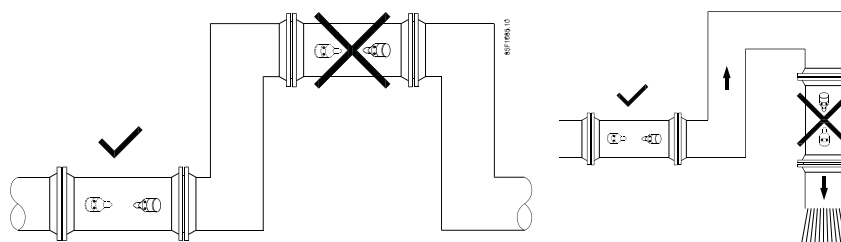
Optimum location

CAUTION
The sensor must always be completely filled with liquid.

- Locate the flowmeter in U-shaped pipes if pipes are only partially filled or have free outlet.

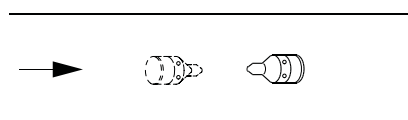


- Avoid the following installations:
 - Installation at the highest point of the pipe system
 - Installation in vertical pipes with free outlet



4.3 Sensor orientation

Horizontal (recommended)



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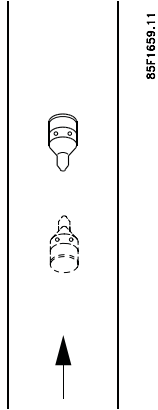
Note

Liquids containing abrasive or other particles:

Mount sensor in vertical or inclined pipe position to minimize wear.

Vertical

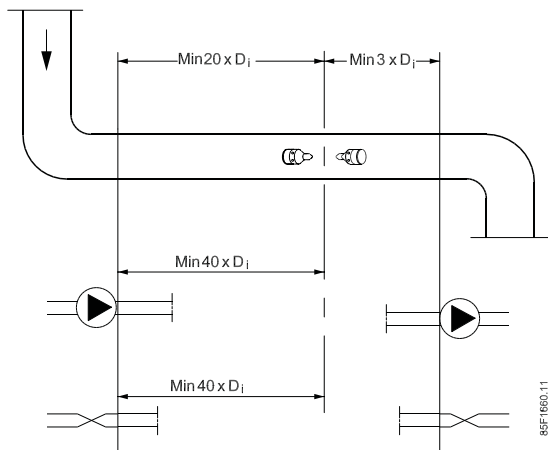
The vertical transducers can be oriented in vertical position with upwards flow.



Note

Indicate the flow direction with an arrow

4.4 Inlet and outlet conditions



- Ensure sufficient distance between meter and bends, pump and valves.
- Install valves influencing the flow profile after the flowmeter. The only exception is installation of the sensor in a vertical pipe (upwards flow direction). In installations in a vertical pipe a valve below the sensor is required to allow zero-point adjustment

Note

Select a valve not altering flow when fully opened.

Recommended inlet	
Fully open valve, ie no flow restriction	Min. 10 × pipe diameter
Partially open valve	Min. 40 × pipe diameter
Pumps	Min. 40 × pipe diameter
Single bends	Min. 20 × pipe diameter
Recommended outlet	3 × pipe diameter

Note

By more than one bend, the optimal inlet is min. 40 × pipe diameter.

Installing/Mounting

5.1 General information

Installation and assembly of the SONOKIT retrofit sensor kit occurs in 5 steps:

1. Calculating the transducer holder position (Page 18)
2. Installing the transducer holders (Page 28)
3. Determining sensor data (Page 34)
4. Connecting the transducer (Page 36)
5. Entering the transducer geometry data into the transmitter

Note

Step 5 is only described in the relevant transmitter Operating Instructions

5.2 Necessary tools

Basic tools

- Angle iron of a length approximately corresponding to the outer diameter of the pipe
- Measuring tape
- Scriber, pencil or the like
- Pocket calculator
- Calipers
- Sliding gauge
- Hammer
- Centre punch
- Spirit level
- Roll of adhesive tape

Tools for installation on steel pipe

- Flame cutter or drill with 60 mm drill bit for making holes in steel pipes
- Electric or TIG welder for welding the mounting plate and the transducer holder

Tools for installation on concrete pipe

- Special drill unit for drilling 46 mm holes in concrete.
The unit is not part of the mounting kit, but can be rented from companies specializing in construction equipment



The unit contains a core drill bit, an ordinary handheld drill and a device for fastening the unit to the pipe wall.
The unit is fastened to the pipe wall by means of vacuum or clamping band.

- Filler

Note

A suitable filler or mortar does not shrink when setting. A comparatively short setting time is preferred.

See also

Items supplied (Page 5)

5.3 Step 1: Transducer holder position

The first step in the installation procedure is to calculate the transducer holder position. The step is completed by the following actions:

1	Determination of wall thickness and circumference of the pipe	
2	Marking of the top line of the pipe	
3	Pipes up to DN 1000: Marking the transducer holder position on the pipe using paper (Page 20)	Pipes larger than DN 1000: Marking the transducer holder position directly on the pipe (Page 25)

Note

The actual procedure depends on the size of the pipe

- DN ≤ 1000: Calculation by use of paper
- DN > 1000: Calculation without use of paper

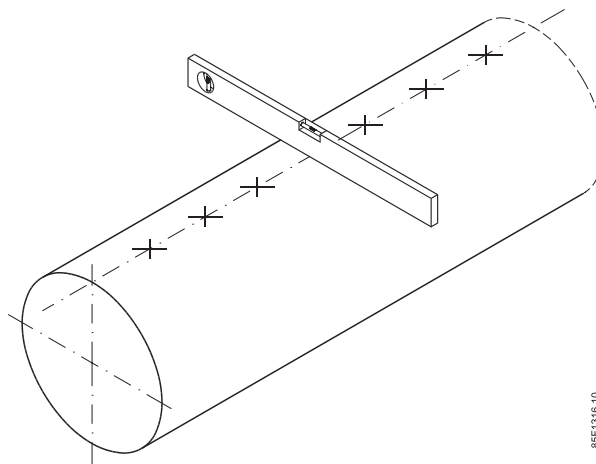
Determining wall thickness and circumference

The following pipe dimensions must be known before calculating the transducer position.

1. Circumference (C)
2. Wall thickness (t)
3. Outer diameter of the pipe ($D_u = C/\pi$)

The circumference is determined using the measuring tape. Make sure that the pipe's surface is plane and free of dirt etc. The measuring tape must fit snugly around the pipe. Read the circumference (C). Repeat the measurement several times to avoid inaccuracies.

The wall thickness is obtained by measuring a similar pipe whose wall thickness is accessible, or by consulting the relevant standard.

Marking the pipe top line

1. Remove any rust or dirt from surface of pipe.
2. Find top line X - X using a spirit level. Place spirit level on top of pipe. When perfectly balanced in horizontal position, it intersects the top line.

- 3. Mark 4 -5 points on pipe top line using this method.
- 4. Draw a line X - X through the marked top points using length of angle iron.



5.3.1 Pipes up to DN 1000

Up to DN 1000 the transducer position is calculated using the roll of paper supplied with the mounting kit.

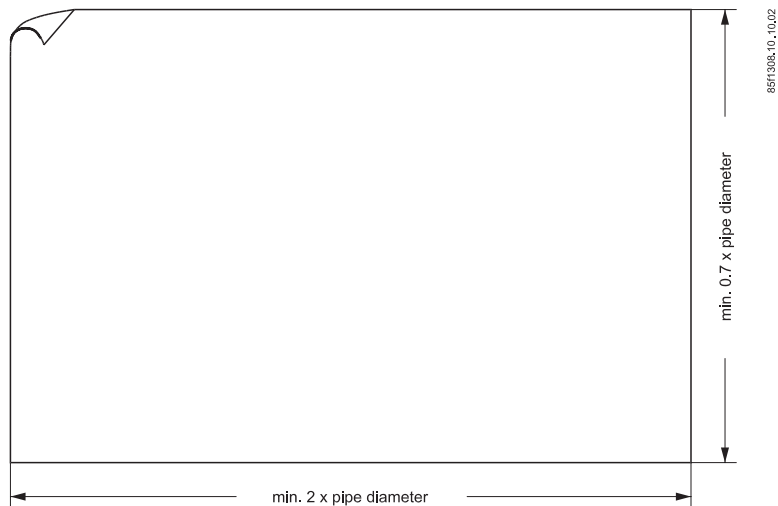


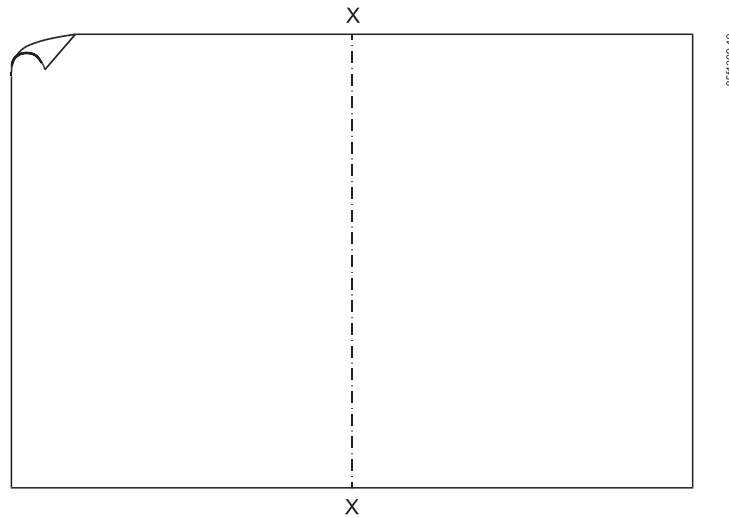
Figure 5-1 Drawing paper (supplied with the SONOKIT up to DN 1000).

Note

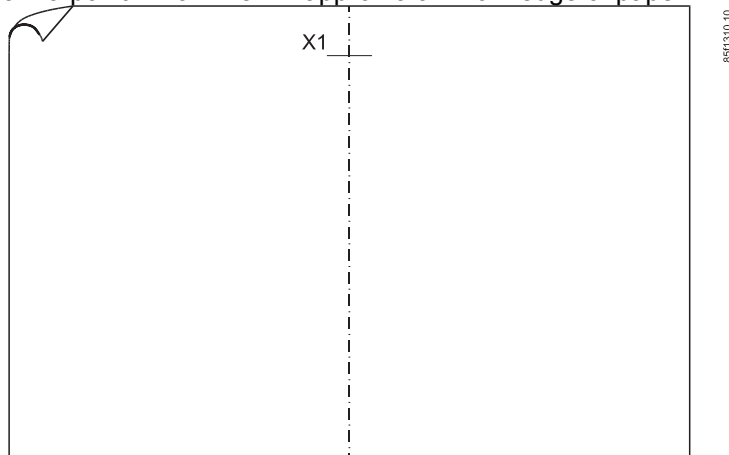
For SONOKITs larger than DN 1000, mark directly on the pipe.

Marking the paper

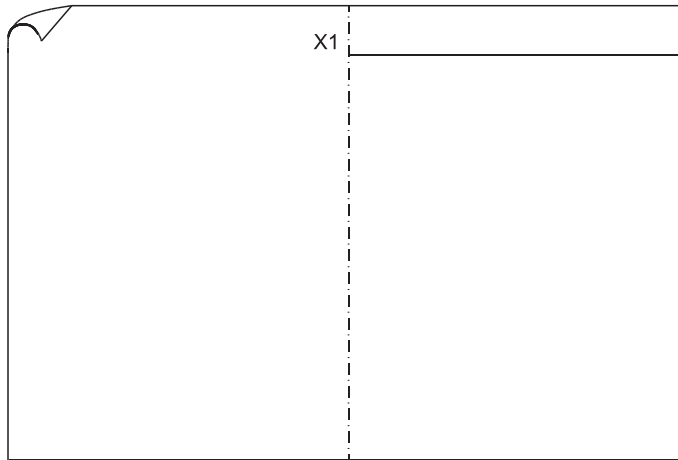
1. Draw a line x-x through the middle of the paper.
Ensure that the line x-x is right-angled to edge of paper.



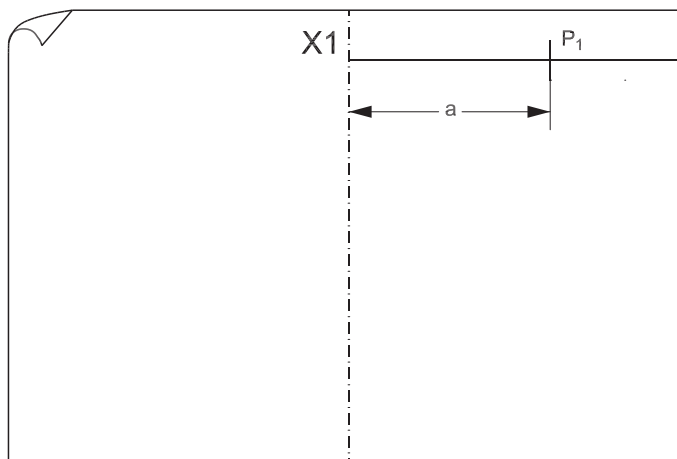
2. Mark a point X1 on line x-x approx 5 cm from edge of paper.



3. Draw a line X1 at right angles to x-x.



4. Mark a point P1 on line X1.
Calculate distance a from X1 to P1 as follows: $a = 0.25 \times C$
C = Pipe circumference



Note

It is useful to draw a circle around P1 ($\varnothing = 60 \text{ mm}$, $r = 30 \text{ mm}$)

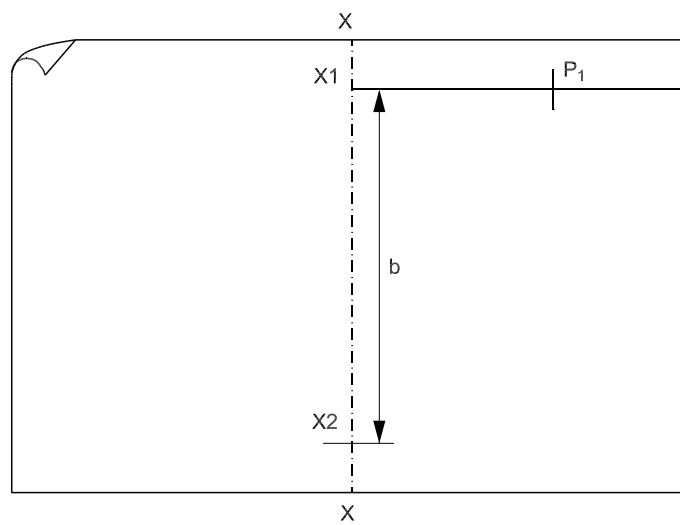
5. Mark point X2 on the line x-x at a distance b from point X1.
Calculate b for the different pipe sizes by using the formula:

DN 100 - 150: $b = 1 \times D_u$

DN 200 - 2400: $b = 0.577 \times D_u$

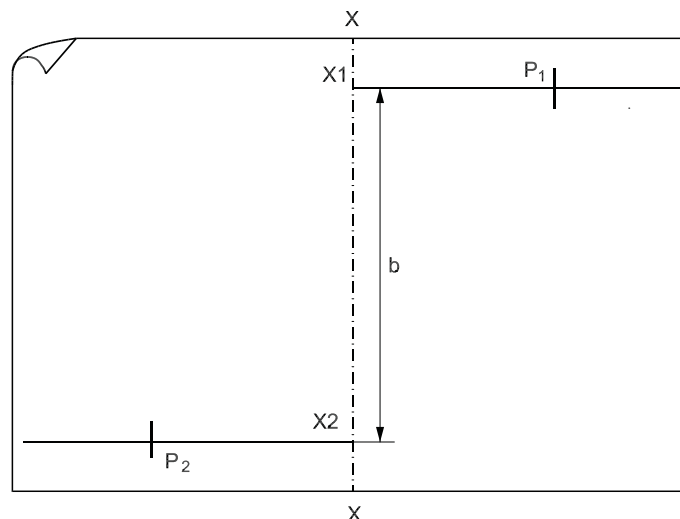
D_u (outer diameter of the pipe) = C/π

C = Pipe circumference



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6. Mark points P2 by repeating the proceeding procedure



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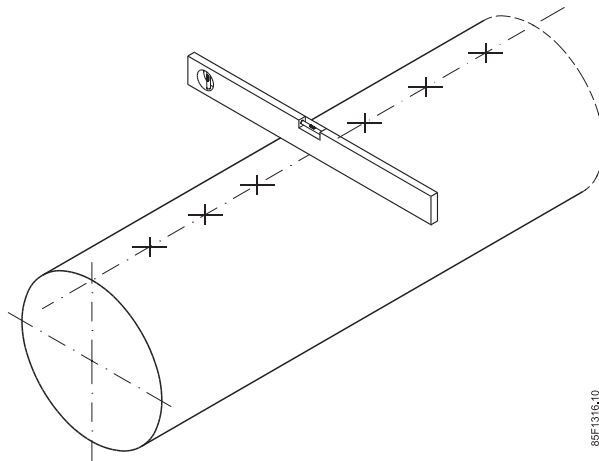
The drawing on the paper is now finished.

Note

It is useful to draw a circle around P2 ($\varnothing = 60$ mm, $r = 30$ mm)

Marking the pipe

1. Place the paper on the pipe in such a way that the line X - X on the pipe coincides with the top line X1 - X2 on the paper
Fix paper to pipe with adhesive tape



2. Punch points P1, P2 onto the pipe with centre punch. Ensure that lines dissecting the points can be redrawn once the paper is removed.



3. Remove the paper.

Note

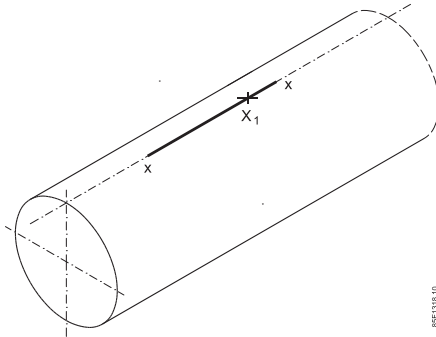
When preparing a steel pipe, it is useful to draw a circle with a radius of 30 mm around points P using the centre punch. This facilitates cutting the holes with a flame cutter.

5.3.2 Pipes larger than DN1000

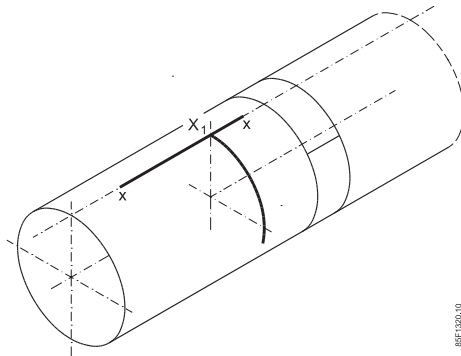
The transducer position is marked directly on pipes larger than DN 1000.

After marking the top line (see above under 5.3.2) following steps should be done:

1. Mark a point X_1 on top line X - X.



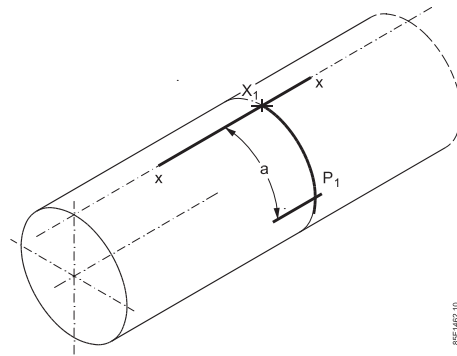
2. Draw a line at right angles to the top line X - X through point X_1 .



Note

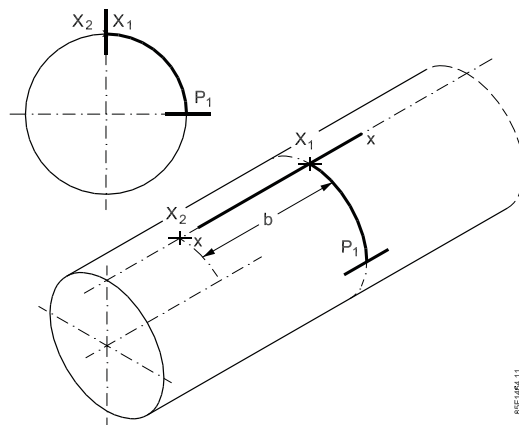
To construct the line through X_1 place a strip of metal foil around the pipe, thus ensuring that the line is at right angles to the pipe

3. Mark point P_1 on the line at distance a from X_1 .
Distance a is calculated as follows:
 $a = 0.25 \times C$
 C = Circumference of the pipe



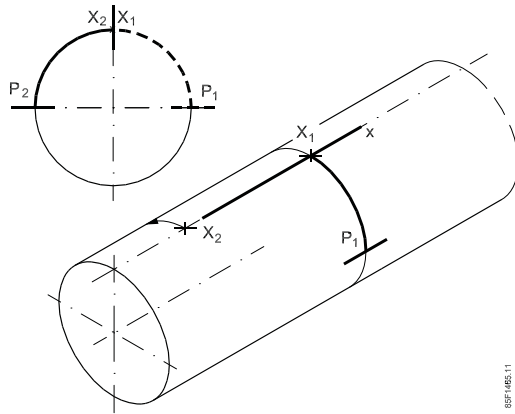
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4. Mark point X_2 on line X-X at distance b from point X_1 .
Calculate b for the different pipe sizes by using the formula:
DN 100 - 150: $b = 1 \times D_u$
DN 200 - 2400: $b = 0.577 \times D_u$
 D_u = Outer diameter of the pipe (C/π)
 C = Circumference of the pipe



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5. Mark P₂ by repeating the preceding procedure on the opposite side of the pipe.



5.4 Step 2: Transducer holder

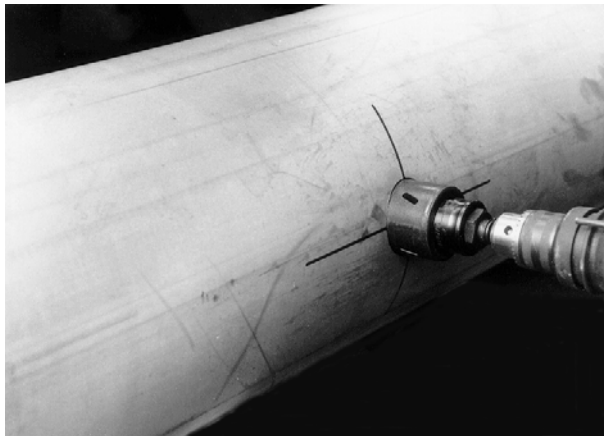
The second step in the installation procedure is to install the transducer holders. In the following it is described how to:

- Install the holders on steel pipes (Page 29)
- Or alternatively how to
- Install the holders on concrete pipes. (Page 32)

5.4.1 Installation on steel pipes

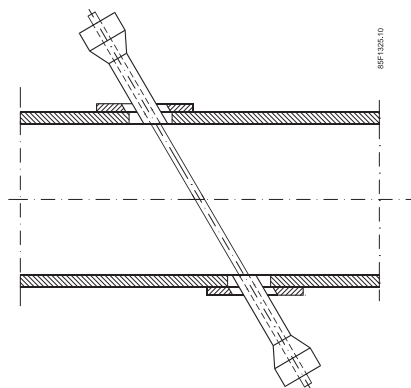
Drilling

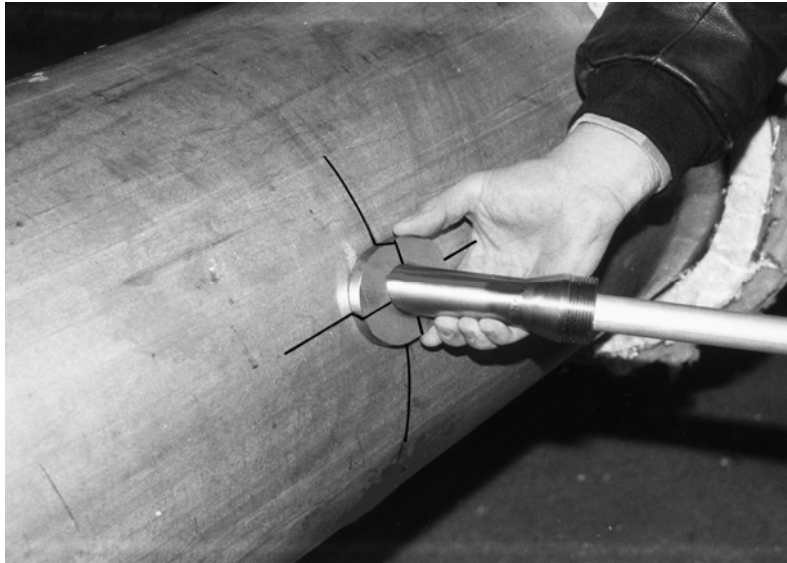
1. Cut or drill 2 holes centred on P1 and 2.
Dimension of the holes: 60 mm $+5/-0$.



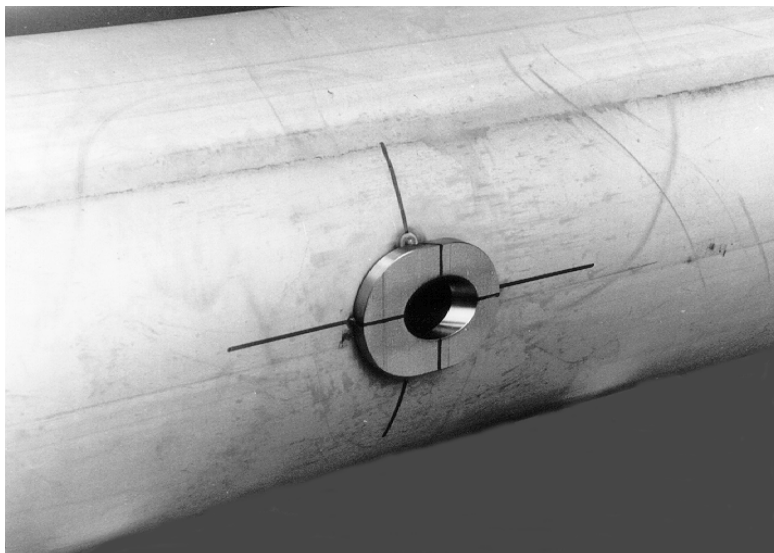
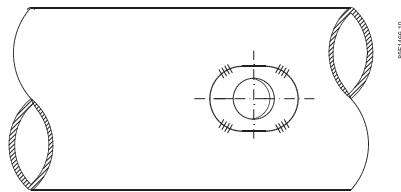
Installing the mounting plates

1. Place a set of transducer holders and mounting plates on the mandrel (supplied with the kit) without permanently fixing them.

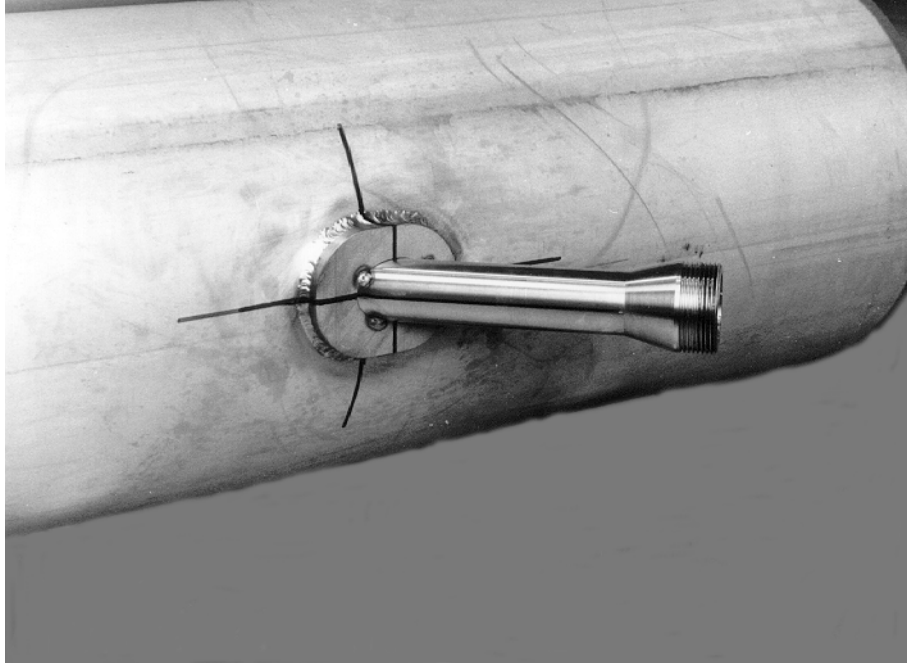




2. Tack-weld the mounting plates in at least 3 places with transducer holders and mandrels mounted.

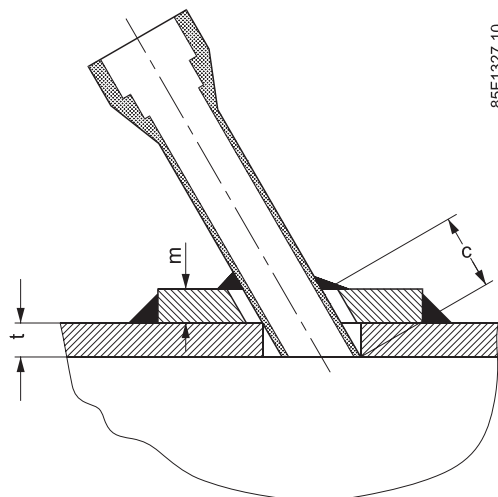


3. Remove transducer holders and mandrel, and weld the mounting plates completely onto the pipe.



Mount the transducer holders

1. Mark a point on the transducer holders marking line at distance c . Determine c by measuring wall thickness t and mounting plate m . Calculate c using the following formula:
 $c = (t + m) \times 1.15$



2. Insert the transducer holders. Ensure that they flush with the inner surface of the pipe.

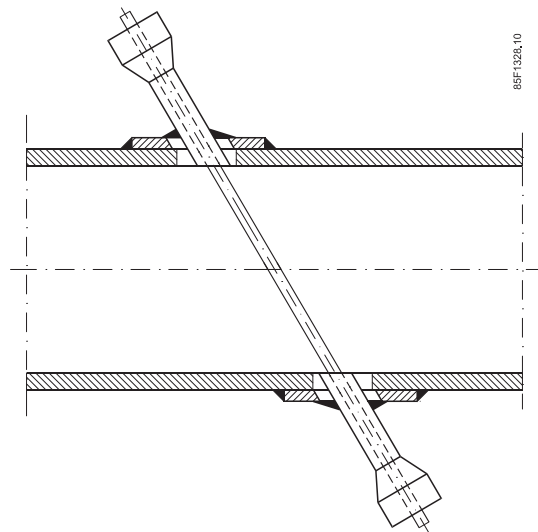
3. Tack-weld the correctly positioned transducer holders in at least 3 places with mandrels inserted.
4. Remove mandrel and fully weld transducer holders.

Note

Make sure that the transducer holders are bent as little as possible by the heat generated during welding.

Installation inspection

1. Check if the mandrel can still pass through transducer holders. If necessary correct the alignment of the transducer holders. Use a 1½" protection nut to protect the transducer holders' thread and a hammer.



5.4.2 Installation on concrete pipe

Making the holes

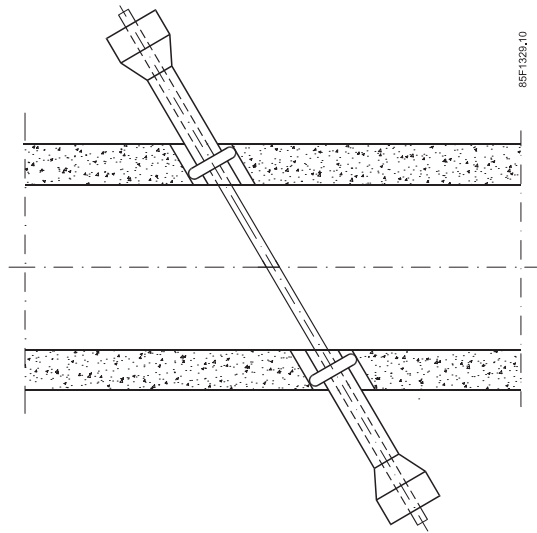
Drill holes at the marked positions, \varnothing 46 mm, into the pipe wall at an angle of 60°.

Note

It is recommended to use special drill units, see above: Necessary tools (Page 17)

Mounting the transducer holders

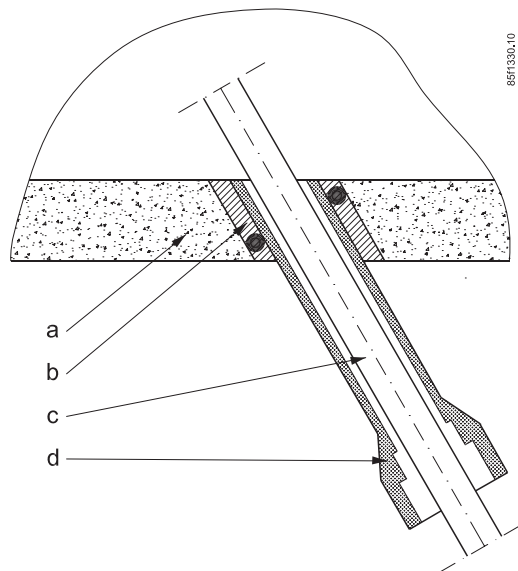
1. After having drilled the four holes, mount transducer holders with the mandrel inserted.
2. Use O-rings to seal transducer holders.



3. Fix the transducer holder to the pipe by means of mortar.

Note

Make sure that mandrel is not exposed to mortar as this might result in mandrel getting stuck to transducer holders. Mandrel keeps transducer holders in place until mortar has set.



- a = Concrete pipe
- b = Repair mortar
- c = Mandrel
- d = Transducer holder

5.5 Step 3: Determining sensor data

In order to allow theoretical calibration by the FUS060 or FUS080 transmitter, the following sensor data must be determined:

- ⇒ θ = Angle between sound track and longitudinal axis of the pipe
- ⇒ L = Distance between transducer windows
- ⇒ Di = Inside diameter of the pipe

These measurements must be programmed into the transmitter (See separate Operating Instructions for the transmitter types FUS060 or FUS080).

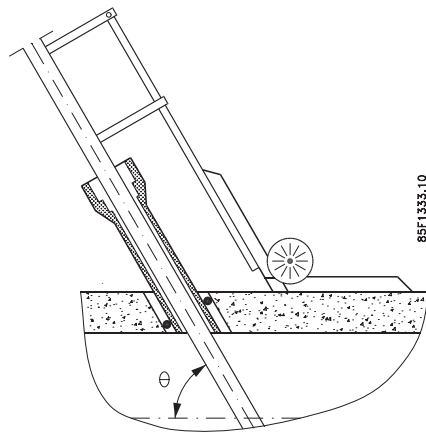
Required measuring accuracy

The inaccuracies with which θ , L, Di and H are measured directly influence the measuring accuracy of the finished system during theoretical calibration. Be sure to choose measuring equipment with a suitable measuring accuracy.

$\Delta\theta$	DN 100-400	0.1°
	DN 400-2400	
ΔL and ΔDi	DN 100-400	0.5 mm
	DN 400-1000	0.8 mm
	DN 1000-2000	2.0 mm
	DN 2000-2400	4.0 mm

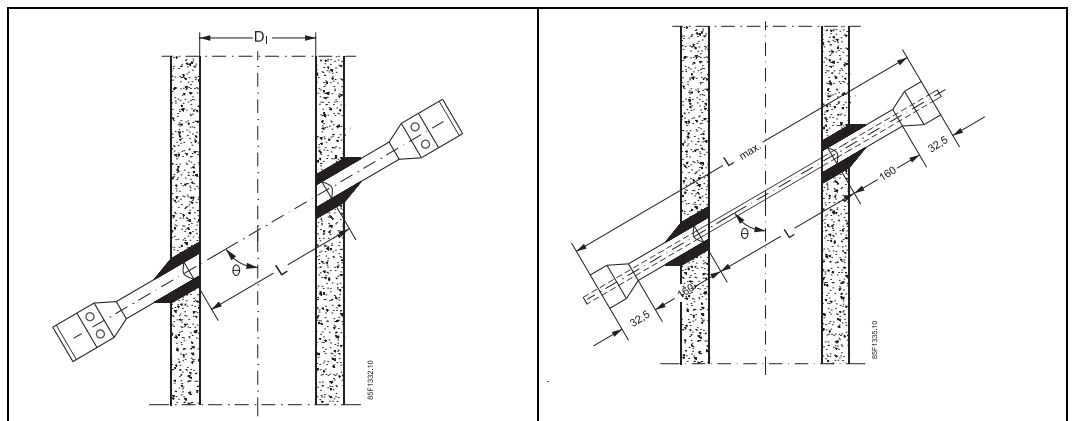
Angle (θ)

1. Measure the angle (θ) at each transducer holder several times and calculate the average of all measurements at each transducer holder.
2. Enter the angle (θ) of each transducer holder in the "Measurement report"



Transducer distance (L)

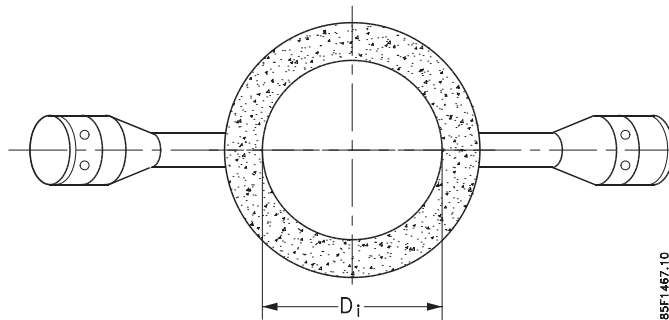
1. Measure L for the sound track.
L can be measured by inserting the mandrel or a similar instrument into the transducer holders, which makes it possible to measure the distance between the thread ends of both transducer holders.
In the graphic below an example valid for standard 160 mm transducers is given. With other transducer lengths, set in dimensions corresponding to these lengths.



2. Enter the value in the "Measurement report "

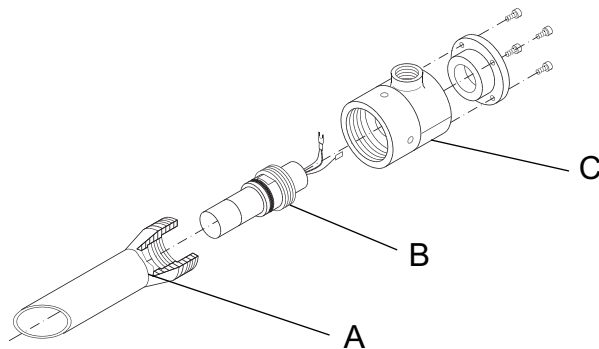
Inner-diameter (Di)

1. Calculate the inside diameter Di can on the basis of the circumference C according to the following formula:
 $D_i = (C / \pi) - (2 \times t)$
The precise wall thickness t is measured with a sliding gauge after the holes have been made.
2. Enter Di into the "Measurement report".



5.6 Step 4: Installing the transducers

The transducers are constructed in three parts:



- A Transducer holder
- B Transducer element
- C Terminal housing, Lit

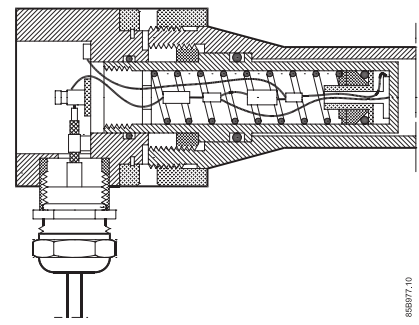
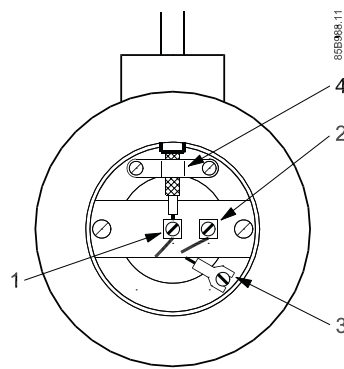
Figure 5-2 Transducer (exploded view)

The transducer element (B) has a screwed union connection for fitting in the holder (A). The union and pipe are sealed with an O-ring.

1. Mount the transducer element (B) into the holder (A).
2. Fasten the terminal housing (C) to the holder (A) by means of a union.
3. Fasten the terminal box to the transducer holder by means of a union.

4. Connect the wire without a spade terminal to position 2 (see below).
5. Connect the wire with a spade terminal to the transducer housing by means of position 3 (see below).
6. Connect the wire of the transducer coax cable to position 1(see below).
7. Fix the shield wire coax cable to the cable clip in position 4(see below).
8. Mount the lit onto the terminal housing (C).

⚠ CAUTION
Avoid stress on the connection wires when passing them through the terminal box.



Disassembling the terminal box

Loosen the wires from the connection board. It is not necessary to remove the transducer cable.

Support the terminal box while loosening the union. Then remove the terminal box from the transducer holder.

⚠ CAUTION
Turning the terminal box can damage the wires to the crystals

Appendix

A.1 Sizing table (DN 100 to DN 2400)

The following table shows the relationship between flow velocity V, flow quantity Q and sensor dimension DN.

Flow velocity calculation formula:

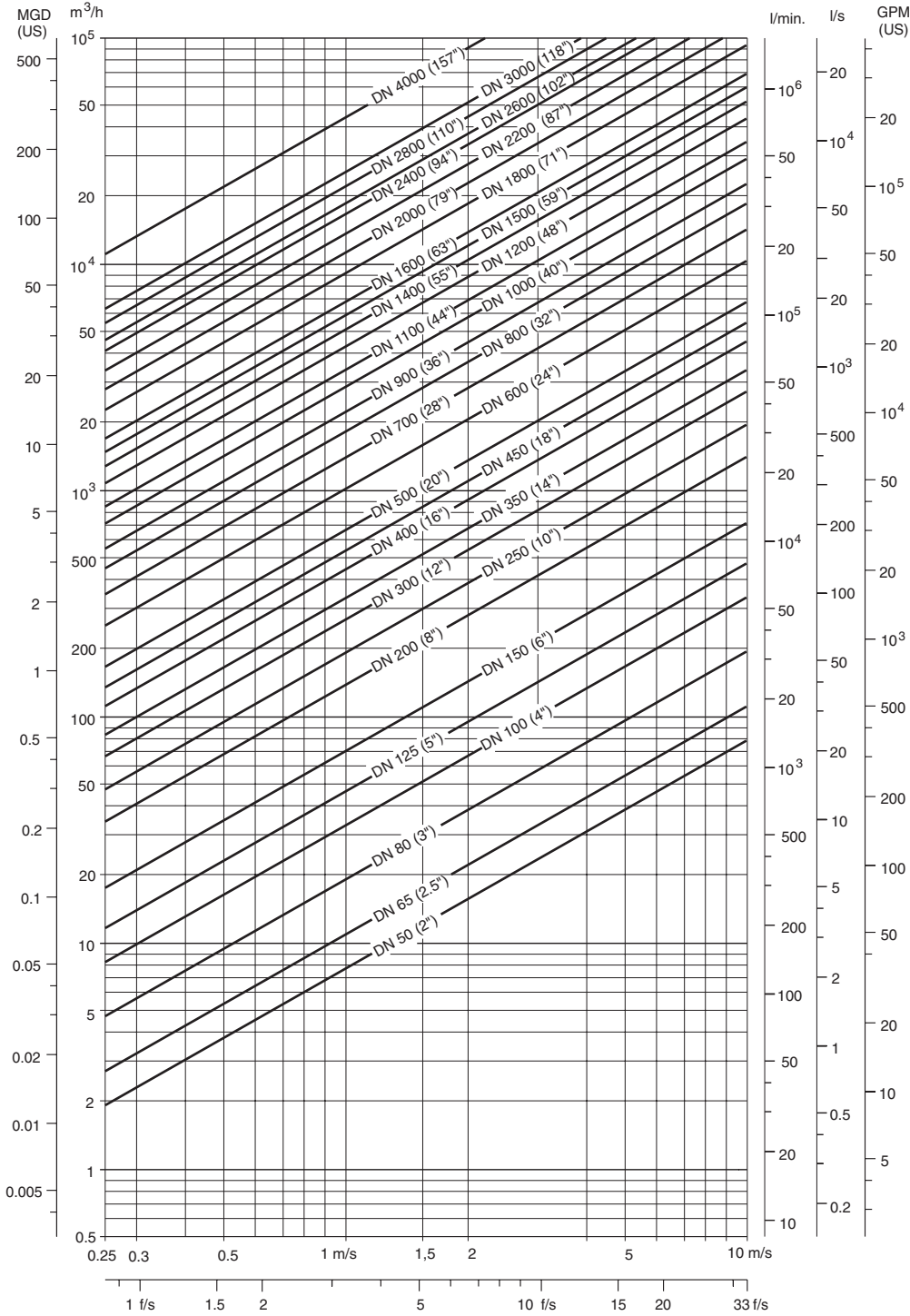
$$V = \frac{1273.24 \times Q \text{ [l/s]}}{Di^2[\text{mm}]} \text{ [m/s]} \text{ or } V = \frac{353.68 \times Q \text{ [m}^3\text{/h]}}{Di^2[\text{mm}]} \text{ [m/s]}$$

Normally the sensor is selected so that V lies within the measuring range 1-3 m/s.

Appendix

A.1 Sizing table (DN 100 to DN 2400)

- Min. measuring range: 0-1 m/s
- Max. measuring range: 0-10 m/s



Note

SONOKIT 1-track only DN 100 to DN 2400

A.2 Measurement report

Sensor geometry measurement report

Company		Name		Approved by	
Date		Sensor size		Pressure (PN)	
				Tag no.:	
Note					
P1 = 1B; P2 = 1A → Flow direction					
Measure		Calculation		Result	
Circumference (C)		$C / \pi = \text{Outer diameter of the pipe } (D_u)$		D_u	
Pipe wall thickness (t)		$D_u - (2 \times t) = \text{Internal diameter } (D_i)$		D_i	
Transducer distance (L)				L ₁ =	
				L ₂ =	
Angle θ transducer 1A (angle 1A = 1B ; +/- 0,1°)				Average track angle $''(1A + 1B) / 2''$	
Angle θ transducer 1B (angle 1A = 1B ; +/- 0,1°)					
Cable length (distance from transducer to converter x 2)				Q _{max}	

Note:

Menu in parentheses refer to parameters to be entered into the transmitter FUS060 or FUS080.

A.3 Typical dimension dependent settings

(Used dimension unit is [m])

Nominal size *)		Max. vol. flow	Pipe diameter	Track angle	Track length
[mm]	[inch]	[m ³ /h]	[m]	[°]	[m]
DN 100	4	100	0.1071	45	0.1795
DN 125	5	150	0.1317	45	0.2143
DN 150	6	220	0.1593	45	0.2533
DN 200	8	380	0.2083	60	0.2584
DN 250	10	600	0.2604	60	0.3185
DN 300	12	850	0.3098	60	0.3756
DN 350	14	1000	0.3396	60	0.4100
DN 400	16	1300	0.3904	60	0.4687
DN 450	18	1700	0.4500	60	0.5375
DN 500	20	2200	0.4920	60	0.5860
DN 550	22	2600	0.5500	60	0.6529
DN 600	24	3200	0.6016	60	0.7125
DN 650	26	3600	0.6500	60	0.7684
DN 700	28	4200	0.6952	60	0.8206
DN 750	30	4800	0.7500	60	0.8839
DN 800	32	5500	0.7968	60	0.9379
DN 900	36	7500	0.9100	60	1.0686
DN 1000	40	9000	1.0000	60	1.1726
DN 1100	44	10000	1.1000	60	1.2880
DN 1200	48	13200	1.2000	60	1.4035
DN 1300	52	14000	1.3000	60	1.5190
DN 1400	56	16800	1.4000	60	1.6344
DN 1500	60	19000	1.5000	60	1.7499
DN 1600	64	22800	1.6000	60	1.8654
DN 1700	68	25000	1.7000	60	1.9808
DN 1800	72	27600	1.8000	60	2.0963
DN 1900	76	31000	1.9000	60	2.2118
DN 2000	80	36000	2.0000	60	2.3273
DN 2100	84	37000	2.1000	60	2.4427
DN 2200	88	42000	2.2000	60	2.5582
DN 2300	92	45000	2.3000	60	2.6737
DN 2400	96	51000	2.4000	60	2.7891

*) For FUS080 transmitter based systems only up to DN1200.

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