BANDELIN
Ultraschall seit 1955

SONOPULS
Ultrasonic homogenisers
Use and application

Laboratory and process engineering

BANDELIN - Ultrasound specialist in the laboratory

SONOPULS ultrasonic homogenisers are in demand worldwide and a must for many laboratories.
The first SONOPULS ultrasonic homogeniser from our company was sold in 1964. Almost 60 years of experience - is what BANDELIN stands for.

Training courses for our sales partners and practice-orientated seminars with our users ensure a constant exchange of experience. In the process, is constantly opening up new applications. The constantly growing application database - is a result of this co-operation - offers new users great support when selecting devices. In the further development of our homogenisers, we not only focus on today's customer needs, but also keep an eye on future requirements. The functionality of the devices always takes centre stage here.

We can respond quickly to special customer requests : Development and production under one roof, short decision-making processes and proximity to the customer make this possible.

SONOPULS ultrasonic homogenisers deliver higher amplitudes with the same electrical power by optimally adapting all components. The amplitude remains constant regardless of changing conditions in the sample to be sonicated, e.g. viscosity. This guarantees reproducible results.

BANDELIN is the only supplier that can combine an ultrasonic generator with ultrasonic converters of different outputs. This means that it is not necessary to purchase a completely new device when upgrading from laboratory scale to pilot plant scale.

All probes and booster horns are fitted with fixed threaded pins. The advantage is obvious: quick and easy installation using the tools provided - no other tools are required!

Would you like to see the advantages of a SONOPULS ultrasonic homogeniser for yourself?
We would be happy to offer you a device with suitable accessories for a trial.

BANDELIN - Ultrasound since 1955

Company portrait

We - a Berlin-based family business in its third generation - specialise in the development, manufacture and sale of ultrasonic devices, corresponding accessories and application-specific cleaning and disinfection products.

A high level of vertical integration, a modern production facility and motivated employees characterise us and are a guarantee for constantly new quality products. Our appliances contribute to the success of our customers in the laboratory, medical, dental, pharmaceutical, industrial, trade and service sectors.

Our company began developing and manufacturing high-performance ultrasonic devices back in 1955. The constant expansion of the product range and the sharp rise in sales figures led to an expansion of the production area in 1985. In 1992, ultrasonic homogenisers and adjustable, constant-power ultrasonic generators were introduced to the market.
The period from 1996 to 2004 was characterised by the development and production of innovative ultrasonic cleaning baths and immersible converters as well as tubular reactors for industrial applications.

In the years that followed, BANDELIN's product range was expanded to include new laboratory ultrasonic devices. Following the introduction of the ultrasonic bath for the simultaneous cleaning and rinsing of MIS instruments, its further development for robotic instruments followed in 2016.

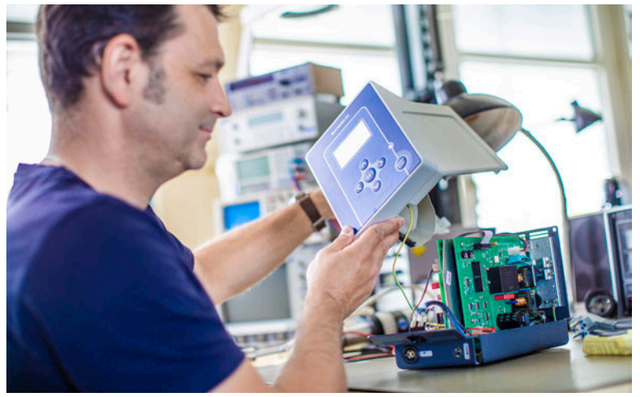
Today, the reputation of our brands SONOREX, SONOPULS, SONOMIC and TRISON stands for the high quality awareness of our employees and is equated with ultrasound in professional circles.

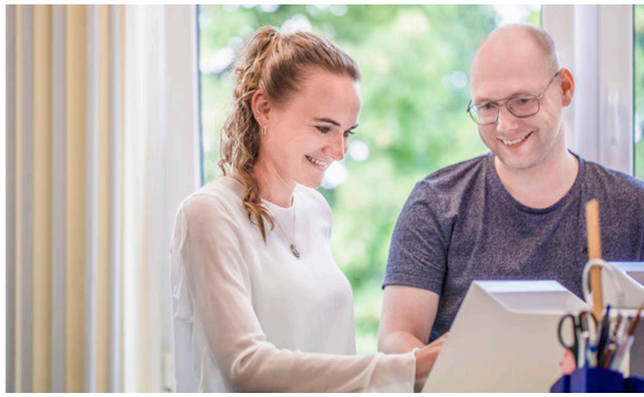
The most important product groups include

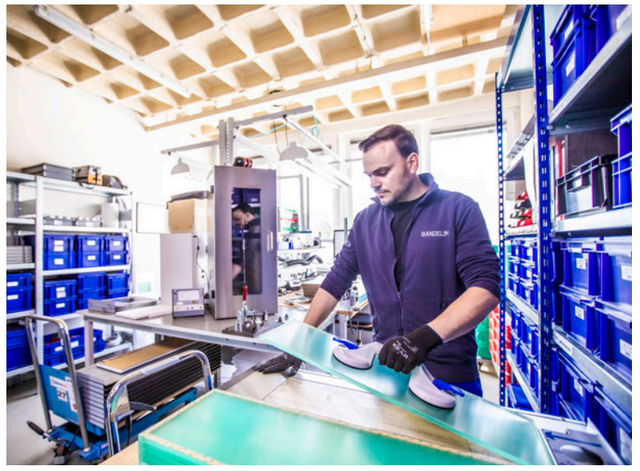
SONOREX	- Ultrasonic baths and reactors
SONOPULS	- Ultrasonic homogenisers
SONOMIC	- Ultrasonic bath for rinsable MIS and standard instruments
TRISON	- Ultrasonic bath for robotic, rinsable MIS and standard instruments
TICKOPUR	- Cleaning preparations
STAMMOPUR	- Cleaning and disinfection products

We are innovators in the development of new ultrasonic devices and the opening up of new areas of application and have registered 79 patents / utility models and 68 trade marks in the past. Our involvement in various committees in the development of new standards and guidelines serves to ensure the highest standards for ultrasonic applications.

BANDELIN is the only full-range supplier of ultrasonic devices, accessories and disinfection and cleaning agents with approvals and certifications in accordance with ISO 9001 and ISO 13485 and is the market leader. over one million devices have already been delivered to our customers.







Take a look at our company portrait laboratory!

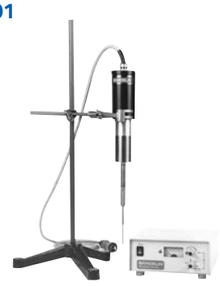
1964

SONOREX HE 1
Production of the first ultrasonic homogenisers with tube technology

1986

SONOPULS SD 9

1991



SONOPULS Series HD 70/200/400

1999

SONOPULS Series HD 2000

2004

SONOPULS Series HD 3000

2016

SONOPULS Series HD 4000

2022

SONOPULS Series HD 5000

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Ultrasound in laboratory and in process engineering

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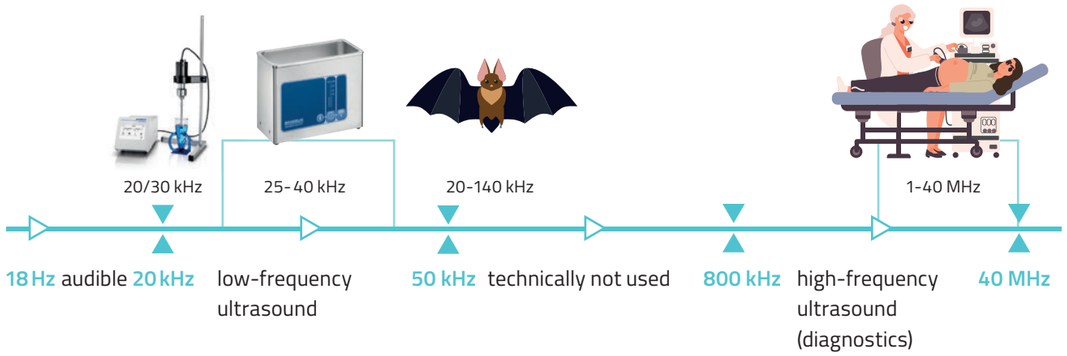
What is ultrasound? How does it work?



What is ultrasound and how does it work?

Vibrations with frequencies above 18 kHz (18.000 oscillations per second) are referred to as ultrasound. The low-frequency ultrasound range is used in laboratories, while a higher frequency range is used in medical diagnostics.

The low-frequency ultrasonic vibrations generate millions of tiny vacuum bubbles in all liquids, which immediately implode again, creating highly effective pressure surges. This process is called cavitation. Low frequencies around 20 kHz generate bubbles of larger diameters with more intense pressure surges than higher frequencies around 35 kHz. The low-frequency ultrasound range has been used for decades in a wide variety of ultrasonic baths.

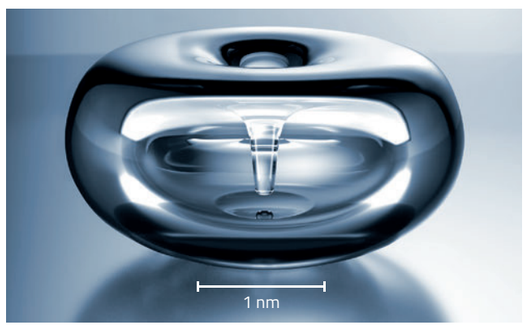
The cavitation process ensures that impuritiesare blown off the surfaces of the parts in the liquid very effectively and gently, even from recesses and holes.

Other applications include degassing or mixing liquids.

Cleaning with a SONOREX ultrasonic bath from BANDELIN

Cavitation

Ultrasound generates an intensive pressure-pull alternation in aqueous liquids, creating extremely fine cavitation bubbles, which grow over several cycles and then implode intensively. The resulting high shear forces and microjets of the implosion blast off all adhering impuritiesfrom the surface in a short time.



Cavitation bubble

Ultrasonic homogeniser vs. ultrasonic bath

Compared to the very common ultrasonic baths, the so-called ultrasonic homogenisers can be used to apply a much higher power density in the liquid. the sonic power is emitted into the liquid via the working tip (probe). The oscillation of the probe creates the millions of tiny vacuum bubbles described at the tip, which implode again very quickly and trigger pressure surges of more than 1,000 bar, leading to the dissolution of particles or mixing of solution components.

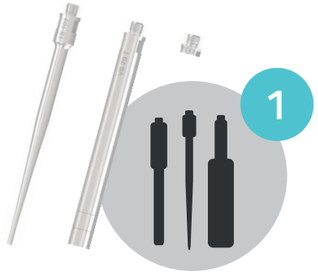
The following table illustrates the differences between ultrasonic homogenisers and baths.

	SONOPULS ultrasonic homogeniser	SONOREX ultrasonic bath
Sample volumes	0.1–3,000 ml	ca. 10–3,000 ml (indirect sample sonication)
Amplitude [µm] (peak to peak)	42–280	ca. 4
Intensity [W/l]	ca. 790 (with indirect sound)	up to 50
Frequency [kHz]	20/30	35/40
Sonic distribution	focused	broad
External input due to cavitation erosion	minor ablation at the probe tip during direct sonication, traces of tiny titanium particles (TiAl6V4) in the sample. With indirect sample sonication: no particle intrusion into the sample.	low

Compared to ultrasonic baths, ultrasonic homogenisers can be used to carry out difficult processes, such as the production of stable emulsions, the disruption of cells, the acceleration of chemical processes or the extraction of substances, as these devices deliver highly concentrated, extremely high energy densities. The emitted sound energy can be regulated in a controlled manner. This makes it possible to break down certain components of the medium and leave others undamaged. The amplitude is constantly recorded and shown on the display. The results are therefore easily reproducible.

Quick Start -
for using devices in the laboratory

On the following pages, the method itself and its many possible applications are explained in detail for a good understanding.
Here are the most important steps for a quick start with SONOPULS:

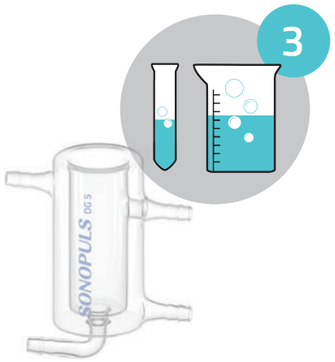


1

Selection of the probe to suit the application
The choice of probe is based primarily on the sonication volume and the size and shape of the sample vessel.

2

Structure of an ultrasonic homogeniser
Assembly according to instructions for use



3

Vessel selection
Narrow, taller containers are generally more suitable than wider, shallower ones with the same volume.
The container should not be more than 2/3 full of liquid (risk of splashing).
A laboratory pump and/or an external cooling system must be available for flow-through vessels.

4

Overview of detailed applications with information on all details of the application
The applications provide information on the selection of sonicationparameters for special applications.

5

Selection of the sonication parameters
The choice of sonication parameters depends on the sample and the process used.
Amplitude, pulsation and sonication duration can be set on the ultrasonic generator.
Temperature monitoring of the sample is possible with an optional temperature sensor.

6

Further instructions for use
Tips and tricks
- Fixing the ultrasonic converter
- Immersion depth of the probe
- Sonication of chunky sample material in a liquid

Use our **LS 40** sound proof box for a significant reduction in noise during use.
Find out more at www.sonopuls.info or get in touch with us!

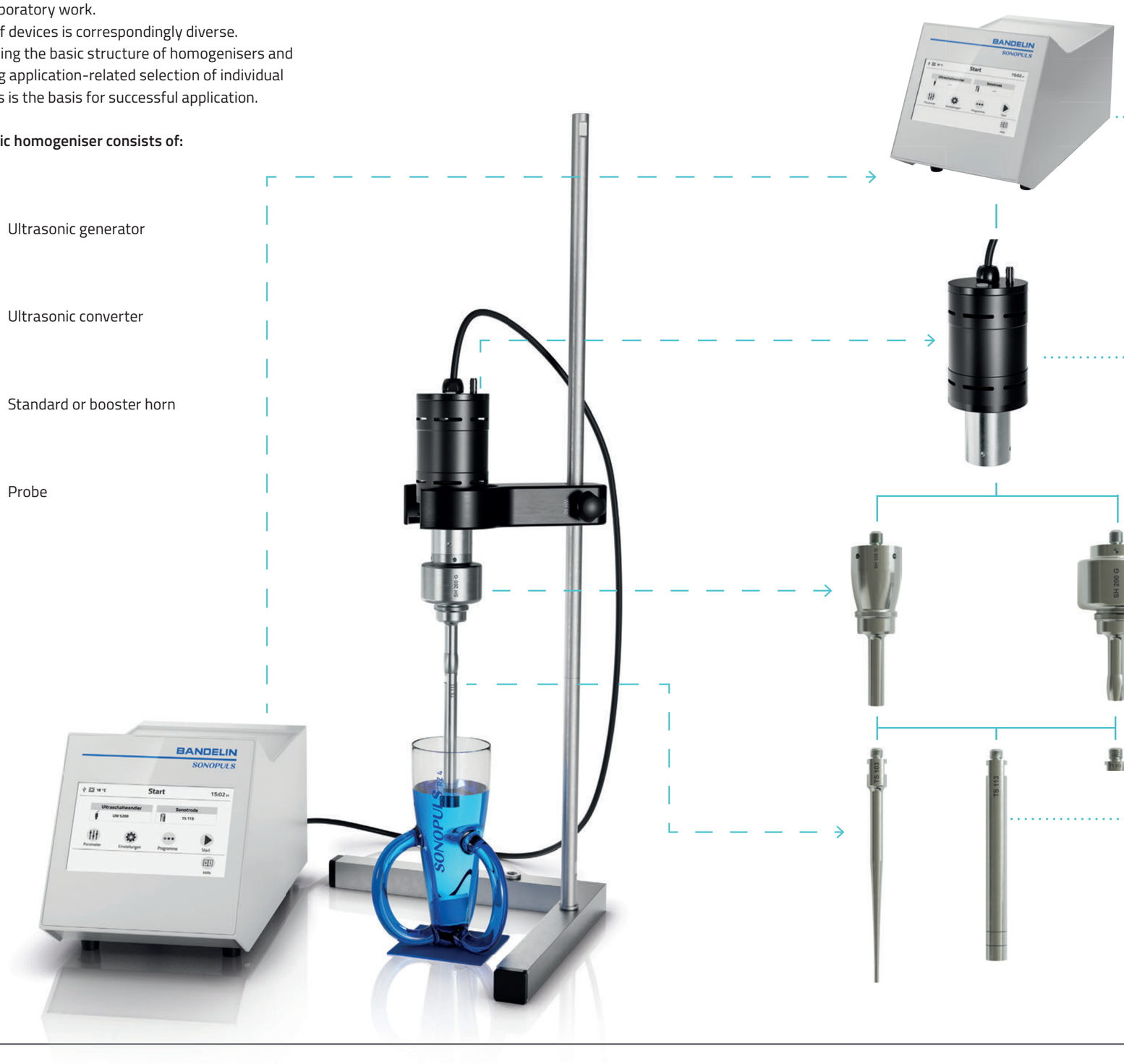
Video about the noise protection box

Structure of an ultrasonic homogeniser

Ultrasonic homogenisers fulfil a wide variety of tasks in everyday laboratory work.
The range of devices is correspondingly diverse.
Understanding the basic structure of homogenisers and the resulting application-related selection of individual components is the basis for successful application.

An ultrasonic homogeniser consists of:

- Ultrasonic generator
- Ultrasonic converter
- Standard or booster horn
- Probe



Ultrasonic generator

Converts the inputted low-frequency mains voltage of 50 or 60 Hz into a high-frequency voltage of 20 or 30 kHz (HD 5020). All process parameters and sequences are shown on the large touch displaymetres.

Ultrasonic converter

Converts the electrical voltage supplied by the generator into longitudinal mechanical oscillations of the same frequency (piezo effect) by using piezo ceramics.

Standard and booster horns

These are resonance bodies made of a high-strength titanium alloy and tuned to a frequency of 20 kHz and amplify the amplitudes of the mechanical vibrations coming from the ultrasonic converter.
The amplification factor of the amplitude depends on their geometry.

Probes

Emit the transferred energy into the sample. The oscillations are only emitted from the tip, not from the sides. A high amplitude means particularly intensive sonication. Due to their geometry, some probes can achieve multiple amplitude amplification. The probes thus achieve the highest ultrasonic power densities in liquids.

Factors for reproducibility of the sonication results

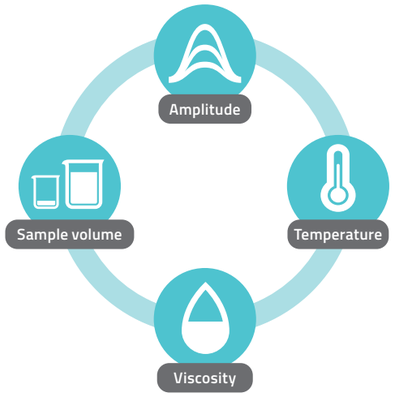
Understanding the terms "power" and "amplitude"

When selecting an ultrasonic homogeniser, the electrical power rating [W] alone is not decisive. This value indicates the **power consumption** of the ultrasonic generator, **but not the power introduced into the sample**. Decisive for the efficiency and reproducibility of the sonication result is the amplitude (longitudinal motion) of the probe in relation to the sample quantity.
SONOPULS ultrasonic homogenisers deliver **higher amplitudes** than commercially available devices with **the same electrical power consumption.**
Amplitude and intensity are directly related; a low amplitude means a low intensity. To ensure the reproducibility of sonication results, the amplitude, temperature, viscosity and volume of the sample must always be the same. The power of the generator is not the decisive parameter. This is in a variable relationship to the amplitude/intensity. When sonicating water, less power is required for the same amplitude than when sonicating highly viscous samples.

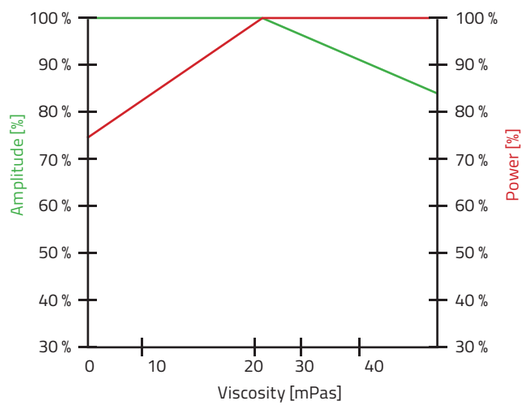
At a viscosity below 20 mPas, the generator changes the power to keep the amplitude constant. At higher viscosities, the generator has reached the power limit, cannot provide any more power and the amplitude therefore decreases.

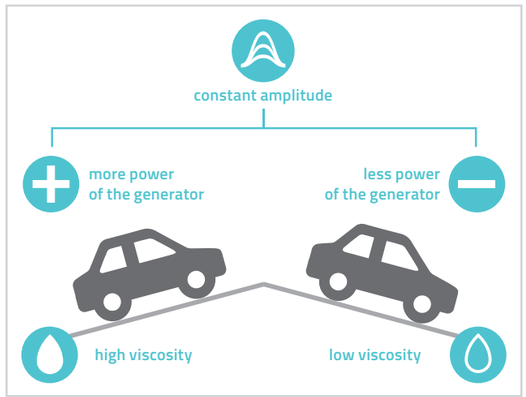
Example
The higher the viscosity of the medium to be sonicated , the more power is required to achieve the same amplitude! You can compare this to the speed of a car: Target: 40 km/h (= amplitude), more power is required to maintain this speed when travelling uphill.

Factors for the reproducibility of the sonication results



Amplitude and power as a function of viscosity





Power determination

In the description of test setups, the power is specified as power density in W/cm² in relation to the sound-emitting surface of the probe.

When determining this parameter, the power input of the ultrasonic homogeniser is often taken as the basis. The losses, which can be considerable in the generator and up to the horn, are neglected. The specification of the electrical power density per unit area using the power consumption and the probe radiation area is therefore only a rough estimate.
At the 2nd Symposium of the European Society of Sonochemistry (ESS) in September 1991, Rotoarinoro et al.[1] presented the principle of calorimetric power determination as a suitable method under the title "Power dissipation measurements in sonochemical reactors".
To determine the applied power, the vessel, ideally a Dewar vessel or another vessel used in everyday laboratory work, should be used as a test vessel. This vessel is filled with water. The water is sonicated for a defined period of time and the temperature increase is measured. In the calorimetric measurement, the amount of heat ΔQ can be determined using the heat capacity c and the temperature difference ΔT. This results in the power input, taking into account the time difference Δt. The following formula[2] applies:

$$P = \frac{\Delta Q}{\Delta t} = \frac{c \cdot m \cdot \Delta T}{\Delta t}$$

It applies:

P	Power [W]
ΔQ	Energy supplied, in this case the amount of heat [Ws]
Δt	Time [s]
c	Specific heat capacity $[\frac{J}{kg\,K}]$
m	Mass of the test water quantity [kg]
ΔT	Temperature difference [K]

The volumetric power density can be calculated by taking the water volume into account.

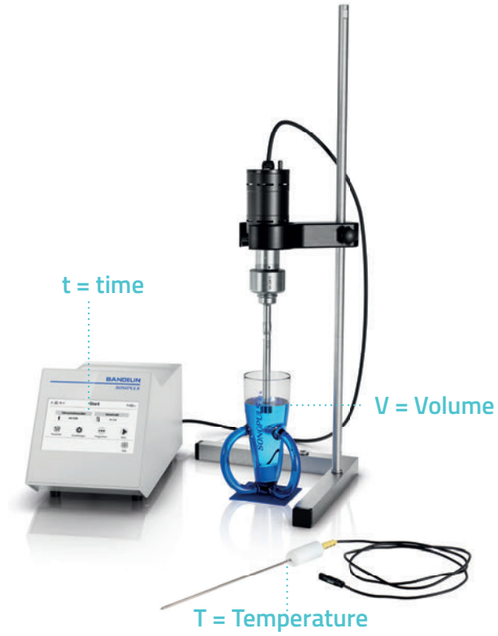
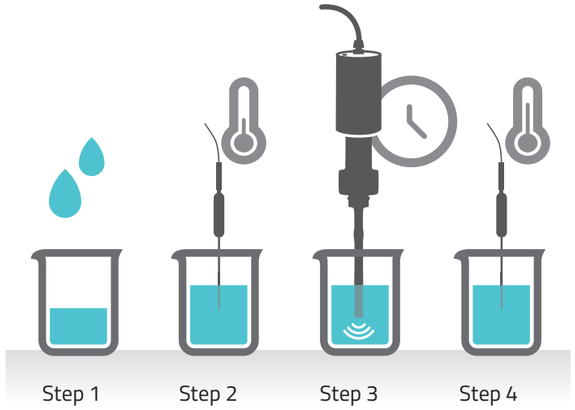


Illustration of the experimental set-up of a calorimetric Measurement to determine performance



The homogenisers are not controlled to a constant electrical power! SONOPULS ultrasonic homogenisers are controlled by the AMPLICHRON circuitry to a constant amplitude of the probe.
When carrying out a reaction and reproducing it, the constancy of the amplitude is of particular importance. All influences from the heating of the sample or the change in viscosity are thus eliminated. This means that the power determination according to the method described must always be carried out with the same type of liquid at the same initial temperatures to ensure reproducible results.

[1] Rotoarinoro, A., M. Wilhelm, J. Berlan, H. Delmas: „Power dissipation measurements in sonochemical reactors", in: Bericht zum 2. Symposium des ESS; 1991; Seite 109 f.
[2] Note: The formula is only sufficiently accurate for small volumes.

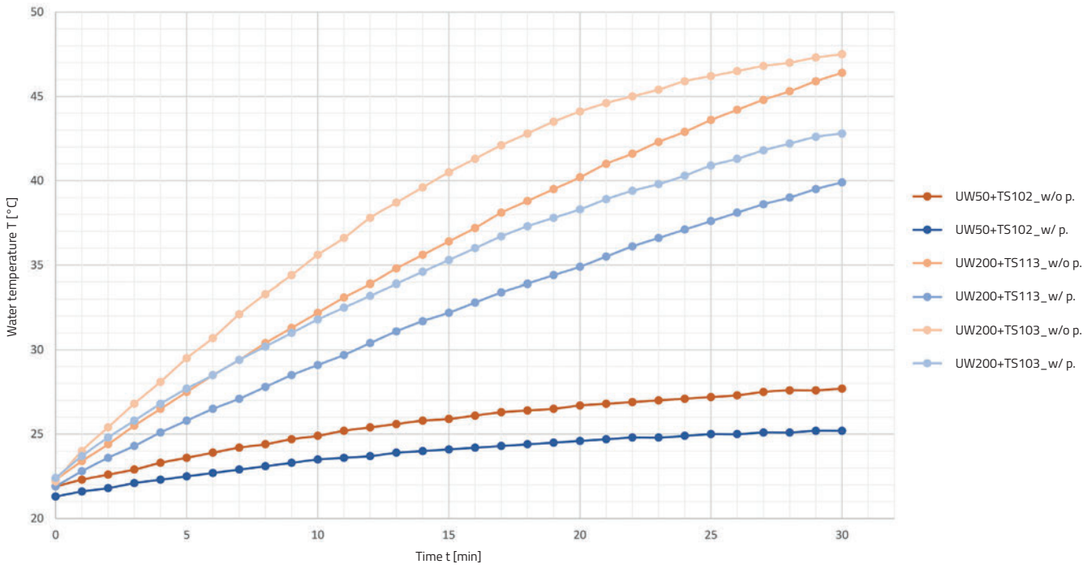
The AMPLICHRON process

The AMPLICHRON method from BANDELIN guarantees a constant amplitude and supports reproducible results, regardless of changing conditions in the sample to be sonicated. The relative amplitude in per cent is specified for BANDELIN devices and shown on the display. If the actual value of the amplitude does not correspond to the set value, e.g. due to probe wear (see chapter 3) or because the viscosity of the medium is too high, this is easy to recognise and provides an indication of the reproducibility of the results!

Pulsation

All SONOPULS ultrasonic homogenisers have a pulse function. This allows the entire process duration to be divided into active sonication times and rest times. This intermittent process limits the temperature increase of heat-sensitive samples. This is particularly important when sonicating very small quantities or resistant microorganisms with a long sonication duration.

Temperature rise during sonication with 20 % relative amplitude with pulsation (w/ p.; ON: 60 s, OFF: 20 s) and without pulsation (w/o p.)



The SONOPULS ultrasonic homogeniser

02

SONOPULS product overview

The right homogeniser with matching accessories for every application

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SONOPULS HD 5020

Ultrasonic homogeniser
30 kHz and 20 W

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SONOPULS HD 5050

Ultrasonic homogeniser
20 kHz and 50 W

Page 25

SONOPULS HD 5100

Ultrasonic homogeniser
20 kHz and 100 W

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SONOPULS HD 5200

Ultrasonic homogeniser
20 kHz and 200 W

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SONOPULS Series HD 5000 – Ultrasonic converter

Presentation of the various ultrasonic converters

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SONOPULS Series HD 5000 – Ultrasonic generator

Explanation of the ultrasonic generator and its operation

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SONOPULS Series HD 4000

Ultrasonic homogenisers
HD 4050, 4100, 4200 and 4400

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SONOPULS Series HD 4000 – Ultrasonic converter

Presentation of the various ultrasonic converters

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SONOPULS Series HD 4000 – Ultrasonic generator

Explanation of the ultrasonic generator and its operation

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SONOPULS Standard and booster horns

Overview of the various standard and booster horns

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Selection and use of the probes

The most important areas of application and features

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SONOPULS – Probe

Overview of the various probes with the most important key data

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Vessel systems for direct and indirect sonication

Various types with and without cooling as well as practical accessories

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SONOPULS HD 4000 / 5000 – Graphics devices and accessories

Schematic overviews of all possible combinations of devices and accessories

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Stand, sound proof box, temperature sensor and footswitch

Work more comfortably with the matching accessories

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LABOCOOL LC 200 Recirculating chiller

Effective cooling during sample sonication with the SONOPULS ultrasonic homogeniser

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SONOPULS Product overview

Thanks to the wide variety of devices and accessories, the optimum equipment can be put together for the respective application:

- Selection of the SONOPULS series
- Probe type
- Direct or indirect sonication
- Sonication of larger quantities in flow-through
- Cooling during sonication

Even after purchasing a device for individual initial applications, there are many options for customising it for further applications by purchasing various accessories at a later date.

HD 5000 Series

The new one with 7" touch display

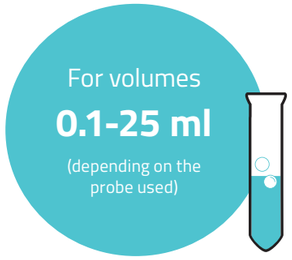
HD 4000 series

Our proven bestseller

	HD 5000 Series	HD 4000 series
Probenvolumine im - Batch operation - Flow-through operation	0.1–1,000 ml up to 100 l / h	0.5–3,000 ml up to 100 l / h
Possible probes Ø [mm]	1.5 / 2 / 2,5 / 3 / 4,5 / 6 / 9 / 13 / 16 / 19 / 25	2 / 3 / 4.5 / 6 / 9 / 13 / 16 / 19 / 25 / 32 / 38
Possible configurations: Ultrasonic generator GM, Ultrasonic converter UW	GM 5050 + UW 5020 or UW 5050 GM 5200 + UW 5100 or UW 5200	GM 4200 + UW 200 or UW 100 or UW 50 GM 4400 + UW 400 or UW 200
Relative Amplitude	10-100 %	10-100 % (setting range depends on probe type)
Automatic Amplitude limitation	after entering the probe type on the generator	after entering the probe type on the generator
Pulsation	Working intervals 0.5-600 s Rest intervals 0.5-600 s	Working intervals 0.2-600 s Rest intervals 0.3-600 s
Time setting	99 h 59 min 59 s or continuous operation	9 h 59 min 59 s or continuous operation
Display elements	7" touch display, color	alphanumeric LC display
Energy display	in Ws	in kJ
Temperaturedisplay and measurement	optional, -10 to 120 °C, Temperature sensor required, optional acoustic signal / switch off	optional, -10 to 120 °C, Temperature sensor required, optional acoustic signal / switch off
Batch operation Sequencing	✓ several batches in succession	✓ several batches in succession
Interface	Ethernet, USB	RS 232 (Sub-D)
Fault diagnosis	✓	✓
Operating frequency	20/30 kHz	20 kHz
Programmememory	8	9
Function test	✓	✓
Mains connection	**HD 5020/5050:** 100-240 V~ (±10 %), 50/60 Hz **HD 5100/5200:** 230 VAC (±10 %), 50/60 Hz	230 V~ (±10 %), AC 115 V~ (±10 %), 50/60 Hz (except HD 4400)

SONOPULS HD 5020
Ultrasonic homogeniser 30 kHz and 20 W

The HD 5020 is ideal for the gentle sonication of very small sample volumes of 0.1-25 ml at 30 kHz with probes with a diameter of 1.5-2.5 mm. The generator produces an output of up to 20 W.



Ready-to-use set:

Nominal ultrasonic power max. 20 W
- Ultrasonic generator GM 5050
- Ultrasonic converter UW 5020
- Probe MS 1.5, Ø 1.5 mm (for volumes 0.1–10 ml)
- Tools for mounting the probes

Code no.
15020 - EU plug CEE 7/7
15020-GB - GB connector BS 1363
15020-CH - CH connector SEV 1011: T12
15020-1 - US plug NEMA 5–15

Note:

Low noise level compared to the more powerful homogenisers.

Sample containers:

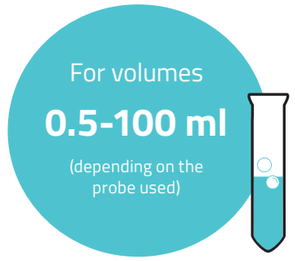
- PCR tubes
- Cryotubes
- Reaction cups

Ultrasonic generator	GM 5050
l × w × h [mm]	380 × 195 × 215
Ultrasonic converter	UW 5020
Ø × L [mm]	50 × 150
Suitable probes Ø [mm]	1.5 / 2.0 / 2.5

MS 1.5 MS 2.0 MS 2.5

SONOPULS HD 5050
Ultrasonic homogeniser 20 kHz and 50 W

The HD 5050 is particularly suitable for the gentle sonication of small sample volumes of 0.5-100 ml at 20 kHz and probes with a diameter of 2-9 mm. The generator operates with an output of up to 50 W.



Ready-to-use set:

Nominal ultrasonic power max. 50 W
- Ultrasonic generator GM 5050
- Ultrasonic converter UW 5050
- Probe TS 102, Ø 2 mm (for volumes 0.5-20 ml)
- Tools for mounting the probes

Code no.
15050 - EU plug CEE 7/7
15050-GB - GB connector BS 1363
15050-CH - CH connector SEV 1011: T12
15050-1 - US plug NEMA 5-15

Sample containers:

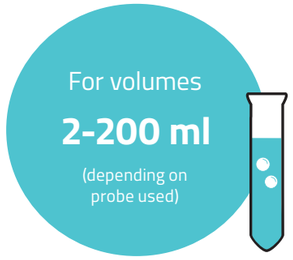
- PCR tubes
- Cryotubes
- Reaction cups

Ultrasonic generator	GM 5050
l × w × h [mm]	380 × 195 × 215
Ultrasonic converter	UW 5050
Ø × L [mm]	50 × 185
Suitable probes Ø [mm]	2 / 3 / 4.5 / 6 / 9

TS 102 TS 103 TS 104 TS 106 TS 109

SONOPULS HD 5100
Ultrasonic homogeniser 20 kHz and 100 W

The HD 5100 optimally sonicates sample volumes of 2-200 ml at 20 kHz and probes with a diameter of 2-13 mm. Up to 100 W of power is provided by the generator.



Ready-to-use set:

Nominal ultrasonic power max. 100 W
- Ultrasonic generator GM 5200
- Ultrasonic converter UW 5100
- Step horn SH 100 G
- Probe TS 103, Ø 3 mm (for Volumina 3-50 ml)
- Tools for mounting the probes

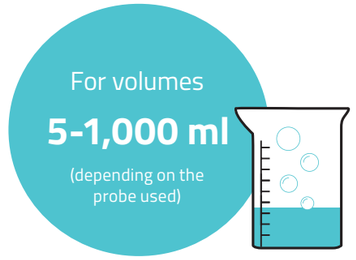
Code no.
15100 - EU plug CEE 7/7
15100-GB - GB connector BS 1363
15100-CH - CH connector SEV 1011: T12

Sample containers:
- Cryotubes
- Reaction cups
- Beakers

Ultrasonic generator	GM 5200
l × w × h [mm]	380 × 195 × 215
Ultrasonic converter	UW 5100
Ø × L [mm]	70 × 155
Suitable probes Ø [mm]	2 / 3 / 4.5 / 6 / 9 / 13

SONOPULS HD 5200
Ultrasonic homogeniser 20 kHz and 200 W

The HD 5200 is ideal for gentle sonication of medium sample volumes in the range of 5-1,000 ml at 20 kHz and with probes with a diameter of 3-25 mm. The generator produces an output of up to 200 W.



Ready-to-use set:

Nominal ultrasonic power max. 200 W
- Ultrasonic generator GM 5200
- Ultrasonic converter UW 5200
- Booster horn SH 200 G
- Probe TT 213, Ø 13 mm (for volumes 20-900 ml)
- Tools for mounting the probes

Code no.
15200 - EU plug CEE 7/7
15200-GB - GB connector BS 1363
15200-CH - CH connector SEV 1011: T12

Sample containers:
- Reaction cups
- Beakers
- Rosette cells
- Laboratory flask

Ultrasonic generator	GM 5200
l × w × h [mm]	380 × 195 × 215
Ultrasonic converter	UW 5200
Ø × L [mm]	70 × 155
Suitable probes Ø [mm]	3 / 4.5 / 6 / 9 / 13 / 16 / 19 / 25

SONOPULS Series HD 5000
Ultrasonic converter

The right ultrasonic converter for every application.

Kompatibilität:
GM 5050 for UW 5020 and UW 5050,
GM 5200 for UW 5100 and UW 5200

Ultrasonic converter UW 5200

Buttons

There is a button on the ultrasonic converter. This can be used to switch ultrasonic operation ON/OFF and to control hand-guided pulsation. There is also a connection socket on the ultrasonic converter for using a temperature sensor to monitor the sample temperature.

Ultrasonic converter UW 5050

Connection for temperature sensor TM 5000

For temperature monitoring, the temperature sensor is connected to the socket provided for this purpose, which is otherwise covered with a dust cap. A temperature display appears on the generator, allowing the user to record the temperature at any time. If the limit temperature is exceeded, a warning signal sounds and/or the process is automatically stopped.

Temperature sensor TM 5000

Ultrasonic converter

An ultrasonic converter is used to convert the electrical energy supplied by the ultrasonic generator into mechanical vibrations.

With the exception of the UW 5020, which operates at 30 kHz, all other SONOPULS ultrasonic converters in the 5000 series operate at an ultrasonic frequency of 20 kHz.

Ultrasonic operation can be started and stopped by operating the "Start", "Pause" and "Stop" buttons on the touch display or via the button on the ultrasonic converter. Two options can be selected for the function of the button on the ultrasonic converter. The options can be selected under "Settings".

Ultrasonic converter UW 5020

Operating frequency:
30 kHz

Dimension:
Ø 50 × 150 mm

Cable length:
2.5 m

Code No. 3738

Ultrasonic converter UW 5050

Operating frequency:
20 kHz

Dimension:
Ø 50 × 185 mm

Cable length:
2.5 m

Code No. 3739

Ultrasonic converter UW 5100

Operating frequency:
20 kHz

Dimension:
Ø 70 × 155 mm

Cable length:
2.5 m

Code No. 3749

Ultrasonic converter UW 5100 with standard horn SH 100 G
Code No. 3764

Ultrasonic converter UW 5200

Operating frequency:
20 kHz

Dimension:
Ø 70 × 155 mm

Cable length:
2.5 m

Code No. 3761

Ultrasonic converter UW 5200 with booster horn SH 200 G
Code No. 3765

SONOPULS Series HD 5000
Ultrasonic generator

There are two different ultrasonic generators to choose from. They are specified for various applications due to their different power ranges. The easy-care and robust plastic housing, equipped with a practical recessed grip for easy transportation and positioning on the laboratory bench, is identical for both versions. The various SONOPULS ultrasonic homogenisers in the HD 5000 series can be connected directly to the ultrasonic generators depending on their compatibility.

The modern 7" touch display offers intuitive, user-friendly operation. Setting the set values for amplitude, pulsation and time and the display of the actual values enable reproducible results.

Ultrasonic generator GM 5050

Suitable for:
- UW 5020 / UW 5050

Further information:
- External dimensions (l × w × h): 380 × 195 × 215 mm
- Mains cable: 1.5 m
- Mains connection 100-240 V~ ±10 %, 50/60 Hz

Code no.
373602 - 230 V EU plug CEE 7/7
373602-GB - 230 V GB plug BS 1363
373602-CH - 230 V-CH Connector SEV 1011: T12
373602-1 - 115 V US plug NEMA 5-15

Ultrasonic generator GM 5200

Suitable for:
- UW 5100 / UW 5200

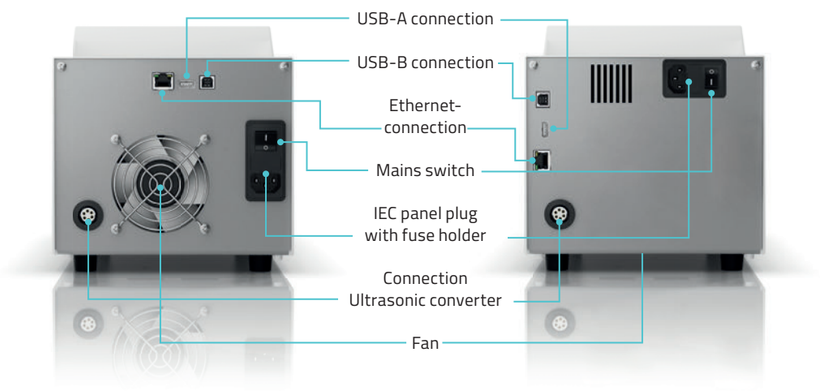
Further information:
- External dimensions (l × w × h): 380 × 195 × 215 mm
- Mains cable: 1.5 m
- Mains connection 230 VAC (±10 %), 50/60 Hz

Code no.
3736 - 230 V EU plug CEE 7/7
3736-GB - 230-V-GB plug BS 1363
3736-CH - 230 V-CH plug SEV 1011: T12

Front side

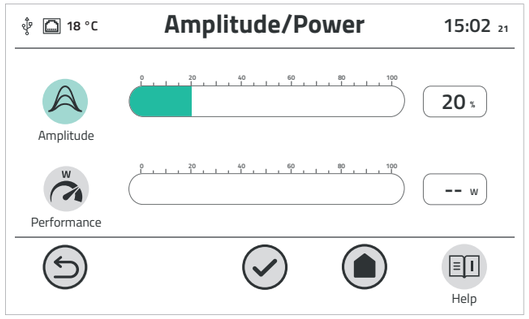
7"-touch display, color, comfortable inclination

Back side GM 5050



Back side GM 5200

Operating concept / Display

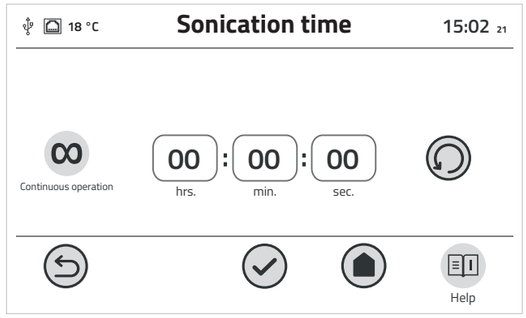


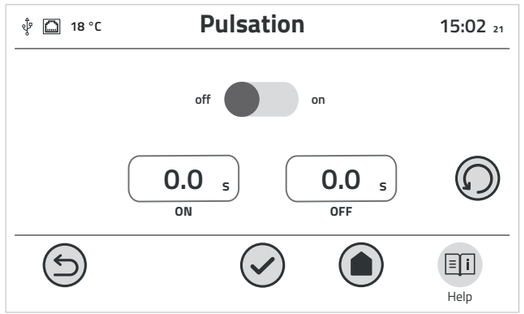
Amplitude and power setting

Amplitude setting in 1-% increments (in the range from 10-100 %) for all probes. The alternative power control in watts is also possible via a slider or a numerical input. The display of actual values allows continuous process control.

Time setting and sequence

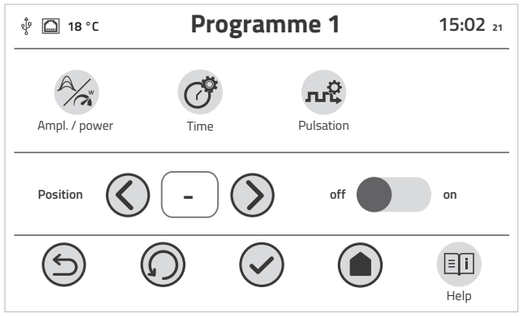
Selectable time settings: Timer (countdown) by setting the sonication time or continuous operation (up to 99 h : 59 min : 59 s). In continuous mode, the elapsed time is displayed, while the remaining time is displayed in timer mode.





Pulsation

For safe sonication of temperature-sensitive samples, the pulse interval can be customised in 0.1-s-steps. The desired sonication duration and the pause can be set independently of each other in the range of 0.5–600 s.

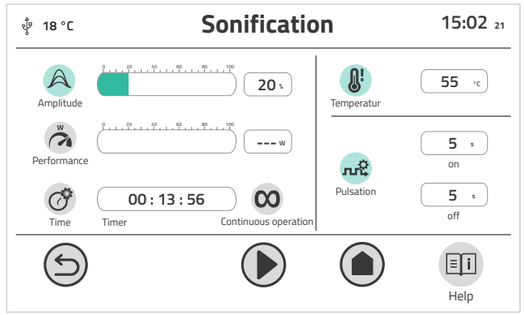


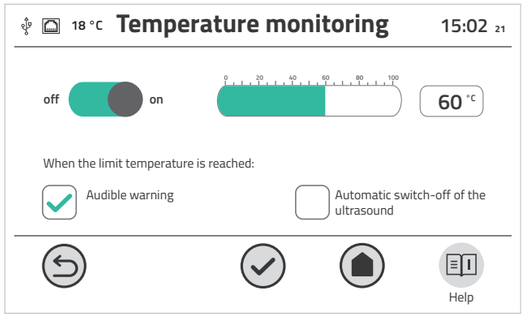
Programme memory

Save recurring processes as a programme to start them quickly and easily at the touch of a button. Up to 8 programmes can also be combined and played automatically one after the other in any order.

Process display

Display and control of all set parameters of the current programme during operation, including the remaining running time or elapsed time.





Temperature monitoring

The optional TM 5000 temperature sensor ensures constant monitoring of the sample temperature. If required, a warning signal appears when the limit temperature is reached or the ultrasound is switched off directly.

Help

If an error occurs, it is shown on the display. Help screens provide step-by-step instructions on how to solve the problem.

SONOPULS Series HD 4000
Ultrasonic homogenisers

SONOPULS HD 4050

for volumes from 0.5–100 ml
(depending on the probe used)

- Available probes Ø:
  2 / 3 / 4.5 / 6 / 9 mm

Ready-to-use set:
Nominal ultrasonic power max. 50 W

- Ultrasonic generator GM 4200
- Ultrasonic converter UW 50
- Probe TS 102, Ø 2 mm
  (for volumes 0.5-20 ml)
- Tools for mounting the probes

Code No.
4050 - EU plug CEE 7/7
4050-GB - GB connector BS 1363
4050-CH - CH connector SEV 1011: T12
4050-1 - US plug NEMA 5-15

SONOPULS HD 4100

for volumes from 2–200 ml
(depending on the probe used)

- Available probes Ø:
  2 / 3 / 4.5 / 6 / 9 / 13 mm

Ready-to-use set:
Nominal ultrasonic power max. 100 W

- Ultrasonic generator GM 4200
- Ultrasonic converter UW 100
- Step horn SH 100 G
- Probe TS 103, Ø 3 mm
  (for Volumina 3-50 ml)
- Tools for mounting the probes

Code No.
4100 - EU plug CEE 7/7
4100-GB - GB Connector BS 1363
4100-CH - CH Connector SEV 1011: T12
4100-1 - US plug NEMA 5-15

SONOPULS HD 4200

for volumes from 5-1,000 ml
(depending on the probe used)

- Available probes Ø:
  3 / 4.5 / 6 / 9 / 13 / 16 / 19 / 25 mm

Ready-to-use set:
Nominal ultrasonic power max. 200 W

- Ultrasonic generator GM 4200
- Ultrasonic converter UW 200
- Booster horn SH 200 G
- Titanium plate TT 213, Ø 13 mm
  (for volumes 20-900 ml)
- Tools for mounting the probes

Code No.
4200 - EU plug CEE 7/7
4200-GB - GB Connector BS 1363
4200-CH - CH Connector SEV 1011: T12
4200-1 - US plug NEMA 5-15

SONOPULS HD 4400

for volumes from 100-3,000 ml
(depending on the probe used)

- Available probes Ø:
  13 / 16 / 19 / 25 / 32 / 38 mm

Ready-to-use set:
Nominal ultrasonic power max. 400 W

- Ultrasonic generator GM 4400
- Ultrasonic converter UW 400
- Booster horn SH 400 G
- Probe TS 425, Ø 25 mm
  (for volumes 500-2000 ml)
- Tools for mounting the probes

Code No.
4400 - EU plug CEE 7/7
4400-GB - GB Connector BS 1363
4400-CH - CH Connector SEV 1011: T12

Ultrasonic converter

An ultrasonic converter is used to convert the electrical energy supplied by the ultrasonic generator into mechanical vibrations.

All SONOPULS ultrasonic converters in the 4000 series operate at an ultrasonic frequency of 20 kHz.

Ultrasonic operation can be started and stopped by pressing the "START/STOP" button on the generator or via the button on the ultrasonic converter. Ultrasonic operation is active as long as the button is pressed. The button can be used to pulse manually.

Ultrasonic converter UW 50

Suitable for:
GM 4200

Dimension:
Ø 50 × 190 mm

Cable length:
2.5 m

Code No. 3720

Ultrasonic converter UW 100

Suitable for:
GM 4200

Dimension:
Ø 70 × 170 mm

Cable length:
2.5 m

Code No. 3721

Ultrasonic converter UW 200

Suitable for:
GM 4200 / 4400

Dimension:
Ø 70 × 170 mm

Cable length:
2.5 m

Code No. 3722

Ultrasonic converter UW 400

Suitable for:
GM 4400

Dimension:
Ø 90 × 180 mm

Cable length:
2.5 m

Code No. 3723

SONOPULS Series HD 4000
Ultrasonic generator

The ultrasonic generator transforms the absorbed mains energy (mains frequency 50 or 60 Hz) into high-frequency energy with a frequency of 20 kHz.
It is housed in an easy-care and robust plastic casing with connections for ultrasonic converter, temperature sensor and foot switch.
The control and display panel with backlit LC display shows operating parameters and status information.
The ultrasonic operating modes are either pulsating or continuous. The ultrasonic power is set via the amplitude on the generator. The nine programme memory locations are used to quickly start recurring processes.

Ultrasonic generator GM 4200

Suitable for:
- HD 4050
- HD 4100
- HD 4200

External dimensions (l × w × h):
335 × 150 × 230 mm

Power range:
30-150 W

Code No.
3711 - 230 V EU plug CEE 7/7
3711-GB - 230-V-GB plug BS 1363
3711-CH - 230 V-CH Connector SEV 1011: T12
3711-1 - 115 V US plug NEMA 5-15

Ultrasonic generator GM 4400

Suitable for:
- HD 4200
- HD 4400

External dimensions (l × w × h):
335 × 150 × 230 mm

Power range:
60-300 W

Code No.
3715 - 230 V EU plug CEE 7/7
3715-GB - 230-V-GB plug BS 1363
3715-CH - 230-V-CH plug SEV 1011: T12

Front side

LC-Display
Control LED
Control buttons
START/STOP" button
Mains switch
Connection for temperature sensor
Connection for ultrasonic converter MINI-SNAP®

Back side

Remote control socket
IEC panel plug with fuse holder
RS-232 interface

SONOPULS
Standard and booster horns for the HD 5000 and HD 4000 series

Standard and booster horns are made of a titanium alloy (TiAl6V4) in various shapes and sizes. They transmit the vibrations from the ultrasonic converter to the probe and increase the amplitude. The corresponding horn is firmly bolted to the ultrasonic converter. All standard and booster horns are equipped with a fixed threaded pin. This enables quick and easy assembly to the ultrasonic converter using the corresponding tool without any additional aids. Horns labelled SH are suitable for connecting probes of different diameters, horns labelled TH have a fixed working tip. The external thread enables the tight connection of vessels with standard ground joint NS 29/32 or 45/40 using standard ground joint adapters NA. Reaction vessels with a DN 20 flange can be mounted tightly using the FA flange adapter.

Horns for interchangeable probes

SH standard and booster horns offer the option of connecting probes with different diameters.

	Standard horns	Booster horns	
Type	SH 100 G	SH 200 G	SH 400 G
For UW	100 / 5100	200 / 5200	400
Code No.	3731	3732	3734

Horns with fixed working tip

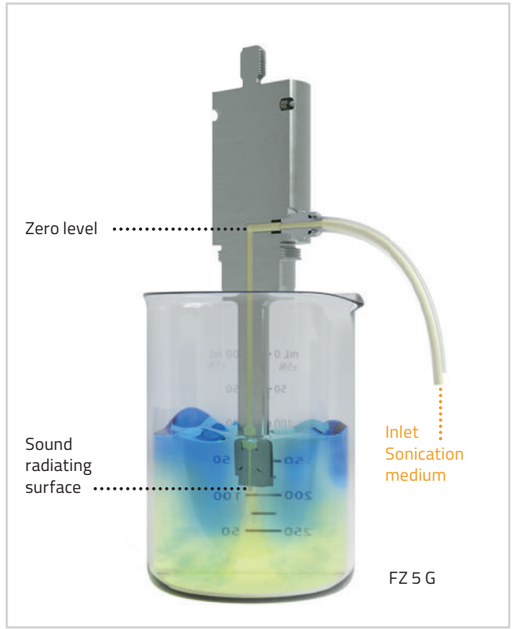
When sonicating samples in screw-on flow-through cells, e.g. DG 4 G, only the flat tip, but not a long probe, can be used as the probe. If the sonication medium is a suspension, the medium can penetrate the titanium disc flat tip/horn screw connection - regardless of how tight the connection is. This leads to an overload of the generator and thus to device failure. To prevent the medium from penetrating, we recommend horns with a fixed working tip.

	Standard horns	Booster horns	
Type	TH 100 G	TH 200 G	TH 400 G
For UW	100 / 5100	200 / 5200	400
Code No.	3968	3969	3970

Flow-through horns FZ

The premixed media are fed into the vibration-free zero plane of the flow-through horn and downwards through the internal channel to the sound-emitting surface. In the titanium disc, the media are exposed to the ultrasonic effect and fed into the sample vessel via the opening in the titanium disc (Ø 1.5 mm).

	Flow-through horn	Flow-through booster horn
Type	FZ 5 G	FZ 7 G
For UW	100 / 5100	200 / 5200
Code No.	490	452



Combination of two media with the flow-through sonication vessel DG and the flow-through horn FZ

A flow-through horn FZ is used instead of a standard or booster horn. The first medium is fed into the sonication chamber via the inflow of the flow -through cell DG 4 G, the second medium via the inflow of the flow-through horn FZ. This medium enters the sonication chamber of the DG via the opening in the sound-emitting surface of the flat tip. Both media can thus be mixed well.

The degree of sonication is determined by the amplitude displayed at the ultrasonic generator and the flow rate of the pump. The flow-through vessel DG is equipped with a cooling jacket, e.g. to prevent excessive heating if the medium remains in the sonication chamber for a longer period of time.

Sleeve adapter NA

Vessels with the standard ground joints NS 29/32 or NS 45/40 are often used for chemical reactions in laboratories.
They are screwed onto the external threads of standard, booster or flow-through horns and inserted into a vessel with standard ground joint.

Sealing ring
Material: EPDM
Hardness: 70 Shore A

Type	NA 29 G	NA 45 G
For	▪ NS 29 / 32 ▪ SH 100 G / SH 200 G ▪ TH 100 G / TH 200 G ▪ FZ 5 G / FZ 7 G with probes, Ø max. 13 mm	▪ NS 45 / 40 ▪ SH 100 G / SH 200 G / SH 400 G ▪ TH 100 G / TH 200 G / TH 400 G ▪ FZ 5 G / FZ 7 G with probes, Ø max. 25 mm
Material	PTFE	PTFE
Code No.	540	487

Flange adapter FA 3 G

With the FA 3 G flange adapter, reaction vessels with a DN 20 flange can be mounted on standard or booster horns with an external thread and connected probes of Ø 2–25 mm. Vibration-free coupling is ensured by the flat sealing flange, the sealing ring encloses the standard or booster horn.
The probe must only be immersed about 1.5-2 cm into the medium to be sonicated. The energy loss is considerable if it is immersed too deeply.

Sealing ring
Material: EPDM
Hardness: 70 Shore A

Type	FA 3 G
For	SH 100 G / SH 200 G / SH 400 G
Compatible with	Probe, Ø 2–25 mm
Material	stainless steel 1.4571
Mounting holes	4 pcs. M 10 (DIN 2573)
Code No.	474

Selection and use of probes

The probes are thermostable, autoclavable and resistant to almost all corrosive media. They are made from a titanium alloy (TiAl6V4 / 3.7165).

The choice of probe depends on several factors: the desired power density, the sonication volume, the shape and size of the sonication vessel, the amplitude and the temperaturesensitivity of the sample. It should be noted that the radiation surface is only located at the probe tip and not at the sides. Depending on the application and process requirements, one or more factors may be decisive for the selection of the probe.

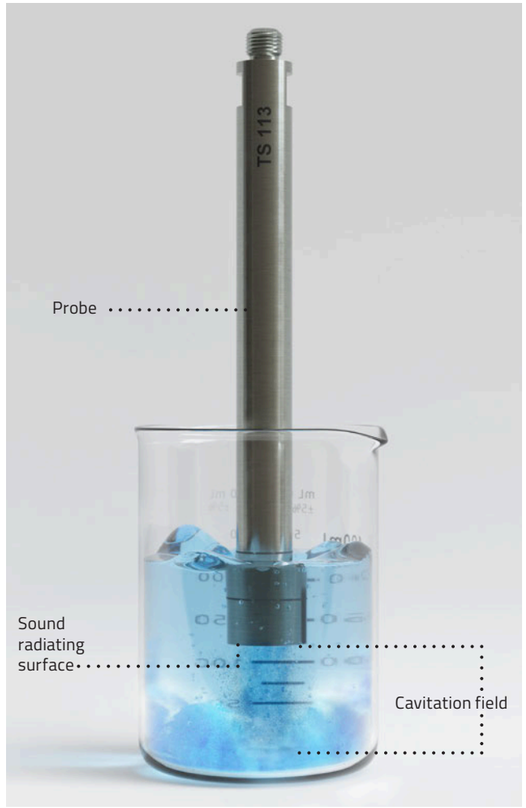
An approximate sample volume range is recommended for each probe. This is only a guide value. The volume to be sonicated is application specific. For example, the 13 mm probe, mounted on the UW 200, can be used for around 20-900 ml. Depending on the size and shape of the sonication vessel, it may be difficult to sonicate a 20 ml volume with the 13 mm probe; a micro tip may be a better option. The size and shape of the sample vessel is therefore another factor when selecting a probe.

Probes with a small radiation surface are recommended for sonication of samples in small, slim vessels, never for samples larger than 50 ml. These probes work with high intensity and are therefore designed for a short sonication time. Probes with a small radiation surface (also known as micro tips) in particular generate a very high level of heat in small volumes. In the case of temperature-sensitive samples, work should be carried out in pulsed mode or the sample should also be cooled.

Larger volumes require a larger probe radiation surface. For example, a 38 mm probe is more suitable for sonicating a 1 litre sample volume than a 25 mm probe.

The use of sample containers with a conical base increases the possible immersion depth and thus reduces the risk of splashing. Indirect sonication is another way of processing very small volumes. Compared to direct sonication, the power density decreases here. However, a very high power density is required to break down yeast cells, for example.

The sound distribution corresponds to a series of "hemispherical shells", whereby these increase in radius with increasing distance from the sound-emitting surface. At the same time, the power density decreases.



The smaller the diameter of the probe tip, the higher the power density [W/cm²] or cavitation strength with the same electrical power consumption!

The cavitation process is associated with erosive material removal from the tip of the probe. After some operating time, this is visible as a "crater landscape" on the sound-emitting surface of the probe. The higher the amplitude, the higher the material removal and the shorter the life time. This means that the smaller the diameter of the emitting surface, the shorter the life time at the same power. Assuming continuous sonication (100 % amplitude, without pulsation), the life time of a probe with a small radiating surface is limited to approx. six hours. The use of a probe with a suitable radiation surface not only reduces the process duration, but also increases the life time of the probe. However, most applications are in the seconds or minutes range. In some cases, the erosion that occurs during direct sonication is undesirable as it always mixes with the sonication medium (e.g. in sample preparation for metal analysis or similar). To avoid erosion, see "Indirect sonication".

Basic probe shapes and their application features

The design of the probe determines the amplification factor of the amplitude and thus, in conjunction with the power provided by the ultrasonic generator, the energy input into the medium. At constant electrical power, the sound intensity transmitted into the medium therefore increases in inverse proportion to the emitting surface of the probe. This means that probes with the smallest emitting surfaces transmit the greater power per surface area [W/mm²] through high amplitudes, depending on the electrical power consumption of the ultrasonic generator.

Micro tip
Stepped design,
Use for processing small volumes in reaction cups or centrifuge tubes

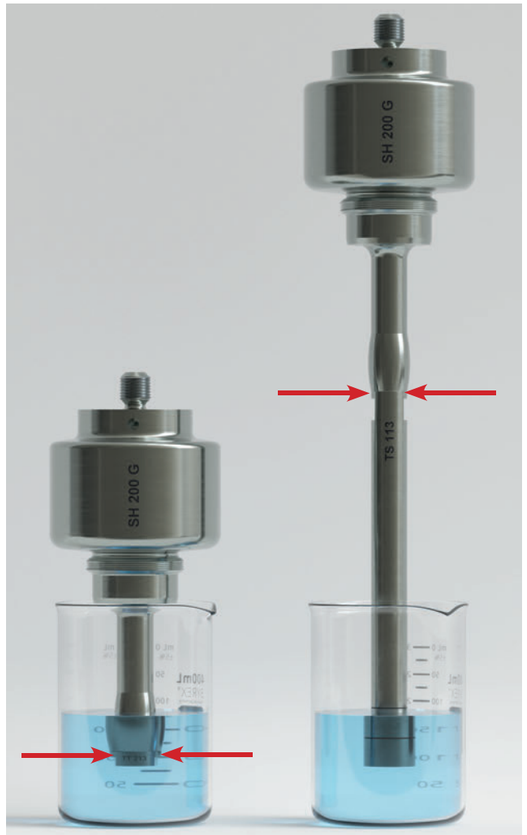
Cone-shaped probe
Conical design, used for processing medium volumes in small beakers, cooling vessels, flow-through vessels or rosettes cells made of glass

Cylindrical probe
Rod shape, used for processing larger volumes in beakers, cooling vessels, flow-through vessels or rosette cells made of glass

Stepped probe
Wide range for small to large volumes from ml quantities to 3 litres in beakers, cooling vessels, flow-through vessels or rosette cells

flat tip vs. probe

The use of a flat tip enables the "sound-emitting surface" to be replaced cost-effectively if the homogeniser is used intensively and frequently. However, when using the flat tip, the screw connection of the flat tip/horn must be immersed into the sonication liquid. If the assembly is not sufficiently tight, very fine particles from the sample liquid can enter the gap and damage the mating surfaces of the system. This will cause the device to malfunction. When using long probes, on the other hand, the penetration of sample material into the screw connection can be ruled out. The use of a flat tip instead of a long probe should therefore be considered taking into account the sample material and the expected usage intensity.



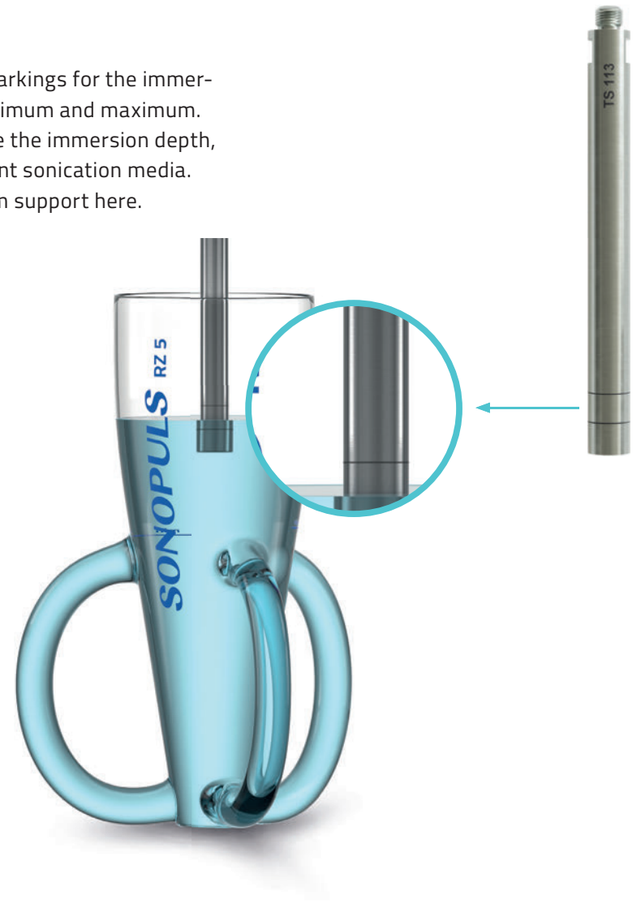
Screw connection horn/titanium disc and horn/probe, cylindrical

Fixed threaded pin on the probes

All probes are equipped with a fixed threaded pin. This enables quick and easy installation on the standard or booster horn using the tool supplied.

Marking immersion depth

Cylindrical probes have two markings for the immersion depth: recommended minimum and maximum. It is often difficult to recognise the immersion depth, especially with non-transparent sonication media. The markings provide optimum support here.



Cavitation erosion test ASTM G32-92

Used for the standard test method according to ASTM G32-16 to determine the cavitation erosion on the sound-emitting surface of a test specimen (= test probe).

Test probe TS ASTM G32
Code No. 37461

The standard conditions for the test probe specified by the standard are complied with:

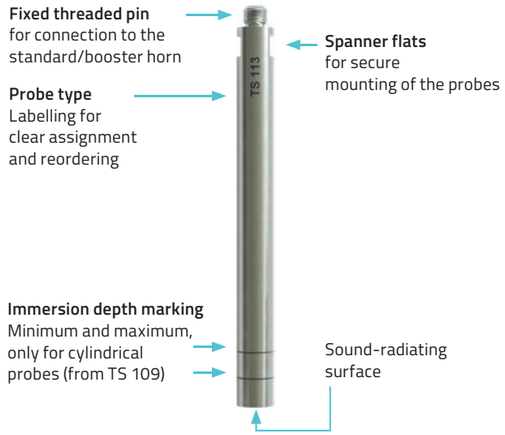
	Specification of the ASTM G32-92 standard	Test probe TS ASTM G32 for HD 4200 / 5200
Frequency [kHz]	20 ± 0.5	✓
Sound emitting surface Diameter [mm]	15.9 ± 0.,05	✓
Amplitude (peak-peak) [µm]	50 ± 5 %	✓

SONOPULS

Probes for the HD 5000 and HD 4000 series

Probes are wearing parts. High power densities occur on the sound-emitting surface. This leads to material erosion (= cavitation erosion) even on this high-strength titanium alloy and therefore limits the life time of the probe. It is therefore recommended to order two to three replacement probes when purchasing the device. The probes are matched to the corresponding working frequency.

The length specifications(*) may vary slightly due to material tolerances in the titanium alloy.



Type	TS 102	TS 103	TS 104	TS 106	TS 109	TT 213	TS 113	TS 216	TS 219	TS 225
Code No.	3740	3741	3742	3743	3744	3750	3745	3746	3747	3748
Diameter [mm]	2	3	4,5	6	9	13	13	16	19	25
Length ca. [mm]	157	147	133	128	126	5	130	137	145	153
Standard horn for HD 4100/HD 5100	SH 100 G	SH 100 G	SH 100 G	SH 100 G	SH 100 G	SH 100 G	SH 100 G	-	-	-
Booster horn for HD 4200 / HD 5200	-	SH 200 G	SH 200 G	SH 200 G	SH 200 G	SH 200 G	SH 200 G	SH 200 G	SH 200 G	SH 200 G
Amplitude HD 4050 / 5050 HD 4100 / 5100 HD 4200 / 5200 (peak-peak) [µm]	135 260 -	105 245 320	90 190 265	75 160 230	65 135 200	- 80 140	- 80 140	- - 105	- - 80	- - 50
Volumes HD 4050 / HD 5050 [ml]	0.5–20	1–25	3–50	5–75	10–100	-	-	-	-	-
Volumes HD 4100 / HD 5100 [ml]	2–25	3–50	5–75	10–100	15–150	20–200	20–200	-	-	-
Volumes HD 4200 / HD 5200 [ml]	-	5–90	5–100	10–350	10–500	20–900	20–900	25–900	25–900	30–1,000

Type	TS 413	TS 416	TS 419	TS 425	TS 425 L	TS 432	TS 438
Code No.	3752	3753	3754	3755	3759	3756	3757
Diameter [mm]	13	16	19	25	25	32	38
Length ca. [mm]	139	132	129	130	254	136	144
Booster horn for HD 4400 [mm]	SH 400 G	SH 400 G	SH 400 G	SH 400 G	SH 400 G	SH 400 G	SH 400 G
Amplitude HD 4400 (peak-peak) [µm]	260	180	130	75	75	50	40
Volume HD 4400 [ml]	100–750	250–1,000	250–1,500	500–2,000	500–2,000	500–2,500	500–3,000

Probe extension

The probe extension is used to extend the working length and to bridge distances in high vessels and is mounted between the standard/booster horn and the cylindrical probe or flat tip. Conical probes or micro tips must not be connected.

- **Probe extension TS 113 V between standard horn SH 100 G / SH 200 G and horn TS 113 or TT 213**
- **Probe extension TS 425 V between booster horn SH 400 G and probe TS 425**
- **Probe extension VS 20 between UW 5020 and MS 1.5 / 2.0 / 2.5**

Type	VS 20	TS 113 V	TS 425 V
For HD	5020	4100/4200 5100/5200	4400
Code No.	3655	3666	3667

Micro tips

Due to the different designs of the probes, different amplitude amplifications can be transferred to the respective sample to be sonicated, depending on the requirements and field of application. Due to the high power input via the relatively small radiation surface of the probe, high power densities can be achieved in the liquid media. The micro tips are mainly used for sonication of very small sample quantities, e.g. complex cell disruption in biology.

Type	MS 1.5	MS 2.0	MS 2.5
Code No.	3639	3654	3652
Diameter [mm]	1,5	2,0	2,5
Length ca. [mm]	64	59	55
Amplitude HD 5020 (tip-tip) [µm]	70	75	80
Volume HD 5020 [ml]	0,1-10	0,25-20	0,5-25

SONOPULS

Vessels for direct sonication

During direct sonication, the probe is immersed in the sample to be sonicated. The advantage of this method is the very high energy input compared to indirect sonication. Information on selecting the appropriate vessels for your application can be found in chapter 3.

All glass vessels are made of borosilicate glass. The material has very good chemical and temperature resistance and is therefore very suitable for laboratory use. Cleaning and/or disinfection can be carried out with appropriate agents in an ultrasonic bath or washer-disinfector. The glass can be autoclaved.

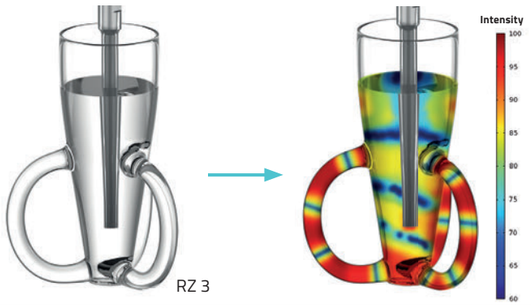
Rosette cells RZ

The rosette cells allow uniform and intensive sonication of liquid media. Due to the sound pressure, the sample is pressed against the bottom of the vessel and thus through the three side arms and can circulate well. This results in continuous mixing of the medium. When the rosette cells are placed in an ice bath, the contents are effectively cooled due to the enlarged glass surface and good circulation.

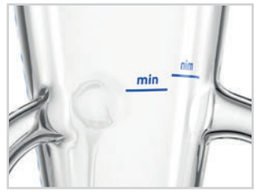
RZ 1 RZ 2 RZ 3 RZ 4 RZ 5

Type	RZ 1	RZ 2	RZ 3	RZ 4	RZ 5
For dia. of samples [mm]	2–3	2–6	3–13	13–25	19–25
For HD	4050/4100 4200/ 5050/5100/ 5200		4100 4200 5100 5200	4200 4400 5200	4400
Min. volume [ml]	20	30	60	260	430
Max. volume [ml]	25	50	100	410	660
Dia. internal [mm]	27	40	50	75	90
Depth [mm]	80	95	130	200	240
Code No.	3606	3607	522	3256	483

Intensity distribution
(Distance between probe tip
and vessel bottom = 3 cm)
Source: Berlin University of Applied Sciences (BHT)



RZ 3



Marking of the minimum fill level

Vessels for direct sonication with cooling

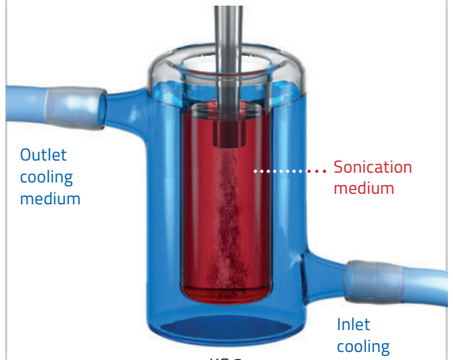
Cooling vessels KG

During sonication, mechanical energy is converted into heat (due to internal friction in the liquid), resulting in a more or less high heating of the samples. Cooling of the medium may therefore be necessary for temperature-sensitive samples.
The sample vessels can be placed in an ice bath, for example. However, the immersion depth of the probe is not visible. A better alternative is the KG cooling vessels with cooling jacket for connection to an external cooler. This enables controlled temperature control during sonication.

KG 3 KG 5

Type	KG 3	KG 5
For dia. of probes [mm]	2–13	13–25
For HD	4050/4100 4200/ 5050/5100/ 5200	4200/5200
Max. volume [ml]	20	90
Dia. internal [mm]	20	35
Depth [mm]	55	95
Cooling jacket	✓	✓
Code No.	536	481

The cooling medium is pumped through the cooling jacket in a circuit using a thermostat.
This allows a quick response to a temperature increase.



KG 3

SONOPULS
Flow-through vessels for direct sonication

Flow-through cells are used for the continuous processing of large batches of low-viscosity solutions. They are well suited for dispersing, emulsifying, mixing or homogenising.

Using a pump, the liquid is pumped from below against the sound-emitting surface of the probe, passes directly through the cavitation field and leaves the chamber via the outlet. A pump must be provided by the user.

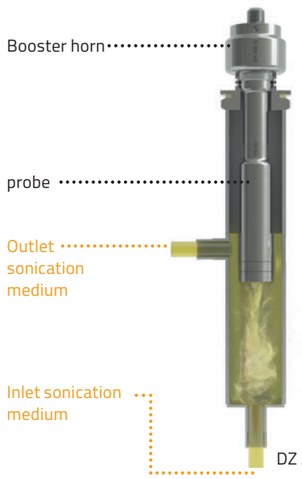
If intensive sonication is required, batches can also be routed through the system several times. The sonication level depends on the set amplitude and the flow rate.

Flow cell DZ 300 E

Material: Stainless steel 1.4404
The connection is made directly to the external thread of the booster horn. The DZ 300 E is particularly suitable for emulsifying, mixing or homogenising. The flow cell is tightly sealed when screwed onto the booster horn. This prevents air from entering.

Type	**DZ 300 E***
For HD	4400
Compatible with	SH 400 G
Max. through-flowrate [l/h]	130
Max. pressure [bar]	4
Code No.	3822

*cannot be used with TS 438



Continuous sonication of larger volumes.
The sample is pumped into the flow cell via the inlet at the bottom, passes through the cavitation field and exits via the outlet. The sample can be sonicated several times. The degree of sonication is determined by both the amplitude and the flow rate.

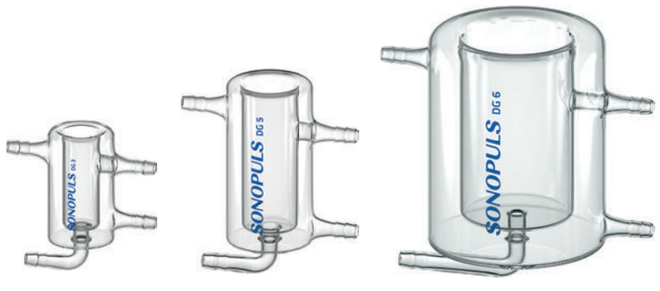
SONOPULS

Flow-through vessels for direct sonication with cooling

DG flow-through vessels

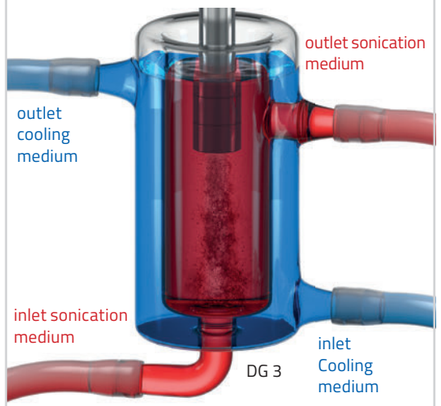
With cooling jacket. Continuous sonication of samples with a flow rate of up to 30 l/h is possible.
The cooling jacket allows the temperature to be controlled by liquid coolant during sonication.

Type	DG 3	DG 5	DG 6
For dia. of probe [mm]	2–13	13–25	25–38
For HD	4050/4100 4200/ 5050/5100/ 5200		4200 4400 5200
Max. flow-through rate [l/h]	5.6	30	30
Dia. internal [mm]	20	35	71
Depth [mm]	55	100	120
Cooling jacket	✓	✓	✓
Code No.	538	482	3819

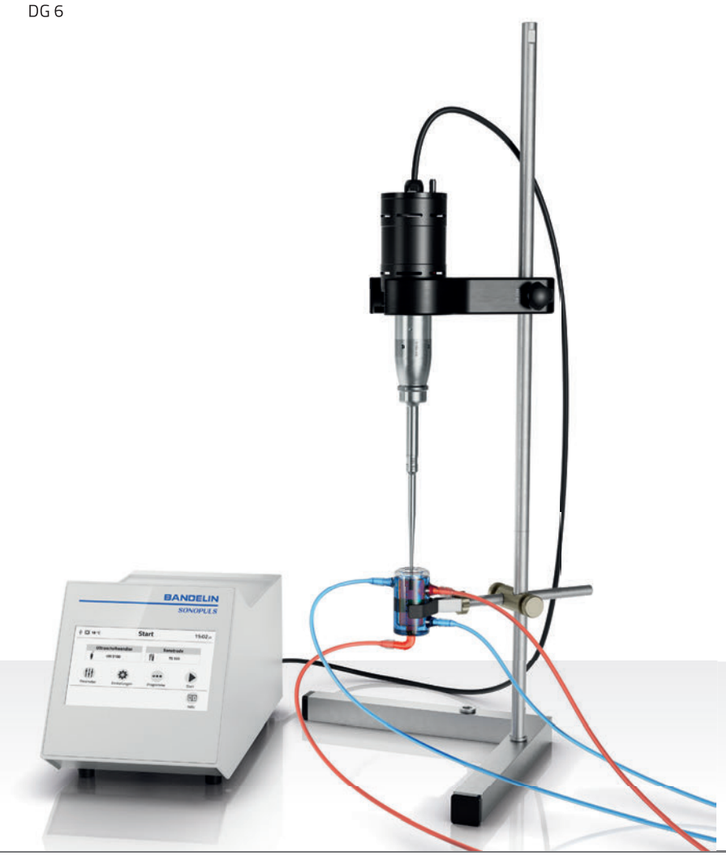


DG 3 DG 5 DG 6

The cooling medium is pumped through the cooling jacket in a circuit with the aid of a thermostat. This enables a quick response to a temperature increase. The sonication medium is channelled directly against the sound-emitting surface of the horn.



DG 3



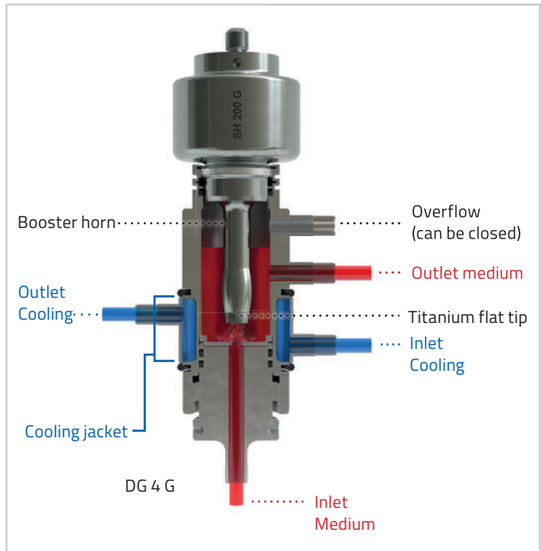
Flow-through PA vessel DG 4 G

Material: Stainless steel 1.4301
The connection is made directly to the external thread of the standard or booster horn. The DG 4 G is particularly well suited for emulsifying, mixing or homogenising. The sonication vessel is "hermetically sealed" when screwed onto the horn (the overflow is also sealed).
This prevents air from entering.
Infectious substances can also be sonicated.
The sample liquid is fed directly into the cavitation field from below via the inlet, sonicated and discharged via the outlet. An external 2-channel pump must be provided. The sonication level is controlled via the amplitude setting on the generator and the flow rate.
The medium can also be sonicated in a circuit to intensify the process. The integrated cooling jacket is used to regulate the sample temperature. An external cooler must be provided by the customer.

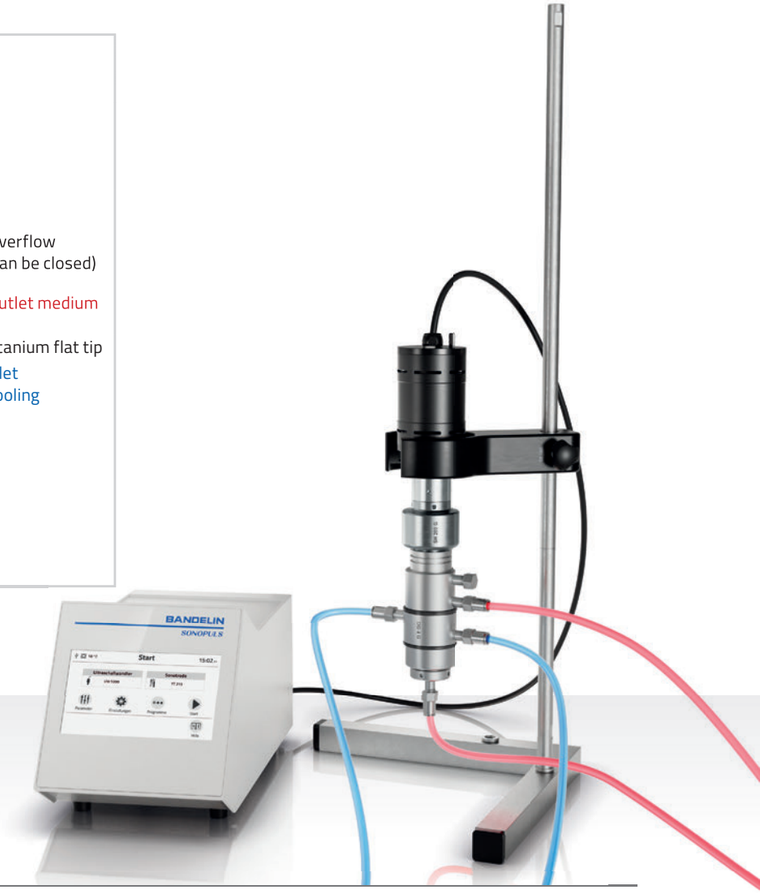
DG 4 G

Type	DG 4 G
For HD	4100 / 4200 / 5100 / 5200
Compatible with	SH 100/200 G with TT 213/TH 100/200 G
Max. flow-through rate [l/h]	50
Max. pressure [bar]	2
Cooling jacket	✓
Code No.	3608

Bottom view DG 4 G, Baffle plate with hole



DG 4 G



SONOPULS
Vessels for indirect sonication

Indirect sonication prevents direct contact between the probe and the sample. The function corresponds to a small, high-intensity ultrasonic bath. The ultrasonic power is transferred into the sample vessels via the contact liquid, titanium particles from the probe are excluded. Indirect sonication is used in particular for the sonication of very small sample quantities: foaming or sample loss are excluded.
The method is well suited for sonicating pathogenic samples - cross-contamination is ruled out. Cooling of the samples is also possible. We recommend connecting the external chiller LABOCOOL LC 200.

It is important that the fill level always remains constant and that the reaction vessels do not float. Otherwise, sonication results could be impaired. The cover plate of the sample holder prevents floating. Adding ice chips is also a way of cooling, but does not ensure a constant temperature. If ice chips are used, they must be located on the sides of the reaction vessels. Below the reaction vessels, they can have a negative influence on the result. The power density [W/l] introduced is approx. 150 times higher than in a "normal" ultrasonic bath, but lower than with direct sonication using a probe.

TR 110 disc resonator

Material: Titanium TiAl6V4 (3.7165)
Equipped with a fixed threaded pin. For quick and easy installation with the specified tool.
The TR 110 disc resonator enables an indirect Intensive sonication of the smallest sample quantities, e.g. bacteria, in up to 14 closed sample vials (reaction cups). The uniform sound field guarantees reproducible results in all vials. Indirect sonication prevents both contamination of the samples by the probe ablation and cross-contamination. The ultrasonic power is transferred to the respective reaction cups via a contact liquid. In addition, the disc resonator has inlet and outlet connections so that the samples can be tempered via the reservoir. For stationary operation, inlets and outlets can be short-circuited using a hose bend.
In cooling mode, inlets and outlets must be connected to a peristaltic pump with a low flow rate or a cooling circuit via suitable hoses.

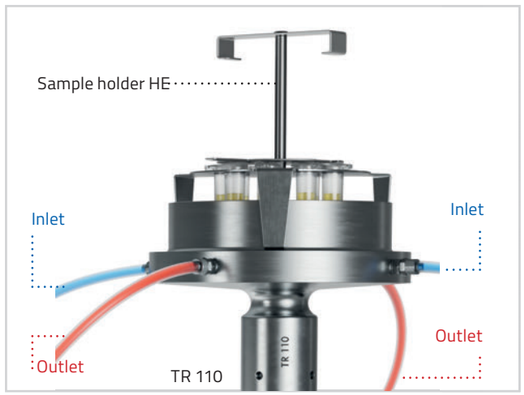
Type	Code No.	For HD	Inner diameter [mm]	Depth [mm]	Capacity [ml]	Connection type for the hoses	Power density [W/l]
TR 110	3902	4200 / 5200	110	25	190 (stationär)	M5 thread	790

Holders for every size of reaction vessel

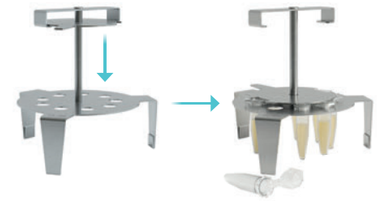
Material: Stainless steel 1.4301
The various sample holders can hold up to 14 reaction cups. Depending on the vessel size, you can choose between four different holders. They are positioned on the edge of the cup booster using a curved handle.

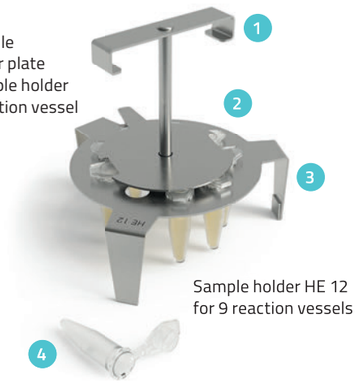

Sample holders HE 6, HE 12, HE 13 and HE 17

Type	Code No.	For	Hole diameter [mm]	Number of holes
HE 6	3903	PCR-Tubes	6	14
HE 12	3904	Reaction cups 0.5/1.5/2.0 ml	11.5	9
HE 13	3905	Polystyrene tubes, long, with/without screw cap 5 ml	13	9
HE 17	3906	5 ml tube	17	9



The reaction cups must be immersed in the contact liquid in the reservoir of the disc resonator. The cover plate prevents the reaction cups from floating during operation.


Cover plate prevents floating



Sample holder HE 12 for 9 reaction vessels

SONOPULS

Vessels for indirect sonication

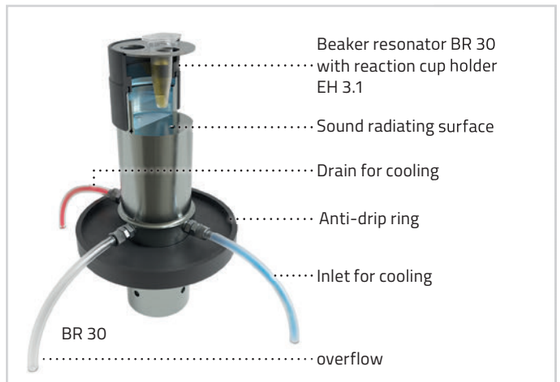
Cup booster BR 30

Material: Titanium TiAl6V4 (3.7165)
The Cup booster is designed for intensive, indirect sonication of the smallest sample quantities, e.g. bacteria in closed sample vessels (microtubes). The samples are placed into the BR 30 with the reaction cup holder EH 3.1. In addition, the Cup booster possesses inlet, outlet, and overflow connections so that the samples can be tempered by the reservoir. In stationary operation, the inlet and outlet can be shorted with the help of a hose bend. In cooling mode, the inlet and outlet are to be connected through suitable hoses to a hose pump with a low output. The beaker resonator is mounted directly on the ultrasonic converter. It is equipped with a fixed threaded pin for easy mounting. Quick and easy assembly with the specified tool is guaranteed.

Cup booster BR 30 and reaction cup holder EH 3.1

Type	Code No.	For HD	Inner diameter [mm]	Depth [mm]	Capacity [ml]	Connection type for the hoses	Power density [W/l]
BR 30	7510	4100 / 4200 / 5100 / 5200	32	15	12	3 hose screw connections with cap nut and sealing ring	12,500

Type	Code No.	For	Material	Hole diameter [mm]
EH 3.1	7527	3 × 1 ml or 2 ml reaction cups 3 × 0.5 ml reaction cups 8 × 0.2 ml PCR-Cups	Stainless steel and POM	8 × 6.5 / 3 × 8.5 / 3 × 11.5



Cup horn BB 6

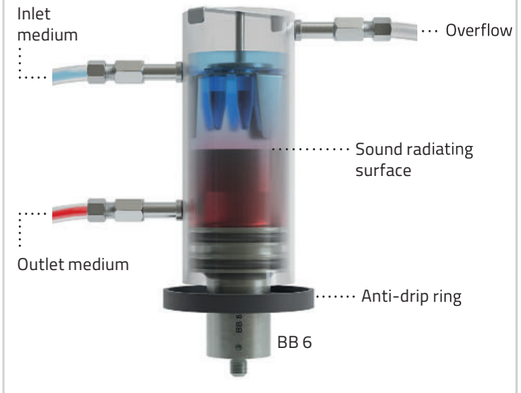
Material: Titanium TiAl6V4 (3.7165) / Makrolon
The cup horn is designed for indirect sonication of the smallest sample quantities, e.g. bacteria, in closed sample vessels (microtubes). The samples are placed in the BB 6 with the EH 6 microtube holder.
In addition, the cup horn possesses inlet, outlet, and overflow connections so that the samples can be tempered.
For stationary operation, the inlet and outlet can be closed using the accompanying screw caps.
It is equipped with a fixed threaded pin for easy mounting.
Quick, easy and direct installation on the ultrasonic converter is possible with the specified tool.

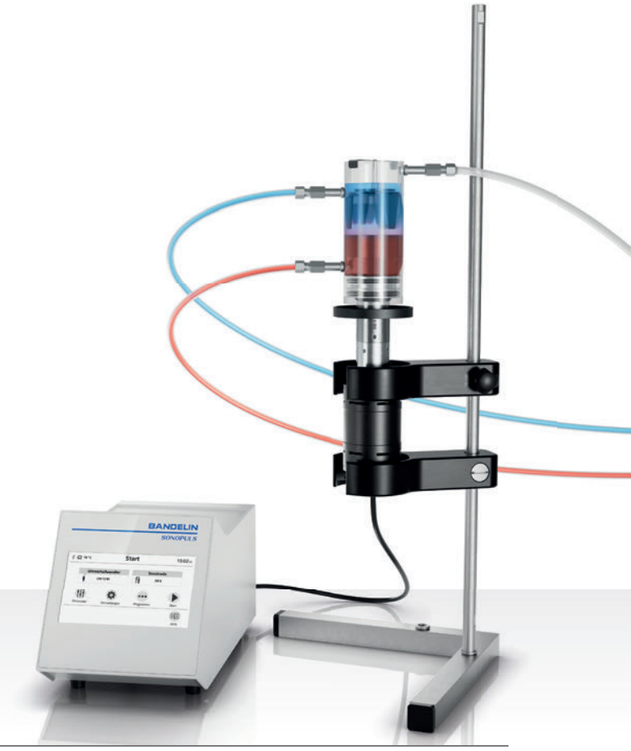
For temperature-controlled application with the *new recirculating chiller* **LABOCOOL** LC 200 suitable.

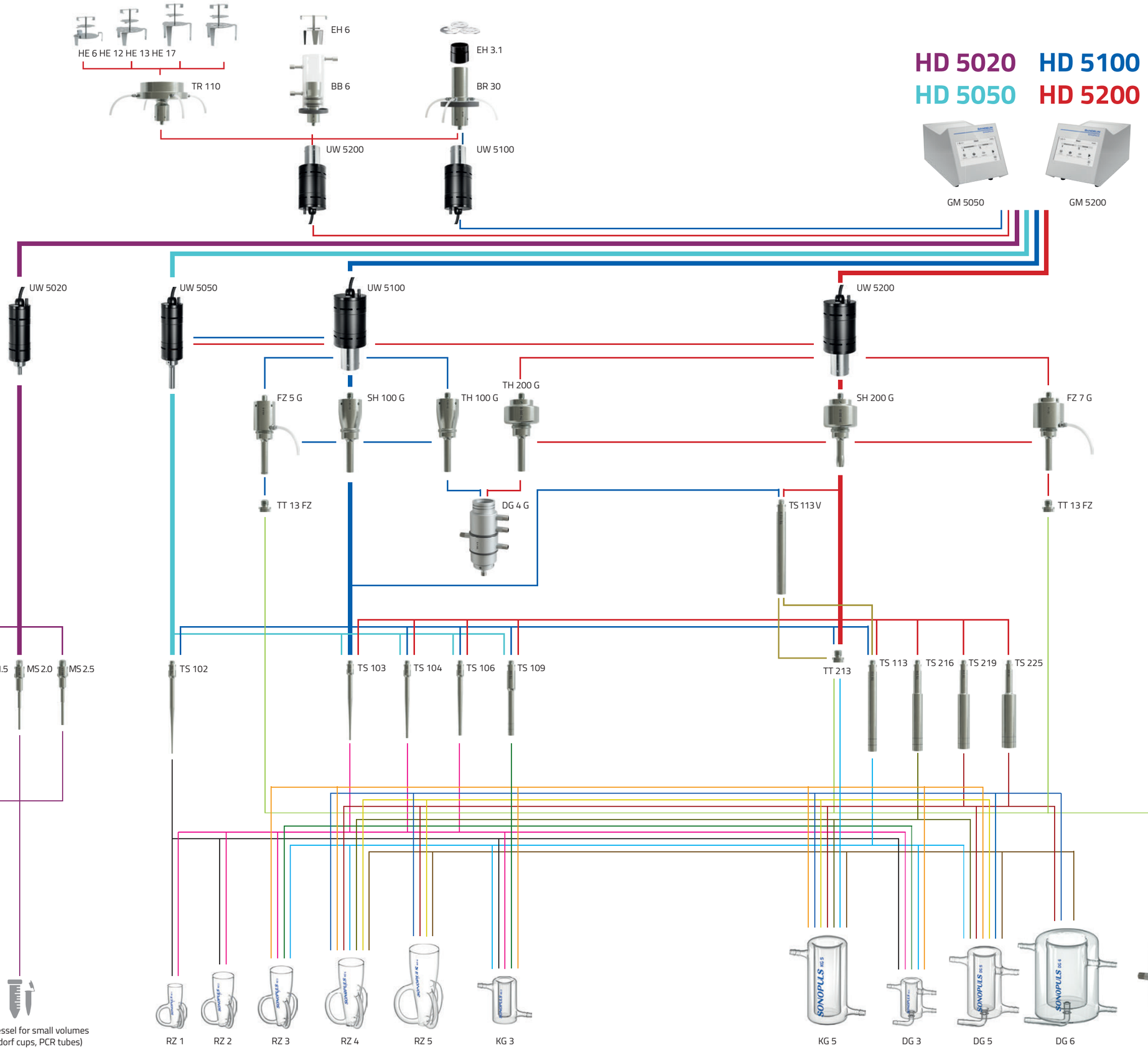
Cup horn BB 6 and reaction cup holder EH 6

Type	Code No.	For HD	Inner diameter [mm]	Depth [mm]	Reservoir-volumen [ml]	Connection type for the hoses	Power density [W/l]
BB 6	3605	4200 / 5200	64	167	200	Hose fittings 5 × 3 mm	750

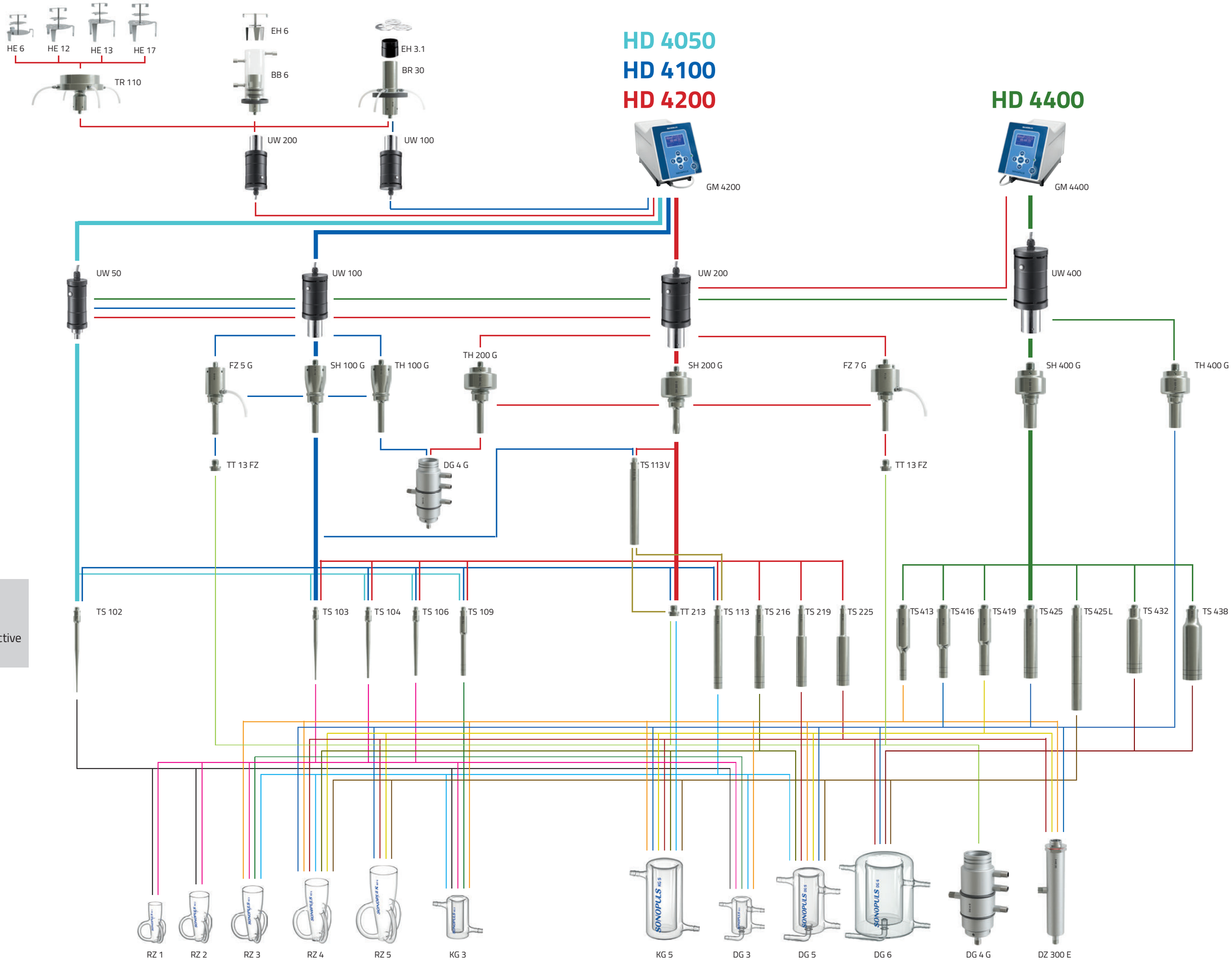
Type	Code No.	For	Material	Hole diameter [mm]
EH 6	7503	6 × 1.5 / 2 ml	Stainless steel	11.5







The thick lines represent the respective SONOPULS sets.



The thick lines represent the respective SONOPULS sets.

Stand, Sound proof box, Recirculating chiller, Temperature sensors and Foot switch

With the standard set, BANDELIN already supplies a ready-to-use device. A comprehensive range of accessories is available for customised adaptations to the applications.

The most practical and popular accessories for the most common applications are presented in more detail below.

Possible accessories:

Stand HG 40

Sound proof box LS 40

Temperature sensors TM 50 and TM 5000

Foot switch TS 8

Recirculating chiller LABOCOOL LC 200

Stand HG 40

Material: Stainless steel 1.4301 and POM
The HG 40 offers a firm stand and flexible handling for adjusting the holder for the ultrasonic converter with probe. The positioning of the sonication vessel can be significantly facilitated by an additional holder with support table. Sufficient free movement for the user is guaranteed.

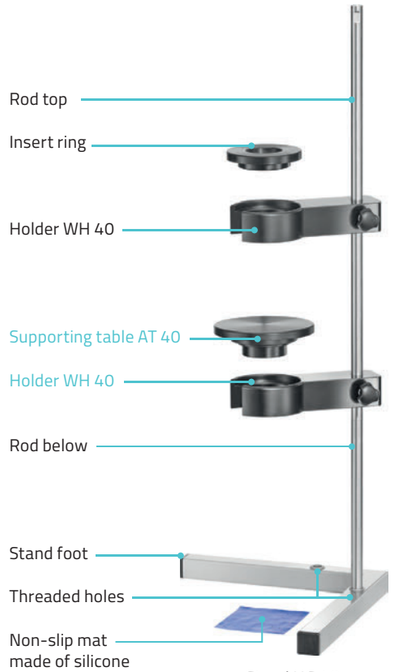
Scope of delivery:

- Holder WH 40
- Insert ring
- Non-slip mat made of silicone

Optional accessories:

- Second holder WH 40
- Supporting table AT 40

Type	HG 40	WH 40	AT 40
For HD	2070.2 / 2200.2 / 3100 / 3200 / 3400 4050 / 4100 / 4200 / 4400 / 5020 / 5050 / 5100 / 5200		
Code No.	3681	3900	3901



Stand HG 40

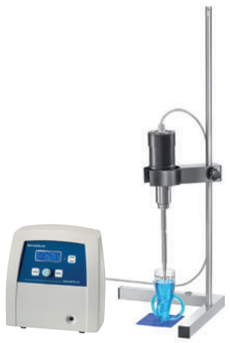
One holding frame, suitable for all SONOPULS ultrasonic converters

All ultrasonic converters from the 5000 series and the 4000, 3000 and 2000 series can be inserted into the holding-frame.
For the ultrasonic converters UW 5020, 5050 and UW 50, the supplied retaining ring is required.

Insert ring

Ultrasonic converter UW 5200

Ultrasonic converter UW 5050



HD 3100 with HG 40

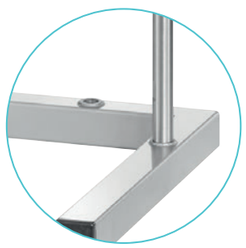
HD 2200.2 with HG 40

HD 4200 mit HG 40

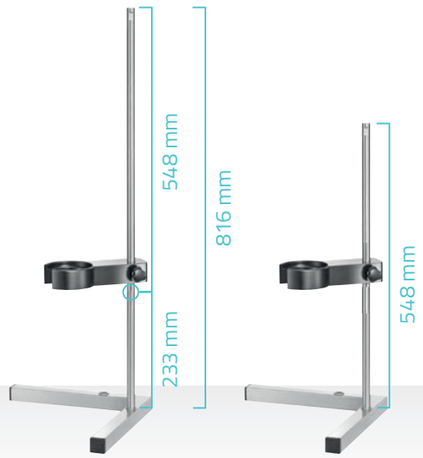
HD 5100 with HG 40

Flexible mounting/installation

The stand rod can be positioned on the left or right side of the stand base.
The Outlet medium is in two parts and is screwed together using a thread. If both parts are assembled, this results in a total length of 816 mm. With just one rod, the stand is 548 mm high. The rod has a standard diameter of 16 mm. Commercially available clamps can also be attached to it, e.g. to fix laboratory vessels with a round base to.



The WH 40 holder for the ultrasonic converter is height-adjustable and can be swivelled.



Flexible: application options for direct and indirect sonication

The stand can be used flexibly for direct and indirect sonication. The scope of delivery includes a silicone non-slip mat, which prevents possible slipping of the sonication vessel during direct sonication. However, a second WH 40 holder is required for fixing the ultrasonic converter for indirect sonication.

Direct sonication

Indirect sonication

1 Possible applications with supporting table

Optionally, a second WH 40 holder can be used in combination with an AT 40 supporting table. This allows the vessels placed on it to be moved directly to the probe and their immersion depth to be easily regulated.

Direct sonication with supporting table

2 Use of two ultrasonic converters

A second WH 40 holder can be used to attach another ultrasonic converter at the same time, for example. Variable positioning of the sonication vessel is made possible with an additional WH 40 holder and the AT 40 supporting table.

Sonication of two samples on one stand

3 Convenient placement in the sound proof box

The HG 40 stand is designed so that it can be placed in the LS 40 sound proof box. Easy sample handling is ensured.

The door opening angle of the LS 40 sound proof box is 180° and the interior has sufficient space for direct and indirect applications.

Take a look at our video.

Sound proof box LS 40

Cavitation produces very unpleasant noises for the user and other people in the vicinity.
To reduce the noise level, it is recommended to use a sound proof box.

The housing, splash guard, drip tray and perforated plate are made of stainless steel (1.4301).

- Noise reduction by approx. 30 dB-AU
- LED interior lighting and acrylic glass for process viewing
- Removeable drip tray; made of stainless steel, easy to clean
- Splash guard, stainless steel insert inside easy to wipe clean
- Closable bushing at the rear side to accomodate lines and hoses for cooling or circulation systems or to connect a temperature sensor
- Ventilation system for reducing a process-related formation of moisture
- Door opening angle 180° for easy sample handling

Type	Code No.	Description	For HD
LS 40	36821	Sound proof box (noise reduction by 30 dB-AU) + 230 V EU plug CEE 7/7	2070.2 / 2200.2 3100 / 3200 3400 / 4050 4100 / 4200 4400 / 5020 5050 / 5100 5200
	36822	Sound proof box (noise reduction by 30 dB-AU) + 230 V-CH plug SEV 1011: T12	
	36823	Sound proof box (noise reduction by 30 dB-AU) + 230 V GB plug BS 1363	
	36824	Sound proof box (noise reduction by 30 dB-AU) + 115 V-US plug NEMA 5-15	

The LS 40 sound proof box can be used with the stand HG 40 or alternatively a suitable laboratory stand.

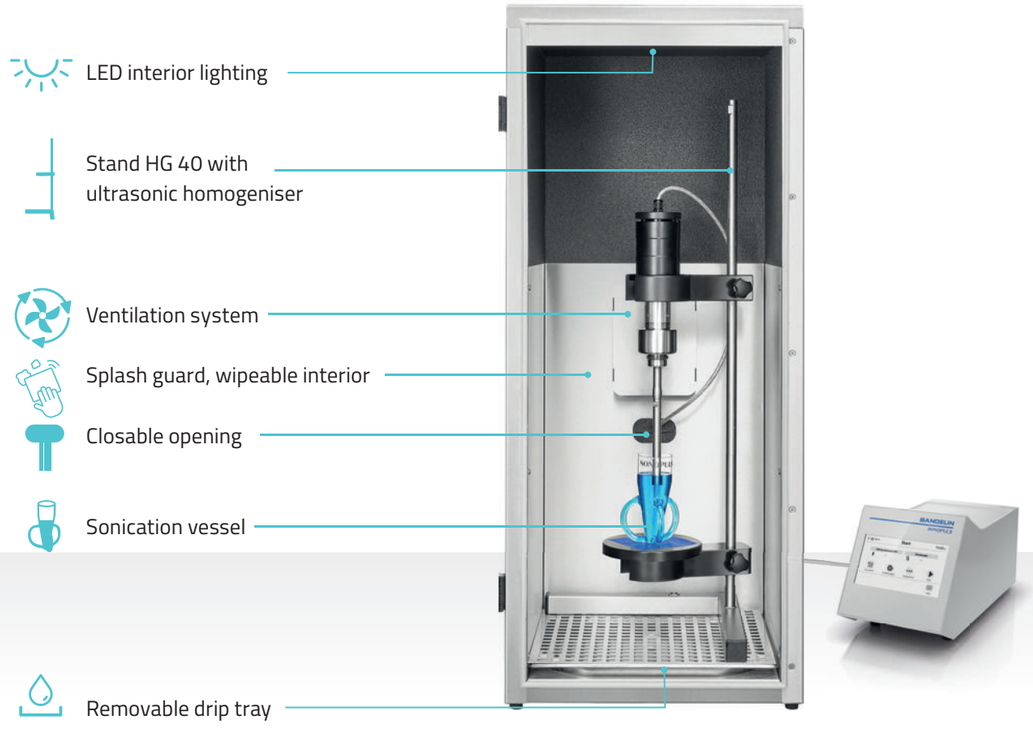
For direct and indirect sonication

The stand HG 40 can be flexibly positioned in the LS 40 sound proof box to provide direct or indirect sonication.

Direct sonication
Sound proof box LS 40, stand HG 40 with holder WH 40, ultrasonic converter UW 200, booster horn SH 200 G, horn TS 113 and rosette cell RZ 3

Direct sonication
Sound proof box LS 40, stand HG 40 with two holders WH 40 and support table AT 40, ultrasonic converter UW 200, booster horn SH 200 G, probe TS 113 and rosette cell RZ 3

Indirect sonication
Sound proof box LS 40, stand HG 40 with two holders WH 40, ultrasonic converter UW 200 and cup horn BB 6 with reaction cup holder EH 6



Temperature sensor TM

By connecting the temperature sensor either to the ultrasonic generator (series HD 4000) or to the ultrasonic converter (series HD 5000), temperature detection is activated and user-defined temperature monitoring is possible during the sonication process.

Sample temperatures in the range from -10 to 120 °C can be measured.

High temperatures must not be allowed to enter the ultrasonic converter (max. 80 °C). Long-term exposure to high temperatures must be avoided!

Type	TM 50	TM 5000
For HD	4050 / 4100 / 4200 4400	5020 / 5050 / 5100 5200
Diameter of the measuring tip [mm]	1.9	2
Sensor length [mm]	100	150
Code No.	3733	3763

TM 50 TM 5000

Foot switch TS

Instead of the "START/STOP" button on the ultrasonic generator, the device can also be operated using the foot switch. With 3 m connection cable.

Type	TS 8
For HD	4050 / 4100 / 4200 / 4400
Code No.	513

LABOCOOL LC 200
Recirculating chiller

LABOCOOL LC 200 is used for either removal of process heat or effective cooling of samples during sonication with the SONOPULS ultrasonic homogeniser. Compared to conventional recirculating chillers, LABOCOOOL LC 200 is characterised by a closed water circuit without an equalization tank. Thus, a constant water level is achieved in the processing vessel and overflowing is excluded.
Due to the natural refrigerant R-290, LABOCOOL LC 200 is particularly efficient and climate-friendly.

For constant media temperature in the ultrasonic bath: ***LABOCOOL*** **LC 400**

Applications with cooling

The sonication of biological samples reduces the processing time for sample preparation for following analysis and enables reproducible results. The high ultrasonic power applied generates frictional heat, which warms-up the sonication liquid in a short time. In order to protect samples from excessive heat input, many applications require an external cooling system. LABOCOOL LC 200 provides a ready-to-connect complete solution which enables a cooling of samples at the push of a button.

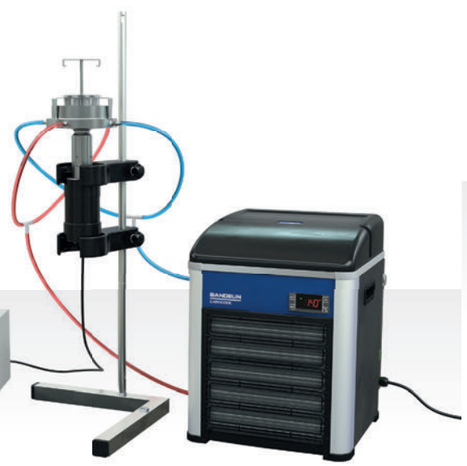
Use for applications with the cup horn BB 6

LABOCOOL LC 200 is connected to BB 6 cup horn using the supplied tubes. BB 6 can also be placed into the sound proof box.

Use in applications with the cup booster TR 110

An outstanding feature of TR 110 is the most efficient cooling system using two cooling water inlets and two outlets. These are easily connected to LABOCOOL LC 200 by supplied accessories. When using in the sound proof box, LC 200 can be placed next to the sound proof box.

LABOCOOL LC 200 with HD 5200 and BB 6



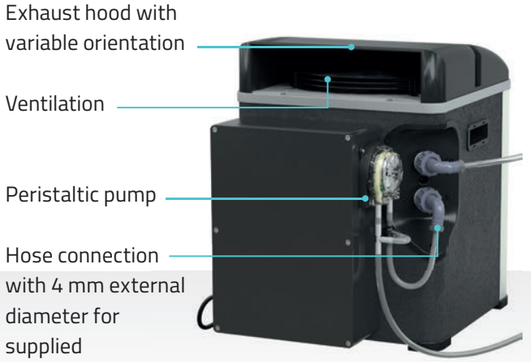
LABOCOOL LC 200 with HD 5200 and TR 110

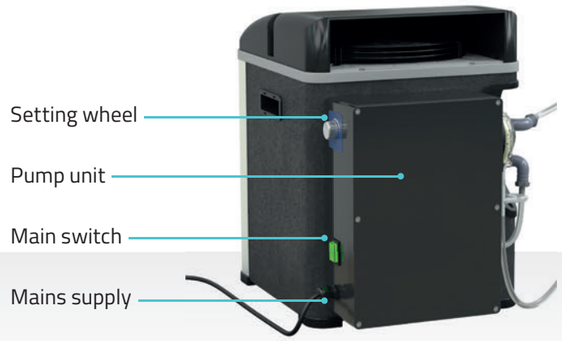
Front side

The display on the front shows the status of the cooling function and the water temperature in the device. The desired water temperature can be set within a range of 5-30 °C using the buttons on the side.

Back side

The pump unit and the main switch are located at the rear of the appliance. The volume flow of the self-priming peristaltic pump can be varied by means of an adjusting knob.





Type	Code No.	For HD series	External dimensions l × w × h [mm]	Cooling power [W]	Refrige-rant	Refrigerant quantity [g]	Pump type	Pump power [W]	max. flow-rate [l/h]
LC 200	3855	4200 / 5200	415 × 320 × 420	200	R-290	90	Peristaltic pump	10	36

Application of the SONOPULS ultrasonic homogeniser

03

Basic instructions for the application

The most important information on handuse in practice.

from page 74

Setting the sound parameters

Explanation of the relevant factors for an optimal result.

from page 78

Application overview

Presentation of various processes and industries for ultrasonic applications.

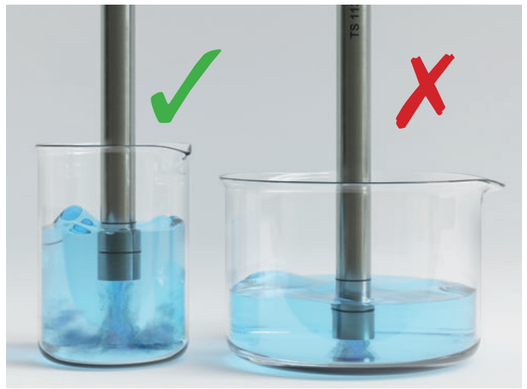
from page 80

Basic instructions for use

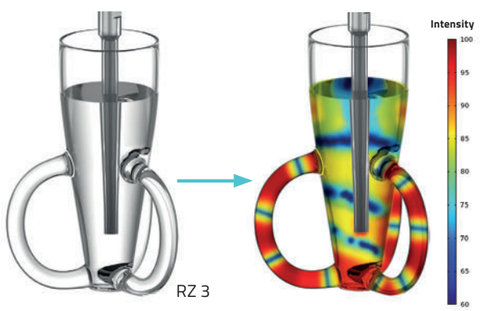
The success of the sonication depends crucially on the right choice of device and method parameters. Based on the previous designs and / or the advice from BANDELIN employees, you have now selected the right device with the right probe and any additional equipment. The following chapter explains the parameters for finding the right method for your problem and successfully carrying out the sonication. As the questions are very individual, the procedure can be chosen in such a way that a basic method is used on the basis of similar application examples, which is modified if necessary to optimise the conditions for your own question in initial test series with the basic knowledge imparted here.

Selection of vessels

In principle, you can use any container and any material (glass, plastic, etc.). However, a narrow vessel is preferable to a wide vessel. The energy is only emitted downwards, not to the side! The sample is pressed downwards and then in all directions. If the vessel is too wide, for example, the sample components cannot mix properly and some of them remain untreated. A slim, tall vessel is better. Good experiences tend to be made with rather narrow and tapered (conical) vessels. Power transmission is optimised and splashing is prevented. A higher degree of turbulence can be achieved with the so-called rosette cells offered as accessories. The sample is pressed against the bottom of the vessel by the sound pressure and then through the three side arms and thus repeatedly sonicated. The sample only remains in the sonication field for a short time, other samples can "follow". When placed in e.g. "crushed ice", the sample liquid is cooled very well and effectively as it flows through the side arms.



Optimum sound distribution in narrow vessels

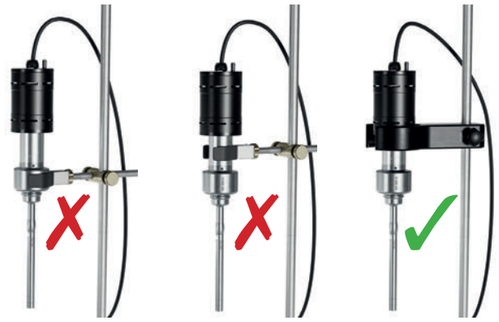


Visualisation of the intensity areas in a rosette cell
Source: Berlin University of Applied Sciences (BHT)

Cooling the sample in a rosette cell RZ with crushed ice

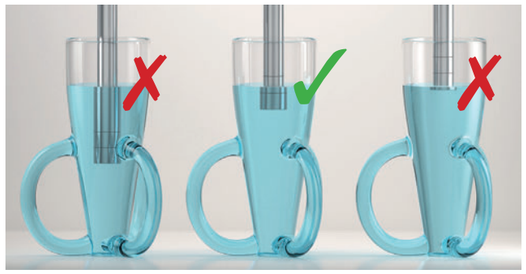
Fixing the ultrasonic converter

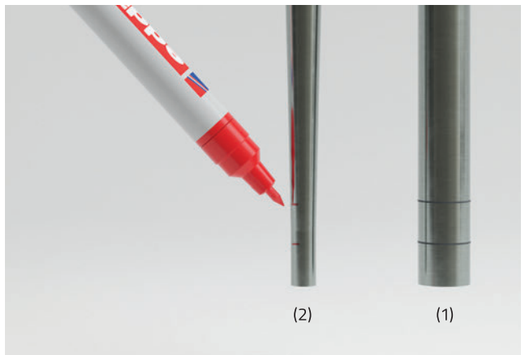
The ultrasonic converters may only be held by the black housing, for example using a stand clamp. Failure to observe this may result in malfunctions or mechanical faults, for example the preset amplitude may not be reached and an error message may be issued.



Immersion depth of the probe

Probes must be immersed correctly, usually approx. 1-2 cm. If the immersion depth is too low, the sample may foam or splash; if the immersion depth is too high, the circulation is not effective and the sample may be attenuated too much at the sides (especially with highly viscous media). Both lead to poor results.





The immersion depth of the probe is often not visible because either the sample liquid is too dark in colour or the reaction vessel is placed "on ice". Our cylindrical probes (1) are therefore provided with markings in the lower area in order to control the immersion depth. With the so-called micro tips (2), you can help yourself by first determining the optimum immersion depth during tests in water and then marking the probe at the corresponding point with a permanent marker. In this way, the correct immersion depth can be realised.

Sonication of chunky sample in a liquid

In many cases, mechanical pre-crushing is required, as ultrasound can have a much more effective effect on small particle sizes. If lumpy sample material is to be sonicated, the probe must be placed directly on the sample.

Probes with "pitted" surface

The probe tip erodes over the course of use. This reduces the efficiency of the sonication and the reproducibility of the sample sonication becomes poorer. The smoother the sound-emitting surface, the better the power output into the medium. Smooth the probe when the pitting is still small (see instructions for use). If the pitting is deeper than about 1 mm, the probe should be reworked in accordance with the instructions for use or replaced.

Mounting the probes

It is essential to ensure that the torque does not fall below a minimum value [Nm] in order to guarantee a secure mechanical connection between the horn and probe and thus the function. The use of a torque spanner is recommended (tightening torques - see instructions for use). The same applies when changing the horn.

Guide values for the life time of the probes

The values listed apply to the maximum amplitude when used in tap water up to a material removal ≤ 1 mm at the tip of the probe. Depending on the operating conditions, the actual life time may be longer or shorter.

The life time is specified in hours [h].

Probe	HD 5020
MS 1.5	40
MS 2.0	25
MS 2.5	30

Probe	HD 4050/5050
TS 102	17
TS 103	36
TS 104	**64**
TS 106	**138**
TS 109	**311**

Probe	HD 4100/5100
TS 102	9
TS 103	19
TS 104	34
TS 106	74
TS 109	166
TS 113	308
TT 213	273

Probe	HD 4200/5200
TS 103	10
TS 104	17
TS 106	37
TS 109	83
TS 113	154
TT 213	136
TS 216	245
TS 219	345
TS 225	560

Probe	HD 4400
TS 413	77
TS 416	122
TS 419	173
TS 425	280
TS 432	432
TS 438	609

Other notes

For **very small volumes**, the probe should be immersed as far as possible so that no strong movements occur on the sample surface.

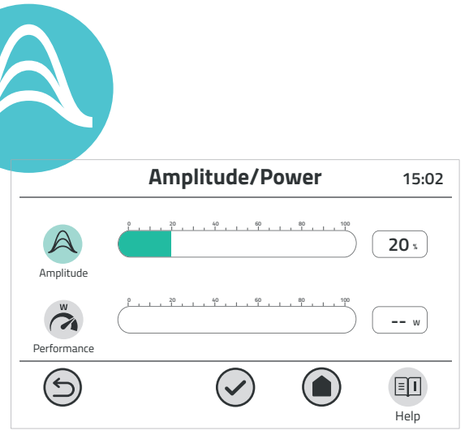
If the sample still tends to foam, you should first work with a lower amplitude, cool the medium and/or select pulse mode. If necessary, glass beads (diameter 0.5 mm) can also be added. These beads sink to the bottom after sonication and can be centrifuged off.

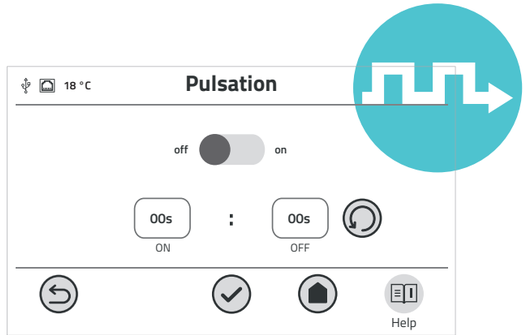
A conical vessel or a vessel with an irregular inner surface is also well suited to prevent foaming.

Setting the sound parameters

Amplitude

The amplitude setting controls the level of power input and the degree of cavitation. The setting is made as a percentage of the maximum amplitude of the probe. The amplitude must be selected for the specific application in order to achieve the desired sonication result. If the amplitude and sonication duration, and therefore the energy input, are too high, this may result in unnecessary heating, splashing or foaming of the sample liquid or possibly the destruction of sample components. Guide values for settings can be taken from our application examples or can be determined experimentally.





Pulsation

By default, the energy should be permanently transferred to the sample during sonication. In this case, the device runs in continuous operation ("non-stop"). There are applications in which it makes sense to apply energy in time intervals. Reasons for pulsing include, for example, an undesirably rapid heating of the sample, a desired settling of the sample on the bottom of the vessel or intended reactions during the pauses.

Sonication duration

The sonication duration in stationary operation is usually between 15 s and 5 min. As with the selected amplitude, too short a sonication may not be sufficient for the desired sonication result. Too long sonication may lead to an unnecessary increase in the temperature of the sample or even to an impairment of the sample properties. Last but not least, the processing effort may be unnecessarily increased. It is therefore advisable, based on the information provided in chapter 4 applications to select a tendency for the sonication duration, but then to analyse in small test series which duration is optimal for the own application. There is usually no 100 % agreement with regard to vessel, sample volume, concentration, etc..

Cooling

Depending on the conditions, the power input is converted into heat; this can lead to a sharp increase in the temperature of the sample with small volumes. The heating can be influenced by the parameters amplitude, pulse and sonication duration described above. It should be checked whether the heating that does occur has a negative effect on the sample. In this case, cooling of the samples is recommended. This can be realised with little effort by placing the sample containers in an ice bath or crushed ice. Alternatively, vessels with a cooling jacket can be purchased from our range.

Coolin with crushed ice

Beads in the reaction cup

Use of beads

For particularly solid materials, it can be helpful to add glass beads to the solution to enhance the effect of ultrasonic cavitation. Beads can be added in various sizes (diameter up to 0.5 mm) and different quantities. A good result can often be achieved with a ratio of 1/3 beads to 2/3 solution. When using beads, a higher removal rate of the probes must be taken into account.

Beads greatly enlarged

Application overview

The number of possible applications is very large and the areas of application are extremely wide-ranging, with new ones being added all the time. The most important processes and industries in which the ultrasonic homogeniser is used in the laboratory or the sonoreactor on a production scale are listed below. Please see it as a suggestion for your individual situation in which the ultrasonic homogeniser or sonoreactor can provide a solution.

Basic procedures

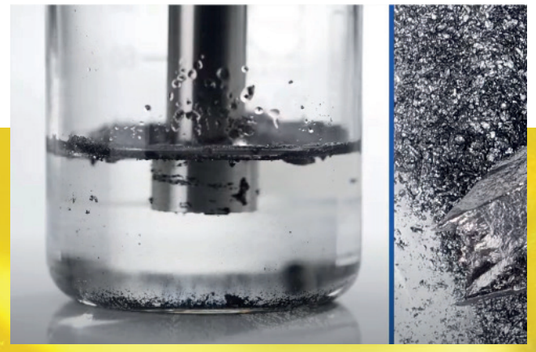
Dispersing: suspending, emulsifying

During dispersion, substances that do not or hardly dissolve in each other are optimally mixed. Depending on the dispersion medium and the dispersed phase, a distinction is made between different types of dispersion.

Emulsion-liquid in liquid (dispersion phase)
Suspension–solid in liquid

Very good results can be achieved by using an ultrasonic homogeniser for both emulsifying and suspending. Particles are disagglomerated and electrostatic forces of attraction (Van der Waals forces) are broken through. The high forces (see fundamentals of ultrasound) result in very finely dispersed emulsions / suspensions with very small droplet or particle sizes down to the micro- and nanometre range, which leads to very good stability of the resulting emulsions /suspensions. In contrast to other methods, there is no formation of clumps or clusters, sedimentation or undesirable air inclusions. Examples of applications include the production of inks, colours, cosmetics, technical oils and much more.

In the field of nanoparticles, a large number of applications have become widespread, particularly in recent years. Ultrasound can be used to achieve particularly good dispersion results in terms of the average particle size and particle size distribution.
Ultrasonic sonication is possible on any scale, from µl to upscaling to production scale. Sonication can be carried out discontinuously or in a continuous flow. One example of this is the production of pharmaceutical preparations, in particular finely dispersed emulsions such as lotionsor ointments. When using mechanical homogenisers, too slow stirring often leads to separation of the liquid and too fast stirring leads to undesirable air inclusions. The ultrasonic homogeniser produces a physically stable emulsion!
The yield of the droplet comminution is determined by the applied amplitude.



Homogenising

If ultrasound is used for homogenising, the particles (liquid or solid) are crushed in a liquid, resulting in more intensive mixing. There is a wide range of possible applications. For homogenisation in sample preparation in analytics, see below.

Extraction

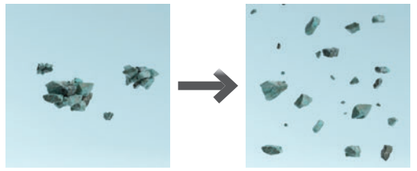
Another extremely interesting area of application is the extraction of ingredients from solid particles into the liquid phase. Advantages that can be achieved in many applications compared to other extraction methods:

- higher yield
- shorter extraction time
- lower required temperature
- lower proportion of solvents
- complete changeover to aqueous phases

In some cases, a combination of ultrasound with other extraction methods is also practical. The application can be adjusted very individually to the requirements, upscaling to production processes is very well possible. One example of the application is the extraction of mineral components from soil as sample preparation for analysis. Extraction is complete after just 10 s, shaking for 1 h in the usual overhead shaker.

Disagglomeration

Agglomerates can be very effectively destroyed with an ultrasonic homogeniser. For example, this is employed in sample preparation for particle size analysis, as preparation for cell count determination in microbiology, for the production of stable protein solutions, etc.
The high variability of the power input makes it possible to ensure that precisely the right amount of power that is required for complete disagglomeration without degrading the particles, cells, etc., is applied.



Degassing, defoaming

The removal of air or other gases from liquids in many cases, the homogenisation of liquids is essential for further use, for example for HPLC liquids, for the analysis of carbonated beverages, for the degassing or defoaming of emulsions, paints or similar. Degassing or defoaming can be carried out very quickly, effectively and easily using an ultrasonic homogeniser. Even large sample volumes, including chemical solutions, can be degassed with ultrasound. This usually takes place in a flow-through cell, which can also be integrated into a production line where, for example, gas has to be expelled from a liquid (degassing opening must be present).

Sample preparation for analysis: Homogenisation, extraction, disagglomeration, degassing

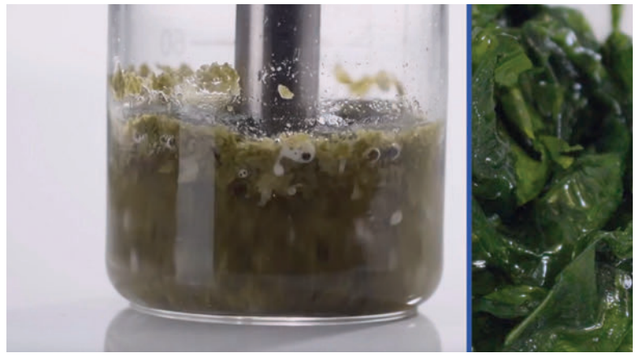
These methods are widely used in sample preparation for analysis and, compared to alternative methods, are particularly effective and easy to use.
Sonication takes a few seconds or minutes. Preparation, use and cleaning are extremely simple and uncomplicated. It is not necessary to dismantle the device for cleaning.
The use of a autosampler is possible.
Examples of applications are

- Disagglomeration as sample preparation for particle size analysis
- Homogenisation of waste, wastewater and food samples for ingredient analysis
- Extraction of ingredients, for example minerals from soil, etc.
- Degassing of carbonated beverages for interference-free analysis of the ingredients

Volumes of µl quantities up to 3,000 ml can be sonicated stationary or with a flow-through vessel made of stainless steel or glass in a size dimension of up to 100 l/h. The solution to be treated can also be circulated through the sonication vessel several times. For coarse pre-shredding is generally advisable for lumpy goods. If necessary, cooling is possible in a simple way (ice bath, flow-through cooling jacket).
Pulsation (cyclical sonication) prevents the sample from heating up too quickly and also achieves good turbulence in the sample.
Long probes are particularly suitable for sonicating ceramic suspensions, for example, or for sample preparation for particle size analysis.

Disruption of cells, microorganisms and tissue

The ultrasonic homogeniser has been established for decades as the standard method for the disruption of cells of all kinds. Bacteria, yeasts, fungi, eukaryotic or plant cells, tissue and algae, even microalgae, can be disrupted. The wide range of variation in power input is particularly relevant here. This allows the degree of disruption to be controlled. For example, fragmentation of the DNA can also be achieved if desired. Too much power input may lead to an excessive degree of disruption or unnecessary heating. Cooling is recommended for most applications. Indirect sonication is sometimes preferred. Even very small quantities in the µl range can be sonicated well and easily.

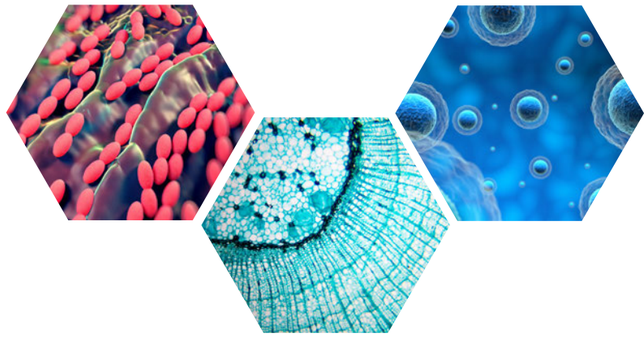


Cell disruption

Sonification with an ultrasonic homogeniser achieves short disruption times, especially for bacteria. 20 ml of a 20 % yeast cellsolution can be disrupted in 20 minutes (use of beads). In the case of animal cells, which are only surrounded by an outer membrane, the disruption time is considerably shorter than with alternative methods. A few seconds to 5 minutes are required.
Plant cells require up to 15 minutes, as the cells have an additional moulding membrane. Thermal damage to the cell contents can be prevented by pulsing, i.e. periodically interrupting the power supply. Suitable time intervals can be set on the device for this purpose. Cooling is made possible during the pulse pause. In addition, cooling vessels made of glass or stainless steel can be used so that temperature control using liquid coolants is possible during sonication. The use of rosette cells, in which the sample can be repeatedly and evenly sonicated due to the shape of the side arms (circulation), is also well suited. Cooling is easily possible here, for example by placing the vessel in an ice bath. Larger

quantities can be sonicated in a flow-through vessel , which is equipped with a cooling jacket.
In the case of particularly resistant bacteria, fungi and spores, direct sonication with microspikes is helpful, as this enables a higher power density.
It should be mentioned again at this point that the probes are made of a titanium alloy and are therefore thermostable and autoclavable.

The direct sonication of µl quantities in 2 ml plastic caps is successfully used in practice with the 20-W-SONOPULS. Alternatively, µl quantities can also be sonicated indirectly in the cup booster. This can be a better alternative if direct sonication results in too much splashing. However, the achievable power densities are lower, but cell disruption is still possible in many cases.



Tissue disruption

The use of ultrasound for tissue disruption is also interesting, especially for difficult tissues such as brain, liver, bladder, aorta, kidney, lungs, skin, muscle, bone, heart muscle and fibrin. When sonicating an intact piece of tissue, the piece of tissue and the probe must be in contact. Cooling may be necessary due to possible rapid heating of the sample. The material, shape and size of the sample container are also decisive. Sample vessels made of thin glass, such as Pyrex or Vycor, tend to break if the probe touches the vessel wall.

The use of stainless steel centrifuge tubes or so-called "Cold Shoulders Cooling Cells" is recommended. These are thin stainless steel test tubes with a comb shape on the sides and a dimple on the bottom. The comb shape increases the heat transfer and the dimple provides a "resting place" for the tissue. When this vessel is placed in an ice-water bath, the temperature of the tissue can be kept at 5 °C using a magnetic stirrer.

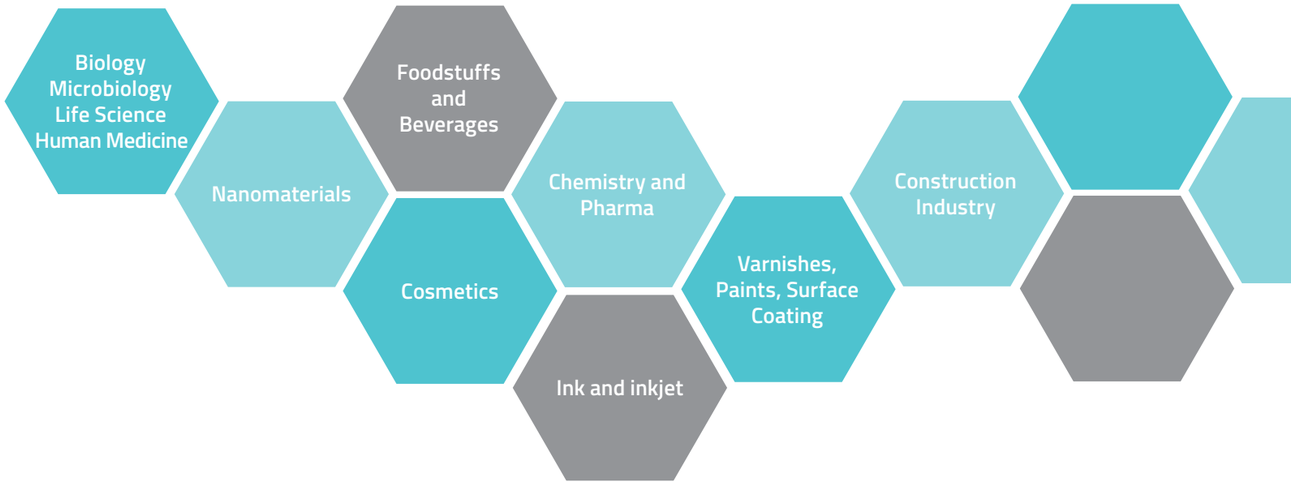
In the case of skin, effective disruption is only possible if the probe is pressed against the tissue and against the bottom of the vessel. Even faster results are achieved if glass beads (up to 0.5 mm in diameter) are added to the solution, which fall to the bottom of the tube after sonication and are then centrifuged or filtered off. A good ratio is 1/3 glassbeads to 2/3 solution. for example, 1 g of skin requires 4 min for disruption.
If glass beads cannot be added, enzymes, such as hyaluronidase, can be used to dissolve the cohesive tissue. The sample vessel should be sufficiently filled with liquid to prevent foaming, but this is only a problem with very small volumes. A plastic ring or wire could also be placed on the surface of the liquid to avoid violent surface movements.
Very small pieces of tissue can be easily disrupted with a micro tip in a narrow vessel.

There is no particular advantage to cutting the tissue into small pieces, unless it is to "flow freely" below the probe. In this case, the probe must not be positioned directly on the tissue.
If freezing and crushing are permitted, the probe does not have to touch the tissue. Larger quantities can also be sonicated. A simple method for larger quantities, for example 10 g of liver, is as follows: The tissue is liquefied for 10 s in a high-speed mixer. The probe is then immersed into the liquid and sonicated for 15 seconds.
If subcellular components are to remain intact, you should work with a lower amplitude and possibly increase the sonication time.

Sonochemistry

The term "sonochemistry" describes the use of ultrasound to influence chemical reactions or polymerisation. The desired and achieved effects are, for example, an increase in reaction speed and yield overall or of individual reactants / catalysts or influencing the reaction path. In some cases, reactions only take place when

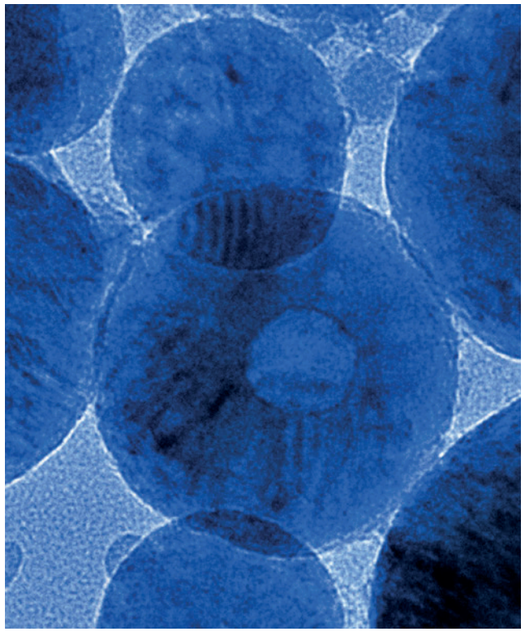
Power is introduced using an ultrasonic homogeniser. The effects are understandably extremely individual, and testing and method development can be very worthwhile.



Branches with ultrasonic applications

Biology - microbiology - life science - human medicine

The disruption of cells or tissue is an established method with good results for a wide variety of cell and tissue types. There are no restrictions in terms of volume, whether for microvials in the laboratory or for use on a production scale.
Fermentation processes can be activated or accelerated and cells can be broken down on a large scale. A special design optimises the turnover in biogas plants.



Nanomaterials

As widespread as the use of nanomaterials is today and as large as their product diversity is, the use of ultrasonic homogenisers in this field is just as varied. Classic applications are the deagglomeration of nanoparticles in solutions for further use, particlesize analysis or the suspension of nanoparticles in solutions for further processing, for toxicity tests or similar. Ultrasonic homogenisers are also used for the production of nanomaterials, for acceleration, reaction control, obtaining defined particle structures and similar applications.
Other successfully tested applications are the positive influence for the production of surface coatings or functionalisation / phase transfers of nanoparticles. In terms of volumes, there are also no restrictions here, whether it is the microvial in the laboratory or the application on a production scale.

Foodstuffs and beverages

For the analysis of foodstuffs, these often have to be homogenised in a liquid phase, which can be achieved extremely easily, quickly and efficiently with the ultrasonic homogeniser. The high power input produces smaller particles and thus achieves a more homogeneous distribution. In many cases, solvent additives are no longer required and smaller sample quantities can be used. The main area of application for ultrasonic homogenisers is in the preparation of samples, homogenising and extracting substances of all kinds. The variety of samples is large. The sonication of hard cheese, cream cheese, salami and ham, for example, has proved very successful in practice. In the beverage industry, degassing using ultrasonic homogenisers is a particularly widespread application, whether for subsequent analysis or other further processing. 0.5 l of beer, for example, is degassed at 100 % amplitude and 50 % pulsation in 1 min.

By using the ultrasonic homogeniser, both time and energy could be saved and a smaller sample quantity was required! Furthermore, 50 g of frozen fish, for example, can be homogenised in less than 1 minute without the addition of solvents. Cheese, especially cream cheese, is homogenised in practice with good application advantages, namely easy handling and very fast cleaning, in sample preparation for analysis (nitrate determination etc. a.). It has been proven that very reliable analysis results are obtained.

Microbial processes such as fermentation, cell disruption, enzyme activation etc. can be carried out in many different ways. Autosamplers can be used for a higher sample throughput in sample preparation. On a production scale, all processes such as homogenising, dispersing, suspending, emulsifying or degassing can be processed using sonoreactors with individual setups. Various reference studies have been carried out in collaboration with universities, various companies and research institutes. At one university, for example, a method for the rapid and gentle isolation of fat was developed to determine intramuscular fat and the fatty acid pattern in pork. For this purpose, 50 pork chop samples were analysed. Pureed meat was compared with ultrasonically homogenised meat.

Cosmetics

Emulsions and suspensions are the keystones of products as well as development, analysis and production processes in the cosmetics industry. As already described, sonication with the ultrasonic homogeniser produces emulsions and suspensions with outstanding properties, easy handling and optimum flexibility in terms of property settings (droplet or particle size, stability, etc.). Another area of applicationis the extraction of ingredients from plants, which can be extracted quickly, efficiently and with high yields. Both the extraction time and the necessary extraction temperature are more favourable for many applications than with other extraction methods.

In some cases, the combination of classic extraction methods with the ultrasonic homogeniser has also proven to be particularly successful.
These processes can be realised both on a laboratory scale and in the production area with individually aligned technology constellations. The ultrasonic homogeniser has also established itself excellently in sample preparation for the analysis of cosmetics, whether for particle size analysis, for the homogenisation of hydrophobic fat-rich substances such as make-up, lipstick or mascara for the analysis of ingredients (e.g. by HPLC) or for other analysis techniques.

Chemistry and pharmaceuticals

The wide variety of products and processes in these two industries results in the large number of possible applications of the processes described above with the ultrasonic homogeniser in the laboratory and the sonoreactors on a production scale. On the one hand, there are the physical processes of suspending, emulsifying for additives such as pigments or other additives for lubricating oils, formulations, etc. On the other hand, sonochemistry can be used to directly influence chemical reactions or polymerisations in terms of yield, reaction speed, reaction control, etc. The overlaps between pharma, chemistry, phyto, cosmetics, life science and nanomaterials are now very numerous and the transitions are fluid. Applications such as extraction, cell disruption and deagglomeration (e.g. for particular polymer structures) should also be mentioned here. In order to avoid excessive duplication, not all aspects are covered here repeatedly. For more information, please refer to the individual sections of chapter 4 basic application options and the other similar sectors listed in this chapter.

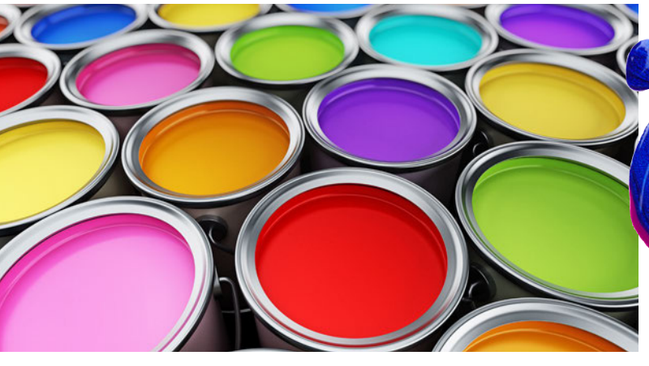
Ink and inkjets

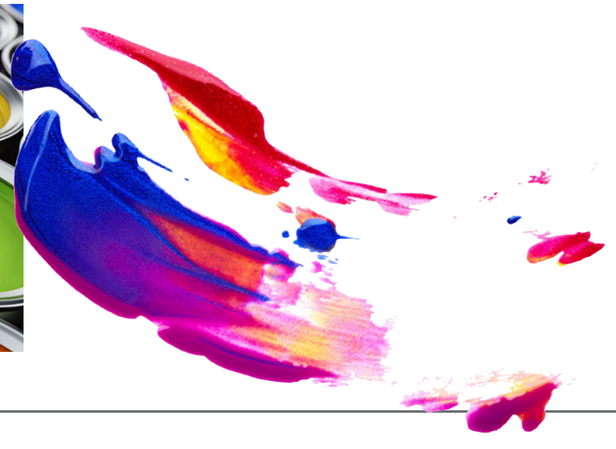
The dispersion of ink pigments is an excellently established application of the ultrasonic homogeniser. Because particle sizes down to the low nanometre range can be achieved, particularly finely dispersed inks with correspondingly high-quality properties of the resulting products are obtained. Both awater-based and solvent-based inks can be sonicated.
Another advantage is that the processis particularly safe. It is also true. Both process development on a laboratory scale and upscaling to production processes are very well possible.

Paints and varnishes, surface coatings

Pigments, fillers and additives of all kinds can be effectively added very effectively to paints, varnishes or other coating materials using ultrasound.
Ultrasonic homogenisers are also used very successfully for nanoparticles in the laboratory, sonoreactors in the production area. When it comes to dispersing, emulsifying, suspending, disagglomerating, defoaming or degassing, ultrasound is an effective means of realising processes or improving product properties, as described above. Ultrasound can also be used to excellent effect in the now increasingly desired shifts from solvent-based to aqueous-based products or the reduction of VOCs, whether in product development on a laboratory scale or after upscaling to the sonoreactor in production.
In the field of analysis, disagglomeration or homogenisation as sample preparation is successfully possible using ultrasonic homogeniser.

There are also potential applications in the field of synthesis, the mini-emulsion polymerisation is just one example.





Construction industry

Ceramics and cement manufacturers, etc. use ultrasonic homogenisers in a variety of ways. The pre-dispersion of slurries, the suspension of solids such as aluminium oxide, silicon dioxide etc., the sample preparation for particle size analysis are examples of practical applications. Here too, the production process, such as cement production, can be positively influenced.

Detailed applications
Examples from practice

04

Detailed applications
A word in advance

Brief explanations of the following practical examples.

Page 92

Application overview

Tabular overview of the most common applications, organised by process and industry.

from page 94

Publications

Recommendations for further specialist literature on ultrasonic homogenisers and their applications.

Page 103

Detailed applications

A word in advance

The method of ultrasonic homogenisation, i.e. the direct introduction of ultrasonic power into the sample, has proven itself in practice for decades as a supplement to the well-known and proven ultrasonic bath in the laboratory. Foodstuffs , soil, waste, nanoparticles, materials, cosmetics, pharmaceuticals, biotech, microbiology, life science and chemistry are just some of the many areas of application in which the ultrasonic homogeniser, manufactured by BANDELIN since 1964, is used.

The application guide was developed at the suggestion of our customers and created for our customers and interested parties. And not only that, it was primarily created with our customers. Users report on their practical experience and provide the method parameters that have proven themselves in practice. We have also incorporated the findings and experiences from our ultrasound user seminars, in which we have delved into the world of ultrasound with theoretical and practical reports. The discussions and practical applications with the participants' samples have resulted in further new experiences for the successful use of the devices: How can the devices be used successfully? How can they be optimally integrated into other processes? Which product features and information are important for users?

Whenever the task involves

- homogenising, suspending, emulsifying,
- sample preparation for analysis,
- disagglomerating, extracting,
- cell and tissue disruption or
- sonochemistry

the use of the ultrasonic homogeniser is interesting if a liquid medium is available.

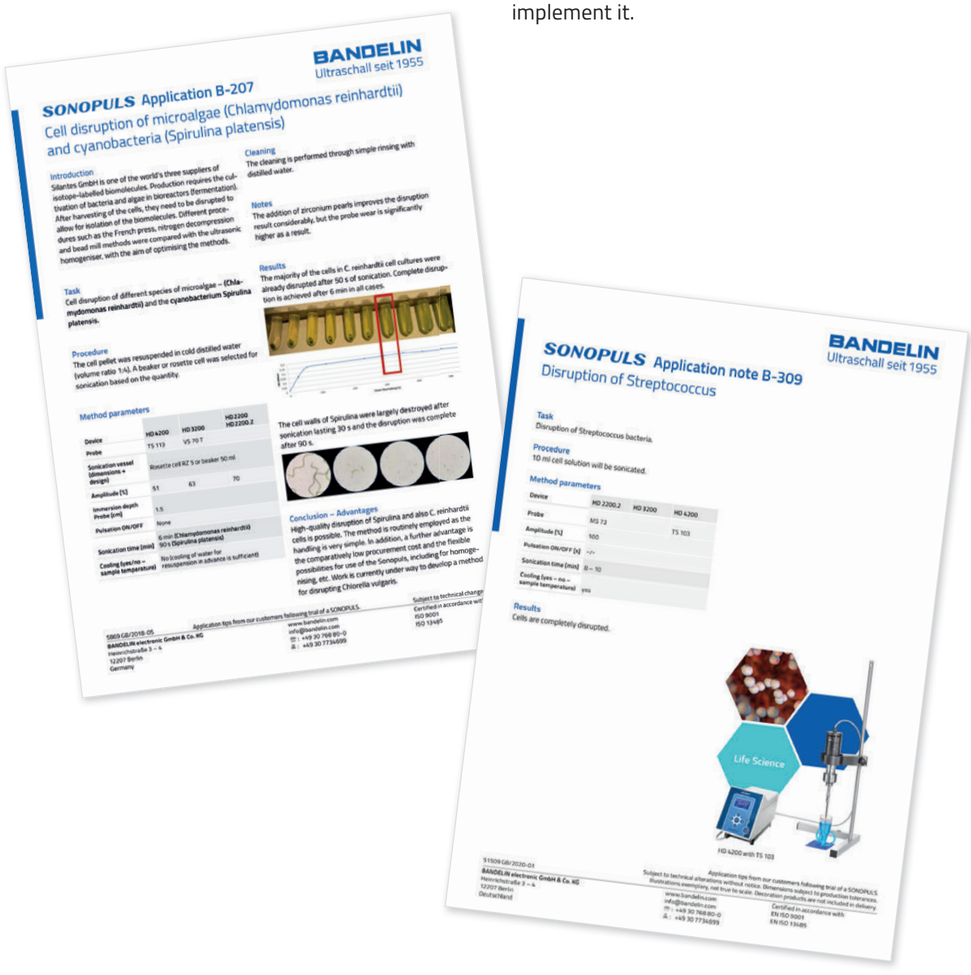
HD 4200 with TS 113

The number of applications in a specific area of application is not closely related to the suitability of the ultrasonic homogeniser for these applications. It is largely due to the segment in which the use of the ultrasonic homogeniser became established in practice years ago or where its use was only recently "discovered", but then often with particular success. Another criterion is the detailed splitting of the application. If cell disruption is described individually for many different organisms, a generalised application is sufficient in other areas such as degassing or similar.

Last but not least, we can include as many practical examples as are made available to us by co-operative users for use in this collection.

The collection of applications is constantly expanding. We look forward to any further feedback on interesting applications.

In the overview you can see which applications are currently recorded in writing as practical reports. We will be happy to send you a copy on request (info@bandelin.com) to send you the relevant application notes. If the application you are looking for is not included, please contact us and we will be happy to give you tips on how to implement it.



Dispersing, suspending

Number	Field of work	Branch	Title
C-104	Dispersing/ Suspending	Materials	Dispersing of carbon nanoparticles in processing oil
C-105	Dispersing/ Suspending	Materials	Dispersing of ceramic raw materials and glass powder
C-107	Dispersing/ Suspending	Pharma	Production of ultrafine pharmaceutical emulsions
C-108.	Dispersing/ Suspending	Polymers	Production of microcapsules with monomers
C-109	Dispersing/ Suspending	Materials	Dispersing of solids such as aluminium oxide and silicone dioxide
C-202	Dispersing/ Suspending	Materials	Suspendinging of multi-walled carbon nanotubes (MWCNTs). GFRPs and other hard-to-dissolve materials
C-203	Dispersing/ Suspending	Materials	Sample preparation of ceramic suspensions for particle measurement – particle size analysis
C-207	Dispersing/ Suspending	Polymers	Production of polymer particle suspensions
L-102	Dispersing/ Suspending	Food	Production of hop emulsions
C-301.	Dispersing/ Suspending	Materials	Producing ceramic slurries (Al_2O_3 in water)
C-302.	Sample preparation	Cosmetician	Sample preparation of cosmetics in organic and aqueous solvents
C-303.	Dispersing/ Suspending	Materials	Dispersing titanium dioxide in oil or water
C-304	Sample preparation	Miscellaneous	Dispersing of ettringite, aluminium and silicon dioxide for particle size analysis
C-305	Dispersing/ Suspending	Materials	Dispersing of solids such as very fine titanium dioxide or aluminium oxide

Disagglomeration

Number	Field of work	Branch	Title
B-208	Disagglomeration	Microbiology	Separation of yeasts for determination of the vital cell count
C-101	Disagglomeration / particle size analysis	Materials	Disagglomeration of tungsten powder for subsequent particle size determination
C-102	Disagglomeration / particle size analysis	Materials	Dispersing of fine metal powder (Al) for subsequent particle size determination
C-106	Disagglomeration / particle size analysis	Water / waste-water	Disagglomeration of water sediment samples in preparation for particle size analysis
C-111T	Disagglomeration / particle size analysis	Materials	Disagglomeration as sample preparation for particle size analysis – Tabular overview
C-204	Disagglomeration / particle size analysis	Materials	Sample preparation for the particle size measurement of catalyst dispersions
C-208	Disagglomeration / particle size analysis	Foodstuffs	Homogenising of solid food supplements in water for sample preparation for particle size analysis
C-211	Disagglomeration	Materials	Disagglomeration of IONP produced using the coprecipitation method
C-304	Sample preparation	Miscellaneous	Dispersing of ettringite, aluminium and silicon dioxide for particle size analysis
C-305	Dispersing/ Suspending	Materials	Dispersing of solids such as very fine titanium dioxide or aluminium oxide
C-306.	Disagglomeration	Materials	Disagglomeration of ceramic nanoparticles

Degassing, defoaming

see section "Degassing, defoaming", page 82

Extraction

Number	Field of work	Branch	Title
C-201	Extraction	Soil	Extraction of exchangeable magnesium from soil
C-206	Extraction	Varnishes / Paints	Extraction of oily ingredients from dried varnish
U-301	Extraction	Soil	Extraction of water-soluble ions from soils
U-303	Extraction/ Sample preparation	Soil	Extraction/homogenising of soil samples in liquids to analyse minerals like Mg, K, P, N

Sample preparation analysis (except grain size analysis)

Number	Field of work	Branch	Title
B-114	Sample preparation	Medicine	Homogenising of sperm for determination of quantity
B-212	Sample preparation	Molecular biology	Dissolving of peptides as sample preparation for analysis
C-110	Sample preparation	Water / waste water	Sample preparation of wastewater samples
C-112T	Sample preparation	Miscellaneous	Sample preparation for analysis for soil and wastewater samples
C-205	Sample preparation	Cosmetics	Homogenising of cosmetics in solvents for sample preparation for analysis
C-210	Sample preparation	Water / waste water	Sample preparation of wastewater containing particles, for TOC determination as per DIN EN 1484
L-101	Sample preparation	Foodstuffs	Fast and gentle isolation of fat for fatty acid determination in meat – Method improvement

Number	Field of work	Branch	Title
L-103	Sample preparation	Foodstuffs	Identification of fatty acid distribution in bovine milk
L-201	Sample preparation	Foodstuffs	Sample preparation for determination of nitrate content in cheese (xylenol process)
L-202	Sample preparation	Foodstuffs	Sample preparation for potentiometric determination of chloride content in cheese
L-203	Sample preparation	Foodstuffs	Sample preparation for potentiometric determination of chloride content in cheese
L-204	Sample preparation	Foodstuffs	Sample preparation / homogenising of cheese and other foodstuffs and extraction of relevant analytes
U-203	Sample preparation	Water / waste water	Sample preparation at a sewage plant
C-302.	Sample preparation	Cosmetics	Sample preparation of cosmetics in organic and aqueous solvents
C-304	Sample preparation	Miscellaneous	Dispersing of ettringite, aluminium and silicon dioxide for particle size analysis
L-301	Sample preparation	Foodstuffs	Homogenising of frozen human milk and disruption of fat globules and disruption of fat globules
U-301	Extraction	Soil	Extraction of water-soluble ions from soils
U-302	Sample preparation	Waste	Preparation of waste samples
U-303	Extraction/ Sample preparation	Soil	Extraction / homogenising of soil samples in liquids to analyse minerals like Mg, K, P, N

Sample preparation for particle size analysis

see section "Disagglomeration", page 81

Cell and tissue disruption

Cell disruption

Number	Field of work	Branch	Title
B-101	Cell disruption	Molecular biology	Cell and tissue disruption, including in µl-batches with indirect sonication in a beaker resonator
B-102	Cell disruption	Molecular biology	Cell disruption of yeast cells
B-108T	Cell disruption	Molecular biology	Cell disruption of Escherichia coli bacteria – tests with diverse parameters with the SONOPULS
B-109	Cell disruption	Molecular biology	Cell disruption of Pseudomonas thailandensis
B-110	Cell disruption	Molecular biology	Lysis and fragmentation of cell cultures via indirect sonication in the scope of cancer research
B-111	Cell disruption	Molecular biology	Procurement of proteins for the western blot technique, e.g., for evidence of HIV or other infections
B-112	Cell disruption	Molecular biology	Cell disruption of eukaryotic cells as preliminary step to protein isolation
B-113	Cell disruption	Molecular biology	Cell disruption of insect cells as preliminary step to protein isolation
B-115	Cell disruption	Molecular biology	Cell disruption of mammalian cells
B-117	Cell disruption	Molecular biology	Production of lysates from purchased cell cultures for antibody reactions
B-119T	Cell disruption	Molecular biology	Cell disruption of different organisms and cells – Tabular overview
B-201	Cell disruption	Molecular biology	Cell disruption of E. coli in volumes from µl to l
B-203	Cell disruption	Algae	Cell disruption of Haematococcus pluvialis microalgae for carotinoid analysis
B-205	Cell disruption	Molecular biology	Cell disruption of Escherichia coli for protein analysis
B-206	Cell disruption	Molecular biology/ medicine	Cell disruption of human cells
B-207	Cell disruption	Algae	Cell disruption of microalgae and cyanobacteria
B-209	Cell disruption	Molecular biology	Production of cell lysates of eukaryotic cells in different volumes
B-211	Cell disruption	Molecular biology	Cell disruption for enzyme processing for E. coli or fungi cultures
B-302	Cell disruption	Molecular biology	Time-efficient disruption of human cells
B-305	Cell disruption	Materials	Disruption of Acetobacter xylinum
B-306	Cell disruption	Genetics	Disruption of Erythrocytes for the paternity test
B-307	Cell disruption	Biochemistry	Disruption of Candida albicans
B-308	Cell disruption	Microbiology	Disruption of Staphylococcus aureus
B-309	Cell disruption	Microbiology	Disruption of Streptococcus
B-310	Cell disruption	Microbiology	Disruption of Pseudomonas aeruginosa
B-311	Cell disruption	Microbiology	Disruption of Enterobacter for protein isolation

Tissue disruption

Number	Field of work	Branch	Title
B-106	Tissue disruption	Tissue	Tissue disruptions, especially also for difficult tissues
B-107	Tissue disruption	Tissue	Tissue disruption of larger quantities, e.g., liver
B-116	Tissue disruption	Molecular biology	Production of protein lysates from tissue
B-118T	Tissue disruption	Tissue	Tissue disruption applications – Tabular overview
B-202.	Tissue disruption	Toxicology	Tissue disruption –Homogenising of organs in forensic medicine
B-301	Tissue disruption	Molecular biology	Homogenising of mouse tissue for RNA isolation
B-304	Tissue disruption	Biochemistry	Disruption of dermal tissue

Miscellaneous

Number	Field of work	Branch	Title
B-103	Miscellaneous	Medicine	Procurement of stroma-free haemolysate from EDTA blood for paternity testing
B-104	Miscellaneous	Molecular biology	Liposome production
B-105	Miscellaneous	Molecular biology	Replication of infectious prions – process acceleration via ultrasound
B-204	Miscellaneous	Molecular biology	Homogenising of peptide with Freund's adjuvant
B-210	DNA isolation	Molecular biology	Disruption of FFPE tissue for DNA isolation
C-103	Miscellaneous	Polymers	Degradation of cellulose using ultrasound
C-209	Miscellaneous	Materials	Phase transfer of iron oxide nanoparticles
B-303	Cell disruption	Biochemistry	Disruption of plant cells
B-305	Cell disruption	Materials	Disruption of Acetobacter xylinum
B-306	Cell disruption	Genetics	Disruption of Erythrocytes for the paternity test
B-307	Cell disruption	Biochemistry	Disruption of Candida albicans
B-308	Cell disruption	Microbiology	Disruption of Staphylococcus aureus
B-309	Cell disruption	Microbiology	Disruption of Streptococcus
B-310	Cell disruption	Microbiology	Disruption of Pseudomonas aeruginosa
B-311	Cell disruption	Microbiology	Disruption of Enterobacter for protein isolation
B-312	DNA fragmentation	Microbiology	Fragmentation of nucleic acid – synthetically degrated DNA

Classification by branches / field of work

Materials

Number	Field of work	Branch	Title
C-101	Disagglomeration / particle size analysis	Materials	Disagglomeration of tungsten powder for subsequent particle size determination
C-102	Disagglomeration / particle size analysis	Materials	Dispersing of fine metal powder (Al) for subsequent particle size analysis
C-104	Dispersing/ Suspending	Materials	Dispersing of carbon nanoparticles in process oils
C-105	Dispersing/ Suspending	Materials	Dispersing of ceramic raw materials and glass powder
C-109	Dispersing/ Suspending	Materials	Dispersing of solids such as aluminium oxide and silicone dioxide
C-111T	Disagglomeration / particle size analysis	Materials	Disagglomeration as sample preparation for particle size analysis – Tabular overview
C-202	Dispersing/ Suspending	Materials	Suspending of multi-walled carbon nanotubes (MWCNTs). GFRPs and other hard-to-dissolve materials
C-203	Dispersing/ Suspending	Materials	Sample preparation of ceramic suspensions for particle measurement – particle size analysis
C-204	Disagglomeration / particle size analysis	Materials	Sample preparation for the particle size measurement of catalyst dispersions
C-209	Miscellaneous	Materials	Phase transfer of iron oxide nanoparticles
C-211	Disagglomeration	Materials	Disagglomeration of IONP produced using the coprecipitation method

Polymers / paints and varnishes

Number	Field of work	Branch	Title
C-103	Miscellaneous	Polymers	Degradation of cellulose using ultrasound
C-108.	Dispersing/ Suspending	Polymers	Production of microcapsules with monomers
C-206	Extraction	Varnishes/ paints	Extraction of oily ingredients from dried varnish
C-207	Dispersing/ Suspending	Polymers	Production of polymer particle suspensions

Environment

Number	Field of work	Branch	Title
C-106	Disagglomeration / particle size analysis	Water / waste water	Disagglomeration of water sediment samples in preparation for particle size analysis
C-110	Sample preparation	Water / waste water	Sample preparation of wastewater samples
C-201	Extraction	Soil	Extraction of exchangeable magnesium from soil
C-210	Sample preparation	Water / waste water	Sample preparation of wastewater containing particles for TOC determination as per DIN EN 1484
U-203	Sample preparation	Water / waste water	Sample preparation at a sewage plant

Life science / molecular biology

Number	Field of work	Branch	Title
B-101	Cell disruption	Molecular biology	Cell and tissue disruption, including in µl-batches with indirect sonication in a cup booster
B-102	Cell disruption	Molecular biology	Cell disruption of yeast cells
B-103	Miscellaneous	Medicine	Procurement of stroma-free haemolysate from EDTA blood for paternity testing
B-104	Miscellaneous	Molecular biology	Liposome production
B-105	Miscellaneous	Molecular biology	Replication of infectious prions – process acceleration via ultrasound
B-108T	Cell disruption	Molecular biology	Cell disruption of Escherichia coli bacteria – tests with diverse parameters with the SONOPULS
B-109	Cell disruption	Molecular biology	Cell disruption of Pseudomonas thailandensis
B-110	Cell disruption	Molecular biology	Lysis and fragmentation of cell cultures via indirect sonication in the scope of cancer research
B-111	Cell disruption	Molecular biology	Procurement of proteins for the western blot technique, e.g., for evidence of HIV or other infections
B-112	Cell disruption	Molecular biology	Cell disruption of eukaryotic cells as preliminary step to protein isolation
B-113	Cell disruption	Molecular biology	Cell disruption of insect cells as preliminary step to protein isolation
B-115	Cell disruption	Molecular biology	Cell disruption of mammalian cells
B-116	Tissue disruption	Molecular biology	Production of protein lysates from tissue
B-117	Cell disruption	Molecular biology	Production of lysates from purchased cell cultures for antibody reactions
B-119T	Cell disruption	Molecular biology	Cell disruption of different organisms and cells – Tabular overview
B-201	Cell disruption	Molecular biology	Cell disruption of E. coli in volumes from µl to l
B-204	Miscellaneous	Molecular biology	Homogenising of peptide with Freund's adjuvant
B-205	Cell disruption	Molecular biology	Cell disruption of Escherichia coli for protein analysis
B-206	Cell disruption	Molecular biology/ medicine	Cell disruption of human cells
B-209	Cell disruption	Molecular biology	Production of cell lysates of eukaryotic cells in different volumes

Number	Field of work	Branch	Title
B-210	DNA isolation	Molecular biology	Disruption of FFPE tissue for DNA isolation
B-211	Cell disruption	Molecular biology	Cell disruption for enzyme processing for E. coli or fungi cultures
B-212	Samplespreparation	Molecular biology	Dissolving of peptides as sample preparation for analysis
B-301	Tissue disruption	Molecular biology	Homogenising of mouse tissue for RNA isolation
B-302	Cell disruption	Molecular biology	Time-efficient disruption of human cells
B-306	Cell disruption	Genetics	Disruption of Erythrocytes for the paternity test
B-308	Cell disruption	Microbiology	Disruption of Staphylococcus aureus
B-309	Cell disruption	Microbiology	Disruption of Streptococcus
B-310	Cell disruption	Microbiology	Disruption of Pseudomonas aeruginosa
B-311	Cell disruption	Microbiology	Disruption of Enterobacter for protein isolation
B-312	DNA-Fragmentation	Microbiology	Fragmentation of nucleic acid – synthetically degrated DNA

Medicine / toxicology / microbiology / algae

Number	Field of work	Branch	Title
B-103	Miscellaneous	Medicine	Procurement of stroma-free haemolysate from EDTA blood for paternity testing
B-114	Sample preparation	Medicine	Homogenising of sperm for determination of quantity
B-202.	Tissue disruption	Toxicology	Tissue disruption – homogenising of organs in forensic medicine
B-203	Cell disruption	Algae	Cell disruption of Haematococcus pluvialis microalgae for carotinoid analysis
B-207	Cell disruption	Algae	Cell disruption of microalgae and cyanobacteria
B-208	Desagglomeration	Microbiology	Separation of yeasts for determination of the vital cell count

Foodstuffs

Number	Field of work	Branch	Title
C-208	Disagglomeration / particle size analysis	Foodstuffs	Homogenising of solid food supplements in water for sample preparation for particle size analysis
L-101	Sample preparation	Foodstuffs	Fast and gentle isolation of fat for fatty acid determination in meat – Method improvement
L-102	Dispersing/ Suspending	Foodstuffs	Production of hop emulsions
L-103	Sample preparation	Foodstuffs	Identification of fatty acid distribution in bovine milk
L-201	Sample preparation	Foodstuffs	Sample preparation for determination of nitrate content in cheese (xylenol process)
L-202	Sample preparation	Foodstuffs	Sample preparation for potentiometric determination of chloride content in cheese
L-203	Sample preparation	Foodstuffs	Sample preparation for potentiometric determination of chloride content in cheese
L-204	Sample preparation	Foodstuffs	Sample preparation / homogenising of cheese and other foodstuffs and extraction of relevant analytes

Pharmaceutical / cosmetics

Number	Field of work	Branch	Title
C-107	Dispersing/ Suspending	Pharma	Production of ultrafine pharmaceutical emulsions
C-205	Sample preparation	Cosmetics	Homogenising of cosmetics in solvents for sample preparation for analysis
C-302.	Sample preparation	Cosmetics	Sample preparation of cosmetics in organic and aqueous solvents

Publications

SONOPULS ultrasonic homogenisers have been used successfully in scientific laboratories for many years. Accordingly, the information on them appears in several hundred scientific publications on a wide variety of topics. These publications can be found in the usual scientific search engines with the search options SONOPULS and BANDELIN.

Probenvorbereitung zur Bestimmung von Partikelgrößen – Desagglomeration mit Ultraschallhomogenisatoren

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Published in GIT Labor-Fachzeitschrift, Issue 01 / 2018, page 24-26

Probenvorbereitung mit dem Ultraschallhomogenisator – Einsatz im Analytiklabor nach Vergleich mit herkömmlicher Methode

(Einsatz des Ultraschallhomogenisators für die Probenvorbereitung Lebensmittel [Käse])
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Lecture VDLUFA Annual Congress 2016 in Rostock, published in VDLUFA publication series 73 (2016), page 598

Moderne Probenvorbereitung mit Ultraschall-homogenisatoren-Praxistest für Lebensmittel und Gewebe

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Published in GIT Labor-Fachzeitschrift, Issue 11/2014, page 44-46

Ultraschallanwendungen in Technik und Produktion

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Published in LABO, issue 09/2016, page 40-42

Effiziente Probenvorbereitung für die Partikelanalyse

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Published in Chemie Extra, issue 06/2018

Preparing a Sample for Determining the Size of Particles

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Published in the GIT Journal:
www.laboratory-journal.com/science/material-science/preparing-sample-determining-size-particles
30 November 2018

Viel Energie, wenig Aufwand

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Published in LABO, issue 02/2019, page 43-44

Service

We are the specialists for ultrasound in the laboratory

05

SONOPULS ultrasonic homogenisators and accessories for hire

Rent one of our ultrasonic homogenisers for a specific period of time.

Page 106

FAQ

The most important questions, briefly answered.

from page 108

Your contact for the laboratory area

Get competent and personal advice from our expert.

Page 110

SONOPULS ultrasonic homogenisers and accessories for rent

Do you need an ultrasonic homogeniser to test your application? We will provide you with a device free of charge for 3 weeks. A rental fee will be charged from the 4th week.

Note: Rentals are only possible within Germany and are only offered to commercial customers.

Rental equipment in just a few steps

1 Download the questionnaire from our website or request it by phone or e-mail. Complete part A here and send it back to us by e-mail.

To the questionnaire:
https://bandelin.com/fragebogen/Questionnaire_SONOPULS_en_BANDELIN.pdf

2 We select the appropriate SONOPULS and accessories for your planned application. You receive the rental agreement and return it signed.

3 Then it starts: The ultrasonic homogeniser is delivered at the agreed time and place.

4 After use, please return the device **including the completed decontamination certificate** to us.

Download the decontamination certificate:
https://bandelin.com/fragebogen/Dekontamination_GB_BANDELIN.pdf

FAQ

FAQ on practical application

Selection of operating frequency: 20 or 40 kHz?
40 kHz is generally used for homogenisation or mixing, as the cavitation bubbles formed are smaller than at 20 kHz. This means that these bubbles have less force during the implosion phase.

Are there technical limits to the use of ultrasound?
A) Viscosity - the higher the sample viscosity, the lower the ability to transmit the sound waves into the sample. Maximum viscosity approx. 1.500 mPa s - separate tests are recommended for higher viscosities.
B) Temperature - max. 80°C in continuous operation

Sample liquid splashes out of the vessel.
What do I need to change? Possible approaches:
- Set a lower amplitude and check whether the result is still satisfactory
- Using conical containers
- Increasing the immersion depth

My sample liquid foams very strongly.
How can I prevent this?
- Increasing the immersion depth
- Adding glass beads
- Use of a conical vessel
- Positioning wire on the sample surface

How deep do I have to immerse the probe?
Normally min. 0.5, max. 2 cm; too deep an immersion causes excessive damping of the probe. This results in insufficient power input into the sample. With Eppendorf cups, immerse as far as possible - make sure that the sample does not foam!

Is the probe allowed to touch the sample vessel during sonication?
No. Damage may occur to the probe and the vessel (melting, breakage).

May the probe be touched with the hands during the sonication process?
No. Damage to the bone tissue may occur.

I would like to seperate / disagglomerate cells, but cells are destroyed in the process.
What do I have to change?
Reduce the amplitude or use a probe with a larger diameter.

How is the performance of SONOPULS ultrasonic homogenisers determined?
To determine the applied power, the vessel that is also used in the laboratory should be used as the test vessel. This vessel is filled with water. The water is sonicated for a defined period of time and the temperature increase is measured. In the calorimetric measurement, the amount of heat ΔQ can be determined using the heat capacity c and the temperature difference ΔT. This results in the power input, taking into account the time difference Δt.
The following formula[1] applies:

$$P = \frac{\Delta Q}{\Delta t} = \frac{c \cdot m \cdot \Delta T}{\Delta t}$$

It applies:

P	Power [W]
ΔQ	Energy supplied, in this case the amount of heat [Ws]
Δt	Time [s]
c	Specific heat capacity [$\frac{J}{kg\,K}$]
ΔT	Temperature difference [K]
m	Mass of the test water quantity [kg]

The volumetric power density can be calculated by taking the water volume into account.
More detailed information can be found at bandelin.com (Performance specification SONOPULS ultrasonic homogenisers - 5169).

Can solvents be sonicated?
Yes, but a safe extraction of the vapours must be guaranteed!
Small quantities only!
Note flash point; cooling may be necessary!

1 The formula is only applicable for small volumes.

FAQ on equipment, probes, safety aspects

What should I do if the horn is already slightly pitted?
Up to depths of approx. 1 mm, the probes can be easily reworked manually, see instructions for use at.

Can probes be manufactured in any length?
No. The probes are always tuned to the resonance frequency and are fixed by the design. They vary in the millimetre range depending on the acoustic properties of the titanium melt (batch) used.

Do I need to take anything into account when disposing of the probes?
Probes can be disposed of easily, there is no potential danger, they do not contain any heavy metals and are therefore environmentally friendly.
Scrap dealers pay a small fee (titanium weighs little, but is valuable)

Can probes also be made from a different material?
Yes, but with certain restrictions:
- **Quartz glass** - only very low amplitudes can be achieved here, as the material cannot withstand high amplitudes.
- **Ceramic** - higher amplitudes than can be achieved with quartz glass, but very fragile.
- **Stainless steel** - is very brittle, breaks very quickly and heats up more quickly.
- **Aluminium** - too soft. A certain hardness is important to delay cavitation erosion to. Limited resistance to chemicals.

Is hearing protection necessary?
The ultrasonic homogeniser can be operated in a sound proof box, purchase via BANDELIN, please contact us.
Alternatively, hearing protection should be used: Ear muffs with an HM value of 25-30 dB or equivalent ear plugs or earmoulds if ear muffs are unsuitable for use.

FAQ on standards and directives

Do ultrasonic homogenisers comply with the ROHS directives?
The devices comply with the ROHS directives.

A word at the end

We hope that we have provided you with a good overview of the practical use of SONOPULS ultrasonic homogenisers. If you have any further questions, please do not hesitate to contact us for personalised advice. Please let us know your ideas for further content in the application guide. We will be happy to include your individual method as an application in the collection for the benefit of the community.

You can request our individual applications in accordance with chapter 4 "Detailed applications" at:
marina.herrmann@bandelin.com

Your contact person in the laboratory area

We will be happy to advise you personally!

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We will be happy to advise you personally!
Ask our experts.

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